Development of a theory- and evidence-informed behaviour change intervention to promote appropriate antibiotic use in acute hospitals

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Declaration

I hereby declare that the work presented in this thesis has not been submitted for any other degree or professional qualification, and that it is the result of my own independent work.

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Abstract

Background: Antimicrobial resistance poses a serious threat to global public health. Behaviours such as inappropriate antibiotic use in hospitals have contributed to this problem, and evidence-based interventions are urgently needed to improve prescribing practices in acute settings. Previous behaviour change interventions aimed at reducing inappropriate antibiotic use in hospitals have been sub-optimal and lacked details on their development.

Methods: Guided by the recommendations of the 2008 MRC Framework for Complex Interventions, intervention development followed a phased approach, including a systematic review and meta-ethnography, two qualitative studies with a total of 35 participants, and the development and operationalisation of the intervention content. A meta-ethnography, the first theoretical stage, synthesised 15 qualitative papers and provided an understanding of the contextual determinants influencing antibiotic prescribing in acute hospitals. The resulting conceptual model reflected how these challenges operate on both micro- and macro-level, highlighting key areas for improvement. Central to the design of an effective intervention was the generation of a robust theoretical basis using the Behaviour Change Wheel. The selection of an intervention content was guided by the APEASE criteria and coded according to an established Behaviour Change Technique Taxonomy. Healthcare professionals and patient representatives were involved at all stages of intervention design and interpretation. Focus groups carried out with key stakeholders filled in gaps in the literature and enabled modelling of the initial draft of the intervention. The optimisation phase, including assessing the intervention acceptability and suitability for clinical practice, was conducted using semi-structured interviews.

Results and Conclusions: A digital antibiotic review tracking toolkit (DARTT), a complex, multifaceted behaviour change intervention to improve antibiotic use in acute hospitals, was developed using systematic methods. This work addresses a gap in the literature regarding how to develop behaviour change interventions that are grounded in theory and acceptable for the target group. Findings from this work are

potentially transferable to a variety of behaviour change interventions and clinical settings.

Publications associated with this research

Wojcik, G., Ring, N., McCulloch, C., Willis, D. S., Williams, B., & Kydonaki, K. (2021). Understanding the complexities of antibiotic prescribing behaviour in acute hospitals: a systematic review and meta-ethnography. *Archives of Public Health*, *79*(1), 1–19. https://doi.org/10.1186/S13690-021-00624-1

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Presentations

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Abbreviations

AMR	Antimicrobial resistance
AMS	Antimicrobial stewardship
BCW	Behaviour Change Wheel
BCT	Behaviour change technique
CDC	Centres for Diseases Control and Prevention
CDSS	Clinical Decision Support System
COREQ	Consolidated criteria for reporting qualitative research
DARTT	Digital Antibiotic Review Tracking Toolkit
DDD	Defined daily dose
ECDC	European Centre for Diseases Control and Prevention
EU	European Union
FG	Focus group
FoD	Form of Delivery
GP	General Practitioner
HCP	Healthcare professional
ID	Infectious diseases
ME	Meta-ethnography
MoAs	Mechanisms of Action
MRC	Medical Research Council
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
QES	Qualitative evidence synthesis
RCT	Randomised controlled trial
TDF	Theoretical Domains Framework
UK	United Kingdom
US	United States
WHO	World Health Organization

Chapter 1: Introduction

This chapter presents the background to the growing problem of antimicrobial resistance and the rising concerns about the dangers to public health this issue poses. An overview of the existing interventions to promote appropriate antibiotic use in a hospital setting is provided, and current knowledge and understanding of the prescribing behaviours are discussed. Finally, a knowledge gap is identified, and the motivation for the research is outlined, setting the scene for the work undertaken in this thesis.

1.1 Background

Antibiotics have revolutionised medical practice since the discovery of penicillin by Alexander Fleming in 1928 and have significantly reduced illness and death rates from infectious diseases since their introduction in the 1940s (Gaynes, 2017). It is estimated that the discovery of penicillin and related antibiotics is responsible for saving more than 100 million lives worldwide (Barrett & Armelagos, 2014). However, decades of misuse and overuse of antibiotics has led to the development of antimicrobial resistance (AMR) (Barber & Swaden-Lewis, 2017).

The continuing emergence and spread of AMR poses a significant threat to public health and patient safety due to associated morbidity, mortality and healthcare expenditure (Tacconelli & Pezzani, 2019). It is estimated that infections caused by antibiotic-resistant bacteria are responsible for at least 70,000 deaths each year globally (Barber & Swaden-Lewis, 2017; Department of Health, 2019). A recent study looking at antibiotic consumption in 76 countries has found that global antibiotic use increased dramatically by 65% (21.1–34.8 billion defined daily doses [DDDs]) between 2000 and 2015 (Klein et al., 2018). Although the increase was primarily driven by misuse of antibiotics in low and middle income countries (LMICs), multidrug-resistant organism rates are rising even within high-income countries. Yet, there has been a simultaneous decline in new drug development by the pharmaceutical industry due to reduced financial inducements and challenging government regulatory mechanisms, such as changes in licensing rules and ineffective communication channels (Gould &

Bal, 2013; Luepke et al., 2017). More specifically, there have been no discoveries of new classes of antibiotics since the 1980s (Gould, 2016). Lack of development of novel drugs and the sustained misuse of the existing antibiotics in healthcare settings has led to fears of a 'post-antibiotic era', where common infections, once considered minor, could kill again, claiming thousands of lives (World Health Organization [WHO], 2016).

Rising resistance levels and unavailability of newer antimicrobials has led to coordinated efforts to implement new local and international initiatives, resume research efforts and minimise the use of currently available antibiotics to preserve their therapeutic effectiveness. These efforts have been underpinned by a concern that, by 2050, AMR-related patient deaths will exceed 10 million per year worldwide, with projected economic costs of $100 trillion (O'Neill, 2016). Despite coordinated efforts, hospitals worldwide currently face significant problems with inappropriate antimicrobial use, with research indicating that 30-50% of that usage remains unnecessary or inappropriate (Centre for Disease Control and Prevention [CDC], 2019; Davey et al., 2017; Hulscher et al., 2010).

In the United Kingdom (UK), despite some progress in secondary care, a sustained reduction in total antibiotic prescribing has not been observed (National Institute for Health and Care Excellence [NICE], 2018). Whilst only 20% of antimicrobial consumption occurs in hospitals, the intensity of use is far higher than in the community. In contrast to primary care, evidence shows that usage continues to rise (an increase by 6.3% over the past five years), despite the wide availability of national and local recommendations (Public Health England, 2020). This suggests that prescribing practice guidelines and recommendations alone are insufficient to change practice and reduce AMR. With the expansion of prescribing to non-medical professions, including nurses and pharmacists (Graham-Clarke et al., 2019), the need for well-designed health interventions to help optimise hospital antibiotic use has never been of more pressing importance.

1.1.1 What is an antibiotic?

Antibiotics or antimicrobials can be defined as any type of therapeutic agent produced by an organism, or made synthetically, that selectively destroys or inhibits the growth of micro-organisms, including bacteria, viruses, fungi and parasites (Brunton et al., 2017). Antibiotics are the only class of medicines whose prime target is not the human cells or their products. Instead, they disturb the harmony of the natural ecological environment by exerting a 'selective pressure' on bacteria driving these organisms' evolution (Gould & Bal, 2013). These agents differ significantly in their physical, chemical, and pharmacological characteristics. For example, broad-spectrum antibiotics, such as meropenem (typically used for treating severe bacterial infections of the skin or stomach), have an antimicrobial spectrum effective against a wide range of causative microorganism, whilst narrow-spectrum antimicrobial agents, such as clarithromycin, only act against specific groups of bacterial types (Hauser, 2018).

While broad-spectrum antibiotics are typically necessary in situations where clinicians do not have information about the cause of an infection (called empiric therapy), they are significant drivers of AMR and should be limited to emergency cases, such as severe sepsis of unknown origin (Holmes et al., 2016). Antibiotics are not effective against viral infections, such as the common cold or influenza. To date, more than 6,000 antimicrobials have been discovered, but only about 100 are used clinically to treat infections (Brunton et al., 2017).

1.1.1.1 Key terminology

While antibiotics are medicines used to prevent and treat bacterial infections, 'antimicrobials' is a broader term that includes all agents that act against various microorganisms, including bacteria (Hauser, 2018). However, for simplicity, when discussing various pathogens, the terms *'antibiotics'* and '*antimicrobials'* will be used interchangeably throughout the thesis, whilst '*antibiotic prescribing*' will refer to the practice of antibiotic use, including initiation, monitoring, review and discontinuation (de-escalation) of antibiotic therapy.

The phrase *'inappropriate or sub-optimal antibiotic prescribing*' will be used to describe incorrect use or practice not concordant with local or national guidelines, including:

- over-prescription (prescribing antibiotics when they are not clinically indicated)
- omission (when required antibiotics for certain infections are not prescribed)
- inappropriate dosages (too high or too low)
- incorrect duration (too short or too long)
- incorrect selection (mismatch between organisms, for example, prescribing a potent broad-spectrum antibiotic when a lower-risk narrow-spectrum agent, which is equally or more effective for treating the same illness/disease, is available)
- unnecessary risk (use of intravenous antibiotics when oral forms would be suitable) (Monnier et al., 2018).

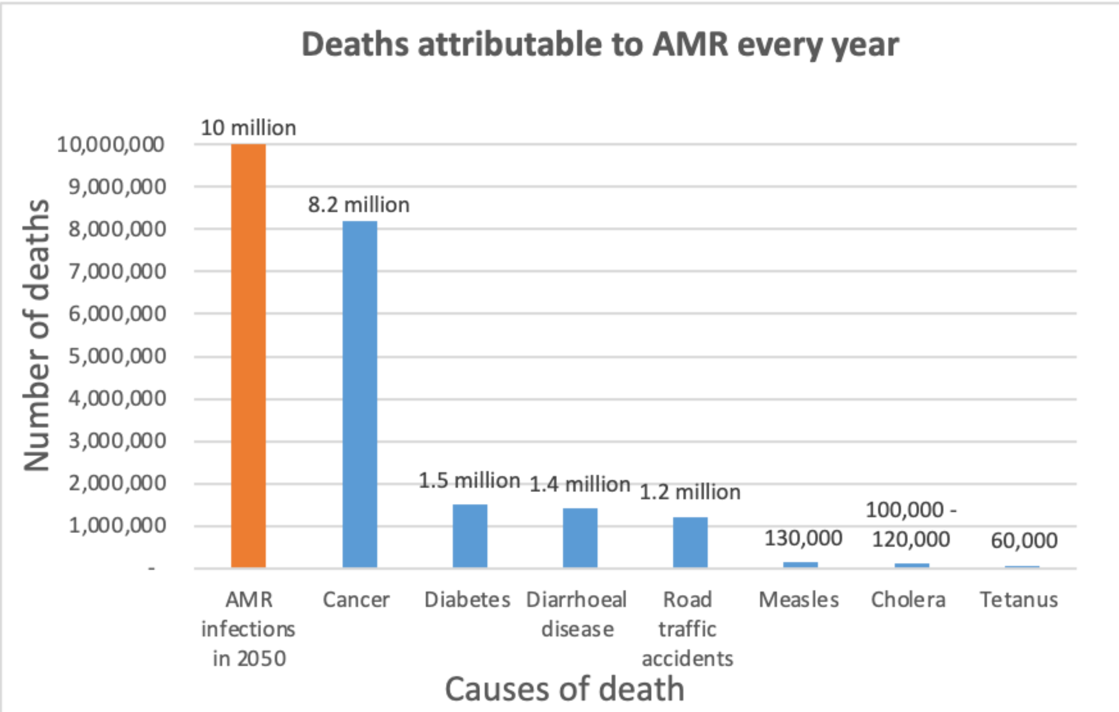
1.2 Antimicrobial resistance – a global concern

Bacteria with antibiotic resistance traits can proliferate, share the genetic material, and bestow resistance on other bacteria and other people (Sendler et al., 2016). This means that resistance can spread between wards, hospitals, communities, and more widely between countries. Antimicrobial resistance is a natural phenomenon. It occurs when an antibiotic loses its inherent ability to stop bacterial growth effectively – the bacteria adapt, become 'antibiotic-resistant' and continue to multiply in the presence of antibiotic treatment (WHO, 2016). There are many AMR drivers, including lack of access to clean water, sanitation and hygiene; poor infection and disease prevention; poor access to affordable medicines, vaccines and diagnostics; and lack of awareness and knowledge (WHO, 2020). However, the current high levels of antibiotic-resistant bacteria have been mainly attributed to misuse and overuse of antibiotics (NICE, 2018). This means that the more antibiotics are prescribed, the less effective they become, giving bacteria a greater chance to survive and proliferate.

1.2.1 The scale of the problem

Antimicrobial resistance is currently one of the top ten global public health threats, and the international human consumption of antibiotics is projected to rise by more than 30% by 2030 (Klein et al., 2018). Antimicrobial resistance creates a significant burden on healthcare systems worldwide, such as increased mortality, morbidity, longer hospital stays with a higher risk of complications, increased healthcare expenditure, and treatment failures with significant economic implications (European Centre for Disease Prevention and Control [ECDC], 2019; Shrestha et al., 2018). A review commissioned by the UK government estimated that AMR could cause 10 million deaths per year by 2050, followed by cancer at 8.2 million, and other causes of death, including diabetes, diarrhoeal diseases, road traffic accidents, measles, cholera, and tetanus, respectively (O'Neill, 2016) (Figure 1). A recent systematic review found that excess economic costs caused by AMR ranged from $21,832 per case to more than $3 trillion in total loss of gross domestic product (GDP) to countries per year (Naylor et al., 2018). The World Bank (2017) estimates an annual reduction in GDP of up to 3.8% by 2050 if current AMR trends continue, with projected costs of $9 billion per year to contain the problem.

Figure 1. Estimated global deaths atrributed to AMR and other causes (data adapted from O'Neill, 2016)

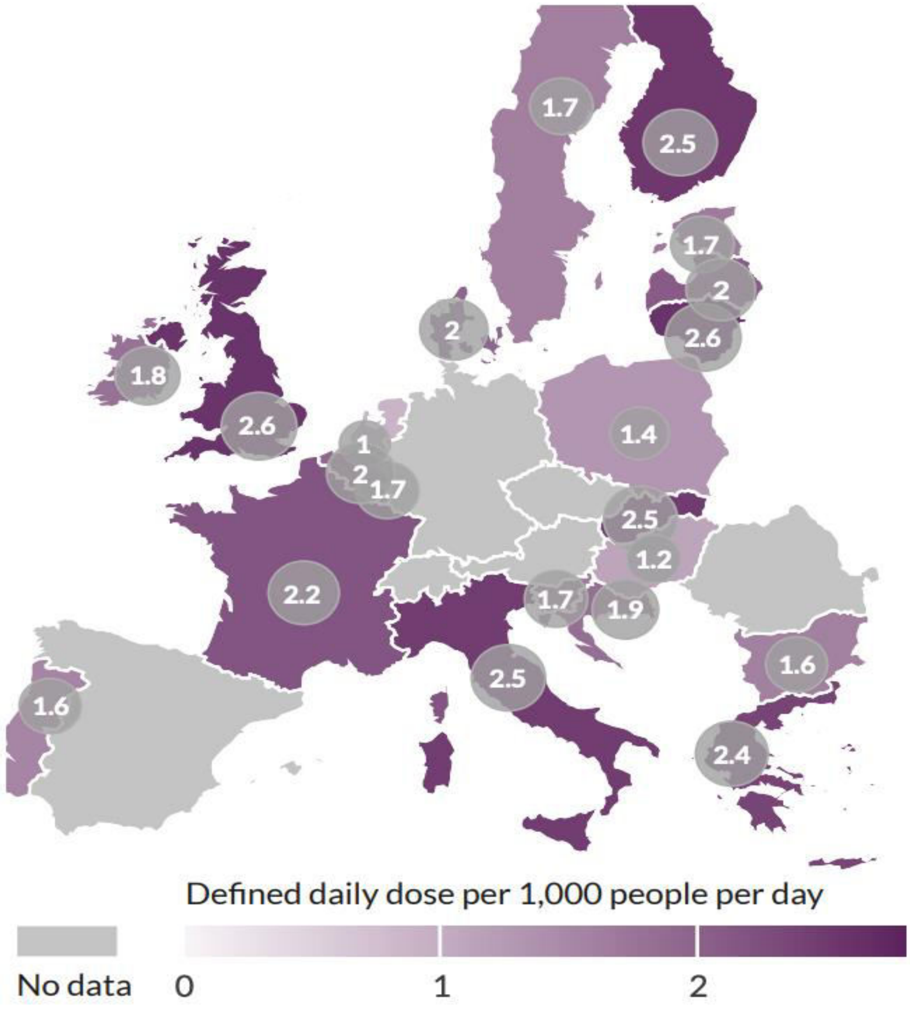


Despite the evidence of AMR's harmful effects, an increasing number of countries report a high prevalence of infections resistant to critical antibiotics (National Institute for Health and Care Experience (NICE), 2018). For instance, in the latest report, based on AMR data from 66 countries, the WHO has identified that resistance rates to ciprofloxacin, commonly used to treat urinary tract infections, varied from 8.4% to 92.9% for Escherichia coli (E. coli) and from 4.1% to 79.4% for Klebsiella pneumoniae infections in 33 and 34 countries, respectively (WHO, 2020). Although AMR affects all countries, the burden is disproportionately higher in LMICs, with alarming rates in the African continent, Asia and the Pacific region (Dramowski et al., 2021; Yam et al., 2019). For example, between 2000 and 2015, the antibiotic consumption rate (measured in DDDs per 1,000 inhabitants per day) increased from 8.2 to 13.6 (63%) in India, from 5.1 to 8.4 (65%) in China, and from 16.2 to 19.6 (21%) in Pakistan (Klein et al., 2018). However, the rates of multidrug-resistant infections are also increasing in high-income countries. For instance, in Canada, the number of deaths directly linked to AMR amounted to 5,400 in 2018 (WHO, 2020), whilst in the United States (US), 2.8 million antibiotic-resistant infections contribute to more than 35,000 deaths each year, adding an excess of 20 billion dollars in direct healthcare costs, and 35 billion dollars in lost productivity annually (Center For Disease Dynamics, Economics & Policy, 2021).

Antibiotic resistance data demonstrates that the harms associated with antibiotic overuse are predominantly an in-hospital problem. A recent population level analysis in the European Union (EU) and the European Economic Area (EEA) has shown that 72% of deaths attributable to AMR occur in hospital (Cassini et al., 2019). The WHO (2020) report has further revealed a high heterogeneity level in AMR trends in the EU and EEA. More than 670,000 infections due to antibiotic-resistant bacteria occur in the member countries each year, with an estimated 33,000 deaths (ECDC, 2019). If no action is put in place, by 2050, AMR will cause more than 569 million extra hospital days annually across countries in the EU/EEA, with estimated costs of 1.1 billion Euros on healthcare systems each year (ECDC, 2019).

In the UK, drug-resistant infections also continue to rise. The English Surveillance Programme for Antimicrobial Utilisation and Resistance (ESPAUR) report estimates that antibiotic-resistant bloodstream infections have increased by 32% from main bacterial species between 2015 and 2019, contributing to 12,000 deaths annually (PHE, 2020). The European Centre for Disease Prevention and Control data show that the UK ranks the third highest out of the 23 European countries for prescribing antibiotics in hospitals (Figure 2) (ECDC, 2018).

Figure 2. Hospital antimicrobial use in Europe in 2016 (adapted from *NICE Impact antimicrobial resistance*, NICE (2018), p.4, Copyright 2018, used with permission)



There are many reasons for the wide discrepancies in antibiotic usage between countries. For example, in the UK, the high consumption rates may be partly associated with the shortage in supply of a key broad-spectrum antibiotic piperacillin/tazobactam due to manufacturing issues and the need to use two or more alternative agents to achieve the same degree of antimicrobial coverage (NICE, 2018). Another explanation may be improved antimicrobial surveillance, patient demographic profiles, percentage of treated patients and patients having more severe infections that have not responded to first-line antibiotics (WHO, 2020). However, indiscriminate use of antibiotics remains the main driver in the spread of AMR (NICE, 2018).

Unequivocal evidence shows that misuse of antibiotics, especially broad-spectrum antibiotics, is one of the major drivers for the development of AMR in bacteria, including Methicillin-resistant Staphylococcus aureus (MRSA) and Clostridium difficile infections (C. diff), causing harmful and long-lasting changes to the body's protective mechanisms (Baur et al., 2017; Hassoun et al., 2017; Marra et al., 2020; Webb et al., 2019; Yogo et al., 2015). To combat the problem, the UK Government has placed particular focus on ensuring that antimicrobial stewardship (explained below) operates across all care settings, including hospitals (Department of Health, 2013). Optimising prescribing practices is considered a key component of this strategy.

1.2.2 AMR and the COVID-19 pandemic

The recent outbreak of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) viral pandemic has put a significant strain on health and economies worldwide (European Medicines Agency, 2021). Increased demand for antimicrobial agents in inpatients at the early stages of the pandemic has led to concerns that the AMR trends will accelerate, impacting the burden of disease in the future (Bork et al., 2020; WHO, 2020). Patients admitted to hospital wards with COVID-19 are most vulnerable to contracting secondary bacterial infections. Exposure to the healthcare setting and invasive procedures, together with increased antibiotic use, create the optimal conditions for resistant pathogens to emerge and spread (Pelfrene et al., 2021).

Moreover, evidence shows that some early clinical features of the severe inflammatory reaction to the Coronavirus may resemble secondary bacterial infections, setting a low threshold for prescribing empirical broad-spectrum antibiotics (Wan et al., 2020). Although much remains unknown about the long-term impact of the pandemic, a recent review has found that 72% of COVID-19 patients hospitalised between January and mid-April 2020, mainly in the Asian region, received broad-spectrum antimicrobials against bacterial or fungal co-infections and secondary infections, even though their occurrence is estimated at less than 10% and 15% respectively (Rawson et al., 2020).

Similar results emerged from a prospective cohort study that recruited patients from 260 hospitals in England, Scotland and Wales between February and June 2020 (Russell et al., 2021). The study has found that 85% of COVID-19 patients received one or more antibiotics during their hospital admission, with high use of broad-spectrum agents (those active against a wide range of bacteria). However, there was evidence that this could be reduced by using more targeted but equally appropriate alternatives (e.g., narrow-spectrum antibiotic treatment). Notably, the researchers found that confirmed bacterial infections in patients with COVID-19 were rare, especially when first admitted to the hospital, suggesting that a more restrictive approach to using antibiotics would be safe (Russell et al., 2021). With the unintended consequences of inappropriate antimicrobial use, employing appropriate stewardship interventions to tackle the threat of AMR remains crucial and should therefore be prioritised.

1.3 Antimicrobial stewardship

The concept of 'antimicrobial stewardship' (AMS) first appeared in the literature in the 1980s to describe rational antibiotic prescribing (Owens et al., 2004). It can be defined as "an organisational or healthcare-system-wide approach to promoting and monitoring judicious use of antimicrobials to preserve their future effectiveness" (NICE, 2015, p.8). The most frequently cited goals of AMS are to optimise clinical outcomes and ensure the cost-effectiveness of therapy while minimising unintended consequences of antibiotic use, including toxic effects, selection of opportunistic pathogens and the emergence of AMR (Dellit et al., 2007; Schuts et al., 2016). Antimicrobial stewardship programmes have been implemented in hospitals worldwide, with evidence showing positive effects, including significant decreases in antimicrobial consumption and cost (Karanika et al., 2016). These include, for example, the establishment of a collaborative multidisciplinary AMS team, the availability of evidence-based practice guidelines and diagnostic tests, and infrastructure to track antibiotic use (Hulscher & Prins, 2017). A brief overview of antimicrobial stewardship in the UK is provided in the following section.

1.3.1 The international perspective on AMS

The problem of AMR and optimising antibiotic use has been on the international agenda for more than two decades. In 1998, the World Health Assembly urged member states to develop measures to slow the development and spread of resistance (WHO, 1998). Recognising the need for improved and coordinated global efforts, in 2000, the WHO called the increase of AMR 'a global crisis' and subsequently published the first global strategy for its containment (WHO, 2001). Nine years later, in 2009, a Transatlantic Taskforce on AMR (TATFAR) was created to improve collaboration between the EU and the US and focused primarily on enhancing the development of new drugs. The issue was further promoted by the Swedish government during its EU presidency, providing a set of recommendations on how to encourage research and development for new antibiotics (Mossialos et al., 2010). In 2010, the European Commission launched a Joint Programming initiative to bring national efforts and make better use of national research programmes, followed by the release of an action plan against AMR in 2011 (European Commission, 2011). In the same year, the WHO launched a six-point policy package to engage all member states and foster change. Since then, many partnerships and networks have been established, serving as essential platforms for nations to engage with the AMR agenda.

However, due to slow uptake of the first WHO (2001) global strategy, 15 years later, the WHO published the Global Action Plan (GAP), setting out five key actions to tackle the problem, including:

- increasing knowledge and awareness of AMR
- reducing the incidence of infectious diseases
- promoting rational use of antimicrobials
- strengthening knowledge through surveillance and research
- innovation for successful containment of the emergence and spread of AMR through development of novel antimicrobial drugs, diagnostic tools, vaccines and other interventions (WHO, 2015).

In 2016, the United Nations member states endorsed the WHO's GAP and pledged their commitment to taking a coordinated international approach to combat the problem of AMR (United Nations, 2016). Surveillance has formed a crucial part of these efforts, with agencies such as the ECDC, the Centre for Disease Control (CDC), and WHO establishing effective international surveillance programmes (CDC, 2019; ECDC, 2014; WHO, 2016). For example, the launch of the Global Antimicrobial Surveillance System (GLASS) helped strengthen the evidence base on the rise of AMR and facilitated resource allocation to reduce antimicrobial use in human health, agriculture, and the environment (Interagency Coordination Group on Antimicrobial Resistance, 2017; WHO, 2020).

1.3.2 Antimicrobial stewardship in the UK

The UK government has a national ambition to reduce antimicrobial use by 15% by 2024 (Public Health England, 2019). A range of AMS initiatives has been implemented in primary care and acute care settings to achieve that goal. Examples of interventions include education and training on AMR and optimal prescribing practice, prospective audit and feedback to prescribers on their antibiotic use, restriction of high-risk broad-spectrum antibiotics, active evaluation of ongoing antibiotic treatment after initiation of therapy, and the use of decision support systems (Ashiru-Oredope et al., 2012; Charani & Holmes, 2019; Davey et al., 2017; Walker et al., 2019).

One of the most successful UK initiatives to assist organisations in the appropriate use of antibiotics has been the dissemination of free and openly available AMS toolkits for organisations, contributing to a reduction in use (Cunney et al., 2019; Jones et al., 2018). These toolkits are Treat Antibiotics Responsibly, Guidance, Education, Tools (TARGET) for primary care within general practitioners' (GP) practices, and Start Smart Then Focus (SSTF) recommended for all antibiotic prescriptions in secondary healthcare settings in England (Ashiru-Oredope et al., 2012; Moore & McNulty, 2012). The SSTF toolkit aims to determine the cause of infection, start appropriate empirical therapy (the 'start smart' element), and recommend that prescribers undertake an active review of an antibiotic prescription and refine it (the 'focus' element).
The toolkit breaks down decision making into five options: stop, switch to oral, continue and review again, change (drug to a narrower spectrum), or move to outpatient parenteral therapy (Ashiru-Oredope et al., 2012). Similarly, in Scotland, the Scottish Reduction in Antimicrobial Prescribing (ScRAP) toolkit and the Hospital Antimicrobial Review Programme (HARP), which focuses on the review of intravenous

(IV) antibiotics and the documentation of duration of oral antibiotic treatment, have provided educational resources to support appropriate antibiotic prescribing within the NHS (NHS Education for Scotland [NES], 2013).

As part of the UK strategy for tackling AMR and improving patient safety, the English surveillance programme for antimicrobial utilisation and resistance (ESPAUR) monitors and evaluates antibiotic prescribing trends in primary and secondary care (Ashiru-Oredope & Hopkins, 2013). Since it was convened, ESPAUR has published annual reports, which have provided a baseline measure for tracking prescribing and resistance patterns, thus assisting clinicians and policymakers in addressing AMR by setting targets for reduction. However, despite an increasing number of AMS interventions, antibiotic decision making remains sub-optimal in the UK. The number of antibiotic-resistant bloodstream infections from key bacterial species increased by 32.5% from 2015 to 2019 in the UK (Public Health England, 2020). The 2017 ESPAUR report indicated that overall antibiotic prescribing in primary care reduced by 13.2% between 2013 to 2017 (Public Health England, 2018). However, a sustained reduction in total antibiotic prescribing in secondary care has not been observed despite advances in AMS. Antibiotic use in hospitals has increased by 3.5% (by hospital admissions) over the last five years (Public Health England, 2020), suggesting that the focus needs to shift from structural and process-driven approaches to understanding the key drivers of inappropriate prescribing behaviour in hospitals (Hulscher & Prins, 2017; Pinder et al., 2015).

1.4 Pitfalls of the current AMS interventions

There is growing evidence that AMS interventions are safe and effective. The most recent Cochrane review of 221 studies of interventions designed to improve antibiotic prescribing for hospital inpatients reported high-certainty evidence that AMS can effectively increase compliance with practice guidelines and reduce the duration of antibiotic therapy without increasing mortality (Davey et al., 2017). However, the Cochrane review's key conclusion was that only a few interventions employed behavioural theory or behaviour change techniques. Consequently, it is likely that even current effective interventions are sub-optimal and could be more effective.

For example, of the 221 studies included in the review, 10% were from the UK (n=22). However, the extent to which they included insights and approaches from behavioural science was minimal. The most common behaviour change techniques used were audit and feedback; educational meetings; dissemination of antibiotic guidelines; reminders (e.g., physical, such as by posters and email), and restrictive (e.g., requirement for expert approval or removal of broad-spectrum antibiotics from clinical areas) (Davey et al., 2017). The interventions were delivered mainly by the local Antimicrobial Management team (AMT) (n=13), pharmacists (n=5) or specialist physicians (n=4). However, careful scrutiny revealed that all studies except one failed to employ an explicit theoretical approach. A study by Stevenson et al. (1988) was the only one that applied an analytical framework for the economic evaluation of policies to improve hospital infection management. The lack of theoretical underpinnings of the interventions may be due to resource limitations or the opportunistic nature of some studies, which coincided with introducing new antimicrobial policies or practice guidelines (McLaughlin et al., 2005). Another possible explanation could be poor reporting of the theoretical basis or lack of clarity regarding how to translate theory into intervention design, such as in Marwick et al. (2014). The characteristics of the UK-based studies included in the Cochrane review are provided in Appendix 1.

Davey and colleagues' key recommendation (2017) was that future work should focus on bringing together key stakeholders and research experts to develop more impactful AMS interventions. One potential approach to address this urgent need is to apply behavioural science to inform the design and delivery of effective antibiotic interventions.

1.4.1 Understanding prescribing behaviours

Antibiotic decision making is a process dependent on a range of inter-related factors (Charani & Holmes, 2019; Teixeira Rodrigues et al., 2013). To change existing behaviours and enhance the chances of planned interventions working in real-world settings, it is essential first to understand the determinants that drive that process. Behavioural and social sciences are concerned with understanding behaviour. They offer a range of methods, evidence-based theories and frameworks that can help inform the development of context-specific interventions to influence that behaviour

(Lorencatto et al., 2018). Achieving large scale behaviour change within an organisation often involves 'cultural' or social change among different groups of people, requiring targeting behaviours amongst, for example, policymakers, healthcare professionals and the general public (West et al., 2020). However, this approach remains underused. Systematic reviews of strategies employed to reduce inappropriate antibiotic use in hospitals have shown that behavioural and social influences are often not considered in the design and evaluations of AMS interventions (Charani et al., 2011; Tonkin-Crine et al., 2015). The lack of underpinning theory in studies was also highlighted in a report by the Department of Health (Pinder et al., 2015).

Antibiotic prescribing has only recently been recognised as a complex behaviour. This recognition has led to more attention being paid to the individual prescriber and the drivers of behaviour than the previous efforts to identify the presumed knowledge deficits (Tonkin-Crine et al., 2015). Understanding the prescribing behaviour has shown that appropriate antibiotic use involves the correct knowledge about local guidelines or resistance patterns and the broader interplay of other factors, such as patient expectations, comorbidities, and social context (Wong et al., 2015). The complexity associated with changing prescribing behaviours is reflected in findings of a qualitative systematic review on doctors' antibiotic prescribing decisions, which identified many factors influencing prescribing practice (Teixeira Rodrigues et al., 2013). These included intrinsic factors, such as prescribers' attitudes (e.g., complacency or fear), and extrinsic factors, including patient-related (e.g., clinical signs and symptoms) and organisational-related factors (e.g., time pressures and antibiotic guidelines).

Moreover, the dynamics of working relationships and the context in which those interactions take place have not received adequate attention in AMS interventions. Yet, a qualitative study carried out by Charani et al. (2013) shows that junior doctors work within a long-established strict medical hierarchical system, and their decisions can be largely driven by senior clinicians' beliefs, experiences and practices. This suggests that prescribing behaviours are heavily influenced by professional relationships and lead to a 'prescribing etiquette', such as a reluctance to change prescriptions started by colleagues or a tendency to follow more senior clinicians' prescribing trends and preferences (Broom et al., 2016c; Lewis & Tully, 2009).

A recent ethnographic study exploring the cultural factors that influence antibiotic decision making across surgical and medical teams in an UK hospital found that different specialities have their own language, behaviours, social norms, and values, leading to a variation in care and an impact on patient outcomes (Charani et al., 2019). This study highlighted that understanding the socio-cultural context and the influences on the behaviour of different groups of prescribers is essential to ensure interventions are impactful. Behavioural science can inform the design of complex interventions by identifying these influences and thus target specific behavioural mechanisms to change antibiotic prescribing (Tonkin-Crine et al., 2015).

1.5 Research gap

A broad range of hospital AMS interventions have been promoted. However, it remains unclear which types of interventions work, why and how they work, and what (if any) refinements are needed for local circumstances. The existing research on the effectiveness of different behaviour change strategies suggests that active and personalised interventions are more effective than passive dissemination of printed material. For instance, an earlier Cochrane review estimating the effectiveness of AMS interventions for hospital inpatients showed that interventions that incorporated active promotion of a change in policy or new care pathway were associated with improvement as opposed to the passive mailing of newsletters, which had no direct effect (Davey et al., 2013). The 25 randomised controlled trials (RCTs) included in the review showed that academic detailing (e.g., face-to-face educational activities that target prescribing behaviours) had a median effect size of 25%. The updated review demonstrated that although provision of feedback further increased the intervention effect, it was utilised in a small number of enabling interventions (Davey et al., 2017).

Academic detailing tends to involve input from a trained pharmacist to improve compliance with practice guidelines. In their early RCT, Dranitsaris et al. (2001) showed that pharmacists challenging particular antibiotic prescriptions reduced inappropriate practice and improved compliance by almost 10%. Similarly, a more recent prospective intervention study evaluating the effect of academic detailing provided by pharmacists showed a 36% reduction in the number of cefixime prescriptions and an estimated 22% decrease in prescription costs (Ndefo et al., 2017). However, consideration has to be given to the context in which these interventions are set. Qualitative evidence has demonstrated the cultural determinants dominating prescribing practice and various barriers to uptake of AMS advice in hospitals, indicating that interventions that do not focus on managing interprofessional relationships may have limited effect in optimising antibiotic use (Broom et al., 2016b; Charani et al., 2013). Attention also needs to be paid to the influence of senior clinicians and local opinion leaders on junior prescribers' practice (Broom et al., 2014; Charani et al., 2019).

A recent systematic review assessing the evidence of the positive effects of appropriate antibiotic use in hospital patients suggests that behaviour change interventions, including persuasive, restrictive and structural, can improve appropriate antibiotic use (Hulscher & Prins, 2017). However, the quality of reporting of the interventions conducted tended to be poor. The majority of studies did not provide any insights into which elements are the key or 'active ingredients' of these interventions. There is uncertainty in the literature regarding why some behaviour change interventions are more effective than others and how to select the most suitable intervention for a particular setting. Therefore, a clear description of behaviour change interventions is essential to enable replication and allow a future analysis of effectiveness (Moore et al., 2015).

The Medical Research Council (MRC) has long advocated the importance of identifying theory to understand the likely causal processes of change before undertaking the intervention effectiveness stage (Campbell et al., 2000; Craig et al., 2008). One such approach is conducting a behavioural diagnosis of 'what needs to change' using the Behaviour Change Wheel (Michie et al., 2014). Understanding the underpinning factors that drive behaviour can facilitate the development of more effective interventions that target specific behaviour deficits (Lorencatto et al., 2018). For instance, educational interventions will only work if the identified behavioural deficit is a lack of adequate knowledge. Therefore, the choice of behaviour change interventions should be informed by the barriers and facilitators that influence behaviour (Grimshaw et al., 2012; Grol et al., 2013).

In summary, there is a lack of information on the underlying mechanisms of how and why the current interventions work on changing prescribers' behaviour and the context in which that change takes place. Moreover, most behaviour change interventions do not explicitly describe whether the behavioural determinants were considered to guide the intervention development (Hulscher & Prins, 2017). Therefore, there is an urgent need for researchers to develop effective behaviour change interventions. The assessment of the likely barriers and facilitators to inform the selection of intervention components is key to that process. The identified gap in evidence and the author's personal motivation outlined below have provided the impetus for this thesis.

1.6 Author's motivation for the research

The author of this thesis has an extensive clinical background, first as a staff nurse and then as a critical care research coordinator. As part of a vibrant multidisciplinary research group, and working closely with a range of collaborators, she participated in the writing up, publication, presentation and dissemination of the research findings to promote various clinical studies. She also undertook numerous antibiotic prescribing audits focused on improving patient outcomes. Of relevance, in collaboration with Health Protection Scotland (HPS) and intensive care unit (ICU) clinicians, she developed and led a prospective pilot study that compared two surveillance algorithms for ventilator-associated pneumonia (VAP): "HELICS" (currently used across hospitals in Europe) and the novel method recently proposed by the Centre for Disease Control (CDC). This study demonstrated how surveillance systems frequently generate discordant results, and importantly, do not account for the majority of antibiotic prescribing in ICUs (Craven et al., 2020).

Moreover, the study results showed that only 19% of cases had antibiotic de-escalated or stopped within five days (Wojcik et al., 2015). Patients with negative microbiology samples or positive cultures that may have allowed rationalisation or de-escalation of treatment comprised 68% of cases. These cases utilised significant antibiotic prescriptions, where the potential to reduce usage existed through more active antibiotic de-escalation. The data gathered illustrated the complexity of understanding antibiotic decision making, even in two ICUs within the same organisation, suggesting further research in this area of growing importance was required. The need to better understand prescribing behaviours provided a personal motivation to undertake the work carried out in this thesis.

1.7 Conclusions

This chapter has outlined the growing problem of antimicrobial resistance, discussed the complexity of understanding prescribing behaviour and its context, and identified the gap in the evidence base on the effective behaviour change strategies likely to alter antibiotic prescribing behaviours. Several conclusions can be drawn from this introductory chapter. Firstly, hospital misuse of antibiotics continues to rise in the UK, and evidence-based interventions are urgently needed to change inappropriate prescribing practice. Secondly, in-depth exploration of the key barriers and facilitators of current practice is essential to help identify an appropriate theory in designing an effective behaviour change intervention. Finally, the contributions of behavioural science to develop antimicrobial stewardship interventions remain underutilised. This thesis addresses this research gap by designing a behaviour change intervention that is informed by a robust theory, tailored to the specific context and target audience, and which can be tested for effectiveness in a future trial. The detailed description of the causal mechanisms of change allows future replication. The research aims of this thesis, the overall methodology applied to fulfil these aims, and an overview of each chapter are provided in Chapter 2.

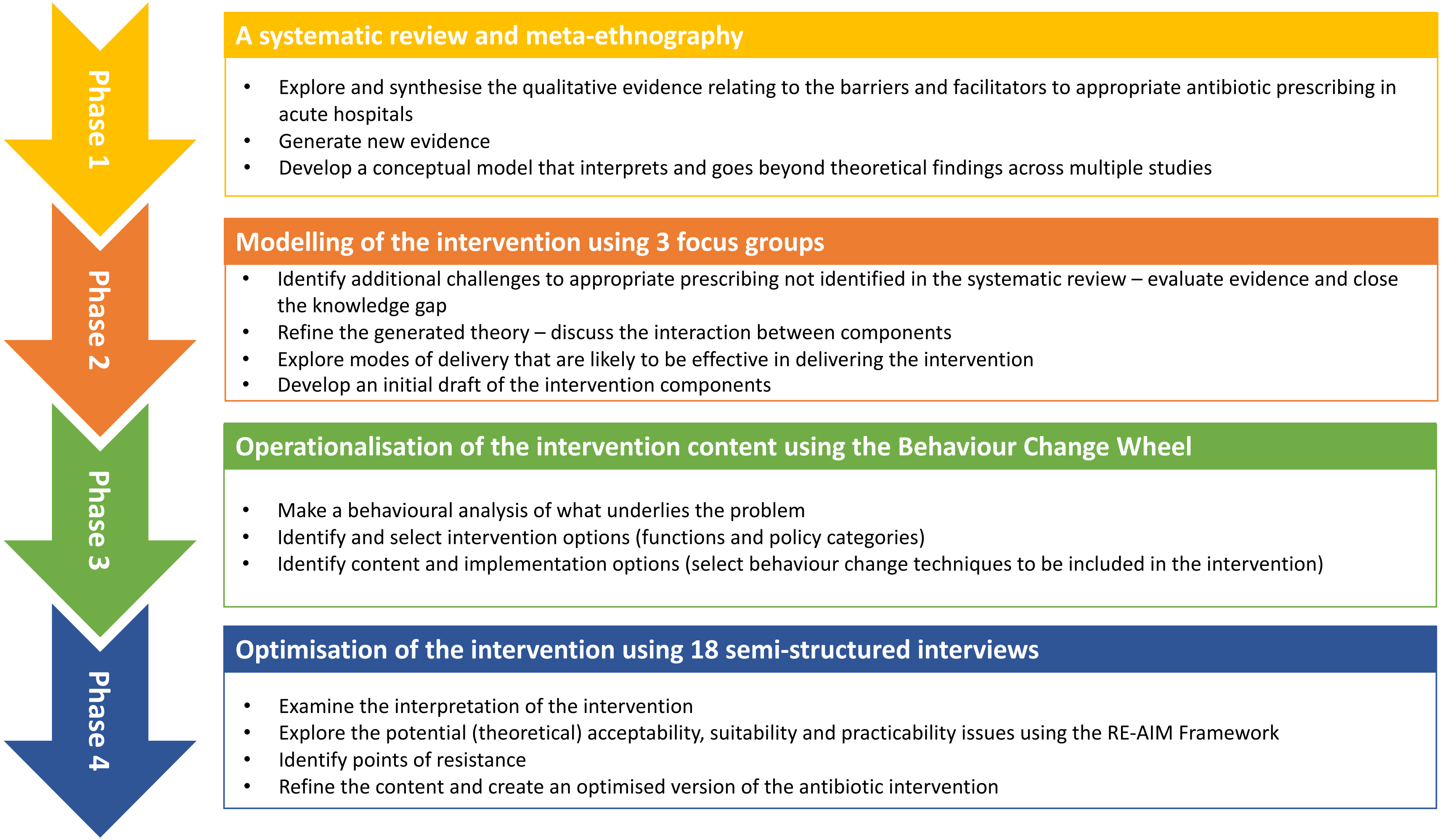
Chapter 2: Overall methodology for the development of a complex intervention

2.1 Introduction

The first chapter of this thesis demonstrated the background of the problem of growing antibiotic resistance, indicating the need for designing interventions to improve antibiotic prescribing in a hospital setting using effective behaviour change techniques but also tailoring these interventions based on the prospectively identified barriers to change. These findings provided the rationale for the development of a complex health intervention, and from this, research aims have been formulated in keeping with the Medical Research Council (MRC) Framework for Complex Interventions (Craig et al., 2008). This chapter describes the overall methodology used for the development of a complex theory-based behaviour change intervention to improve antibiotic use in a hospital setting. Details and justification of the adopted methods are provided at each stage of the research process.

Aligned with the overarching aims, this thesis comprises four distinct research phases. Phase 1 involved carrying out a systematic review and a meta-ethnography on barriers and facilitators to appropriate antibiotic prescribing in acute hospitals and developing a new conceptual model/theory. In Phase 2, three focus groups were conducted with healthcare professionals (HCPs) and health service users to explore their perspectives of the developed theory derived from the meta-ethnographic work and to model the key elements or features of a behaviour change intervention to improve antibiotic use in hospital settings. In Phase 3, the Behaviour Change Wheel (BCW) was applied to operationalise the intervention content and select implementation options. The APEASE criteria were used to help make context-based decisions and provide recommendations on intervention content. Finally, Phase 4 entailed conducting semi-structured interviews with HCPs and health service users to explore potential acceptability issues using the RE-AIM Framework and refine the content of the intervention. The focus groups and interviews (Study 1 and 2) have been reported using consolidated criteria for reporting qualitative research (COREQ) framework (Tong et al., 2007). An overview of the research phases is presented in Figure 3.

Figure 3. An overview of the research phases



2.2 Philosophical stance

Research philosophy or a 'paradigm' is "the set of common beliefs and agreements shared between scientists about how problems should be understood and addressed" (Kuhn, 1962, p. 12). In other words, it is the way individuals view or perceive the world around them and how these assumptions underpin research strategy and thus have an impact on generation of new knowledge and the nature of that knowledge. Research paradigms can be characterised through ontology, the set of the researcher's assumptions or beliefs about reality; epistemology, the method of acquiring knowledge and the way of learning about reality; and lastly methodology, a system of methods and processes used in the design of research.

Briefly, this thesis embraces the philosophical standpoint of pragmatism. Pragmatism advocates the use of mixed-methods research and sidesteps from a single truth or view of reality by adopting a more practical approach (Feilzer, 2010). Andrew and Halcomb (2007) describe six advantages to using pragmatic approaches in research, such as triangulation, complementarity, development, initiation, expansion and enhancement of significant findings (see Section 2.6 for more details). The focal point of pragmatism is action and change, as well as the 'tools' required to perform that action. Pragmatism is concerned with using methods that are best suited to the research question under investigation and focuses on the complementary nature of bringing together quantitative and qualitative research methods and their application to practice. This thesis has an underlying interest in finding a solution to a real-world problem, more specifically, improvement in practice of antibiotic use. Due to the pursuit of practicality of pragmatism and its action-focus perspective, the pragmatist position was deemed appropriate in the development of a complex health intervention.

2.3 Theoretical basis of complex interventions

The theoretical basis is an essential element of developing a complex health intervention. The MRC framework puts emphasis on the use of a theory-driven approach in the development of interventions. This involves developing a theoretical knowledge of the likely behaviour change processes by drawing on existing evidence and theory (Craig et al., 2008). However, the MRC framework does not explicitly suggest any specific theory nor provide guidance on how to incorporate a theoretical basis into the design or modelling of an intervention. A theoretical basis may integrate a new set of ideas elicited from different sources, such as behavioural medicine, or social and health psychology.

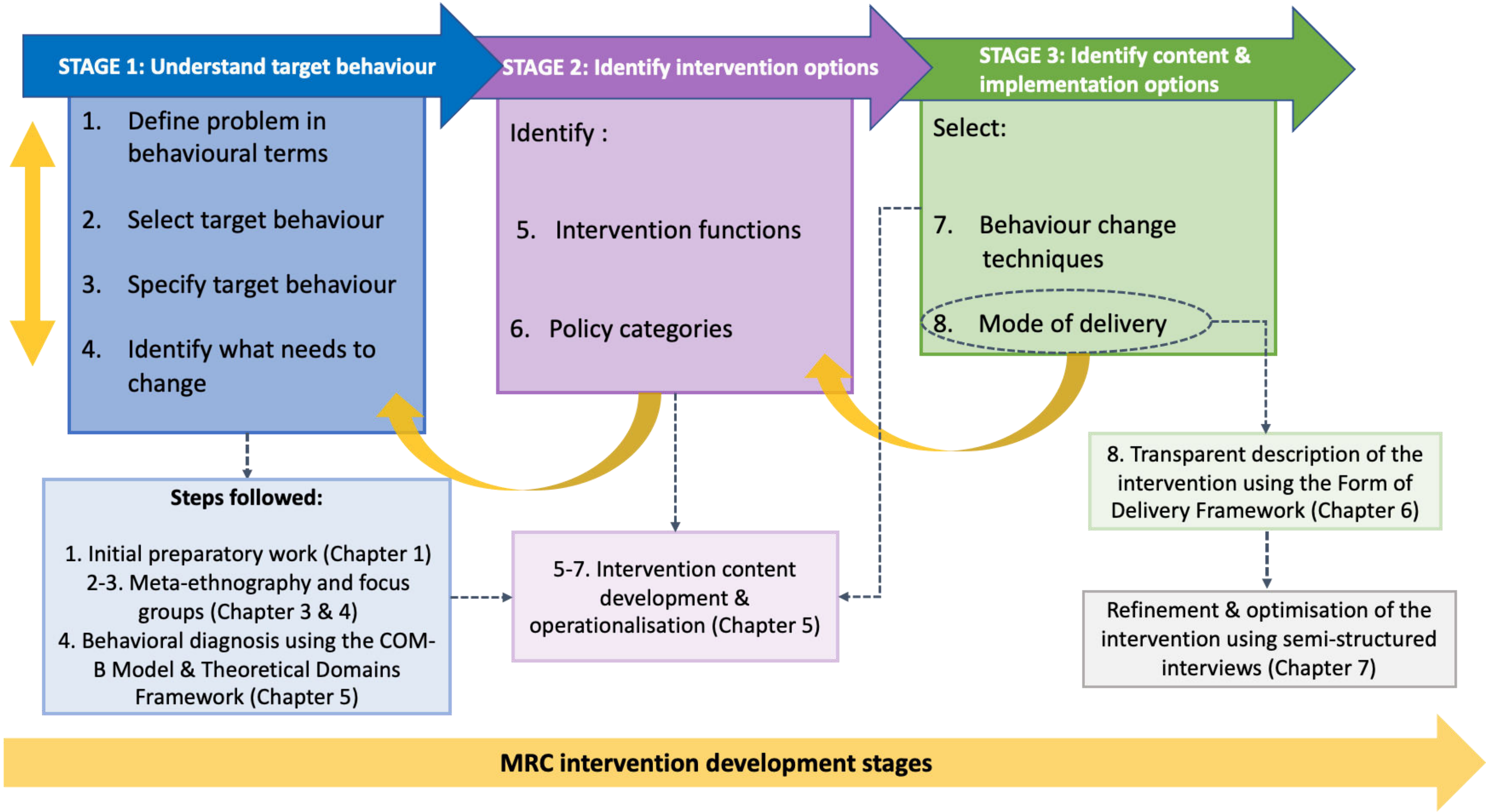
The work of Michie and Prestwich (2010) suggests that theoretically-based interventions lead to better outcomes and the use of theory during that process has many advantages. For example, theories can help explain complex psychological concepts by providing explanations as to why specific behaviours occur and what factors cause that behaviour to change. Theory-informed interventions can then address these factors. The use of behaviour change theories in the design of complex interventions can provide a better understanding of why interventions are effective or ineffective (NICE, 2015). To meet these recommendations, Chapters 3 to 7 of this thesis contribute towards the development of a sound theoretical basis for the development of a complex behaviour change intervention to improve antibiotic use. For the purpose of this thesis and to aid clarity, a sound theoretical basis is defined as a set of well-established psychological and behavioural theories, incorporating several interconnected elements, including:

- prospectively identified barriers and facilitators to change, likely to improve practice
- empirical findings to establish conceptual foundation for the intervention from the perspective of healthcare professionals and health-service users
- 'active ingredients' of the intervention (i.e., behaviour change techniques [BCTs] predicted to change antibiotic prescribing behaviour and the processes through which that behaviour change is likely to occur) (Connell et al., 2019)
- the optimal modes of delivery that are likely to be effective
- issues surrounding acceptability and practicability in clinical practice.

2.3.1 Behaviour Change Wheel theoretical framework

To ensure that the intervention development was guided by relevant theory and evidence, determine causal links between intervention components, and provide a set of recommendations demonstrating how theory can be applied in practice, the researcher drew on the Behaviour Change Wheel (BCW) framework (Michie et al., 2014). Figure 4 illustrates the BCW three-stage eight composite steps approach and how these stages have been integrated within the MRC framework. A more detailed description of the BCW, including the rationale for using the framework, is provided in Chapter 5.

Figure 4. The applied stages of the BCW and MRC framework mapped onto thesis chapters (adapted from Michie et al., 2014)



The process followed the three key stages of intervention development recommended in the BCW, which have been mapped onto the stages of MRC framework for complex interventions:

Stage 1: Understanding target behaviour is described in Chapters 1, 3-5. Chapter 1 outlines the problem and its background. Chapter 3 identifies the evidence base through the results of a systematic review and meta-ethnography investigating the barriers and facilitators to appropriate prescribing. Chapter 4 describes the focus groups conducted with HCPs and health service users exploring the target behaviour and possible ways to achieve it. Based on the evidence gathered in the preceding chapters, Chapter 5 identifies what needs to change for the target behaviour to occur.

Stage 2: The identification and selection of intervention options is further outlined in Chapter 5, which demonstrates how the BCW was applied to develop a proposed mechanism of action.

Stage 3: The identification of the intervention content and implementation options are discussed in Chapters 5 and 6. While Chapter 5 operationalises the intervention and provides future recommendations on the content, Chapter 6 describes the proposed intervention components using the Form of Delivery Framework. How the content and mode of delivery of the intervention was refined and optimised using semi-structured interviews with HCPs and health service users is described in Chapter 7. A summary of the work carried out, the strengths and limitations, and future implications for practice are provided in the final thesis chapter.

While the curved arrows illustrated in Figure 4 (under stages two and three) indicate that the process is cyclical and guided by the data gathered at the proceeding stages, requiring a series of interpretative judgements; the double-headed arrow placed to the left side of stage one indicates that some of the steps taken overlapped. For example, as it was unclear from the systematic review and meta-ethnography (Chapter 3) which target behaviour was amenable to change, it was considered necessary to first explore this topic with HCPs and health service users before making decisions on selecting the target behaviour. Similarly, to select appropriate intervention functions, it was also necessary to review the behaviour change techniques (BCTs) to see how they align with the identified behavioural deficits. Therefore, the proposed intervention content was created through an iterative approach, where the BCTs were mapped back to intervention functions. The long arrow underneath the BCW stages signifies that the overall process is guided by the MRC Framework for developing and evaluating complex interventions (Craig et al., 2008), which is further described in the following section.

2.4 Research methods

Research methods is a broad term that encompasses the tools, strategies and techniques used to collect data for analysis to answer the research question, whilst methodology refers to the justification for the adopted strategy to generate data, which indicates the way research is to be undertaken (Howell, 2012). This section describes the overall methodological approach and the research methods used throughout the thesis. This is to supplement more specific details of each study, which are outlined in corresponding chapters.

Briefly, the development of a theory-based behaviour change intervention described in this thesis was carried out using a systematic, rigorous, evidence-based approach. This process was facilitated by carrying out behavioural analysis of what underlies the problem and identification of behavioural deficits as drivers for improving antibiotic prescribing practice in a hospital setting. Guided by the BCW, the identified behavioural determinants were then mapped onto widely recognised behaviour change taxonomy (Michie et al., 2014), which helped develop a proposed mechanism of action by linking BCTs and intervention functions to address the modifiable behavioural deficits. The intervention components were then operationalised in a form suitable for testing the initial acceptability, a process known as causal modelling (Hardeman et al., 2005). To ensure the appropriate research methods were applied, each stage of the development process followed the 2006 MRC Framework for complex interventions (Craig, 2008).

2.4.1 The MRC Framework for complex interventions

There are several essential albeit individual and interacting elements that make an intervention in health truly complex, whether it is therapeutic or preventative (Richards & Hallberg, 2015). The MRC defines these elements as 'active ingredients', including:

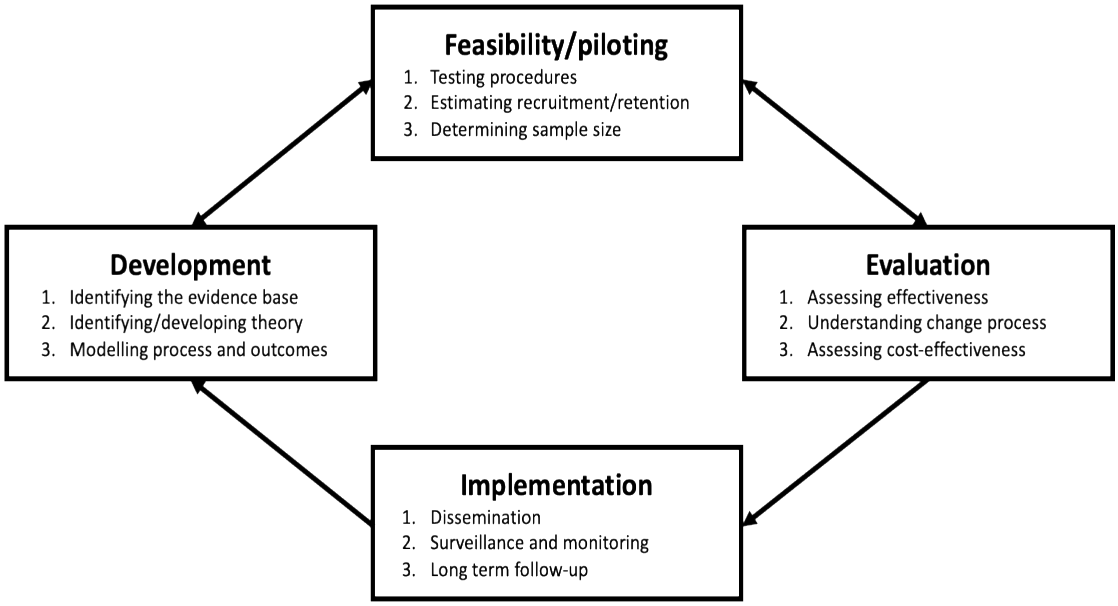
- the number of interacting elements within the intervention
- number and difficulty of behaviours required by those delivering or receiving the intervention
- number of groups or organisational levels targeted by the intervention
- number and variability of outcomes
- the amount of flexibility or tailoring required in the intervention delivery (Craig et al., 2008).

However, how these elements are incorporated and evaluated will depend on the aims of the intervention and this can pose many challenges for the researcher. A multitude of behavioural, organisational and structural factors and constraints will play a role in the researcher's choice of an intervention. The MRC framework outlines the purpose and importance of each stage and acts as a pragmatic guide to design and evaluate such interventions in a systematic way (Dowding et al., 2017). It puts emphasis on the significance of the development phase of intervention design, ensuring that there is an empirical and conceptual foundation for the intervention, modelling the active components of the intervention and what effect they might have in everyday practice, before it is considered for feasibility (Craig et al., 2008). Importantly, the guidance highlights the importance of flexibility, stating that strict standardisation or fidelity to a protocol may not be practical in some interventions, particularly where adaptation to local circumstances could increase the effectiveness. In those instances, the key is transparency of reporting the degree of change or tailoring in the implementation phase.

Development of complex interventions is required to generate improvements in healthcare delivery and patient outcomes. This process often involves change in the healthcare professional's behaviour as well as structural changes in the organisation of services. The UK Medical Research Council first provided guidance for researchers on how to develop, evaluate and implement a complex intervention to improve health in 2000 (MRC, 2000). However, although the guidance was pragmatic and highly influential by recognising the many practical and methodological challenges that researchers may face during the process of intervention development, the document was superseded in 2006 by a new version due to a number of limitations (Craig et al., 2008). These limitations included little attention paid to the early phase piloting and development work, a linear process of development rather than separate iterative progression linked to previous and subsequent stages, standardisation of template and lack of tailoring to local contexts, lack of process and outcome evaluation and underestimation of the value provided by theoretical underpinnings (Craig et al., 2008).

The 2006 framework can be summarised as a process consisting of four stages: development, testing, evaluation and implementation. This non-linear process may take many different forms. Figure 5 below provides a schematic representation of these stages and their main functions with the arrows demonstrating constant interaction between the key elements. During each stage of the process, the key is to address the uncertainties of the intervention, the design and methodology underpinned by theoretical evidence before proceeding to evaluating the effects of the intervention and working to implement it into routine healthcare practice (Richards & Hallberg, 2015). The purpose of the framework is to ensure that a complex intervention is established on robust empirical and theoretical evidence, and that attention is paid to both the effectiveness of the intervention and how or why it works (Dowding et al., 2017). Importantly, the framework is intended to help researchers to choose the most suitable methods to answer the research questions.

Figure 5. The 2006 MRC Framework for developing and evaluating complex interventions



This thesis comprises a systematic review and two empirical studies, which map onto the first two phases of the 2006 MRC framework – the development process and the key elements of feasibility testing. The work undertaken does not follow a linear pattern; rather, the process was iterative as some steps taken were repeated, building on knowledge gained in previous stages. This was a reflexive and systemic process, which provided insights and enabled the researcher to identify the key uncertainties. As the 'implementation-evaluation' process generally involves conducting a randomised controlled trial (RCT) and embedding the intervention into routine practice, these elements of the MRC framework were deemed beyond the remit of this PhD. However, Chapter 7 addresses the sustainability of the proposed intervention and provides recommendations for implementation of the antibiotic intervention in clinical practice.

2.4.2 Key stages of the MRC Framework

This section outlines the key stages of this doctoral work, which link to the MRC framework.

2.4.2.1 Development

Development of a complex intervention, the first stage of the 2006 MRC framework, is what happens between generating an intervention idea and formal pilot testing in the next stage (Hoddinott, 2015). This phase is thoroughly described and systematically referred to throughout this thesis, more specifically, in Chapters 3-7. The following steps have been taken during the development process:

Identifying existing evidence: The MRC recommends identifying and evaluating the relevant existing evidence base as the first step in intervention development (Craig et al., 2008). The evidence should ideally be based on a recent high-quality systematic review. If no such review exists, the first step is to conduct one. Reviews are a central activity of science and tend to be undertaken by researchers to gain a better understanding of the current knowledge in a particular area and identify gaps or inconsistencies within it (Petticrew & Roberts, 2006). For this thesis, a recent Cochrane systematic review of quantitative evidence, assessing effectiveness of interventions to improve antibiotic prescribing practices for hospital inpatients, already existed (Davey et al., 2017). However, there was absence of qualitative systematic reviews on the barriers and facilitators to antibiotic stewardship in acute hospitals.

The MRC Framework suggests that when developing a complex intervention, it is essential that its elements are clearly described in the qualitative research and inductively generated, focusing on research that aims to understand the issue in question from the experiences and points of view of the groups of people targeted by that intervention (Craig et al., 2008). Qualitative research plays a central role in answering questions that cannot easily be evaluated by experimental studies (Jackson & Waters, 2005). Although it does not provide probability estimates or effect sizes, qualitative evidence synthesis can complement quantitative approaches and thus improve the overall quality of the study and the validity of the findings. Therefore, to comply with the MRC recommendations and further clarify the evidence base, a systematic review using a meta-ethnographic interpretative approach for synthesis of multiple qualitative studies was carried out (Chapter 3).

Identifying/developing theory: This stage of intervention development is concerned with providing a strong theoretical rationale for a complex intervention, with an understanding of the likely mechanism of change to increase its effectiveness (e.g., what changes are expected) (Craig et al., 2008). This can be achieved by drawing on the already existing theoretical concepts and models of behaviour change or be endorsed, if necessary, by new empirical research. The theoretical basis may consist of a psychological theory that underpins many behaviour change techniques, and which has been proven to be effective in changing the behaviour in other settings, such as antibiotic prescribing in general practice. In this thesis, a new theoretical model was generated from the meta-ethnography (Chapter 3) depicting multiple micro- and macro-level influences on hospital doctors' prescribing behaviour and then evaluated and refined by empirical research exploring the experiences of HCPs and health service users (Chapter 4). The identified behavioural determinants were then mapped onto the BCW (Michie et al., 2014), and the proposed mechanism of action operationalised, demonstrating a strong theoretical basis for the intervention (Chapter 5). This process was facilitated by close discussions with the supervisory team, members of which have vast expertise in the relevant disciplines.

Modelling process and outcomes: There is no uniform method of modelling a complex intervention (Levati et al., 2016). However, the MRC framework suggests that the purpose of this step is to identify how the intervention components relate to outcomes (Craig et al., 2008). The modelling process of a complex intervention involves bringing together all the 'active ingredients' that have been previously identified as effective (Richards & Hallberg, 2015). This step can provide vital information about the design by identifying the strengths and weaknesses of the proposed intervention before costly resources are spent on a full-scale trial. The MRC further recommends that the RE-AIM model (described in more detail in Section 2.4.3) can provide a source of ideas. The modelling process in this thesis refers to steps undertaken and described in Chapters 4 and 6 and the qualitative study described in Chapter 7 to determine the acceptability, practicability and implementation issues.

2.4.2.2 Feasibility/piloting

The second stage of the MRC framework, feasibility and piloting, includes testing procedures for acceptability, estimating recruitment and retention, and determining sample size (Craig et al., 2008). Richards and Hallberg (2015) suggest that this critical step tends to be overlooked or poorly reported in intervention development. Yet, even the most robust behaviour change interventions are impractical if they cannot be implemented in a real-world setting. This may be due to poor intervention design, recruitment or retention, lack of compliance or acceptability or simply due to genuine ineffectiveness (Levati et al., 2016). Therefore, pre-trial strategies are essential in providing key information, such as intervention delivery and contextual factors to reduce the likelihood of design or implementation failure (Moore et al., 2015).

Most feasibility and pilot studies are conducted in preparation for a future definitive RCT. However, the framework does not explicitly define or distinguish between feasibility and pilot studies, unlike other sources, which provide conflicting definitions. For example, the UK National Institute for Health Research (NIHR) defines feasibility studies as a forerunner to pilot studies to test whether something works, whilst pilot studies are a small-scale version of the planned full trial to test whether components of the study can work together (National Institute for Health Research, 2016). This contrasts with the MRC framework that explicitly specifies that pilot studies need not be a “scale model” of the main evaluation (Craig et al., 2008, p. 10). A Delphi study conducted with research experts by Eldridge et al. (2016, p. 9) concluded that feasibility studies ask “whether something can be done, should we proceed with it, and if so, how”; whereas pilot studies ask the same questions but are part of a future trial conducted on a smaller scale.

The MRC recommends testing the core components of the intervention and the acceptability of the planned procedures on the target group (Craig et al., 2008). Lack of stakeholders’ satisfaction with the intervention can simply lead to a lack of engagement. Within the remit of this thesis, the initial testing of acceptability and practicability of the intervention was carried out using semi-structured interviews with HCPs and health service users (Chapter 7). The prototype intervention was presented to the target group for feedback. Based on the information gathered, the intervention components were refined and an optimal version of the intervention was subsequently created.

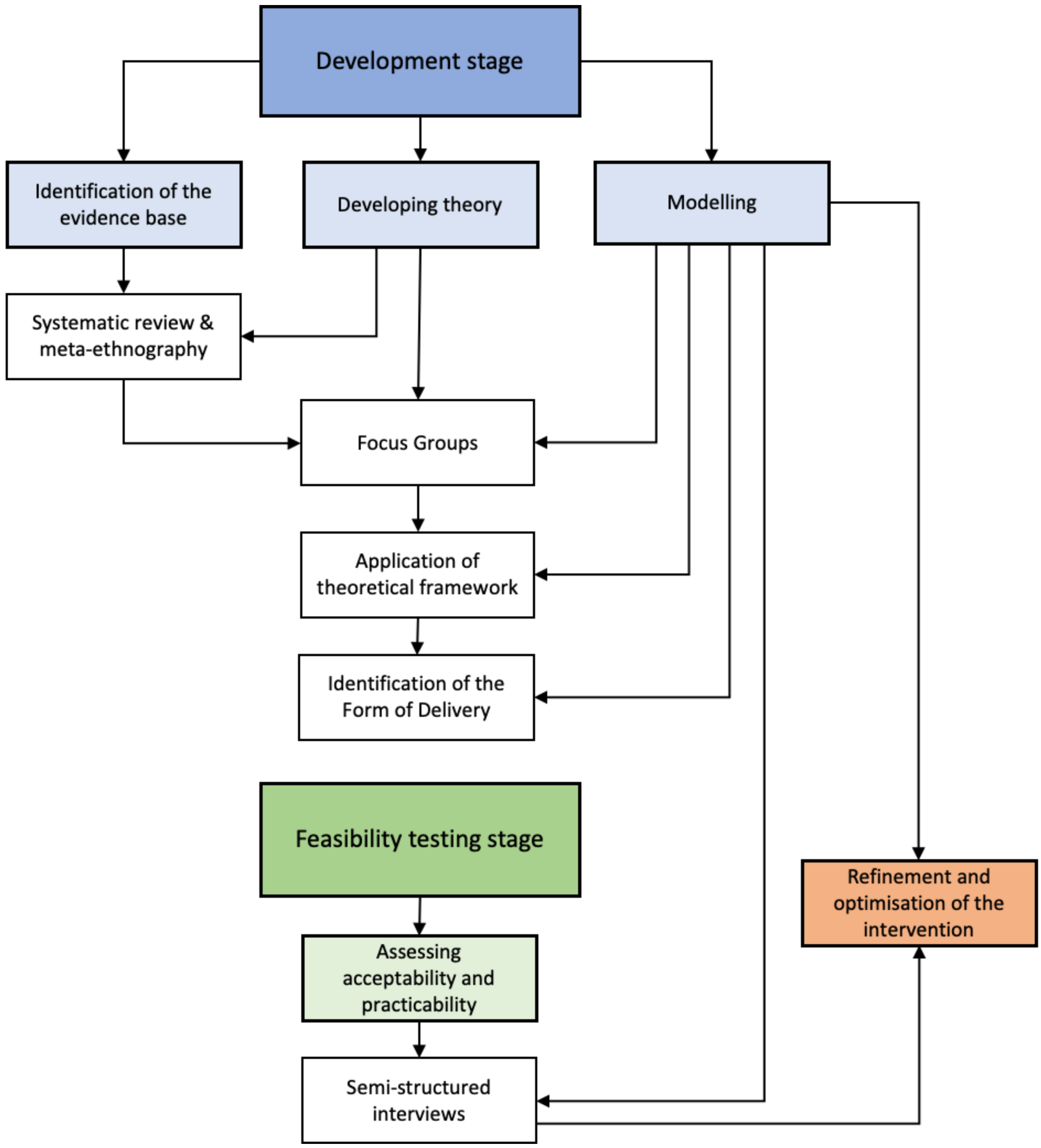
2.4.2.3 Evaluation and Implementation

The evaluation of the intervention is beyond the scope of this thesis. However, to help develop recommendations for future implementation, it is essential to describe the processes involved.

Despite this stage being a crucial part of intervention optimisation, the MRC does not provide detailed information regarding how evaluations should be conducted. It does, however, recommend that, if possible, an RCT should be carried out to assess intervention effectiveness. By applying high methodological standards, researchers can draw robust conclusions about why an intervention works or fails, consolidate that knowledge, and refine intervention design. The framework also places emphasis on embedding process evaluation within a trial to provide key information on potential causal mechanisms, contextual factors and variation in outcomes (Craig et al., 2008). Lastly, the MRC recommends publishing results to facilitate translation of findings into routine policy and practice (Craig et al., 2008). It further highlights the importance of a follow-up to establish whether short-term changes are sustained, understanding factors contributing to maintaining current behaviour, and the barriers and facilitators to such change.

A visual representation of the main methods utilised to inform the development of the antibiotic intervention is provided in Figure 6. A more detailed overview of the research carried out in this thesis and how it relates to the key stages of the MRC framework is provided in Section 2.5.

Figure 6. A schematic representation of the main research methods utilised in the thesis to inform the development of the antibiotic intervention.



2.4.3 The RE-AIM Framework

In order to translate the planned intervention into practice and thus enhance its applicability in real-world settings, it is important to look beyond measuring the traditional outcomes, such as effectiveness. The MRC recommends the application of the RE-AIM framework to maximise the impact of the intervention and help achieve the desired outcomes at later stages (Moore et al., 2015). The model was originally developed to help researchers in sustainable adoption and maintenance of multi-level public health and community- based interventions (Glasgow et al., 1999). In short, the RE-AIM model provides a practical means of the planning, evaluation and reporting of research (Shoup et al., 2015). Qualitative data are of value in RE-AIM as they can provide answers as to why and how something happened.

The model includes five dimensions that translate research into action, including:

- **Reach** the intended target population
- **Efficacy** or effectiveness
- **Adoption** by target staff, settings, or institutions
- **Implementation** consistency, costs and adaptations made during delivery
- **Maintenance** of intervention effects in individuals and settings over time (Glasgow et al., 1999).

Although intended to be used at all stages of the research process from planning through to evaluation, the framework was applied at the modelling stage (Chapter 6) and then initial stages of testing the acceptability and practicability of the prototype intervention to systematically consider its strengths and weaknesses (Chapter 7).

2.5 Research aims and questions

The first chapter of this thesis outlined the problem in behavioural terms, taking the specific context into account and identified a gap in the evidence base on what behaviour-change strategies work in a hospital setting, how to implement them and what refinements are needed to tailor the interventions to the local context. The identified need for more effective interventions to improve antibiotic use in hospitals provided a basis for the research aims of this thesis, which have been drawn up in accordance with the MRC guidance for developing complex interventions.

The overall research aims are:

1. To identify the essential components required in a successful intervention to improve appropriate antibiotic use in hospital settings.
2. To develop a prototype behaviour change intervention to optimise antibiotic use in acute hospitals underpinned by a robust theoretical basis.
3. To assess the acceptability, practicability and suitability of the intervention in clinical practice.

To fulfil the research aims, the following questions were developed:

1. What are the barriers and facilitators to appropriate antibiotic prescribing in acute hospitals? (Chapters 3 and 4)
2. What 'active components' are likely to be effective in motivating and directing behaviour change around antimicrobial prescribing? (Chapters 3-5)
3. What behavioural deficits could be selected as intervention targets? (Chapters 4 and 5)
4. What are the causal mechanisms of the intervention likely to predict and influence appropriate antibiotic prescribing behaviour? (Chapter 5)
5. What methods can optimise the delivery of the content of the intervention? (Chapters 4-6)
6. What are the perceived acceptability, practicability and suitability issues related to the delivery of the antibiotic intervention in clinical practice? (Chapter 7)
7. How can the prototype intervention be refined and optimised to maximise its uptake and effectiveness? (Chapter 7)

As the thesis progressed, specific aims were generated for each chapter. These are presented in Table 1, which outlines the structure of the research undertaken mapped onto the stages of the MRC framework.

Table 1. An outline of the thesis structure, including specific aims and methods, mapped onto the key stages of the MRC Framework

STAGE OF THE 2006 MRC FRAMEWORK	CHAPTER	TITLE	AIM(S)	METHOD
Development: - Identifying the evidence base - Identifying/developing theory	3	A systematic review and meta-ethnography.	To identify, examine and synthesise qualitative research reporting doctors' views and experiences of the barriers and facilitators to appropriate antibiotic prescribing in acute hospitals and explain how these factors influence prescribing behaviour.	A systematic review of qualitative evidence and a synthesis of studies using meta-ethnographic approach and from this, gain insights into what facilitates or hinders appropriate antibiotic use and thus identify active components that could be incorporated into a future antibiotic intervention.
Development: - Identifying/developing theory	4	Exploring the views and opinions of healthcare professionals and health service users using focus groups – Study 1.	To establish conceptual foundation for the intervention.	Focus groups with healthcare professionals and health service users.
Development: - Modelling process and outcomes			To generate new ideas around the content and delivery of the intervention.	
Feasibility/piloting: - Testing procedures			To explore potential issues surrounding the acceptability of a prototype intervention.	
Development: - Identifying/developing theory	5	Development and operationalisation of the intervention content using the Behaviour Change Wheel theoretical framework.	To identify and develop a theoretical understanding of how the intervention is likely to achieve the desired outcomes.	The development of the intervention content guided by the application of the Behaviour Change Wheel, a three-stage, eight composite steps approach.
Development: - Modelling process and outcomes			To identify causal links between components and maximise effectiveness.	
			To develop the content of an intervention.	
Development: - Modelling process and outcomes	6	Exploration of a form of delivery for the intervention.	To specify the intervention components likely to be effective in motivating and directing behaviour change.	Review relevant literature on the effectiveness of the specific intervention components.

			To develop a prototype intervention which can be tested for feasibility.	Application of the Form of Delivery Framework to intervention components to allow future replicability.
Development: - Modelling process and outcomes	7	Refinement and optimisation of the intervention using interviews with healthcare professionals and health service users – Study 2.	To evaluate the acceptability, practicability and suitability of the planned intervention.	Qualitative semi-structured interviews with the target group (healthcare professionals and health service users) for feedback on the intervention.
Feasibility/piloting: - Testing procedures			To explore implementation issues and the potential impact on practice.	
			To refine and optimise the intervention based on feedback received.	

2.5.1 Research design

To effectively address the research questions, the set methods and procedures used to collect and analyse data should be outlined. This thesis consists of a systematic review and meta-ethnography (Chapter 3), two qualitative studies (Chapters 4 and 7) and the development of an intervention to promote timely antibiotic review (Chapters 5 and 6). The research methods applied are briefly outlined below and described in more detail in each chapter.

Chapter 3: A systematic review and qualitative evidence synthesis using a meta-ethnography approach to understand barriers and facilitators to appropriate antibiotic use. This step helped to identify active components that could be incorporated into a future complex intervention. An original conceptual model reflecting multiple challenges to appropriate antibiotic medical prescribing at micro- and macro-level was created and robust conclusions about what works and why and recommendations for improving practice were provided.

Chapter 4: Three focus groups were carried out with HCPs and health service users to explore supplementary barriers and facilitators to appropriate antibiotic prescribing not identified in the meta-ethnography (Chapter 3). The study provided an opportunity to identify the mode of delivery, content and appearance, likely to be effective in motivating and directing behaviour change of antimicrobial prescribing and explore the predicted implementation issues of introducing an intervention into clinical practice. Data were analysed using framework analysis.

Chapter 5: Drawing on the theoretical basis generated in Chapters 3-4, the intervention content was developed, operationalised and transparently reported using the BCW framework. Use of the BCW allowed triangulation of the findings and enabled development of recommendations by taking into account the barriers and facilitators to the target behaviour.

Chapter 6: This chapter discussed the optimum methods to deliver the intervention based on the evidence generated in Chapters 3-5. The rationale behind the decision to use the selected forms of delivery is provided, and for each component, methods for maximising its effectiveness are described. The prototype intervention elements and features are summarised using the Form of Delivery framework to allow future replicability.

Chapter 7: Eighteen semi-structured interviews with HCPs and health service users were conducted to assess the acceptability, practicability and suitability of the intervention. Using prototypes, participants were asked for their feedback on the intervention design, content and functionality. The feedback gathered was used to refine and optimise the intervention components. Data were analysed using framework analysis.

2.5.2 Qualitative systematic review

As previously discussed, within the development phase of the MRC framework, it is essential to identify the existing evidence base using a systematic review (Craig et al., 2008). A traditional literature review tends to be a descriptive discussion of a particular topic written by experts using informal or unstructured methods (Aveyard, 2016). In contrast, systematic reviews are considered the least biased type of a review as they use an explicit, rigorous and reproducible methodology selected according to a carefully defined inclusion and exclusion criteria in order to synthesise the results of many high-quality studies and produce a result of higher statistical power (Gough et al., 2017).

However, although intended to reduce uncertainty, systematic methods of review have attracted criticism on the grounds that they synthesise the findings of studies which only use experimental controlled designs and tend to focus on a single explicitly defined question, particularly questions concerning the impact of interventions (Aveyard, 2016). This poses a problem for a researcher aiming to present diverse perspectives, and the depth and breadth of evidence without placing excessive emphasis on randomised controlled trials and other empirical studies within the research hierarchy (Jones, 2010).

The Cochrane Qualitative Implementation and Methods Group has increasingly recognised the importance of including qualitative findings within evidence-based healthcare research (Noyes, 2010). Qualitative research is particularly valuable in providing detailed descriptions of human thinking and behaviour in the contexts in which it occurs and capturing the depth and richness of people's views and experiences of, for example, delivering or receiving health interventions (Dixon-Woods et al., 2006). Systematic reviews of qualitative research evidence, when used within the healthcare context, can explore:

- health-related behaviours or experiences of illness
- why and how an intervention works
- acceptability and suitability of interventions
- barriers to implementation of health interventions
- the knowledge gaps in qualitative studies (Flemming et al., 2019).

Therefore, to enhance the chances of the planned intervention working in real-world settings, it was deemed essential to first carry out a systematic review of qualitative evidence. To date, some qualitative syntheses have been conducted, such as in prescribing for respiratory infections in general practice (Tonkin-Crine et al., 2011) and in hospitals globally, including different groups of prescribers (Krockow et al., 2019). Although there is a large body of qualitative studies exploring hospitals doctors' antibiotic prescribing experience, there has been no attempt to systematically search for and integrate this knowledge into a qualitative synthesis using the methods of meta-ethnography. To close this knowledge gap, the researcher conducted qualitative synthesis to carefully analyse the key elements of that experience and generate a new, clinically applicable, theory that would then inform development of a future behaviour change intervention. Details of the seven-step meta-ethnographic approach employed to synthesise the evidence are provided in Chapter 3.

2.6 Triangulation

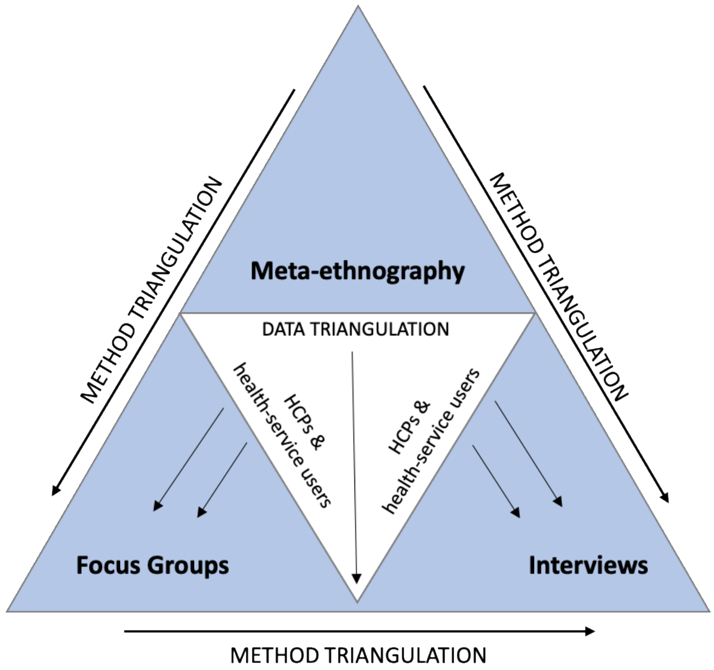
Triangulation refers to using multiple methods of data collection on the same topic of interest. It has been proposed that the credibility and validity of the conclusions are enhanced if different approaches produce more comprehensive findings (O'Cathain et al., 2010). Triangulation is a rigorous approach to explore a research question from various perspectives by combining multiple data sources, study groups, data collection methods, settings or different theoretical approaches (Denzin & Lincoln, 2005). It typically involves examining data from interviews, focus groups, observations or other sources (O'Cathain et al., 2010). Mertens and Hesse-Biber (2012) explain that the purpose of triangulation is strengthening the design, minimising bias, gaining greater overall understanding of the phenomena and thus creating a comprehensive study. Using two different methods or approaches to collect and analyse data allows the researcher to obtain complementary data sets and completeness of research designs.

Denzin (1978) identifies four types of triangulation:

1. Methodological triangulation is the use of more than one method of data collection and can be categorised into two types: 'within-method triangulation' (using more than one data collection technique but one methodological approach) and 'between method triangulation' (using two or more methodological approaches to data collection).
2. Investigator triangulation entails the use of multiple researchers in the study.
3. Data triangulation includes the use of different sources of information.
4. Theory triangulation involves the use of multiple perspectives to draw conclusions from the data collected.

In this thesis, two types of triangulation were employed: within-method and data triangulation, which are illustrated in Figure 7.

Figure 7. Methodological and data triangulation applied in the thesis



Firstly, the data were collected from more than one participant group and of varied expertise (healthcare professionals and health service users). Obtaining information from a range of participants with varied antibiotic decision making roles and responsibilities was an important aspect of the data collection activity within the context of intervention development. This supported the objective to explore a range of experiences and perceptions on antibiotic use in a hospital setting. Secondly, a range of qualitative research methods were used in the thesis, including a meta-ethnography, focus groups and semi-structured interviews. Using a variety of methods helped to gain a deeper understanding of complex human behaviour and offered a more balanced explanation of the topic.

For example, the theoretical knowledge generated in the systematic review and meta-ethnography was supplemented by the focus groups. Once the data were coded and thematically analysed, the themes were then cross-checked for any refutations and new emergent knowledge (Chapter 4). The next step involved carrying out a 'behavioural analysis' as recommended by the BCW (described in detail in Chapter 5). The meta-ethnography and focus-groups provided a contextual understanding of the barriers and facilitators most important to HCPs for affecting their prescribing behaviour. This information was retrospectively mapped onto the BCW and recorded in a matrix form. The outcome of this analysis process formed the foundations for the intervention design, outlining the factors that needed to be addressed to create a change in antibiotic use practice and provide a mechanism of action for the proposed intervention.

Triangulation can also occur sequentially or simultaneously. Although particularly associated with mixed-methods research, in this thesis, sequential triangulation was applied, which included using the results of one data collection method to guide the implementation of the other (Morgan, 1998). This thesis was specifically designed to allow earlier phases to inform the later stages of development. For example, the results of the meta-ethnography and the inductively generated conceptual model (Chapter 3) were presented to key stakeholders during focus groups (Chapter 4) to challenge the interpretations and ensure clarity and relevance of findings.

Similarly, the triangulated findings from the meta-ethnography and focus groups informed the selection of the form of delivery for the intervention (Chapter 6). The matrix created in Chapter 5 helped to inform the need for and then guide the focus of semi-structured interviews described in Chapter 7. This qualitative study provided a further level of verification. The conclusions drawn from the data gathered during semi-structured interviews were compared against the findings from the focus groups, which allowed the researcher to make refinements and thus optimise the intervention. In addition, the data gathered during the empirical work (Chapters 4 and 7) helped close the knowledge gaps, which could not have been achieved by examining the existing literature. This multi-method approach provided an opportunity to explore various dimensions of the phenomenon of interest and thus enhance validity of the research.

2.7 Participants and procedures

This thesis aims to develop a theory-based behaviour-change intervention to optimise antibiotic use in hospital settings. Given the exploratory nature of the research carried out in this thesis and to gain a better understanding of the problem, both primary studies required a qualitative methodological approach. An overview of the practical and ethical considerations of carrying out the qualitative research and the justifications for the design are provided below.

2.7.1 Sampling and recruitment strategy

A well-defined sampling and recruitment strategy is a central element of the research design and there are various approaches available. Recruitment of participants can be particularly challenging when the intended study population are HCPs due to time and workload constraints, lack of interest in the topic, or reservations about the value and applicability of the research (Broyles et al., 2011). Yet, little evidence exists on successful strategies to attract healthcare staff into research.

Nevertheless, participant selection should have a clear rationale and purpose depending on the research aims and questions (Collingridge & Gantt, 2008). The most common sampling strategies used in qualitative research are nonprobability sampling – convenience and purposeful (also known as purposive or selective). Firstly, convenience sampling involves locating any convenient cases of the target population who meet the required criteria, including easy accessibility, proximity, availability, or a willingness to take part (Robinson, 2014). However, one of the limitations of using convenience sampling in qualitative research is a possibility of inaccuracies in the selection process known as a sampling error (Etikan, 2016). Using a broad sample may also lead to difficulties in acquiring generalised results and, consequently, problems with replication.

In contrast, purposeful sampling is a deliberate selection of participants due to the attributes they possess. It is a non-random technique that does not require a set number of participants (Etikan, 2016). By employing this technique, the researcher does not intend to represent the population but capture diverse perspectives relating to the topic and thus make generalisations. This sampling strategy is typically used in qualitative research to identify and select the information-rich cases (e.g., individuals or groups of individuals) who are knowledgeable about or experienced with the phenomenon of interest (Creswell et al., 2011). Therefore, to achieve maximum variation in perspectives and thus gain a good understanding of the topic, this sampling strategy was deemed appropriate for the two qualitative studies carried out within this thesis (Chapters 4 and 7).

Once the sampling strategy is determined, the next step involves deciding how participants will be recruited, for example, via a targeted approach. Newington and Metcalfe (2014) argue that the recruitment strategy needs to be relevant to the target population and the research methodology used. Traditional recruitment methods include the use of flyers, posters, letters or emails, and media advertisements. Namageyo-Funa et al. (2014) suggest that a successful recruitment strategy in health research relies on the following:

- collaborating with healthcare providers and community gatekeepers trusted by the participants
- using face-to-face recruitment in clinical settings
- using word of mouth from participants and gatekeepers
- building trust with participants.

However, novice researchers may encounter several challenges during the recruitment phases due to their limited research experience, funds and time delays. Establishing rapport with gatekeepers to aid recruitment, and support from the supervisory team when faced with recruitment challenges, is essential. Gatekeepers are people who act as an intermediary between the researcher and potential participants. They can facilitate but also withhold access to study settings and personal data (names and contact details) of potential participants due to their knowledge, connections with or membership in a research population (McFadyen & Rankin, 2016). For example, these could be healthcare professionals whose permission is required to obtain access to patients under their formal care. Although reliance on gatekeepers is necessary where a researcher does not have legitimate access to participants, the gatekeepers' professional aim to protect participants means that they may deny access to research participation to an eligible person, which can in turn create bias (Spacey et al., 2021). To overcome these challenges, sufficient time for recruitment was allocated at the outset of the research and keeping gatekeepers well informed was considered essential.

2.7.2 Patient and public involvement

Patient and public involvement (PPI) in research is an active partnership between researchers and patient contributors. As explained by the UK-established INVOLVE Advisory Group, and later adopted by the National Institute of Health Research (NIHR), PPI is undertaken 'with' or 'by' patients or members of the public, rather than 'to', 'about' or 'for' them (Vale et al., 2012). PPI is also an indicator of good research practice as it may help design research relevant to the target group and thus reduce waste of research resources (Staniszewska et al., 2018). This may include involvement in joint grant applications, identifying research priorities, offering advice as members of a project steering group, advising on and developing research materials, or participating in interviews as part of a research study.

Actively involving patients and/or the public throughout all stages of the research process has increasingly become a requirement of research funders (INVOLVE, 2015). Although PPI is becoming standard practice in clinical research, it is important that researchers carefully consider who should be involved in the research project, when to involve them, how to gain access to contributors, the required training and support mechanisms for PPI members, and also what follow-up and dissemination approaches are put in place (Biggane et al., 2019). Failure to consider these issues may potentially have a negative impact, including a scientific and ethical conflict on protocol design, bias in recruitment, and difficult power dynamics between researchers and PPI representatives (Popay & Collins, 2014).

To minimise the potential problems, PPI involvement in the research project was carefully considered and discussed with the relevant gatekeepers. To increase the study quality, PPI was initially sought during the planning phases of protocol development. Members of the local Wellcome Trust Clinical Research Facility advisory group provided valuable comments on the relevance of the research, the outline of time requirements, study materials and dissemination plans. Health service users (lay participants) were then recruited to both qualitative studies (Chapters 4 and 7) to share their unique knowledge, expertise and perspective on the content and design of the antibiotic intervention.

2.7.3 Data collection methods

Data collection in qualitative health research usually involves focus groups, interviews or observations. How the information is collected should be determined by the research question that needs answering (Teherani et al., 2015). However, practical considerations, such as the time and budget available should also be considered when selecting an optimal data collection method. The empirical data collection methods chosen in this thesis are focus groups and interviews. As the primary focus of the research is to explore views, opinions and prior experiences, observational methods, including naturalistic and participant observation (watching people's behaviour in the environment in which it typically occurs), were considered unsuitable to achieve this (Holloway & Galvin, 2016).

In qualitative research, interviewing is a means of data collection which allows an in-depth exploration of people's experiences and understanding the context for their behaviour. Although traditionally conducted face-to-face, data can also be gathered remotely using telephones or computers. The main types of interviewing in research include structured, semi-structured and unstructured interviews (Hennink et al., 2020). A structured interview is a method most suitable for quantitative research where the interviewer asks a set of predetermined questions to investigate research variables (Bell & Waters, 2018).

Unstructured and semi-structured interviews tend to be better suited for qualitative inquiry. In unstructured interviews, the researcher does not use any set questions but instead asks open-ended questions regarding a specific research topic, allowing the interview to flow like a natural conversation. With a semi-structured interview format, the agenda is set, but the approach is flexible as the interviewer is free to follow the ideas expressed by the respondent and rephrase the questions depending on the issues raised (Bell & Waters, 2018). For the reasons outlined above, a semi-structured interviews format was considered most appropriate for both qualitative studies carried out within this thesis.

Qualitative interviews can be carried out in one-to-one or group settings. Individual interviews enable participants to express their views and opinions freely and safely in a private setting, without any judgement imposed by the researcher or other participants (Teherani et al., 2015). Good interpersonal skills are vital to enable qualitative researchers to develop rapport with participants, encourage open conversation and enable depth of data to emerge. Focus groups enable researchers to gain detailed understanding of participants' opinions and also to obtain reactions to new ideas (e.g., voting and ranking) and conduct group brainstorming (Ritchie & Lewis, 2013).

2.7.3.1 Topic Guides

Once the data collection methods were decided, the next step involved determining what questions should be asked. As the semi-structured (group and individual) interviews undertaken in this thesis addressed different research questions, they required separate topic guides. This section describes the general process involved in developing a topic guide. The methods section of each qualitative study (Chapters 4 and 7) provides more detailed descriptions of this process.

A comprehensive topic guide serves many purposes in qualitative interviews. It can act as a memory aid with follow-on prompts to ensure the researcher covers the topic areas and obtains the necessary detail (Holloway & Galvin, 2016). It also offers a practical framework for the discussion during the interview. However, the interview guide should not be followed strictly. Instead, it should provide guidance on the areas to be explored in the interview (Atkinson & Delamont, 2012). That way, the researcher can be flexible in their approach and add additional questions about unexpected but relevant points that are raised in the interview. Ritchie and Lewis (2013) advise that the topic guide should be altered or 'fine-tuned' over the course of the study as insights gained or issued raised in an earlier interview can inform subsequent interviews, providing an opportunity to explore further.

When developing a topic guide, McGrath et al. (2019) offer some useful tips for novice researchers, including the following:

Prepare the interview guide in advance and test it: By conducting a test interview, the researcher can gain skills prior to undertaking data collection. An informal interview may be carried out with peers or volunteers who have experience in the relevant area.

Undertaking preliminary work provides an opportunity to check the clarity of the language and questions and explore the aspects of active listening.

Ensure it aligns with the methodological approach: A semi-structured interview guide will typically include only a few predetermined questions (i.e., 5-15 questions) covering the key topics, allowing the researcher to probe through follow-up questions and thus further explore issues raised by the interviewee. The key topics should be drawn from the original research questions and by consulting the relevant literature on the subject.

Use opening and closing statements: An opening statement ensures that all participants are given the same information required for making informed consent and provides an opportunity for introductions and informal conversation. A closing statement brings the interview to a close and provides a chance to add or clarify a previous statement. It should also assure participants that the confidentiality and anonymity of their data will be maintained at all times.

Guided by these principles, two separate topic guides were prepared for the focus groups and interviews, containing an outline of topics to be addressed which were derived from the original research questions. However, the wording and order of the questions were flexible. The topic guide for FGs was tested during a pilot group consultation with academic staff and PhD students within the University prior to the study commencing (more details are provided in Chapter 4, Section 4.4.5). The topic guide for the second study was tested with a lay participant during a brief online meeting to check the presented information and interview questions for understanding and clarity. The topic guides provided directions for exploring, in an in-depth manner, topics that were unique to the experiences of the participants and which facilitated an open and relaxed discussion. Allowing participants the freedom to express their views and opinions encouraged a two-way conversation and allowed new ideas to be brought up during interviews. The sequence of questions was refined as the interviews progressed, and new or unanticipated issues that emerged were further explored in the subsequent interviews.

2.7.3.2 The interviewer's role

McGrath et al. (2019) further suggest that the interviewer is the main instrument of data collection in qualitative research and the quality of information obtained during an interview is largely dependent on the interviewer. Therefore, he/she needs to be knowledgeable, reflexive and conscious about how their role might impact the discussion. To put both the researcher and the participant at ease and establish rapport, opening an interview with 'easy' questions can make those involved feel more comfortable. This entails being non-judgemental, authentic, trustworthy and asking genuinely open-ended questions (Patton, 2015). If the participant perceives that their responses are being judged, they may provide answers desirable to the researcher. It is also important to be clear so that the interviewee understands what is being asked, avoid confusing language, ask follow-up questions and use probes when appropriate to obtain more in-depth and detailed data (Ritchie & Lewis, 2013). Lastly, skilled interviewing also involves active listening to help draw meaningful responses from the participants with the use of silence or gaps to give participants time to respond.

The researcher applied the following principles during both of her qualitative studies. Relevant open-ended questions were asked where possible to elicit meaningful and in-depth responses. To ensure the questions asked were clear, focused and understandable, the researcher checked with participants for meaning and summarised the information gathered to determine accuracy and provide an opportunity for clarification. The researcher actively listened and let the participants know that they were being heard. To gather richer responses, probes – such as "it would be helpful to hear more about that" were used (Patton, 2015, p. 436). The researcher paid attention to the participants' non-verbal cues during each interview, such as facial expressions, eye-contact, tone of voice and gestures for any sign of discomfort and adapted the questions accordingly to the interviewee's reactions. Being empathetic, neutral and showing interest in a non-judgemental way was also important. Participants were guided through the interview process at their own pace and the researcher ensured a flexible and responsive approach, allowing for unanticipated issues to arise.

2.7.3.3 Reflexivity

There are many ways in which researcher bias could impact the study, from the creation of data collection tools, the choice of the surroundings, to analysing and reporting the data gathered (Berger, 2015). Reflexivity is an essential aspect of qualitative research to ensure rigorous standards. It involves the examination of one's own beliefs and practices during the research process and the role of subjectivity in the research process (Holloway & Galvin, 2016). The researcher's reflexivity also entails taking responsibility for one's own position within the research and the effect it may have on study participants, questions asked, and data interpretation. To acknowledge the author's personal contributions to her work, the reflexivity sections in Chapters 4 and 7 are written in the first person.

Within the context of these studies, the researcher needed to consider the ways in which her participant interactions may have been influenced by her own professional background, experiences and prior assumptions. The researcher was an academic research student from a clinical (nursing) background, and she was clear about this from the outset to avoid confusion and potential misinterpretation of information. An important question the researcher needed to address in interpreting the data gathered was whether and/or how the participants' knowledge of her professional background might have influenced what they said. While completely avoiding bias may not be possible, the researcher took several steps to minimise it. Firstly, the questions asked were phrased in an engaging manner. Secondly, general questions were asked first, before moving to more specific or sensitive questions to allow participants to feel comfortable to express their own views and opinions. Thirdly, the researcher made sure that she avoided asking leading questions that could prompt participants to provide responses supporting a particular assumption. Additionally, all data gathered were carefully considered and analysed, and the researcher's pre-existing assumptions were kept at bay by keeping an objective mind and having regular briefing sessions with the academic supervisors. This aspect is described in more detail in the methods section for each study.

Careful consideration also needs to be given to power relations between the interviewer and the interviewee, taking into account the fact that an interview is a form of relationship (Atkinson & Delamont, 2012). In qualitative research, the aim is to give participants some control over the extent to which the topics are discussed. However, it is the researcher who sets the agenda and leads the conversation (Ritchie & Lewis, 2013). The researcher took steps during the interviews to balance the power differential. She was respectful of participants' views, shared the rationale for undertaking research, and explained clearly how the data would be gathered and stored, and their privacy protected. The researcher also took a neutral stance and allowed the participants to take the lead in 'setting the pace' of the interview. By doing that, she ensured that participants would feel they had some control over the interview process. Additionally, there were shifts in the dynamics of relations between the researcher and participants and vulnerability on the part of the researcher emerged. For example, some participants (doctors *specifically)* took a more 'authoritative' position in their interactions with the researcher in terms of their professionally based knowledge of the subject matter. Practice of reflexivity and debriefing with the academic supervisors was essential to resolve these issues.

Consideration was also given to choosing appropriate interview locations where participants felt most comfortable answering questions. The focus groups were conducted in participants' workplaces as this was more convenient for them. Individual interviews were carried out online due to the COVID-19 pandemic. Most participants chose to be interviewed at home rather than at their workplace. This approach ensured that the participants felt relaxed. The researcher was aware and sensitive to the possibility that discussing the research topic could potentially cause distress, particularly in lay participants who reflected on their personal experiences of being acutely unwell and subsequently hospitalised. Therefore, at the end of each interview, she took time to ensure that participants were not feeling distressed and provided them with a debriefing sheet. One participant chose to be interviewed via telephone rather than online. In this case, identifying the subtle nuances was challenging. In the absence of observations, special attention was paid to the participant's and her own vocal inflection. The researcher remained alert to the manner in which she phrased questions and the way in which the participant responded.

Additionally, to reduce bias, the researcher ensured that the research design incorporated a wide range of different perspectives, including contributions from various HCPs and lay participants. Data analysis included a constant comparison between views and opinions of each participant group to check for similarities and differences, which were then clearly outlined. Lastly, the collaborative nature of the supervisory team input enabled multiple perspectives to be brought together in the process of data interpretation.

2.7.4 Ethical considerations

Ethical approval for both studies was sought and obtained from the School of Health and Social Care Research Ethics Committee at Edinburgh Napier University (ENU) and NHS Lothian Academic and Clinical Central Office for Research and Development (ACCORD) Committee (reference number: 2018/0007) prior to the research being undertaken (see Appendices 2 and 3). As there was no direct patient contact at any stage, NHS Lothian Research Ethics Committee (REC) approval was not required. After seeking clarification on a few minor points, the University Research Ethics Committee provided the ethical approval on the condition that lay participants were recruited via appropriate gatekeepers. An additional requirement was that a debrief sheet was provided to all participants. Subsequently, the NHS R&D Committee provided an approval with no required changes.

After commencing the study, two non-substantial amendment approvals to the initial study design were sought and approved by both review bodies (Appendices 4-7). The following changes to the research project were requested:

Study 1 amendment: The initial study design was to conduct two focus groups (FGs) (Chapter 4). However, following discussions with the academic supervisors and having revised the literature, permission was sought to hold an additional FG. This was to allow the researcher an opportunity to present the research findings to the participants, provide a forum for further discussion/engagement and invite feedback. The approach also provided a way of clarifying and eliciting more detailed answers from participants on the issues that were raised in the previous sessions. Additionally, sharing the findings with the participants enabled the researcher to check the accuracy and completeness of the findings (Holloway & Galvin, 2016).

Study 2 amendment: The means of data collection planned for the second study were face-to-face interviews with hospital prescribers. However, due to the exploratory nature of this research, capturing a wide range of perspectives was deemed necessary to gain more in-depth information on the subject being investigated. Therefore, a decision was made not only to include a variety of healthcare professionals involved in everyday decisions about antibiotic prescribing but also three lay participants, increasing the overall sample number to 18. Due to the COVID-19 pandemic lockdown restrictions, recruitment to the study was initially paused and approval to re-commence the study was conditional on ensuring compliance with prevailing Scottish and UK Government instructions and guidance. Conducting research during the pandemic required changes to the data collection approach and individual interviews had to be undertaken entirely online or via telephone to minimise any detrimental impact on participants.

2.7.4.1 Informed Consent

The Royal College of Nursing defines informed consent as "an ongoing agreement by a person to receive treatment, undergo procedures or participate in research, after risks, benefits and alternatives have been adequately explained to them" (Gelling et al., 2011, p. 3). Obtaining written informed consent from participants before taking part in a study is an ethical and legal requirement and an internationally accepted standard (Rivera et al., 2007). The reason for it is twofold: to safeguard participants' autonomy and to protect them from harm (Wendler, 2011). For consent to be truly informed, potential participants must be advised about the purpose of the research; their rights, including what will happen if they decide to withdraw from the study; the practicalities, procedures and people involved in the research; possible risks and benefits of participation as well as the alternatives available; expected duration of the study, the ethical considerations and the confidentiality aspects of their data (Gelling et al., 2011). Based on that information, the participant can make a voluntary decision, without any coercion or persuasion on the researcher's part. Consent forms for both studies are provided in Appendices 8 and 9.

The required information outlined above was included in the participant information sheets for both studies (Appendices 10 and 11). Potential participants were emailed the information sheets, giving them sufficient time to read the information before obtaining consent. Prior to starting the FGs and interviews, the researcher ensured that participants were able to give consent by checking the information and asking questions to check their understanding of the study.

2.7.4.2 Privacy and confidentiality considerations

Confidentiality is an ethical principle designed to protect the privacy of participants during all research activities, including collecting, analysing, and reporting data (Saunders et al., 2015). It means not disclosing any information gained from a participant, deliberately or accidentally, and not to identify an individual (Wiles et al., 2008). In the context of this thesis, maintaining confidentiality involved the following steps. Participants were informed that all information collected in the research process would be kept concealed from everyone except the primary researcher and that they would not be traceable from the data presented about them. All identifiable information was removed from transcripts and individuals were assigned a pseudonym to ensure their anonymity. Basic demographic information, such as age, ethnicity and employment status, was coded as broadly as possible. The issues that arose from the interviews were discussed with the supervisory team in ways that would not identify any individual. Lastly, all data were anonymised in the dissemination of the study to protect participants' identity.

2.7.4.3 Maintaining data security

All data collected, processed and stored for the purposes of this thesis complied with ENU Code of Practice on Research Integrity and the principles of the Data Protection Act 1998 (Edinburgh Napier University, [ENU], 2013). The Code supports the University's commitment to promoting high standards of ethical research practice. To ensure data security, the following actions were taken:

- Participant consent forms for FGs were stored in a locked filing cabinet within the ENU for the project duration, to which only the researcher had access. As individual interviews were undertaken during the COVID-19 pandemic, consent forms were signed electronically, converted into a PDF file, and subsequently transferred onto the researcher's personal space on the University's V-Drive, which is the most secure place to store data.

- Notes taken during the interviews, and demographic data were typed up fully into separate PDF documents. Any printed copies of interviews for analysis were already anonymised so that there were no identifiable markers stored with the interviews. These were placed in a lockable drawer.

- Interviews were recorded on to the researcher's own digital audio Dictaphone and transferred in an MP3 format onto the University's V-drive at the first opportunity. The recordings were deleted from the Dictaphone immediately after transfer.

- Computers used to store and analyse the data had limited access measures via usernames and passwords, only accessible to the researcher. Stored files were named with a short descriptor, version and dates, where appropriate. The University-managed data storage is resilient, with multiple copies stored in multiple physical locations and protected against corruption.

- ENU Management Policy requires research data to be kept for at least 10 years after project completion and stored securely on the University data repository.

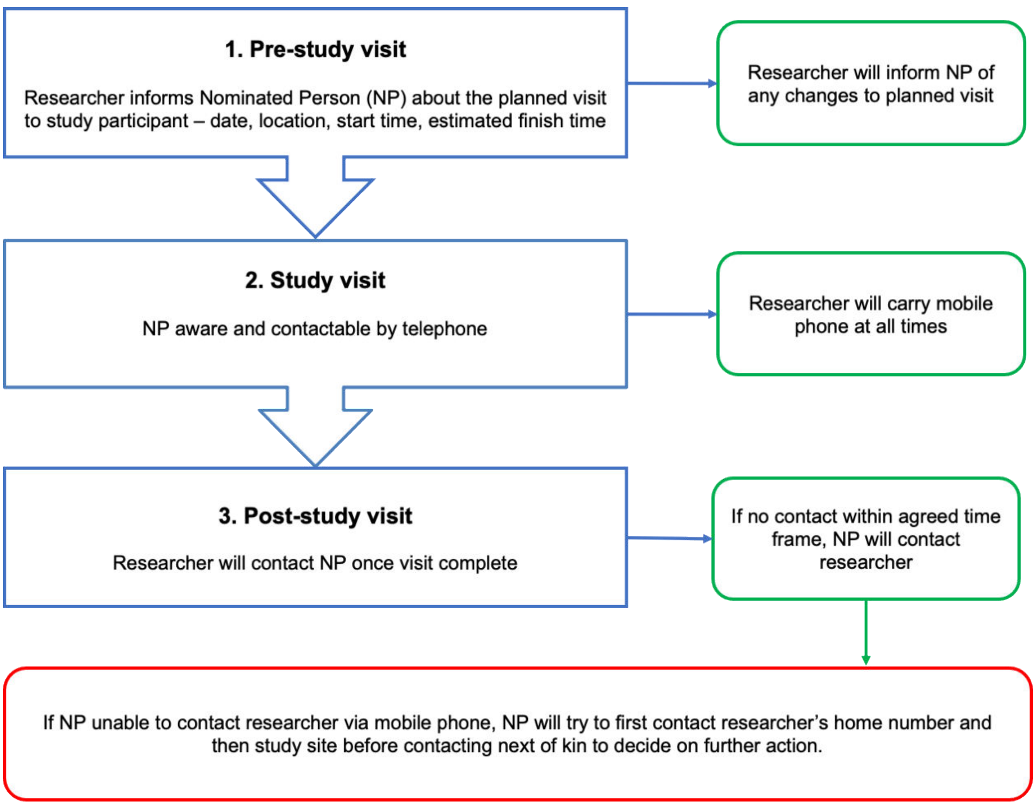
- To comply with the EU General Data Protection Regulation (GDPR), all participants were provided with a Privacy Notice explaining the purposes for which personal data were collected and used, how the data would be used and disclosed, how long it would be retained, and the data controller's legal basis for processing (Appendix 12).

2.7.4.4 Safety of participants and the researcher

While no negative effects were anticipated on individuals taking part in this research, it is possible that involvement in qualitative interviews where individuals are asked to reflect on their experiences can, in some cases, cause anxiety (Patton, 2015). Although the topics discussed were not sensitive and no such difficulties arose, this issue was carefully considered. Elmir et al. (2011) suggest that if the researcher becomes aware that a participant is distressed and at risk as a result of the interview, she or he should pause and give the participant the option to discontinue the interview, and then offer advice on how to seek appropriate services. All participants were informed at the start that they could opt out of the research processes at any time without giving any reason for doing so. At the end of each interview, a debriefing sheet (Appendix 13) was provided to all participants. The purpose of debriefing in research is to provide information about how the participant can be informed of the study results, provide contact information for relevant support services, and to thank the participants for taking part (Ritchie & Lewis, 2013). It also provides an opportunity to answer any queries and for participants to give feedback to the researcher.

To ensure the safety of the researcher, the ENU Lone Working guidance (2018) was adhered to. This provided a mechanism for ensuring that the exact whereabouts of the researcher at any time point during data collection was known by a Nominated Person (e.g., an academic supervisor or another identified member of staff within the university). One of the academic supervisors was fully aware of the researcher's whereabouts and she was contactable at all times via mobile phone. Figure 8 below provides a graphical representation of this process.

Figure 8. Mechanism for ensuring the researcher's safety



2.7.5 Qualitative data analysis

Analysing qualitative data is significantly different to quantitative research methods. It is not a technical procedure of collecting and analysing numerical data, but a dynamic and inductive process (Ritchie & Lewis, 2013). As opposed to quantitative research, the analysis of qualitative information is a continuous process which starts at the onset of data collection. The focus of analysing qualitative data is the exploration of values, beliefs, thoughts and people's experiences of the phenomenon under study (Holloway & Galvin, 2016). Bogdan and Knopp (2006) define qualitative data analysis as the process of systematically arranging the interview transcripts, notes, or other materials (e.g., images or videos) that the researcher has gathered to increase the understanding of the subject being investigated. This process entails coding large amounts of text into categories or themes to make sense of it. By reducing the volume of raw data and identifying patterns or relationships, the researcher can start building a picture of the whole.

There are various ways of undertaking qualitative data analysis and selecting an appropriate theoretical approach depends on the purpose of the research. Although different possibilities were explored, framework analysis was considered the most suitable for analysing the qualitative data gathered within this thesis, for several reasons (Chapters 4 and 7). Firstly, the researcher considered the research question she was trying to address, the nature of the data and the practical aspects of conducting the study. Although the general approach in framework analysis is inductive, it allows both a priori issues and the emerging concepts from the data to guide the development of the analytic framework (Ritchie & Spencer, 1994). This form of analysis fitted the aims of the study because there were predefined areas that the researcher needed to explore but at the same time remain open to discussing new ideas. In addition, framework analysis is a rigorous approach, but it allows a degree of flexibility during the analysis process to either analyse the data after collection is completed or to carry out data analysis during the collection process (Parkinson et al., 2016). It can also manage large qualitative data sets and is compatible with NVivo qualitative data software, which is important when considering practical issues of undertaking the research. Lastly, framework analysis is not bound by any specific epistemological position (Ritchie & Spencer, 1994), which is in alignment with the pragmatic approach taken in this thesis.

One of the main benefits of using framework analysis is that it provides systematic and transparent stages during the data analysis process, so that others can be clear about how the results have been obtained from the data (Ritchie & Spencer, 1994). This five-step process is briefly outlined below and detailed in Chapters 4 (Section 4.5) and 7 (Section 7.5).

Familiarisation: The first stage involves the researcher becoming immersed in the data by listening to the interviews and repeatedly reading the transcripts and field notes. In this process, the researcher becomes familiarised with the data set and the key emerging themes.

Identifying a thematic framework: The aim of this stage to organise the data in a manageable way. This process involves developing an initial coding framework both from a priori questions and from emerging ideas during the familiarisation stage. Notes taken during the familiarisation stage help form a foundation of a thematic framework that can be refined in the subsequent stages. For instance, the coding framework for Study 1 consisted of twelve codes (sub-themes), clustered into four categories (themes), including Barriers and Enablers to appropriate prescribing, Lay participants' voice, and Proposed components of the antibiotic intervention.

Indexing: This stage entails systematically applying the thematic framework to the interview transcripts. The themes are identified and grouped together using numerical or textual codes. This process is more commonly known as coding (Parkinson et al., 2016).

Charting: The indexed data for each category is summarised using headings from the thematic framework and organised in a chart form. Charts can be either thematic for each theme across all participants or by case for each participant across all themes. For example, in Study 1, the researcher used spreadsheets to organise the data into a more manageable format and the descriptive summaries of the indexed data were then ‘charted’ into the matrix so that all data could be visualised as a whole (examples provided in Chapters 4 and 7).

Mapping and Interpretation: The aim of this final stage is to move beyond data interpretation to making sense of the data. Displaying themes in a pictorial or graphic form can aid the researcher in this process. Ritchie and Spencer (1994) describe this as bringing together the main characteristics of the data to map and interpret the data set as a body.

2.7.5.1 Rigour

Evaluating the quality of research is crucial if findings are to be applied in practice. However, qualitative research has been frequently criticised for lacking scientific rigour. The main reasons mentioned in the literature are poor justification of the methods chosen, lack of transparency in the data collection and analytical procedures and findings consisting of personal opinions (Noble & Smith, 2015).

Bias is a concept drawn from quantitative research and refers to any influence that creates a distortion in the results of a study (Polit & Beck, 2014). Galdas (2017) suggests that considering concepts such as rigour and trustworthiness is more suited to the reflexive nature of qualitative inquiry. For the novice researcher, demonstrating rigour can be challenging as there is no consensus about the standards by which a qualitative study should be judged. Rigour can be defined in simple terms as the quality of being thorough and accurate (Polit & Beck, 2014). Unlike quantitative researchers, who aim to establish the validity and reliability of research findings by using statistical methods, qualitative researchers strive to ensure the trustworthiness of the findings (Noble & Smith, 2015).

In this thesis, rigour was ensured by applying systematic, explicit and transparent methods of data collection and analysis, using NVivo computer software to assist with the data analysis process, triangulation of data (discussed in Section 2.6), checking disconfirming evidence, objective and comprehensive reporting of the findings, and regular debriefing sessions held with the supervisory team. The rigour and transparency of the research was strengthened by applying a validated theory-informed approach to data interpretation and further complemented by a set of specific criteria that aided decisions when translating research into practice (Chapter 5). Lastly, although the purpose of qualitative research is to provide in-depth explanations and meanings rather than generalised findings, analytical generalisability was achieved by applying the findings from the meta-ethnography and focus groups to the established BCW theoretical framework, providing findings that may have significance in other research, even if the contexts or populations are different (Polit & Beck, 2014). Table 2 outlines the range of strategies employed within this thesis to ensure trustworthiness of the research using Lincoln & Guba's (1985) criteria of credibility, transferability, dependability and confirmability.

Table 2. Strategies employed to ensure trustworthiness of the research

CRITERION	PURPOSE	STRATEGY
Credibility	To establish confidence that the results (from the perspective of the participants) are true, credible and believable.	Interview topic guide questions were tested for both studies prior to conducting research.
		The researcher ensured that she had the required knowledge and research skills to perform her roles during focus groups and online interviews.
		Methodological and data triangulation were used to strengthen the design, minimise bias and achieve complementarity of the research.
		A process of member checking was used in Study 1 to validate and assess trustworthiness of the data. Key points raised during the focus groups were summarised at the end of each session for participants to confirm or alter, and to ensure an accurate summary of the discussion; whilst the generated themes were presented to the subsequent groups to check and confirm for agreement. Two researchers (the author and her academic supervisor) independently coded the first three transcripts for Study 2.
		Regular debriefing sessions were held with the academic supervisors.
Transferability	To extend the degree to which the results can be generalised or transferred to other contexts or settings.	Purposive sampling was used for both studies to identify, select and capture a range of opinions and experiences related to the phenomenon of interest.
		Rich description of the study methods was prepared in the Study Protocol and adhered to during the study.
		Meta-ethnography protocol was devised and registered with PROSPERO systematic reviews website and the findings reported using the eMERGe reporting guidance.
Dependability	To ensure the findings of this qualitative inquiry are repeatable if the inquiry occurred within the same cohort	Inductive approach was used to ensure data-driven analysis.
		Measures were taken to ensure objective and comprehensive recording of data, findings representative of the data gathered and not biased by the researcher, evidenced by including direct quotations from participants.
		The data interpretation was presented to academic supervisors to increase coherence and establish coding accuracy and achieve a high degree of clarity.

	of participants, coders and context.	The intervention was designed using a comprehensive theory-driven approach, which allowed detailed specification of the mechanism of action.
Confirmability	To extend the confidence that the results would be confirmed or corroborated by other researchers.	Reflexivity was considered to address the bias in the contextual relationship between the researcher and the participants.
		Disconfirming evidence was checked to identify refutational findings and better represent the developed theoretical ideas resulting from the data.
		A detailed track record was used to capture and describe data collection and analysis process.
		NVivo qualitative software was used for all data analysis carried out in the thesis.
		Sufficient study details have been provided using the COREQ reporting guidelines and the intervention components have been described using the Form of Delivery Framework to allow reliable replication.

2.7.5.2 Reporting qualitative research

Adequate and complete research reporting using a structured approach is essential for maintaining high standards, ensuring transparency and allowing replicability. There are many useful reporting tools and checklists in health research. These include CONSORT for RCTs, Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) for observational studies, PRISMA for systematic reviews and meta-analyses and the recently developed eMERGe reporting guidance for meta-ethnography (EQUATOR Network, 2020).

In response to calls for improvements in the quality of reporting of qualitative studies, Tong et al. (2007) developed the consolidated criteria for reporting qualitative research (COREQ), a 32-item checklist for interviews and focus groups. This comprehensive checklist consists of items grouped into three domains: research team and reflexivity; study design; and data analysis and reporting. To ensure explicit reporting of important aspects of the qualitative studies conducted in this thesis (Chapters 4 and 7), the COREQ criteria were applied and details provided for each study chapter.

2.8 Chapter summary

This chapter has provided an overview of the methodological approach employed to achieve the overall aims of this thesis. The intervention development process comprised four phases guided by the 2006 MRC framework for developing complex health interventions. The underpinning methodology was explained, the methods for the research design were provided alongside the justifications for their use, and the practical and ethical considerations of undertaking qualitative research were discussed. Chapter 3 examines and synthesises the existing qualitative evidence to close the identified gap in the evidence base and explores how this information can be used to inform the development of a future behaviour change antibiotic intervention.

Chapter 3: Systematic review and meta-ethnography

This chapter presents a step-by-step process of the seven methodological phases of meta-ethnography for synthesising qualitative evidence in the form of a 'worked example'. It starts with the background to the emerging field of qualitative synthesis, describing the potential benefits of this evolving method and its contribution to generate knowledge and inform policy and practice. The rationale for choosing this method is provided, and the challenges related to undertaking the synthesis of evidence derived from qualitative studies are also discussed, followed by a detailed description of the applied methodology. The last part of this chapter presents the findings of a systematic review and meta-ethnographic synthesis, and a newly generated conceptual model. Strengths, limitations, and reflexivity are discussed, and the implications of the synthesis on practice and research are outlined. To ensure systematic and robust reporting, the review follows the meta-ethnography reporting (eMERGe) guidelines (France et al., 2019).

3.1 Introduction

The importance of other forms of research evidence than positivist in generating knowledge for healthcare practice, such as qualitative findings, has been increasingly recognised by international collaborations, including the Cochrane Qualitative Research Methods Group (Noyes, 2010). Other agencies have also formally acknowledged the contribution of synthesising multiple qualitative primary research studies, known as 'qualitative evidence synthesis' (QES), to healthcare decision making. For example, QES has become part of the guidance produced by national organisations, such as the UK National Institute for Health and Clinical Excellence (NICE) and the US Agency for Healthcare Research and Quality (AHRQ), as well as research funded by private, public, and charitable bodies, as a unique way to capture the voices of participants (Booth, 2016). However, given that qualitative synthesis originated in the 1980s, whilst the first Cochrane QES was not published until 2013, it must be acknowledged that recognition is relatively recent. It signifies a new milestone in developing the methodology (Gülmezoglu et al., 2013).

QES aims to combine and analyse research findings from individual qualitative studies addressing similar research questions across different contexts and make them accessible for the public, policy, and practice (Flemming & Noyes, 2021; Toye et al., 2017). Various methods exist for synthesising qualitative research (Dixon-Woods et al., 2007; Barnett-Page & Thomas, 2009; Flemming et al., 2019). Meta-ethnography (ME) is a research method originally developed in education research by Noblit and Hare (1988). It is an interpretative method of creating deeper meaning to an existing set of primary studies by 'going beyond' the original authors' concepts and ideas through a process of constant comparison and abstraction (Dixon-Woods et al., 2007). It involves seven stages of the synthesis process, a summary of which is provided in Table 3 and further explained in the following section.

Table 3. A summary of the applied seven phases of meta-ethnography

META-ETHNOGRAPHY PHASE	HOW IT WAS CARRIED OUT
Phase 1: Getting started	No previous ME identified on the topic. ME chosen as the most appropriate method to fill the knowledge gap and generate theory required for the development of a complex behaviour change intervention to improve antibiotic use in acute hospitals. ME's aims and objectives provided.
Phase 2: Deciding what is relevant to the initial interest	The rationale and the employed strategy described, including the application of the SPIDER tool, comprehensive electronic searches using a combination of key terms and hybrid qualitative filters, supplemented by non-electronic searches. The process and outcome of study screening and selection reported using PRISMA.
Phase 3: Reading the studies	Data extraction method and processes using NVivo software described. Key terminology used in ME, the rationale and outcome of undertaking quality appraisal using CASP tool, and the included studies' characteristics provided.
Phase 4: Determining how studies are related	The methods and processes for comparing the included studies described, including the data categorisation and extraction approach applied (e.g., using tables and Excel spreadsheets). The outcome of relating studies (developed study clusters grouped by primary themes, concepts, and higher conceptual categories) presented using matrices. A *priori* research question answered.
Phase 5: Translating the studies into one another	The steps taken to translate studies and generate four overarching themes, including three reciprocal and one refutational, described. Themes discussed using exemplar excerpts.
Phase 6: Synthesising the	A new line-of-argument developed and illustrated with a conceptual model representing the multi-dimensional nature of medical antibiotic

translations	prescribing in acute hospitals.
Phase 7: Expressing the synthesis	The main interpretive findings of the translation and synthesis summarised and compared to existing literature. Strengths, weaknesses, and implications of ME reported.

3.1.1 Phase 1 – Selecting meta-ethnography and getting started

This stage of the research is concerned with "finding something worthy of the synthesis effort"; in other words, formulating a research question that could be answered using qualitative research (Noblit & Hare, 1988, p. 27). Although there are many possible approaches to undertaking a review and organising, and presenting data, the first step is to identify information already known on the subject.

3.1.1.1 Rationale and context for the meta-ethnography

Chapter 1 of this thesis described the threat posed by antimicrobial resistance and how hospital misuse and overuse of antibiotics has contributed to this problem, giving rise to urgent calls for well-designed antimicrobial stewardship (AMS) interventions. However, to develop effective and sustainable complex health interventions, it is essential to adopt a prospective, theory-informed intervention design process (Craig et al., 2008). As Wight et al. (2015) argue, changing a behavioural problem entails an understanding of what shapes and perpetuates it. A key principle for successful change is the premise that the choice of behavioural change intervention components should be informed by an assessment of the likely determinants (e.g., barriers and facilitators) that influence the behaviour (Grimshaw et al., 2012; Hulscher & Prins, 2017).

As discussed in Chapter 2 (Section 2.4.2), when intervention development is considered, the first step should include identifying and evaluating the existing evidence base for content and validity (Craig et al., 2008). The evidence should ideally be based on a recent high-quality systematic review. If no such review exists, the first step is to conduct one. A thorough literature search identified a recent Cochrane review, which provided recommendations on the effectiveness and safety of interventions to improve antibiotic prescribing to hospital inpatients (Davey et al., 2017). However, there remains a gap in the evidence base on what behaviour change strategies work in hospitals, how to implement them and what refinements are required to tailor the interventions to local contexts (Nielsen & Miraglia, 2017). To improve practice, research is needed to develop interventions that address prospectively identified barriers and facilitators to change (Baker et al., 2010).

To date, some related qualitative syntheses have been conducted, such as in prescribing for respiratory infections in general practice (Tonkin-Crine et al., 2011) and hospitals globally, including different groups of prescribers (Krockow et al., 2019). However, an in-depth exploration of the wide-ranging contextual, organisational, and interpersonal determinants in antibiotic decision making and their influence on specific groups of prescribers has not received adequate attention. A preliminary search showed that there is a large body of qualitative studies exploring hospital doctors' antibiotic prescribing experience but, this has not yet been systematically searched for and integrated within a robust qualitative synthesis. If not synthesised, the potential to learn from all the single studies cannot be maximised. Such research is therefore required to enable knowledge gained from these hospital doctors' insights to generate new, clinically applicable theory to inform the development of a much-needed future behaviour change intervention.

Existing hospital AMS initiatives are not contextually designed or implemented with end-users of different specialities in mind (Charani et al., 2019). Yet, the Medical Research Council (MRC) recommends that when developing a complex intervention, it is essential that its elements are explicitly described and inductively derived (Craig et al., 2008). The focus should be placed on research that aims to understand the issue in question from the experiences and perspective of the groups of people targeted by that intervention. Therefore, to comply with the MRC guidance but also ensure that the future antibiotic intervention does not contribute to increasing 'research waste' (Ioannidis et al., 2014), it was deemed appropriate to carry out a high-quality systematic review of the existing qualitative evidence that addressed prescribing as a human behaviour influenced by a wide range of factors to help better understand the 'how' and 'why' of that behaviour. Given that antibiotic prescribing is human behaviour, a review and synthesis of evidence was required to generate personal perspectives on the issue and provide richer insights. An in-depth exploration of the determinants that drive prescribing behaviour within a specific context is crucial to changing that behaviour and enhancing the chances of planned interventions working in a real-world setting (Teixeira Rodrigues et al., 2013).

3.1.1.2 Aim(s) and focus of the meta-ethnography

The aim of this review is to identify, examine, and synthesise qualitative research that has explored doctors' views and experiences of antibiotic use in acute hospitals. Antibiotic use will refer to the practice of initiation, monitoring, review, and discontinuation of antibiotic therapy. The review addresses a broad question:

'What are the barriers and facilitators to appropriate antibiotic prescribing in acute hospitals?'

More specifically, the objectives of this ME are:

1. To gain personal insights into current antibiotic prescribing practice for inpatients in acute hospitals from the perspective of doctors and thus identify the barriers and facilitators to appropriate antibiotic use.
2. To identify the essential components of a theory-based behaviour change intervention to promote appropriate antibiotic use in acute hospitals.
3. To provide recommendations for the development, refinement, evaluation, and implementation of a future behaviour-change intervention in keeping with the MRC Framework (Craig et al., 2008).

The protocol for this review has been registered on PROSPERO, an international database of respectively registered systematic reviews in health and social care, registration number: CRD42017073740. This ME has recently been published in a peer-reviewed journal (the full text is available in Appendix 14).

3.1.1.3 Rationale for using meta-ethnography

Qualitative research plays a central role in answering questions that experimental studies cannot easily evaluate (Jackson & Waters, 2005). The functionality of qualitative research is not merely restricted to the understanding or interpretation of process measures. Still, it may directly address many essential healthcare issues and inform evidence-based practice as a stand-alone methodology (Dixon-Woods et al., 2006). As qualitative methods are concerned with illuminating subjective perceptions, they are particularly valuable in providing detailed descriptions of human behaviour in the contexts in which it occurs (Dixon-Woods et al., 2007). By capturing people's views and experiences, and what matters most to them, qualitative research may also offer explanations for unanticipated findings elicited from quantitative research (Noyes, 2010). For instance, a meta-analysis may provide evidence on the effectiveness of a complex intervention, but it will not inform the reader regarding how people, whether it is patients or healthcare professionals, experience that intervention, how that intervention affects individual behaviour, or the factors affecting its uptake, such as context, lifestyle or human choices and expectations (Ring et al., 2011b).

Although methods of synthesising qualitative evidence are still in the early stages of development, they are increasingly recognised as central in informing healthcare policy and practice, especially among commissioners of services who rely on this type of evidence to make decisions (France et al., 2014; Noyes, 2010). The application of one type of evidence (e.g., RCTs) to all contexts and research questions is unhelpful and counterproductive to achieving evidence-based healthcare. Therefore, the Cochrane Collaboration has acknowledged the potential value of QES for policy and practice change and called for more than one hierarchy of evidence to accommodate different types of questions (Noyes et al., 2021). The merit of qualitative synthesis lies in making connections between the individual studies and merging findings and theory into the current work context to gain richer insights and descriptions of the phenomena. This process minimises the potential for 'reinventing the wheel' – wasting precious resources for creating something that already exists – and facilitates identifying gaps in the body of research.

Despite ongoing debates and lack of consensus surrounding the appropriateness of synthesising qualitative work, interest in this method to inform health-related policy and practice has continued to evolve, alongside a profusion of various terms to describe the process, including 'meta-ethnography', 'meta-synthesis' and 'meta-study' (Barnett-Page & Thomas, 2009; Booth, 2017; Ring et al., 2011b). The key difference between various types of QES is those *describing* or *aggregating* findings and those, like ME, which require a degree of innovation to generate new insights and richer understanding and provide new conceptual interpretation of the phenomena of interest (France et al., 2014).

Meta-ethnography is a unique, rigorous and systematic method of synthesising multiple primary qualitative studies (France et al., 2014). By providing new rich insights on the phenomenon of interest and developing a new conceptual theory about a specific health service, policy or programme performance and its impacts on patient experience, a well-conducted ME can advance understanding of complex health care issues (Campbell et al., 2011; Noyes et al., 2010). It can also be used to explore behaviour patterns to increase the understanding of patient experiences across a broad spectrum of illness trajectory (Malpass et al., 2009). A high-quality ME can inform clinical guidelines, such as the synthesis of qualitative evidence on medicine taking by patients with a range of conditions (Britten et al., 2002), which generated new knowledge and contributed to the development of the 2009 NICE recommendations on medicines adherence (NICE, 2009), or the qualitative review carried out by Ring et al. (2011a) on asthma action plans that later contributed to the development of British guidelines for asthma management.

In addition, for projects aiming to develop a complex theory-based health intervention, the value of high-quality QES such as ME is indispensable. It can render information on intervention feasibility, appropriateness, and acceptability, and inform the future implementation process (France et al., 2016). The MRC Framework emphasises the importance of developing a theoretical understanding of intervention before applying it to specific groups and settings (Craig et al., 2008). This review forms the first stage in identifying theoretical elements of a new behaviour-change complex healthcare intervention to improve antibiotic use in acute hospitals. In light of the lack of a specific method considered as the ‘gold standard’ for synthesising qualitative research (Toye et al., 2014), ME, which is particularly suited for developing conceptual models and theories, was deemed the most appropriate methodology for undertaking an interpretive synthesis (France et al., 2019).

3.2 Methods

This section outlines the details of the applied methodology as informed by the eMERGe meta-ethnography reporting guidance, consisting of 19 criteria (France et al., 2019) (see Appendix 15). The described stages comprise the design and data collection process, including defining the scope of the synthesis and the applied search strategy, scrutinising, and classifying the papers, determining how studies are related, and translating and synthesising the evidence. The final stage of the process – expressing synthesis, which provides a summary of the main interpretations and the findings of the ME, is outlined in the subsequent section.

3.2.1 Phase 2 – Deciding what is relevant to the initial interest

This stage involves deciding what should be included in the review and the steps taken to carry out the search process. Determining the scope of the investigation is a crucial step in any systematic review. It may involve a series of processes, such as carrying out a systematic search, screening and appraising the quality of the literature to decide which studies to include in the final synthesis (Toye et al., 2014). The following section describes how each of these steps was carried out.

3.2.1.1 Search strategy

With the ever-evolving field of qualitative research and the expanding body of publications, qualitative syntheses are anticipated to identify an increasing number of studies. However, the aim of an ME is not always to review the entire body of evidence but to generate conceptual insights (Noblit & Hare, 1988). Therefore, it is important to first carry out a systematic and comprehensive search of all the existing primary studies before deciding which articles should be included in the final synthesis (Toye et al., 2014). A preliminary search confirmed no QES developed *or* in progress that specifically addressed the topic of interest, and a sufficient number of primary studies existed that could be synthesised. However, due to practical issues, including a large number of eligible studies to work through and the time and resource constraints of a PhD project, a pragmatic approach was taken to refining the inclusion and exclusion criteria, which are outlined in the following section. Complete definitions are provided in Appendix 16.

The search strategy was informed by the objectives and the ME's purpose. Firstly, it was essential to ensure that the conceptual theory generated from translating the primary studies was relevant to the context and setting of the planned intervention. Context plays a crucial role in designing health interventions and evaluating whether that intervention might work in other settings (France et al., 2014; Noblit & Hare, 1988). However, an array of disparities between developed and developing countries exist, including healthcare infrastructure, resources, access and provision, and various social, cultural, political, and economic conditions (WHO, 2016). Therefore, only studies carried out in countries deemed to have a well-developed healthcare system were considered for inclusion (e.g., the UK, Europe, USA, and Australasia).

The searches were also limited to the time between January 2007 and December 2017. Given that local and national antimicrobial management guidelines are updated and released frequently, conducting a search over the last ten years was considered a pragmatic approach to maximise relevance and cover a period of heightened interest in the topic of antibiotic prescribing; also, to ensure that the findings are relevant to the current hospital practice. Moreover, taking into account that beliefs, views, experiences and social phenomena change over time (France et al., 2014), a date restriction for publications to the last ten years was applied to ensure views and experiences reflected current policy and practice. The reason for excluding non-English language papers was the unavailability of resources for translating studies from foreign languages, also the concern about the transferability and preservation of the original meaning of quotes across different languages (Briggs & Flemming, 2007).

Although hospital teams consist of a range of healthcare professionals, the majority of antimicrobial prescribing in UK hospitals is currently performed by medical staff (Pinder et al., 2015). These hospital teams are hierarchical in nature, and the level of influence is generally determined by the seniority or experience of the treating clinician within a clinical team (Charani et al., 2019; Lewis & Tully, 2009). Traditionally, antibiotic prescribing has been exclusively a medical role, and the influence of senior clinicians on prescribing decisions is still dominant in today's practice. This has led to the concept of ‘prescribing etiquette’ – a set of cultural rules that dominate healthcare professionals' prescribing behaviour and forms the prescribing habits of junior clinicians (Charani et al., 2013). Therefore, it was essential first to understand this group's prescribing behaviour *specifically* to change that behaviour. Other healthcare professionals, including pharmacists and nurses, were excluded from the review to minimise reporting bias.

Given the challenges of locating qualitative research, a thorough and transparent search strategy that others could replicate was essential (Higgins & Green, 2011). Systematic quantitative reviews carried out by the Cochrane Collaboration commonly apply the PICO (Population, Intervention, Comparison and Outcomes). However, conducting comprehensive literature searches of qualitative evidence using the PICO search tool can be problematic (Methley et al., 2014). For example, search terms such as 'intervention' or 'outcomes' may not be relevant to qualitative literature and using the tool may not locate relevant studies. To address this issue, Cooke et al. (2012) developed a new search tool called "SPIDER" (Sample, Phenomenon of interest, Design, Evaluation, Research type) to aid the identification and retrieval of relevant qualitative and mixed-method studies and thus ensure research rigour.

Methley et al. (2014) expanded on the work of Cooke et al. (2012) and compared the two approaches: the traditional PICO method with the newly devised SPIDER tool. Although SPIDER had lower sensitivity, it showed greater specificity, suggesting that the method might benefit researchers aiming to complete qualitative syntheses (Methley et al., 2012). Therefore, the search strategy was constructed using the SPIDER tool, which is outlined in Table 4.

Table 4. Search terms identified using the SPIDER tool

Sample (hospital doctors of any level or speciality involved in everyday decision making around antibiotic use)	Doctor* OR physician* OR clinician* OR medical staff OR health personnel
Phenomenon of Interest (antibiotic prescribing in acute hospitals)	Antibiotic prescribing OR overprescribing OR misuse OR overuse OR antibiotic stewardship OR resistance OR guideline adherence OR decision making OR practice behaviour AND hospital* OR acute care OR hospital ward
Design (studies that have a qualitative focus or use recognised methods of data collection and analysis)	See Appendix 17 for Hybrid Qualitative Filters
Evaluation (views and experiences of hospital doctors)	View*, experience*, belief*, perspective*, attitude*
Research type (qualitative)	See Appendix 17 for Hybrid Qualitative Filters

3.2.1.2 Search processes

To maximise return, a comprehensive and exhaustive search process was applied using the following terms and techniques. First, extensive search terminology and relevant synonyms were used. This included thesaurus terms also referred to as the medical subject headings (MeSH) used to index the records in electronic databases. MeSH consists of sets of terms or keywords arranged in a hierarchical format that facilitates searching at various levels of specificity (Shaw et al., 2004). To ensure that the search was comprehensive, it was supplemented with free-text terms and broad-based terms. The final search strategy was tested and completed in consultation with an academic librarian and subsequently tailored to the electronic database requirements.

Both, the MeSH terms and keywords were compared with relevant studies, as well as those from similar reviews. The search technique employed a combination of various key terms and Boolean operators, such as 'AND', 'OR' and 'NOT' first to maximise and then filter the search; also, truncation searching (Aveyard et al., 2016). Truncations and appropriate wildcards were also used to account for plurals and variations in spelling. The search strategy consisted of a combination of various search strings, including keywords such as: 'antibiotic', 'hospital', 'doctors OR clinicians', 'prescribing', ‘choice behaviour’, ‘decision making’, ‘practice patterns’ and ‘guidelines adherence’. Figure 9 illustrates an example of the first part of the search strategy using a mixture of phrases and truncated keywords grouped together in three main concepts.

Figure 9. Example of the first part of the search strategy applied in MEDLINE

1	exp antibiotic agent/ or exp antiinfective agent/ or "Anti-Bacterial Agent*".mp. or exp antifungal agent/ or exp antibacterial activity/ or exp bacterial infection/
2	exp drug resistance/ or exp antibiotic resistance/ or "Drug Resistance, Microbial*".mp.

AND

3	"medical staff".mp. or exp medical staff/ or doctor*.ti,ab. or physician*.ti,ab.
4	health personnel.mp. or exp health care personnel/
5	attitude of health personnel.ti,ab.
6	view*.ti,ab.
7	opinion*.ti,ab.
8	perspective*.ti,ab.
9	belief*.ti,ab.
10	(prescription or "prescri$ authority").ti,ab.
11	exp clinical practice/ or exp practice guideline/
12	("decision making" or "clinical decision making").ti,ab.
13	inappropriate prescri$.ti,ab.
14	overprescribing.ti,ab.
15	(stewardship or "antibiotic misuse").ti,ab.
16	behavio$r.ti,ab.

AND

17	(hospital* or "acute care").mp.

The second part of the search process included systematically filtering through the available evidence to identify qualitative studies. A vast array of published search filters, also known as ‘hedges’ for identifying qualitative research, exists. These filters typically comprise predetermined search terms arranged to locate all primary research using qualitative methodologies (DeJean et al., 2016). However, they have attracted criticism because they produce large numbers of irrelevant papers whilst potentially missing relevant studies (Booth, 2016). With these concerns in mind, it was deemed appropriate to replicate a hybrid qualitative research filter developed by DeJean et al. (2016), which combines the search terms of all the published search filters tailored to each database. Compared to other search filters, this explicit hybrid filter has a consistently high sensitivity across databases and topics, and it can reduce the resource-intensive task of searching through false positives to a minimum (DeJean et al., 2016). An example of the hybrid qualitative filters applied in Ovid MEDLINE, CINAHL and Web of Science is provided in Appendix 17.

3.2.1.3 Electronic searches

Twenty electronic databases were systematically searched, the scope and coverage of which is outlined in Appendix 18. The selection was guided by the content and remit of each database and the likelihood that relevant articles would be indexed therein. As a single database is not exhaustive, many databases were targeted to increase the yield, including other than exclusively medical sources, such as PsycINFO, Social Science Citation Index and ERIC (Education Resources Information Center). An example of the complete search strategy carried out in the Ovid MEDLINE bibliographic database is outlined in Appendix 19. However, database searches were not straightforward. For instance, evidence shows that Google Scholar's (GS) coverage for the studies included in 29 Cochrane Systematic Reviews (containing 738 original studies) was 100% (Gehanno et al., 2013). However, due to the database's inexplicit search limits, GS produced more than 7,000 results. Also, GS's recall capability is low due to the search engine's policy of only 1000 viewable search results (Bramer et al., 2016). With these concerns in mind, a customised GS search was considered a supplementary method to ensure an exhaustive and high-quality search.

The importance of incorporating grey literature in systematic reviews, including documents that are not published in academic sources, such as books and journals, has been emphasised by the Institute of Medicine Standards for Systematic Reviews to ensure that potentially relevant work has not been omitted (Eden et al., 2011). However, as there is no 'gold standard' or explicit guidance for carrying out rigorous grey literature searches (Godin et al., 2015), a specific search strategy had to be developed. This included institutional repositories to search for dissertations and theses, also key organisations to search for reports and audits, such as the Audit Commission, Healthcare Improvement Scotland and NICE. Additionally, experts and leading authors in the field were contacted by email for comments and suggestions on key publications and a list of items that could be included in the review. However, only seven authors out of 17 contacted replied.

Additionally, deep web searching was also carried out. The ‘deep web’, also known as ‘the invisible web’, refers to web pages that are not indexed and cannot be captured by performing standard searches using academic databases (Pappas & Williams, 2011). However, a vast repository of high-value information can be accessed within the invisible web, including academic studies, papers, and government publications. The deep web search included electronic repositories, such as OAIster, OpenGrey and MedNar. The results of the search strategy for each database are presented in Appendix 20.

3.2.1.4 Non-electronic searches

The supplementary search included reference list checking, citation pearl searching and hand searching. The Cochrane Collaboration recommends reference list checking, also known as ‘snowballing’, of already retrieved papers for the identification of additional, relevant records when conducting systematic reviews (Horsley et al., 2011). The reference list checking was carried out by scrutinising the reference list of seminal papers related to the topic of interest (e.g., Broom et al., 2016a). This technique is particularly useful when individual references are hyperlinked and provide automatic access to the original papers. This process helped to identify useful keywords that were subsequently added to the search strategy.

Citation pearl searching is the process of using the features of a key article, a pearl (i.e., citation, keyword, descriptor), to identify other relevant materials on the topic (De Brun & Pearce-Smith, 2014). Google Scholar allows forward citation searching, automatically retrieving, and displaying articles cited by other authors. Searches for citation pearls were carried out in Google Scholar using the ‘Cited By’ option by typing each title in quotation marks to locate all papers citing these pearls (Appendix 21).

Finally, to ensure comprehensive retrieval, hand searching was employed. However, as manual screening can be laborious and time-consuming (Booth, 2016), only hand searching of the key journals was carried out. These included the American Journal of Infection Control, BMJ Open, The Journal of Antimicrobial Chemotherapy, Clinical Infectious Diseases, Journal of Hospital Infection and Social Science and Medicine. Additionally, all individual journal websites identified through citation pearl growing were also searched, using various combinations of keywords.

3.2.1.5 Selecting primary studies

The screening process included selecting relevant papers identified through the applied search strategy, in other words, creating a data bank that will undergo quality appraisal and subsequently a process of synthesis. Upon applying each search string in the selected databases, the harvested records were exported to Mendeley online reference manager software. The use of Mendeley facilitated the storage and management of the retrieved papers into separate folders. Due to the precision of the employed search strategy and high-quality qualitative hybrid filters, a lengthy screening process was reduced by yielding a manageable number of records. Possible items for the ME were screened initially by title and abstract and then full text against the inclusion and exclusion criteria (Table 5) by two reviewers, working independently and then comparing outcomes. Where title and abstract were equivocal, the full-text paper was then read to make a definite decision on the study’s relevance for inclusion in the final synthesis. Any disagreements were referred to the supervisory team for arbitration. Where information was unclear or missing from potentially relevant papers, the authors were emailed and asked for additional information. Literature searching outcomes were reported using PRISMA. The outcome of this process is described in Section 3.3.1 and outlined in Appendix 22.

Table 5. Review inclusion and exclusion criteria

INCLUSION CRITERIA	EXCLUSION CRITERIA
Primary research studies reporting doctors' views and experiences of antimicrobial prescribing in acute hospitals, including adult and paediatrics; public and private; tertiary and secondary care.	Primary research reporting doctors' views and experiences of prescribing other treatments or other aspects of prescribing, e.g., costs, effectiveness. Research on prescribing antibiotics in other settings, e.g., primary care, hospices or residential settings.
Used qualitative methods of data collection (e.g., interviews, focus groups) and inductive analysis (e.g., grounded theory, phenomenological analysis).	Studies conducted in countries not considered to have a developed health care system.
Mixed-methods studies only if the qualitative data are discreet and findings reported adequately and discussed separately from the quantitative findings.	Samples including prescribers other than acute hospital doctors, e.g., general practitioners, pharmacists, or nurses.
Studies carried out in countries considered to have a developed health care system according to the international classification.	Studies that do not report primary qualitative data collection and analyses, e.g., quantitative research, descriptive case studies, commentaries, editorials, reviews. Mixed-methods studies where qualitative data are not reported separately.
Published in the English language between 2007 and 2017.	Studies that do not contain direct quotations from research participants (first-order constructs) or where direct quotations cannot be obtained from a supplementary file or the study authors.

3.2.2 Phase 3 – Reading included studies

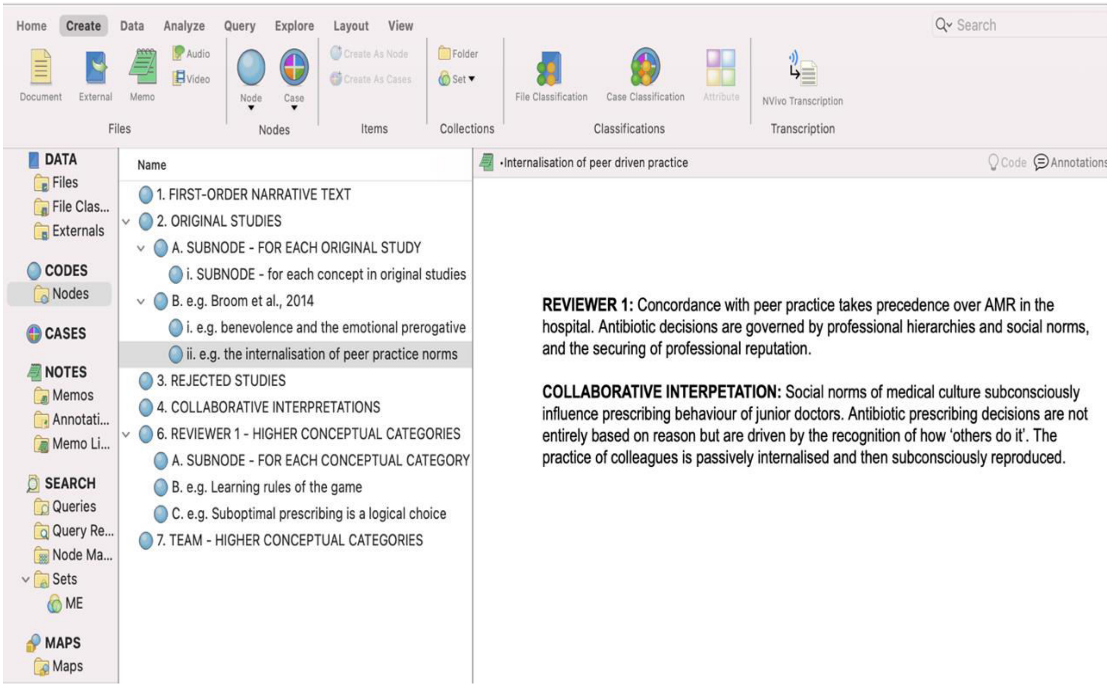
This ME stage involves a careful reading of the studies and becoming familiar with their content and methods. The primary aim is to identify the key themes in each paper through reading, re-reading, and recording the main ideas (Noblit & Hare, 1988). This stage is not distinct, and repeated reading of studies continues throughout the subsequent phases of ME. However, as the researcher becomes more familiar with the details of each study, the aim of the reading changes, leading to the development of greater understanding and interpretations in consecutive phases (Campbell et al., 2011).

3.2.2.1 Reading and data extraction approach

To progress with the synthesis, three tasks were performed at this point. Firstly, the emphasis was put on a meticulous reading of all studies and developing an initial knowledge of the content. Secondly, a quality appraisal was carried out to help assess each study's contribution to the final synthesis (Campbell et al., 2011). Data extraction from each included paper was carried out using a comprehensive, standardised template piloted before use. A customised form was designed based on the specific characteristics of the review, including the author, year of publication, country, setting, aims, participant characteristics, data collection, analysis method and the key findings (reported themes). This process was carried out independently by the author and checked for accuracy by the second reviewer. Lastly, the PDF version of each paper was uploaded into NVivo 11 qualitative software.

Similar to the approach taken by Toye et al. (2014), data were extracted from across the full primary studies, including participant quotes (first-order constructs) and concepts developed by the study authors (second-order constructs), entered verbatim into NVivo and coded (see Figure 10). Although the software cannot understand and examine text (Houghton et al., 2016), its functions allowed new ways of exploring the meaning of the data and enhanced transparency of the process. As only a few studies addressed the review question directly, the focus was initially placed on a more inductive approach, involving thematic coding of the primary study findings. The findings were first coded under different themes, or 'nodes', which served as repositories for textual data and assisted in indexing generated ideas.

Figure 10. Using NVivo to organise data extraction and analysis



Although new 'nodes' and 'sub-nodes' were created early in the project, the coding advanced as the analysis progressed, resulting in the proliferation of new ideas and metaphors. Creating new nodes and sub-nodes helped arrange the text from several sources. Writing memos and linking these memos to specific data sources assisted in keeping track of the developing ideas. The terminology used for the units of synthesis (Table 6) was guided by the existing MEs (Campbell et al., 2011; France et al., 2019; Toye et al., 2017).

Table 6. Meta-ethnography key terminology

KEY TERM	DEFINITION
Reviewer	The researcher(s) conducting the meta-ethnography.
Raw data	All text contained under abstract, results and findings sections of each study.
First-order constructs	The primary data reported in each study (participant quotes)
Second-order constructs	The primary authors' interpretations of the data (metaphorical themes or concepts)
Third-order constructs	The higher-order interpretations developed from an analysis of the first- and second-order constructs.

Concept (or metaphor)	A well-articulated and meaningful idea that emerges by comparing particular examples, which explains rather than just describes the data.
Higher conceptual category	Concepts and metaphors merged and collapsed into larger inter-related categories pertaining to the same aspects of antibiotic prescribing.
Overarching theme	Higher conceptual categories translated and abstracted into final themes.

3.2.2.2 Quality appraisal in meta-ethnography

Although not essential for ME, critical appraisal of empirical evidence is an important element of systematic reviews (Campbell et al., 2011). The Cochrane Collaboration recommends using quality appraisal tools to aid the appraisal process of qualitative evidence and ensure that the research is methodologically sound and conducted according to minimum established criteria (Noyes et al., 2021). These criteria include the suitability of the research design to meet the aims of the study, rigour of data collection and analysis process, well-described and appropriate sampling strategy, clear descriptions of findings, explicit account of participants' voices, a statement depicting the researchers' potential influences, a clear rationale for the conclusions drawn from the data, and value and transferability of the findings. However, Noblit and Hare's (1988) original work provides no concrete guidance on how to conduct a quality appraisal of studies considered for inclusion in the synthesis. Moreover, there is no agreement among the authors of published MEs whether critical appraisal should form part of qualitative evidence synthesis at all and, if it should, what criteria to use and how to apply them (Ring et al., 2011; Toye et al., 2014). Compared to quantitative reviews where performing sensitivity analysis can guide exclusion of studies with a high risk of bias, the lack of a gold standard appraisal tool for qualitative studies and lack of consensus in the literature about what constitutes 'good quality' makes the exclusion decisions challenging.

Many different checklists or guidelines developed to aid critical appraisal exist. Yet, they all place emphasis on different components of the research design, with minimal consensus on which one should be used. For example, the UK National Centre for Social Research published a Framework for Assessing Qualitative Evaluations (Spencer et al., 2003). This framework was constructed by drawing on 29 existing frameworks, and although proven useful, it is lengthy and potentially arduous. Other appraisal instruments include the Popay et al. (1998) tool, where the focus is on the appropriateness of the method used and a detailed assessment of methodological rigour, also the Walsh and Downe (2006) appraisal framework, the Joanna Briggs Institute's Qualitative Appraisal and Review Instrument checklist (JBI-QARI) (Joanna Briggs Institute, 2017), and many more.

Considering the opposing standpoints concerning the need to conduct critical appraisal in ME and the level of experience of the first reviewer, who is a novice in qualitative methods, a decision was made to adopt a pragmatic approach and use a structured tool to aid the process. After the existing checklists were scrutinised, the Critical Appraisal Skills Program (CASP) tool was selected. The rationale behind choosing this tool was that it is a validated instrument that has been extensively applied in previous MEs, has a clear format and is practical (Atkins et al., 2008; Campbell et al., 2011; Toye et al. 2014). The appraisal tool comprises ten questions: two screening questions and a checklist of eight areas requiring an appraisal (Critical Appraisal Skills Programme, 2018).

The CASP was used as a guide to consider the key issues and aid transparency of reporting. As conceptually rich studies can be poorly conducted and findings may be unreliable, the CASP was considered as an objective means of excluding papers. This method ensured the credibility, rigour, and trustworthiness of the final synthesis (Porritt et al., 2014). However, there were concerns that excluding studies with poorly reported methods may lead to the omission of relevant and insightful findings (Campbell et al., 2011). Therefore, it was decided that although conceptual richness is fundamental to the process of ME (Toye et al., 2014), the reported methods had to meet a certain degree of methodological 'soundness' before inclusion in the synthesis. For example, the studies had to present a reliable account of the undertaken research process to allow a judgement about the authors' interpretation.

Two independent reviewers, including the author of this thesis and a more experienced qualitative researcher, carried out the quality appraisal. However, it was necessary to find a way of ensuring that evidence which lacks methodological integrity was judged accordingly. Therefore, before studies were excluded based on the quality (inadequate, incomplete or ambiguous methodological reporting with a score of less than 7), the strengths and weaknesses of the evidence that could potentially influence the ME results were discussed with the supervisory team. Similarly, papers with a score of more than 7 but judged to be purely descriptive and potentially lacking conceptual depth were also addressed for an overall opinion.

Thus, the CASP allowed a degree of flexibility, facilitated framing the discussions and prompted transparent decision making. The guidelines were also easy to follow, especially for a novice researcher. In addition, given that this ME pertains to an aspect of clinical practice, and with a view that different disciplines may place a value on different aspects of study design, the quality appraisal needed to reflect the purpose and function of the ME for the anticipated target audience, that is, hospital prescribers and policymakers. The results of the quality appraisal are described in Section 3.3.1 and presented in Appendix 23.

3.2.3 Phase 4 – Determining how studies are related

This stage requires careful consideration of the relationship between the concepts emerging from the different studies (Britten et al., 2002). Noblit and Hare (1988, p. 28) recommend creating "a list of key metaphors, phrases, ideas and/or concepts" from each study and making comparisons between them to determine how they are related. An alternative approach is to present themes and ideas across all studies using grids, tables or matrices to display common concepts and recurring themes (Atkins et al., 2008). A combination of both approaches was adopted in this ME.

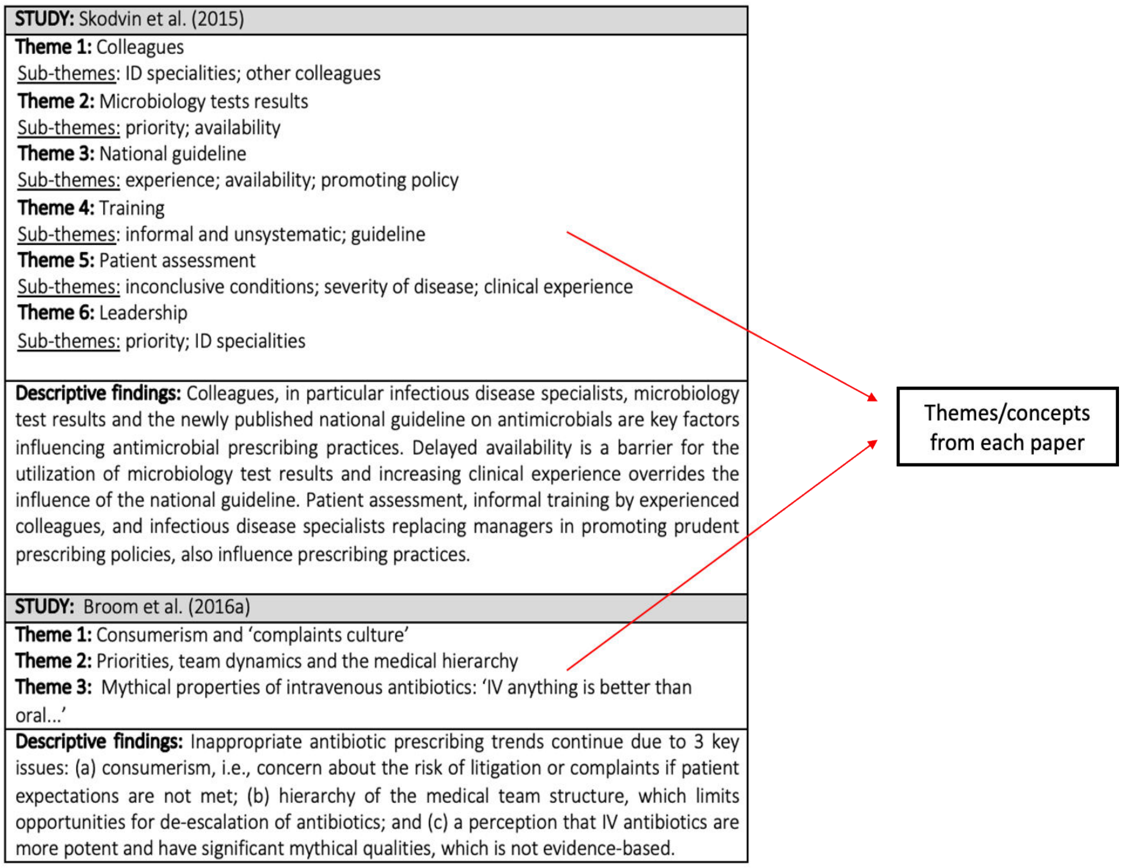
Data were categorised using the following approach:

1. Identifying concepts from the primary studies.
2. Deciphering (or re-coding) concepts for meaning.
3. Grouping them into higher conceptual categories.
4. Further re-grouping categories into overarching themes (Phase 5).
5. Developing a line of argument that makes sense of the themes (Phase 6) (Toye et al., 2017).

3.2.3.1 Process for determining how studies are related

This phase was carried out in several steps. Firstly, the included papers were compared by their characteristics, including the author, year of publication, country/setting, study focus, population, methodology, and the key findings (Section 3.3.2, Table 7). A list of key themes from each paper was then created, including descriptive findings and conclusions, and listed under each study name (Figure 11).

Figure 11. Making a list of themes/concepts from each paper



Studies were initially grouped by their primary thematic focus into two clusters or 'piles'. Papers in both clusters were organised chronologically. Data, including first- and second-order constructs (entered and coded onto NVivo in Phase 3), were extracted onto a Microsoft Word document and tabulated. Extracts were then colour-coded to aid the identification and differentiation of the studies. Through constant comparison, studies were related by findings to identify 'concepts' (key metaphors, phrases, and meaningful ideas – the raw data of ME) and see how they compared or not. As the papers were re-read, a third column was added to the tabulated data, and additional ideas that arose were noted (Appendix 24). New insights were allowed to emerge iteratively without any assumptions.

A large amount of data were then organised using Excel spreadsheets (example provided in Appendix 25). Continual reference throughout to original studies and conservation of their unique language/terms was critical. As the analysis progressed, the focus changed to grouping related data. The concepts from the different studies were reduced into more prominent factors that either hinder or facilitate appropriate antibiotic prescribing (Figure 12). For example, concepts such as 'anxiety about missing an infection' and 'antibiotic use is a dark art' later become a barrier to an appropriate practice called 'clinical uncertainty'. This process allowed the researcher to answer the *a priori* research question, the outcome of which is illustrated using matrices (see Section 3.3.3).

Figure 12. Reducing themes/concepts into larger factors

Newly formed larger factors influencing antibiotic prescribing

BARRIER	THEME/CONCEPT	STUDY
Reputational and legal pressures	Decisions around antibiotics are governed by securing of professional reputation.	Broom et al. 2014
	Sense of clinical competence is influenced by not missing an infection.	Livorsi et al. 2015
	Fear of attracting disapproval.	Broom et al. 2016b
	The immediate professional risks supersede longer-term risks of AMR.	Broom et al. 2016c
	Concerns around reputational and legal risks contribute to antibiotic overprescribing.	Broom et al. 2017
Clinical uncertainty	Too uncertain to be restrictive.	Bjorkman et al. 2010
	Balancing the plethora of risks in the context of potential or actual infection.	Broom et al. 2014
	Complex cases and situations cause uncertainty.	Mattick et al. 2014
	Lack of certainty in the diagnosis leads to discomfort.	May et al. 2015
	Anxiety about missing an infection.	Livorsi et al. 2015
	It feels safer to prescribe antibiotics than not when diagnostics are inconclusive.	Skodvin et al. 2015
	Antibiotic use is a `dark art` imbued with a sense of ambiguity about the initial infection predictions.	Broom et al. 2016c
	Ambiguous clinical situations lead to a more 'generous' management.	Eyer et al. 2016

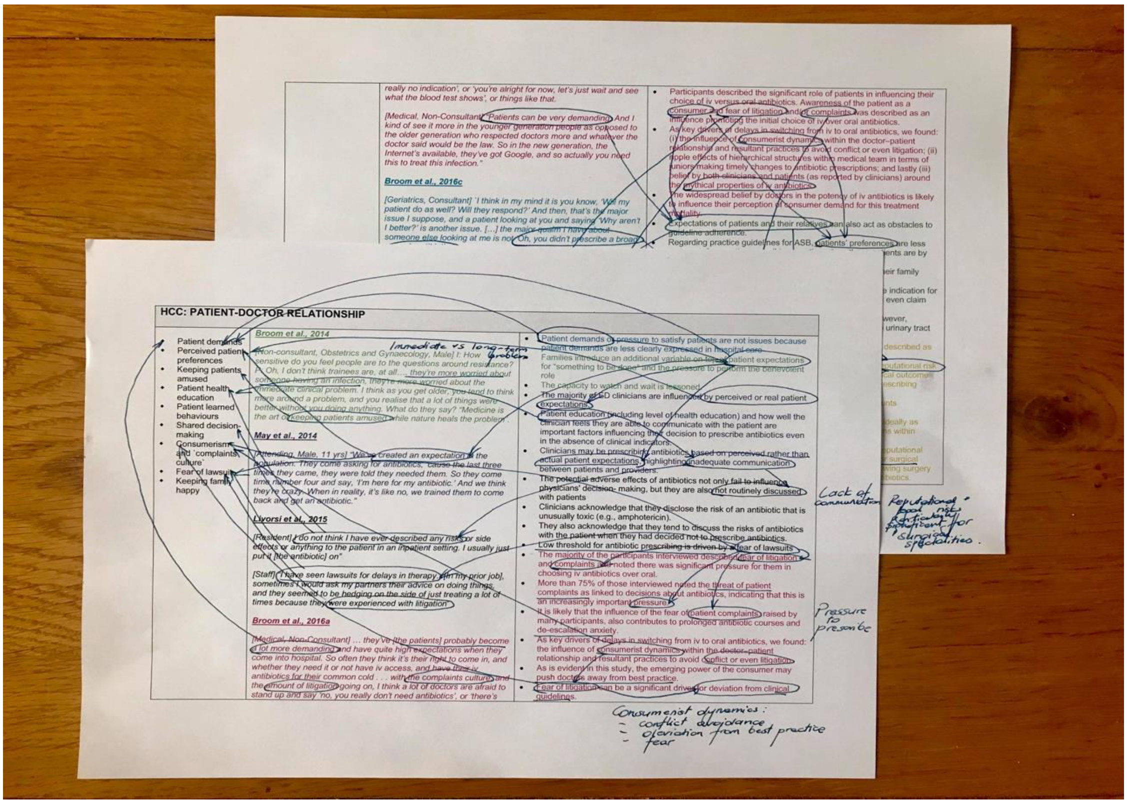
3.2.4 Phase 5 – Translating studies into one another

This ME stage is concerned with developing new interpretations and conceptual insights (Noblit & Hare, 1988). There are different ways of translating studies into one another. In this ME, the emphasis was placed on maintaining the relationship of key concepts and metaphors and their interactions between the studies.

3.2.4.1 Process of translating studies

Concepts from across two clusters of papers were initially examined separately. Similar reported concepts were then refined, merged, and collapsed into higher conceptual categories (HCCs) pertaining to the same aspects of antibiotic prescribing. The author wrote a description for each HCC, which was subsequently refined through regular discussions of the arising ideas. First- and second-order constructs (participants' quotes and authors' interpretations) in each study were continuously compared with those in other studies. A hands-on approach was used in this stage, drawing arrows and lines (see Image 1), creating matrices (Figures 16 and 17) and concept maps (Appendix 26). This method helped establish that all the concepts drawn from the primary studies were encompassed by one of the created HCCs (Section 3.3.4, Tables 8 and 9).

Image 1. Translating studies using a 'hands-on' approach



This process of translation was idiomatic and carried out chronologically, starting from the earliest publication. Key concepts from paper one were compared with paper two, synthesised and the outcome compared with paper three, and so on. The expanded groupings were then refined and re-arranged for two clusters of studies, first separately and then drawn together until they were considered to reflect the synthesised findings explicitly and precisely. Finally, the interpretations and explanations provided by the original study authors were compared and translated across papers to achieve a synthesis. This process was supported by creating translation tables to display the level of synthesis.

However, translation was not straightforward and required a degree of 'deconstruction'. A proportion of the study findings were presented as broad categories rather than explicit themes, and the labels did not reveal much about the content. Therefore, study themes had to be first 'deciphered' by going back to original texts and examining the authors' interpretations. For example, the label 'Working relations' in the study by Mattick et al. (2014) did not explain the dynamics of those relations or their impact on antibiotic prescribing. In contrast, the label 'Negotiating multiple masters: junior doctors stuck in the middle' used by Broom et al. (2016b) clearly depicted the tensions experienced by junior doctors in working with senior colleagues. This explicit thematic characterisation could be easily translated into its existing form, allowing the researcher to preserve the true meaning of the original concepts. This ambiguity of the study thematic labels is illustrated in Appendix 27.

Using an approach similar to grounded theory's constant comparative method (Corbin & Strauss, 2015), different concepts were compared for similarities and differences to achieve a suitable 'fit', leading to the adoption of existing labels (e.g., 'Benevolence and the emotional prerogative') or the generation of new ones (e.g., 'Mastering guideline-concordant care') that provided a better descriptor of antibiotic prescribing experiences. This process was time and labour intensive. However, preserving the original terminology and definitions was essential (Noblit & Hare, 1988). To increase the validity of the process, it was also carried out in reverse, and the original studies were re-checked to ensure accurate interpretations.

Finally, translation of findings was reciprocal where similar concepts (albeit expressed differently) were drawn together, and refutational, where contradictory or disconfirming concepts were noted. Where differences were noted, for example, if a study reported different concepts from the others, full-text papers were re-read to understand its context (i.e., whether participants were in a different setting or of a different gender). Analytical and reflexive notes were made during the translations, which were then discussed and challenged by the supervisory team. This process enabled 'going beyond' findings from individual studies, from simple descriptions of the data to developing third-order interpretations (Britten et al., 2002). Translation led to the development of overarching themes, described in detail in Section 3.3.4.

3.2.5 Phase 6 – Synthesising translations

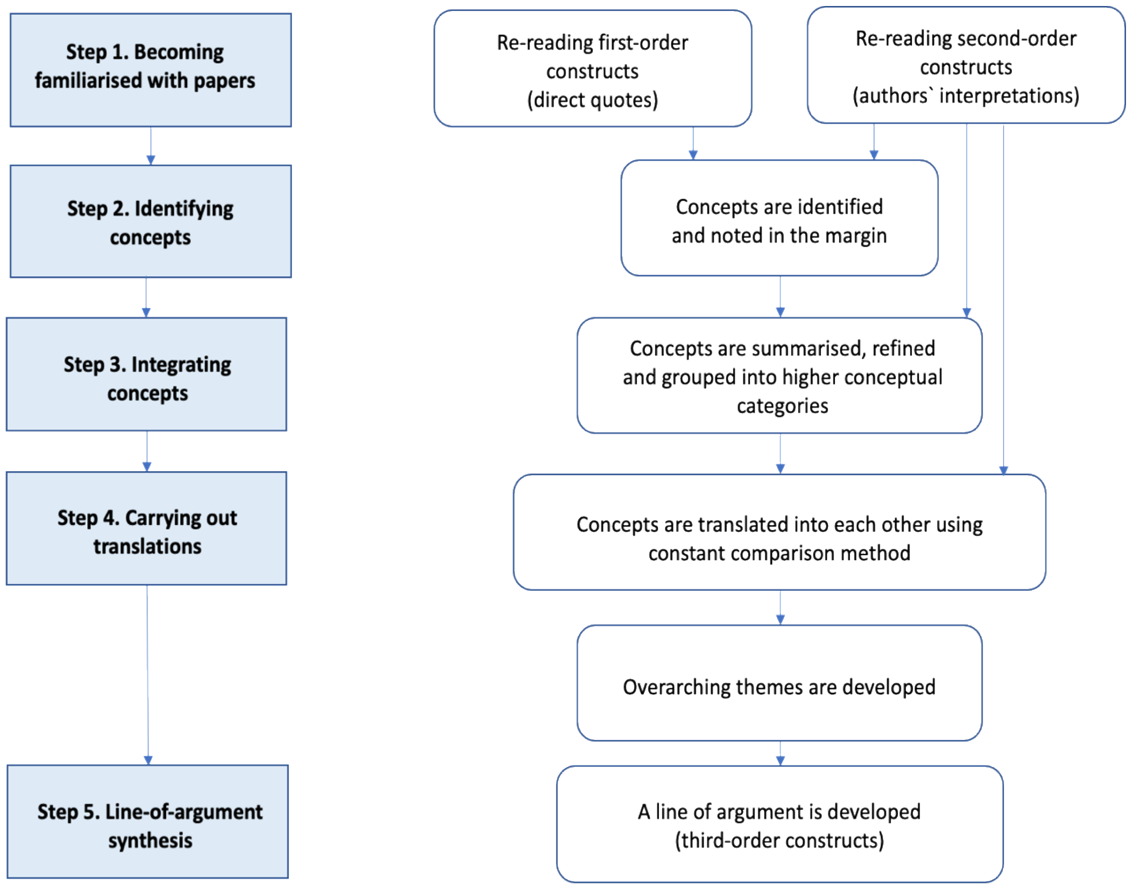
Once the HCCs were developed and described, the next stage of meta-ethnography is to synthesise or 'make sense' of these categories (France et al., 2019; Noblit & Hare, 1988). This continuing process is unlike other synthesis approaches, in which the analysis stops at the point of developing theoretically-saturated categories. However, the aim of synthesising translations is to further abstract the findings to form a conceptual model or a framework.

3.2.5.1 Synthesis process

The overall synthesis of data was achieved through an iterative process of thematic analysis, drawing on the discussions, continually comparing original studies, concepts, and HCCs. Subsequently, a 'line of argument' (LOA) was created to build a picture of the findings based on the individual parts of the studies. This was essentially a process of conceptual enhancement, otherwise known as the "third-order constructs interpretation" (Britten et al., 2002, p. 213). Findings generated during the translation, created spreadsheets, data matrices and our explanations and interpretations, provided the foundation for higher analysis. Themes were brought together and matched against original author interpretations and participant quotes from each study to create a new LOA.

Reflection is critical in ME (Toye et al., 2014), and this was achieved in three ways: team discussions to check the accuracy and emerging findings/perspectives; three focus groups across the study with key stakeholders (health professionals involved in hospital antimicrobial stewardship and health service users) (Chapter 4) and, comparing the LOA with findings in studies which were excluded following quality appraisal to determine whether their inclusion would have altered our final synthesis. Overall, these processes enabled the researcher to reflect on and refine the LOA and propose a new conceptual model of the multi-dimensional nature of medical antibiotic prescribing, which was then expressed in the synthesis of findings using narrative and visual representation (Phase 7). The steps taken in this process are illustrated in Figure 13.

Figure 13. Synthesis process (adapted from Henderson 2015)



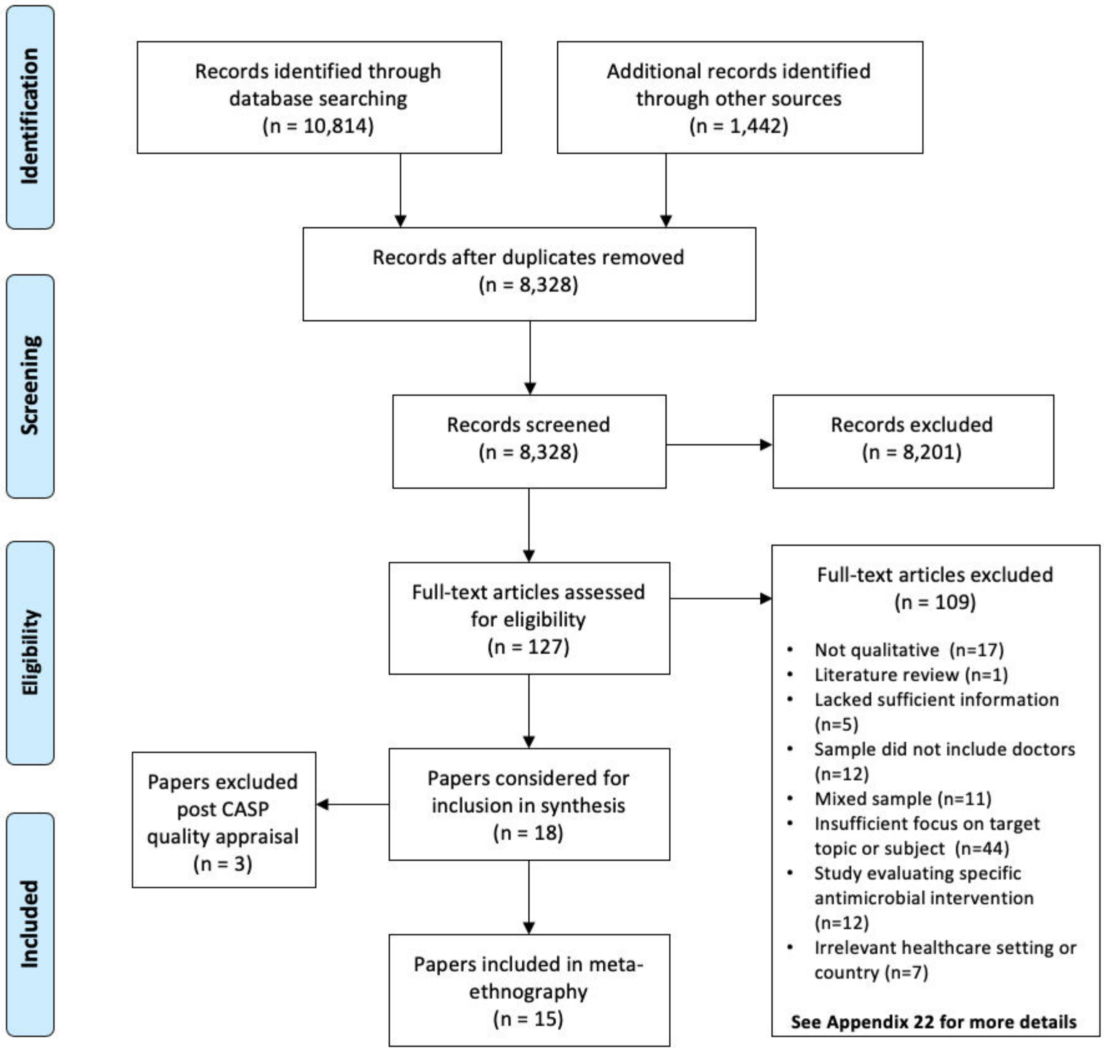
3.3 Findings

This section presents a summary of the main interpretations and the ME findings, including the search results and characteristics of included studies. The synthesis stages are more analytical in nature, from determining how the included studies are related, translation of concepts across them, the resultant LOA, and expressed synthesis.

3.3.1 Outcome of study selection (Phase 2)

In total, 12,256 references were identified through various rigorous search strategies (see Appendix 20). Once duplicates were removed, 8,328 records were available for the title and abstract reading. As a result, 127 were potentially eligible and read in full, most of which (*n*=109) were subsequently excluded based on their methodology, setting and topic relevance. However, this information was not always included in the abstracts, reflecting issues, such as the inadequate indexing of qualitative studies across different databases, descriptive titles, and abstracts containing ambiguous information. The reasons for excluding studies after reading full texts are in Appendix 22. After excluding irrelevant papers, 18 qualitative papers met the inclusion criteria and underwent critical appraisal. The search and screening process results are presented in a PRISMA flow diagram (Figure 14).

Figure 14. PRISMA diagram



Of the 18 papers that underwent the quality appraisal, eight required a lengthy discussion with a third reviewer (NR) due to their methodological weaknesses. Inadequate, incomplete, or ambiguous methodological reporting was a common obstacle to accurately assessing study quality. In particular, the way the studies were conducted, including the data collection process, analysis methods and the actions taken to avoid threats to internal validity, was not always sufficiently reported. Following detailed discussion with the supervisory team and reconciliation of the assessment with the third reviewer (NR), a consensus was reached to exclude three papers (Almatar et al., 2014; Almatar 2015; Barlow et al., 2008). None of the studies were excluded on ethical grounds. However, the studies by Almatar et al.'s (2014) and Barlow et al.'s (2007) were judged to lack methodological rigour. The third excluded paper (Almatar, 2015) was a thesis containing a carbon copy of the 2014 study by Almatar et al. Full details of the appraisal process are provided in Appendix 23.

Quality appraisal revealed that the quality of the existing work pertinent to doctors' lived experiences of hospital antibiotic prescribing was variable. The reporting of methods across papers was descriptive and often lacked clarity. However, poor reporting does not necessarily mean that the study quality is low; rather, the information provided was often insufficient to judge the quality. For example, a close reading of the study by Almatar et al. (2014) revealed that interviews with the participants only lasted no more than 10-15 minutes and were conducted in a ward setting, which did not allow for an in-depth analysis. Moreover, one of the derived themes ('prescribing etiquette') had been already reported by another author (Charani et al., 2013). The lack of sufficiently rich data to support the findings and the descriptive interpretation of the findings did not provide any new insights. The study by Barlow et al. (2008) employed a mixed-methods design but lacked a clear description of the qualitative data analysis process. It was not evident how the themes were derived from the data. Moreover, the authors did not provide an explicit description of the analysis process and it was unclear how the data presented were selected from the original sample. Consequently, these papers were excluded, and the PRISMA diagram updated accordingly.

Finally, 15 papers reporting findings from 13 studies were considered methodologically sound and were included in the synthesis (Björkman et al., 2010; Broom et al., 2014; Broom et al., 2016a; Broom et al., 2016b; Broom et al., 2016c; Broom et al., 2017; Cortoos et al., 2008; Eyer et al., 2016, Livorsi et al., 2015; Livorsi et al., 2016; Mattick et al., 2014; May et al., 2014, Rawson et al., 2016; and Sedrak et al., 2017; and Skodvin et al., 2015).

3.3.2 Presenting characteristics of included studies (Phase 3)

The included studies were from seven countries across three continents: Australia (Broom et al., 2014, 2016c; Broom et al., 2017; Sedrak et al., 2017), USA (Livorsi et al., 2015, 2016; May et al., 2014) and Europe, including the UK (Broom et al., 2016a; 2016b; Mattick et al., 2014; Rawson et al., 2016), Belgium (Cortoos et al., 2008), Sweden (Björkman et al., 2010), Switzerland (Eyer et al., 2016) and Norway (Skodvin et al., 2015). Studies were conducted in 43 acute hospitals, including regional, metropolitan, tertiary, and secondary care. All included studies involved research carried out in public hospitals, and four papers drew the sample from a mix of hospitals (i.e., public, private, and federal) (Livorsi et al., 2015, 2016; May et al., 2014; Skodvin et al., 2015). Thirteen papers described the hospitals as teaching (Cortoos et al., 2008; Broom et al., 2016a, 2016b, 2016c; Broom et al., 2017; Eyer et al., 2016; Livorsi et al., 2015; Mattick et al., 2014; May et al., 2014; Rawson et al., 2016; Sedrak et al., 2017; Skodvin et al., 2015).

The studies reported the experience of 336 doctors practising across various disciplines from a range of medical and surgical fields. However, not all authors provided details of their study context (e.g., hospital type), and it was not always possible to determine participants' ethnicity, speciality, length of clinical experience, and exact area of medical expertise. Most studies (*n*=14) specified participants' level of experience representing a range of seniority, including consultants/senior specialists, registrars, and doctors in training. One study focused explicitly on junior (defined as 'foundation year') doctors (Mattick et al., 2014). The age of participants ranged between 20 (Mattick et al., 2014) and 70 years (Björkman et al., 2010). The sample size varied considerably from 10 (Sedrak et al., 2017) to 64 doctors (Broom et al., 2017). All except three studies (Eyer et al., 2016; May et al., 2014; Rawson et al., 2016) provided gender information that included 274 participants, of which 106 (39%) were women. The ratio of female clinicians was higher than male in three studies, including one carried out in the UK (Mattick et al., 2014), Norway (Skodvin et al., 2015) and Australia (Sedrak et al., 2017).

In terms of methodology, data were collected using individual interviews (*n* = 13) (Björkman et al., 2010; Broom et al., 2014; Broom et al., 2016a, 2016b, 2016c; Broom et al., 2017; Eyer et al., 2016; Livorsi et al., 2015, 2016; Mattick et al., 2014; Rawson et al., 2016; Sedrak et al., 2017; Skodvin et al., 2015), focus groups (*n* = 1) (Cortoos et al., 2008) and a mixed-methods approach comprising an online survey and semi-structured interviews followed by an observational study (*n*=1) (May et al., 2014). Various methods were employed to analyse data. Nine papers used thematic analysis

(Broom et al., 2014; Broom et al., 2016b, 2016c; Eyer et al., 2016; Livorsi et al., 2015, 2016; May et al., 2014; Sedrak et al., 2017; and Skodvin et al., 2015), and four used framework analysis (Broom et al., 2016a; Broom et al., 2017; Cortoos et al., 2008; Mattick et al., 2014). Rawson et al. (2016) employed grounded theory and Björkman et al. (2010) used phenomenographic analysis. Although qualitative themes were a preferred method of displaying findings in most studies (*n*=12), the degree of clarity differed considerably, from a simple classification of findings to meaningfully described theme structures.

Overall, the studies had an acceptable methodological quality. However, most studies neglected the value of reflexivity (*n*=12). Four studies did not provide any details concerning the background and experience of the researchers who conducted interviews and data analysis (Björkman et al., 2010; Broom et al., 2014; Broom et al., 2016c; and Mattick et al., 2014), seven provided some details, and only three studies adequately reported how the authors' social background, location, role, and assumptions might have affected the research process and findings (Rawson et al., 2016; Sedrak et al., 2017; and Skodvin et al., 2015).

Characteristics of the 15 papers, including author, year of publication, country/setting, study focus, population, data collection, analytic approach, and the key findings, are detailed in Table 7.

Table 7. Summary of qualitative papers included in the synthesis

Study	Aim(s)	Sample	Data collection & analysis	Key findings
Cortoos et al. 2008 Belgium	To determine the opinions and problems concerning the use of a local antibiotic hospital guideline.	1 public tertiary care university teaching hospital. 22 physicians from internal medicine (7 residents/ 6 staff) and surgery (6 residents/3 staff). Ages: 26-60, 5 females/17 males.	Focus Groups Framework Analysis	7 themes reported: General attitudes and guideline interpretation; guideline familiarity and awareness; guideline contents and agreement; social influence; multidisciplinary approach, organisational constraints; attitudes about specific interventions.
Björkman et al. 2010 Sweden	To explore and describe perceptions of antibiotic prescribing among Swedish hospital physicians.	7 acute public hospitals. 20 hospital physicians (5 urology physicians, 5 from surgery, 10 from internal medicine). Ages: 31-70, 5 females/15 males.	Semi-structured Interviews Phenomenographic Analysis	5 main categories of perceptions of hospital antibiotic prescribing and AMR: Prefer "effective" treatment; too uncertain to be restrictive; stuck in the healthcare system; aware and restrictive, but support required; aware, interested, and competent.
Broom et al. 2014 Australia	To investigate the experiences of doctors who prescribe antibiotics.	1 acute regional public hospital. 30 doctors from emergency medicine (3), general medicine (4), geriatrics (3), intensive care (2), obstetrics and gynaecology (3), oncology (2), orthopaedics (2), paediatrics (1), renal medicine (2), sexual health (1), surgery (2), urology (1) and infectious diseases (4). House officers (4), registrars (7), advanced trainees (2), consultants/ staff specialists (11), consultants/ senior staff specialists (5). 9 females/21 males.	Semi-structured Interviews Thematic Analysis	6 main themes reported: Everyday sensitivity toward resistance; risk, fear, and uncertainty; time, pressure, and uncertainty; benevolence and the emotional prerogative; habitus and the internalisation of peer practice norms; hierarchies and the localisation of antibiotic prescribing.
Mattick et al. 2014 UK (England &	To explore the antimicrobial prescribing experiences of foundation year (FY) doctors.	2 public secondary care teaching hospitals. 33 junior doctors (21 FY1 and 12 FY2) working in medical and surgical wards.	Narrative Interviews Framework Analysis	6 overarching themes reported: Personal incident narratives about antimicrobial prescribing; antimicrobial prescribing experiences; systems issues;

Scotland)		Ages: 20-35, 18 females/15 males		working relations; educational experiences and needs; process-related data.
May et al. 2014 USA	To explore current practices and decision making regarding antimicrobial prescribing among Emergency Department (ED) clinical clinicians.	8 acute hospitals, including 5 private (2 tertiary care and 3 tertiary academic centres), 2 federal and 1 public. 21 clinicians (attending physicians, residents, and mid-level clinicians with at least 2 years of ED experience). No gender documented.	Semi-structured Interviews (mixed-methods study) Thematic Analysis	5 overarching themes reported: Resource and environmental factors that affect care; access to and quality of care received outside of the ED consult; patient-provider relationship; clinical inertia; local knowledge generation
Livorsi et al. 2015 USA	To understand the professional and psychological factors that influence physician antibiotic prescribing habits in the inpatient setting.	2 acute teaching hospitals (1 public tertiary care and 1 federal). 30 inpatient physicians: 10 physicians-in-training (8 internal medicine, 2 internal medicine/paediatrics) & 20 supervisory staff (17 hospital medicine, 3 pulmonary/critical care). 10 female/20 males.	Semi-structured Interviews Thematic Analysis	4 themes reported: Antibiotic over-use is recognised but generally accepted; the potential adverse effects of antibiotics have a limited influence on physicians' decision making; physicians-in-training are strongly influenced by the antibiotic prescribing behaviour of their supervisors; reluctance to provide critique, feedback or advice.
Livorsi et al. 2016 USA	To assess physician knowledge and acceptance of antibiotic-prescribing guidelines using case vignettes.	2 acute teaching hospitals (1 public tertiary care and 1 federal). 30 inpatient physicians: 10 physicians-in-training (8 internal medicine, 2 internal medicine/paediatrics) & 20 supervisory staff (17 hospital medicine, 3 pulmonary/critical care). 10 female/20 males.	Semi-structured Interviews Thematic Analysis	3 major themes reported: Lack of awareness of specific guideline recommendations; tension between adhering to guidelines and the desire to individualise patient care; scepticism of certain guideline recommendations.
Skodvin et al. 2015 Norway	To investigate factors influencing antimicrobial prescribing practices among hospital doctors.	12 public and 1 private hospital (3 teaching and 10 non-teaching). 15 doctors from five major medical fields (internal medicine (4), surgery (4), infectious diseases specialists (2), other medical fields: oncology, neurology, and intensive care).	Semi-structured Interviews Thematic Analysis	6 major themes reported: Colleagues; microbiology; national guideline; training; patient assessment; leadership.

		Interns/residents/consultants 2/5/8. Ages: 25-65, 8 females/7 males.		
Broom et al. 2016a UK	To identify why inappropriate prescribing trends continue.	1 public teaching hospital. 20 doctors: 8 consultants, 12 non-consultants from medical (15) and surgical speciality (5). 9 females /11 males.	Semi-structured Interviews Framework Analysis	3 major themes reported: Consumerism and complaints culture; priorities, team dynamics and the medical hierarchy; mythical properties of intravenous antibiotics.
Broom et al. 2016b UK	To explore doctors' experiences of antibiotic prescribing and the role of social and institutional factors in influencing the decision making process.	1 public teaching hospital. 20 doctors: 8 consultants, 12 non-consultants from medical (15) and surgical speciality (5). 9 females /11 males.	Semi-structured Interviews Framework Analysis	3 major themes reported: Negotiating multiple masters; junior doctors 'stuck in the middle' between infectious diseases, clinical microbiology, and their supervising team; the dynamics of laboratory vs clinical medicine; the transmission of habit: evidence confronts mentoring, anecdote, and experiential learning.
Broom et al. 2016c Australia	To explore the potential social dynamics underpinning doctors' antibiotic use and infection management practices.	1 public regional teaching hospital. 30 doctors from emergency medicine (3), general medicine (4), geriatrics (3), intensive care (2), obstetrics and gynaecology (3), oncology (2), orthopaedics (2), paediatrics (1), renal medicine (2), sexual health (1), surgery (2), urology (1) and infectious diseases (4). Sample included house officers, registrars, advanced trainees, consultants/staff specialists and consultants/senior staff specialists. 9 females /21 males.	Semi-structured Interviews Thematic Analysis	4 main themes reported: Contesting 'best' practice: risk and ambivalence; 'fear of losing them' and the role of patient vulnerability; intra-professional and workplace context; 'craft groups' and the perpetuation of localised norms.
Eyer et al. 2016 Switzerland	To determine reasons for using antibiotics to treat asymptomatic bacteriuria in the absence of a treatment indication.	1 public tertiary care university teaching hospital. 21 general medicine physicians: 12 residents/9 senior physicians. No gender documented.	Semi-structured Interviews Thematic Analysis	5 main themes reported: Treatment of laboratory results without considering the clinical picture; physician-centred factors; external factors; lack of attention to detail or analytical thinking, particularly under time constraints;

				overtreatment due to trivialisation of urinary tract infection.
Rawson et al. 2016 UK	To map out and compare the decision making processes employed for acute infection management on the hospital wards by non-infection medical specialities and explore any factors that influenced this process.	3 public university teaching hospitals (mix of secondary and tertiary care providers). 20 physicians (9 consultants, 4 registrars, 2 trainees, 5 junior doctors) from non-infection medical specialities (general internal medicine, such as cardiology, respiratory, and geriatric medicine) and augmented care specialities (haematology and nephrology). No gender documented.	Semi-structured Interviews Grounded Theory	3 overarching themes reported: Mapping the decision making process; factors influencing the decision making process; windows of influence on decision making.
Broom et al. 2017 Australia	To examine how hospital doctors balance competing concerns around antibiotic use and resistance.	2 acute public teaching hospitals (1 regional and 1 metropolitan). 64 doctors from anaesthetics, emergency, geriatrics, gynaecology, haematology, ICU, infectious diseases, nephrology, oncology, orthopaedics, paediatrics, palliative care, respiratory, sexual health, and surgery. 27 junior doctors, 37 consultants. 28 females/36 males.	Semi-structured Interviews Framework Analysis	2 key themes: The significance of resistance for the hospital and the role of doctors in perpetuating resistance; Overprescribing easier and without perceived immediate risk.
Sedrak et al. 2017 Australia	To elucidate potential barriers and enablers to the adherence to antibiotic guidelines by clinicians treating community-acquired pneumonia.	1 public tertiary teaching hospital. 10 clinicians from emergency medicine (4), general medicine (4) and infectious disease (2). 5 registrars and 5 consultants. 5 females/5 males.	Semi-structured Interviews Thematic Analysis	3 main categories reported: Knowledge (familiarity with guidelines); Attitudes (confidence in antibiotic guidelines); Behaviour (documentation and communication, experience, and clinical judgement).

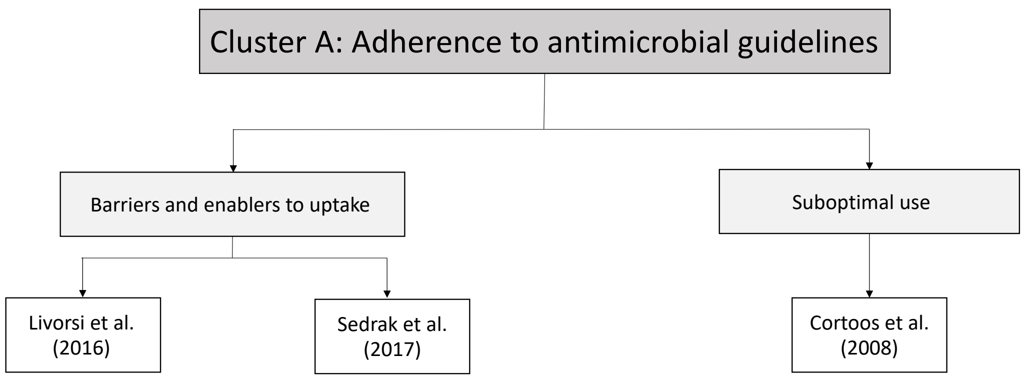
3.3.3 Outcome of relating studies (Phase 4)

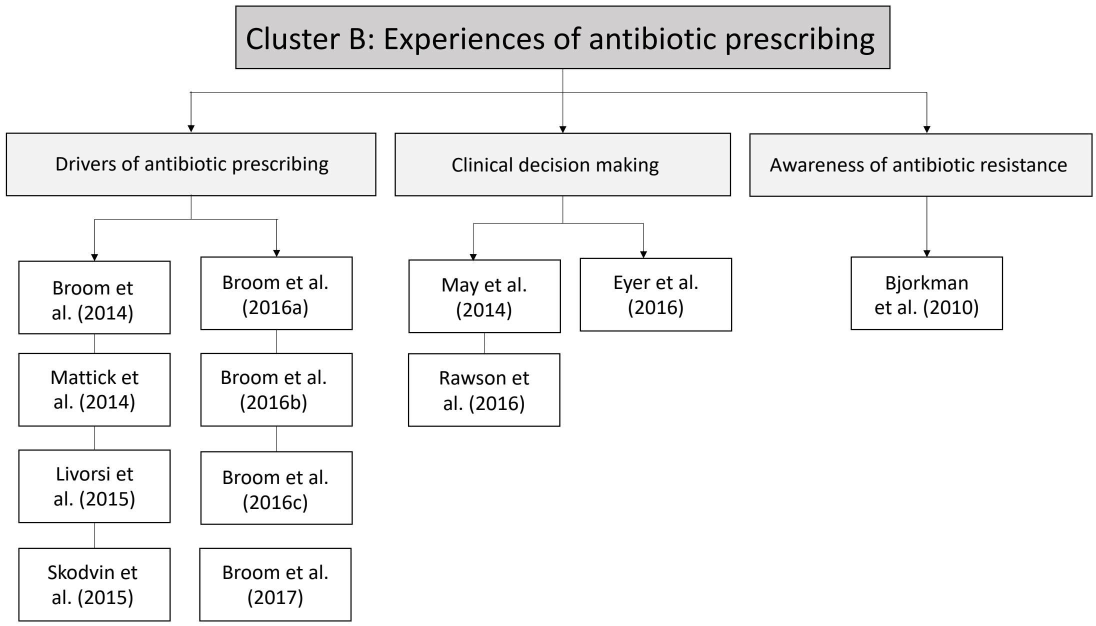
The studies' findings pertained to several different aspects of doctors' experience of antibiotic prescribing. They were therefore arranged and grouped in line with their primary thematic focus (Figure 15). Studies related by their focus into two clusters:

- **Cluster A** (*n*=3): Studies that focused on the adherence to antimicrobial guidelines, including the barriers and enablers to uptake and the sub-optimal use (Cortoos et al., 2008; Livorsi et al., 2016; and Sedrak et al., 2017).

- **Cluster B** (*n*=12): Studies describing the experience of antibiotic prescribing with differing levels of emphasis placed on the influences on the prescribers' behaviour, ranging from the drivers of antibiotics prescribing, clinical decision making to awareness of AMR (Björkman et al., 2010; Broom et al., 2014; Broom et al., 2016a, 2016b, 2016c; Broom et al., 2017; Eyer et al., 2016; Livorsi et al., 2015; Mattick et al., 2014; May et al., 2015; Rawson et al., 2016; and Skodvin et al., 2015).

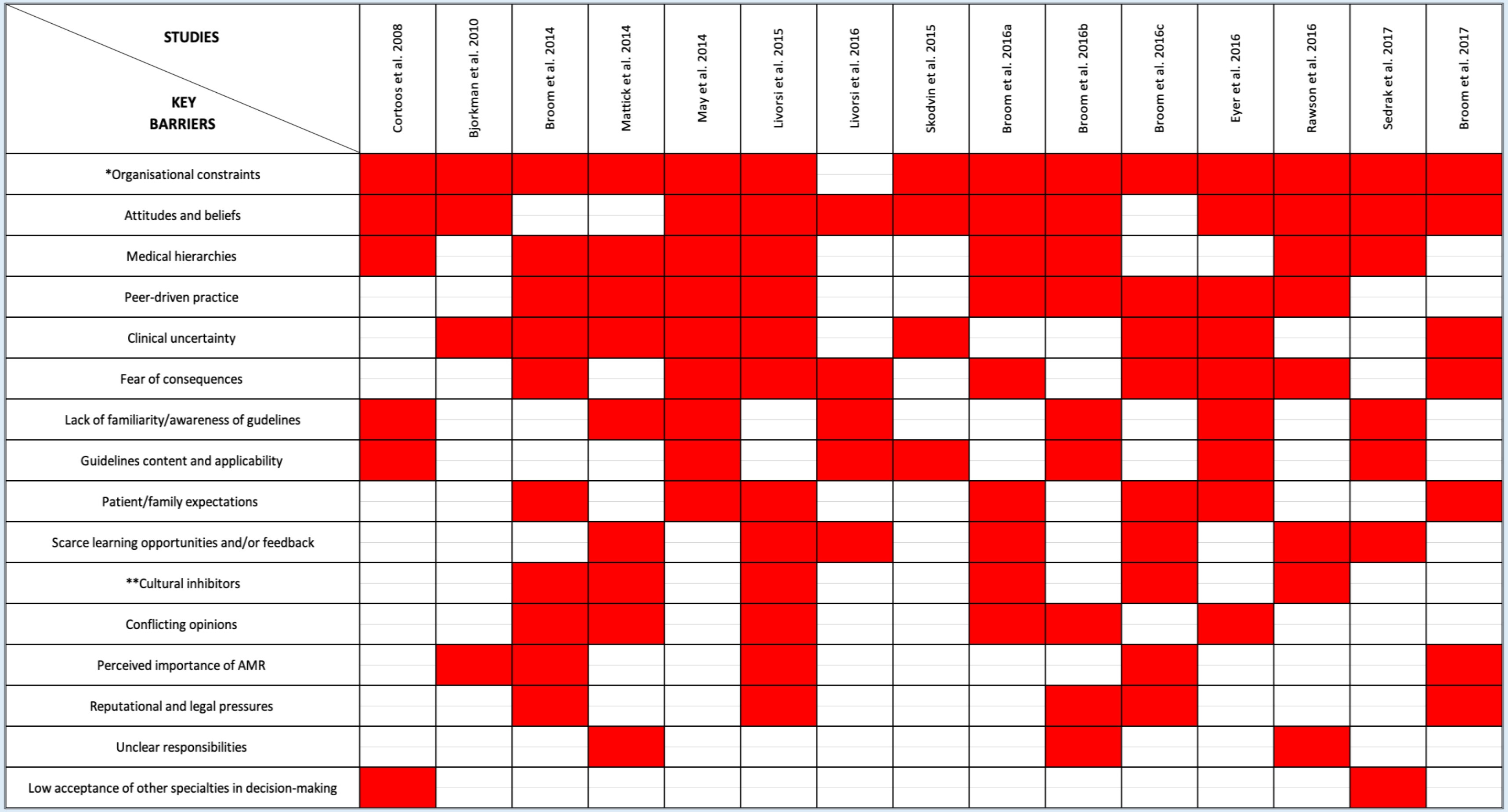
Figure 15. Initial categorisation of studies by focus





During relating studies by findings, 142 concepts across clusters A (*n*=28 concepts) and B (*n*=114 concepts) emerged. These clusters were not completely distinct, and there was a significant overlap between the concepts. For example, it was difficult to examine the experience of antibiotic prescribing without considering the non-adherence to guidelines; or solely focus on the barriers and enablers to antibiotic guidelines uptake without the scrutiny of the broader social and organisational context and its impact on prescribers' behaviours. These concepts largely represented a range of influence factors that hinder or facilitate appropriate antibiotic prescribing in acute hospitals. These factors are presented in Figures 16 and 17 in descending order from the most frequently reported ones to the least.

Figure 16. Matrix of key barriers to appropriate antibiotic use



***Organisational constraints** include: lack of follow-up, poor continuity of care, variations in practice, out-of-hours working, frequent rotations, diagnostic testing availability, time pressures, cumbersome IT system, delayed results.

****Cultural inhibitors** include: lack of rationale sharing for prescribing decisions and unacceptability of contesting colleagues` decisions.

Figure 17. Matrix of key facilitators to appropriate antibiotic use

KEY FACILITATORS \ STUDIES	Cortoos et al. 2008	Bjorkman et al. 2010	Broom et al. 2014	Mattick et al. 2014	May et al. 2014	Livorsi et al. 2015	Livorsi et al. 2016	Skodvin et al. 2015	Broom et al. 2016a	Broom et al. 2016b	Broom et al. 2016c	Eyer et al. 2016	Rawson et al. 2016	Sedrak et al. 2017	Broom et al. 2017
Multidisciplinary approach	■	■		■	■	■		■	■	■			■	■	
Audit and/or feedback on performance	■			■	■	■		■					■	■	
Formal and systematic education		■		■	■			■			■			■	■
Clinical leaders as role models	■			■		■		■	■					■	
Guideline distribution, promotion and easy accessibility	■				■		■	■						■	
Improved line of communication	■			■		■		■					■		
Recognition of social norms of practice						■			■	■	■				
Antibiotics/AMR awareness raising		■						■	■						■
Engagement of nurses					■			■	■				■		
Staff meetings/in person discussions	■				■	■								■	
Guidelines tailored to different target groups	■				■							■		■	
Bedside teaching				■	■			■							
Organisational and process chnages		■			■						■				
Improved diagnostics					■	■									
Shared decision-making with patients					■	■									
Distribution of responsibility for prescribing decisions										■			■		
Watchful waiting & re-assessment					■							■			
Use of posters	■													■	
Induction packs				■											
†Clinical decision support system					■										
Support for clinicians															■

†**Clinical decision support system** includes: alerts, pre-authorisation, or automatic stop orders

Among the most cited barriers to appropriate antibiotic prescribing were organisational constraints, including lack of follow-up, poor continuity of care, variations in practice, out-of-hours working, deficient communication/documentation, frequent rotations, diagnostic testing unavailability, time pressures, cumbersome IT system and delayed results (all papers except Livorsi et al., 2016). Other challenges included the difficulties of managing the social dynamics of the hospital, such as hierarchical structures of medicine (Broom et al., 2014; Broom et al., 2016a, 2016b; Cortoos et al., 2008; Livorsi et al., 2015; Mattick et al., 2014; May et al., 2014; Rawson et al., 2016; Sedrak et al., 2017) and peer-driven practice (Broom et al., 2014; Broom et al., 2016a, 2016b, 2016c; Eyer et al., 2016; Livorsi et al., 2015; Mattick et al., 2014; May et al., 2014; Rawson et al., 2016). Localised norms, including lack of rationale sharing for prescribing decisions and unacceptability of questioning colleagues' decisions, were reported to dominate antibiotic decision making (Broom et al., 2014; Broom et al., 2016a, 2016c; Livorsi et al., 2015; Mattick et al., 2014; Rawson et al., 2016).

Eleven studies found that clinical pressures, such as fear of consequences and clinical uncertainty coupled with patient/family expectations drive the prioritisation of immediate patient concerns over long-term AMR effects (Broom et al., 2014; Broom et al., 2016a, 2016c; Broom et al., 2017; Eyer et al., 2016; Livorsi et al., 2015, 2016; Mattick et al., 2014; May et al., 2014; Rawson et al., 2016; Skodvin et al., 2015). Scarce learning opportunities and lack of feedback on prescribing were identified as further barriers (Broom et al., 2016a, 2016c; Livorsi et al., 2015, 2016; Mattick et al., 2014; Rawson et al., 2016; Sedrak et al., 2017). Unclear responsibilities (Broom et al., 2016b; Mattick et al., 2014; Rawson et al., 2016) and low acceptance of other specialities in decision making (Cortoos et al., 2008; Sedrak et al., 2017) were also reported to create challenges, especially for junior doctors seeking advice.

The key interventions suggested to improve inappropriate use of antibiotics were guideline distribution and easy accessibility (Broom et al., 2016a; Cortoos et al., 2008; Livorsi et al., 2016; May et al., 2014; Sedrak et al., 2017; Skodvin et al., 2015), clinical leaders acting as role models (Broom et al., 2016a; Cortoos et al., 2008; Livorsi et al., 2015; Sedrak et al., 2017; Skodvin et al., 2015), multidisciplinary approach and normalisation of other specialities within the decision making process (Björkman et al., 2010; Broom et al., 2016a, 2016b; Cortoos et al., 2008; Livorsi et al., 2015; May et al., 2015; Rawson et al., 2016; Sedrak et al., 2017; Skodvin et al., 2015). Other facilitators included audit and feedback (Cortoos et al., 2008; Livorsi et al., 2015; Mattick et al., 2014; May et al., 2014; Rawson et al., 2016; Sedrak et al., 2017; Skodvin et al., 2015) and recognition of social and cultural norms of hospital practice (Broom et al., 2016a, 2016b; 2016c; Livorsi et al., 2015).

While some authors provided concrete recommendations to optimise future practice, such as posters, induction packs, and ward-based teaching (Mattick et al., 2014), others proposed broad organisational and process changes (Björkman et al., 2010). However, not all study authors offered practical solutions to the highlighted challenges. For instance, Broom et al. (2014) did not recommend any interventions except stating that understanding antibiotic use as a social game is a critical step toward organisational and practice change. Additionally, although there was a fair degree of overlap across the studies in terms of the challenges reported, there were fewer similarities concerning the strategies that the authors suggested to overcome those barriers. Moreover, the proposed strategies did not always seem to match the identified problems. This would indicate that while there is a desire for a quick fix solution to antibiotic prescribing in a busy hospital environment, the results of Phase 4 have demonstrated the complexity of prescribing decisions.

3.3.4 Outcome of translation (Phase 5)

Undertaking deconstruction of the second-order constructs described in Phase 4 seamlessly led to the translation of studies into one another. Collapsing and merging the 142 concepts across cluster A and B resulted in 17 higher conceptual categories (HCCs) or ‘piles’ that shared meaning. The reported concepts within each HCC are presented in translation Tables 8 and 9 with descriptions, illustrating whether they were represented by direct quotes (first-order constructs) and the author’s interpretations (second-order constructs)

Table 8. Translation table for Cluster A papers: 'Adherence to antimicrobial guidelines'

HIGHER CONCEPTUAL CATEGORY FOR CLUSTER A STUDIES	CONCEPTS INCLUDED IN THIS CATEGORY	STUDIES INCLUDING 1ST ORDER CONSTRUCTS	STUDIES INCLUDING 2ND ORDER CONSTRUCTS
1. Factors that enable and hinder adherence to antimicrobial guidelines Barriers to guideline-concordant practice include familiarity and complacency in accessing guidelines, inadequate or passive guidelines distribution, content not tailored to different specialities and areas, and various guideline sources. Only up-to-date guidelines are viewed as trustworthy. High awareness and acceptance of guidelines, active distribution, accessibility, and user-friendly format improve concordance to antibiotic guidelines.	◆ Distribution & accessibility	1, 14	1, 7, 14
	◆ Clarity & interpretation	1	1
	◆ Content & agreement	1, 7, 14	1, 7, 14
	◆ One size doesn't fit all	1, 7, 14	1, 7, 14
	◆ Need for a cookbook approach	1	1
	◆ Familiarity, awareness & acceptability	1, 7, 14	1, 14
	◆ Need for evidence-based guidelines	1, 7	1, 7, 14
	◆ Guidelines are no dogma but an instrument	1, 7, 14	7
	◆ Scepticism around guidelines	7, 14	7, 14
	◆ Stringency of applying guidelines	1, 7	14
	◆ Different requirements between clinician groups for guideline contents	1	1, 7, 14
	◆ Perceived effective strategies to improve guidelines concordance	1, 14	1, 7, 14
2. Tension between individualising patient care and adhering to standardised recommendations Tension exists between complying with guidelines that only work for standardised patients and the desire for individualised patient care. Clinicians must rely on their knowledge and experience and tailor care to the specific conditions of the patient. Guidelines are perceived to conflict or be at odds with the 'objective evidence' clinicians collect at the bedside.	◆ Need to 'do something'	7	7
	◆ Not to treat is 'tough to swallow'	7	7
	◆ Stopping antibiotics is nerve-wracking	-	7
	◆ Guidelines in conflict with the 'objective evidence'	7, 14	7
	◆ Fear of missing something	7	-
	◆ Offering antibiotic is easier than withholding treatment	7	7
	◆ Modifying guidelines in favour of the clinical judgement	7, 14	7, 14
	◆ Experience gets in the way of following guidelines	7	7, 14
3. Navigating a patchwork system of insufficient healthcare resources Busy working environments, disparate prescribing practices between hospitals and wards, poor communication, deficient information transfer, sub-optimal follow-up of cultures and treatments are a source of confusion for the less experienced doctors.	◆ Differences in practice cause confusion	1	1
	◆ Documentation, information transfer and patient follow up	1, 14	1, 14
	◆ Working pressures & time constraints	1, 14	1, 14
	◆ Communication	1, 14	14

Key: Cortoos et al., 2008 (no 1); Livorsi et al., 2016 (no 7); Sedrak et al., 2017 (no 14)

4. Multidisciplinary collaboration Doctors value multidisciplinary collaboration, including contact and advice from AMS services. Opposing views between clinical subgroups exist towards the presence of clinical pharmacists on the ward. Microbiology specialists are viewed to have lower acceptance than infectious disease.	◆ Interpersonal relationships	1, 14	1, 14
	◆ Role of other specialities (pharmacists, microbiologists, and ID colleagues)	1, 14	1, 14
	◆ Nurses' influence	-	1
	◆ Involvement of AMS	14	14
5. Balancing hierarchy and autonomy Senior clinicians are considered opinion leaders and role models as their practice strongly determines the subsequent prescribing behaviour of junior doctors. This hierarchical and apprentice-based model of medical prescribing is a prominent influence in a hospital.	◆ Role models	1, 14	1, 14
	◆ Apprentice-based model of medical prescribing	14	14

Key: Cortoos et al., 2008 (no 1); Livorsi et al., 2016 (no 7); Sedrak et al., 2017 (no 14)

Table 9. Translation table for Cluster B papers: ‘Experiences of antibiotic prescribing’

HIGHER CONCEPTUAL CATEGORY FOR CLUSTER B	CONCEPTS INCLUDED IN THIS CATEGORY	STUDIES INCLUDING 1ST ORDER CONSTRUCTS	STUDIES INCLUDING 2ND ORDER CONSTRUCTS
1. Mastering guideline-concordant care Guidelines’ significance decreases with increased experience and knowledge. Whilst less experienced clinicians are dependent on the guidelines, senior doctors tend to be more sceptical. Senior clinicians recognise their responsibility to ensure that guidelines are followed, but they rationalise non-compliance by their autonomy and the need to adjust treatment to individual patients’ clinical situations.	◆ Distribution & accessibility	8	5
	◆ Clarity & interpretation	6, 13	4, 13
	◆ Content & agreement	2, 5, 8, 10, 13	8
	◆ One size doesn’t fit all	5, 13	8, 10, 13
	◆ Familiarity, awareness & acceptability	2, 3, 5, 8, 10, 13	4, 5, 6, 8, 10, 12, 13
	◆ Need for evidence-based guidelines	8	-
	◆ Guidelines are only an instrument	-	3, 8
	◆ Scepticism around guidelines	5, 13	3, 8, 10
	◆ Stringency of applying guidelines	8, 13	2, 8, 10
	◆ Guidelines give a sense of security	5, 8	2, 4, 8, 13
2. Patient-doctor relationship The dynamics of the patient-doctor relationship are driven by family expectations (actual and perceived), fear of lawsuit and inadequate communication. Fear of patient complaints results in a low threshold for antibiotic prescribing in hospitals. This emerging culture of consumerism plays a significant role in deviating from best practice and hinders the use of clinical guidelines.	◆ Patient demands	3, 5, 6, 9, 15	3, 5, 9, 12, 15
	◆ Perceived patient preferences	5, 9, 11, 13	3, 5, 9, 11
	◆ Keeping patients amused	3, 5, 6	6, 9, 12
	◆ Patient health education	5, 6	5, 6, 15
	◆ Patient learned behaviours	5	-
	◆ Shared decision making	6, 9	5, 6
	◆ Consumerism and ‘complaints culture’	5, 6, 9	9, 15
	◆ Fear of lawsuit	6, 9, 15	6, 9,15
	◆ Keeping family happy	3	2, 3, 11, 12
3. Learning the medical rite of passage A passage occurs through years of ‘learning to doctor’, acquiring knowledge and experience to become an independent decision-maker able to tolerate more significant risks. Being able to progress through a medical career while maintaining a sense of competence is achieved by accumulating clinical experience. When faced with clinical	◆ Knowledge and experience	2, 3, 4, 6, 8, 9, 11, 12, 13	2, 3, 4, 6, 8, 9, 11, 12, 13
	◆ Lack of confidence	3, 4, 6, 9, 11, 13	3, 9, 11
	◆ Erring on the side of caution	3, 6, 9, 11, 12, 15	6, 8, 11, 12, 13, 15
	◆ ‘Get them through the night’	3, 9, 13	-
	◆ De-escalation anxiety	9, 13	6, 9, 12, 13
	◆ Being able to defend decisions	3, 4, 5, 6, 9, 11, 13	6, 9, 11, 12, 13
	◆ Fear of being criticised	3, 4, 6, 11	3, 6, 10, 11, 15

Key: Björkman et al., 2010 (no 2); Broom et al., 2014 (no 3); Mattick et al., 2014 (no 4); May et al., 2015 (no 5); Livorsi et al., 2015 (no 6); Skodvin et al., 2015 (no 8); Broom et al 2016a (no 9); Broom et al., 2016b (no 10) Broom et al. 2016c (no 11); Eyer et al., 2016 (no 12), and Rawson et al., 2016 (no 13); Broom et al., 2017 (no 15)

uncertainty, junior clinicians experience anxiety and tend to focus on short-term outcomes. The reassurance of prescribing antibiotics, ‘just in case’ there is an infection, is preferred.	◆ Learning to be independent	13	3, 10
	◆ Fear of missing something	2, 3, 6, 11, 12, 15	3, 6, 9, 11, 12, 13, 15
	◆ Sense of competence	11, 13, 15	6, 10, 11, 12, 13, 15
4. Sub-optimal prescribing is a logical choice Antibiotics are considered a ‘peripheral thing’ and of little concern at the bedside. The threat of AMR is a theoretical problem, which is morally and professionally important, but not necessarily practical in the hospital. Sub-optimal antibiotic prescribing is, therefore, a logical choice within the hospital. The threat of resistance is an abstract problem, as compared to the practical issue of patient care. Therefore, overtreatment of antibiotics is more favourable than the potential for adverse patient outcomes and losing professional reputation.	◆ Narrow-spectrum antibiotics not considered effective	2, 15	2, 8, 12, 13, 15
	◆ Antibiotics are a peripheral thing	3, 9	6, 9
	◆ Overtreatment due to trivialisation	3, 9, 12, 13	2, 5, 12
	◆ Mythical properties of IV antibiotics	9	9, 12
	◆ Anxiety leads to generosity of treatment	2, 3, 6, 9, 11, 12, 13, 15	2, 3, 6, 8, 9, 11, 12, 15
	◆ Clinical uncertainty	2, 3, 6, 11, 12, 13	2, 3, 4, 5, 6, 8, 11, 12
	◆ Low threshold for initiation of antibiotics	2, 3, 5, 6, 9, 11, 12, 13, 15	5, 6, 11, 12, 15
	◆ Guidelines at odds with the bedside evidence	3, 10, 11, 12, 13	2, 9, 10, 11, 13, 15
	◆ AMR awareness not practical at the bedside	3, 6, 15	2, 3, 15
	◆ Benefits of antibiotics outweigh the risks	6, 12, 13, 15	3, 5, 6, 9, 11, 12, 15
	◆ Therapeutic powerlessness	6, 12	12, 15
	◆ ‘Wait and see approach’	2, 5	2, 5, 8, 13, 15
5. Benevolence and the emotional prerogative Antibiotic prescribing is an ‘act of kindness’ driven by the hope of improving patient condition or at least providing a ‘beacon of hope’. Prescribing antibiotics treatment is seen as confirmation of the doctor’s role, a trigger that at least something was done. Not doing anything is much more difficult. Immediate patient improvement means ‘good doctoring’ even if it is at the cost of increasing AMR.	◆ Professional identity	3, 11	3, 11, 12
	◆ Doing the ‘right thing’	5, 6, 11, 12, 13	2, 3, 4, 11, 12, 13,
	◆ Need to ‘do something’	3, 5, 12, 13	3, 5, 12, 15
	◆ Being seen as a good doctor	3, 11	3, 11
	◆ Not going home empty-handed	3, 5	3
	◆ Prescribing antibiotics for the placebo effect	3, 5	5
	◆ Beacon of hope	-	12
	◆ Providing optimal care	5, 6, 12, 15	2, 3, 10, 13, 15
6. Clinical inertia and transmission of habit Less experienced clinicians are vulnerable to the norms of a	◆ Path of least resistance	6, 9, 10, 12, 13	3, 6, 10, 12, 15
	◆ Not ready to change	3	2, 10

Key: Björkman et al., 2010 (no 2); Broom et al., 2014 (no 3); Mattick et al., 2014 (no 4); May et al., 2015 (no 5); Livorsi et al., 2015 (no 6); Skodvin et al., 2015 (no 8); Broom et al 2016a (no 9); Broom et al., 2016b (no 10) Broom et al. 2016c (no 11); Eyer et al., 2016 (no 12), and Rawson et al., 2016 (no 13); Broom et al., 2017 (no 15)

'generous' prescribing environment and experience pressure to conform to the current practice norms. They feel stuck in the system dominated by prescribing trends. Certain clinicians prefer specific combinations or options of antibiotics. The idea of contesting or challenging existing practices of seniors is not attractive and causes additional stress. Conflicting with opinion leaders is more difficult than giving in.	◆ Stuck in the healthcare system	6, 9	-
	◆ Prescribing antibiotics is just a tick box exercise	5, 9	-
	◆ Inability to make a diagnosis drives prescribing	11	5, 11, 12
	◆ Knee-jerk reactions	3, 6, 9, 12, 13	3, 5, 12
	◆ Mindlines	3, 6, 9	3, 5
	◆ Prescribing trends	3, 4, 6, 9, 11, 10, 12	3, 5, 6, 11
	◆ Ripple effects of hierarchical structures	3, 6, 9, 10, 13	3, 5, 6, 9, 10, 12
	◆ Opposing the system causes stress	6, 9, 12	3, 12, 15
7. Internalisation of peer-driven practice Social norms of medical culture subconsciously influence prescribing behaviour of junior doctors. Antibiotic prescribing decisions are not entirely based on reason but are driven by recognising how 'others do it'. The practice of colleagues is passively internalised and then subconsciously reproduced.	◆ Continuing the status quo	3, 6, 9, 10	3, 6, 9, 10
	◆ Blind spots & subconscious influences	3, 6	3, 6, 13
	◆ Hidden reasoning	3, 6, 10, 13	3, 6, 10, 12, 13
	◆ Autonomy	8, 9, 10	9,
8. Learning rules of the game Within the medical culture, antibiotic prescribing practice is governed by a set of rules, where behaviour, attitudes and opinions of senior clinicians strongly influence the practice of junior doctors. Learning the 'rules of the game' of the hospital and securing professional credibility within the hierarchical team structures translates to becoming 'competent'.	◆ Hierarchy	3, 6, 9, 10, 11, 13	3, 4, 5, 6, 9, 10, 11, 13
	◆ Role models	3, 11	3, 5, 6, 9, 10, 11, 13
	◆ Social game	4, 6, 9, 11	3, 11
	◆ The apprenticeship model of learning	3, 11	3, 10, 11
	◆ Avoiding confrontation	6, 9, 10	3,
	◆ Fraternal obligation	6, 11	3, 6, 11
	◆ Maintaining professional credibility	6, 11	3, 6, 11, 15
9. Managing interpersonal relationships Managing interpersonal relationships within the hospital culture is not straightforward. Competing dynamics mean that junior doctors often experience conflict and feel like a 'piggy in the middle'. They must learn to decide whose opinion to follow in their daily practice. Negotiating prescribing decisions can be difficult, especially if there is an influence from various authoritative figures, including own clinical team versus other specialities.	◆ Us vs they	10, 13	10
	◆ Conflicting opinions	4, 5, 8, 9, 10, 13	4, 10
	◆ Piggy in the middle	4, 5	4
	◆ Dynamics between different specialities	5, 10, 13	10
	◆ Support and advice from colleagues	8, 9, 10, 11, 13	2, 3, 4, 6, 8, 10, 11, 13
	◆ Competing interests	5, 10	10
	◆ Poor communication due to trivialisation	5	12
	◆ Advice from ID specialists	2, 5, 8, 9, 10	2, 8, 10
	◆ Influence of microbiologists	4, 8	8, 10, 13

Key: Björkman et al., 2010 (no 2); Broom et al., 2014 (no 3); Mattick et al., 2014 (no 4); May et al., 2015 (no 5); Livorsi et al., 2015 (no 6); Skodvin et al., 2015 (no 8); Broom et al 2016a (no 9); Broom et al., 2016b (no 10) Broom et al. 2016c (no 11); Eyer et al., 2016 (no 12), and Rawson et al., 2016 (no 13); Broom et al., 2017 (no 15)

	◆ Role of clinical pharmacists	9, 13	6, 13
	◆ Nurses' influence	-	12
10. Perceived facilitators to antimicrobial stewardship Within the busy hospital environment, support and regular feedback from more experienced clinicians and the opportunity to work independently are valued by junior doctors. A collaborative culture fostering a multidisciplinary approach and normalisation of the role of other specialists in decision making is crucial to aid improvements. The quality of inter-professional relationships between clinicians is key to achieving change. Equal distribution of the responsibility of prescribing decision beyond that of the senior consultant in charge of the patient needs to be addressed.	◆ Patient and provider education	4, 5	2, 5, 6, 8, 9, 10, 15
	◆ Supervision & performance feedback mechanisms	4, 11	4, 5, 6, 8, 11
	◆ Formal Teaching	4, 5, 8, 11	-
	◆ Induction	-	4
	◆ Good handovers	-	4, 8
	◆ Clinical decision making support	5	5
	◆ Improved diagnostic testing	5	5, 6
	◆ Written materials & signposting	-	4, 8
	◆ Raised awareness of AMR	-	2, 15
	◆ Healthcare system that supports restrictive prescribing	5, 9	2, 3, 4, 5, 9, 13
	◆ Multidisciplinary approach and support from senior colleagues	3, 4, 6, 8	4, 5, 6, 8, 9, 10, 13
	◆ Tailored guidelines	-	5
	◆ Approval system	-	10
	◆ Distribution of responsibility	-	13
11. Organisational constraints that prevent optimal treatment The opportunities to learn and refine the craft of prescribing within the complex ward-based environment are scarce due to the fast-paced hospital environment and time pressures. Limited senior support and feedback on prescribing contributes to communication problems and poses a challenge to the continuity of patient care. Variability in practice and lack of continuity or a follow-up of prescribing decisions due to doctors' rotations and patients being moved between wards, error-prone handovers, unclear instructions, and lack of follow-up all contribute to a lack of ownership of prescribing decisions.	◆ Time pressures and fast-paced environment	3, 4, 5, 6, 9, 12, 13	2, 4, 5, 12
	◆ Lack of follow-up	2, 5, 6, 8, 9, 15	4, 5, 6, 8, 9, 13, 15
	◆ Continuity of care	2, 5, 6, 9, 13	4, 5, 6, 9, 12, 13
	◆ Poor communication	6	4, 13
	◆ Out of hours working	13	4, 8, 11, 12
	◆ Variations in practice	6, 11	4, 6, 9, 11, 12, 13
	◆ Feeling pressurised	3, 4	4
	◆ Poor handovers	4, 11	4, 9, 11
	◆ External institutional influences	4, 15	2, 12, 15
	◆ Navigating a patchwork system of resource allocation	4, 5, 8	2, 5, 8
	◆ Lack of induction and formal teaching	2, 4, 8	4
	◆ Lack of support from seniors	11	4, 9, 11, 13
	◆ Unclear responsibilities	-	4, 13
12. Factors influencing antibiotic decision making	◆ Severity of disease determines prescribing	6, 8, 13	8, 13
	◆ De-escalation based on micro results/patients'	9	-

Key: Björkman et al., 2010 (no 2); Broom et al., 2014 (no 3); Mattick et al., 2014 (no 4); May et al., 2015 (no 5); Livorsi et al., 2015 (no 6); Skodvin et al., 2015 (no 8); Broom et al 2016a (no 9); Broom et al., 2016b (no 10) Broom et al. 2016c (no 11); Eyer et al., 2016 (no 12), and Rawson et al., 2016 (no 13); Broom et al., 2017 (no 15)

The fear of patient deteriorating linked with the expectation placed on juniors to prescribe antibiotics as soon as possible can often lead to overtreatment. When patient diagnostics are inconclusive or in circumstances of clinical uncertainty when the infection is difficult to distinguish from other disorders, it feels safer to prescribe antimicrobials than not.	improvement		
	◆ Consideration of AMR	2, 3, 5, 6, 11, 15	2, 3, 11, 15
	◆ Dilemma of prescribing vs non-prescribing	6, 11, 15	11, 15
	◆ Clinical picture is a good indicator of patient status	13	6, 8, 12, 13
	◆ Antibiotic decisions not prioritised	-	9, 15

Key: Björkman et al., 2010 (no 2); Broom et al., 2014 (no 3); Mattick et al., 2014 (no 4); May et al., 2015 (no 5); Livorsi et al., 2015 (no 6); Skodvin et al., 2015 (no 8); Broom et al 2016a (no 9); Broom et al., 2016b (no 10) Broom et al. 2016c (no 11); Eyer et al., 2016 (no 12), and Rawson et al., 2016 (no 13); Broom et al., 2017 (no 15)

From these 142 concepts and 17 HCCs, four overarching themes were identified during study translation: (1) Loss of ownership of prescribing decisions, (2) Tension between individual care and broader public health concerns, (3) Evidence-based practice versus bedside medicine, and (4) Diverse priorities between different clinical teams. Themes 1-3 were derived from reciprocal translation (findings were compatible). Theme 4 arose from refutational analysis when it was noted that some translated findings described dissonant alternative perspectives of the same phenomenon. Themes are presented below with narrative exemplars (first-order constructs).

3.3.4.1 Themes 1-3 – reciprocal translations

The findings of included studies were relatively comparable in their focus and addressed similar issues. Therefore, the process of 'reciprocal translation' was appropriate to adopt, leading to the development of the first three themes.

Theme 1. Loss of ownership of prescribing decisions

Many hospital healthcare professionals have a role in antimicrobial stewardship but, overall responsibility for antibiotic decisions lies with prescribing clinicians. The majority of decisions are made by senior doctors and then enacted by junior doctors. However, nine studies reported that during nights and weekends, this arrangement shifts, and less experienced doctors are often expected to manage complex cases alone and make decisions to prescribe antibiotics on behalf of their senior colleagues, with limited support and feedback available at the time (Broom et al., 2014; Broom et al., 2016a, 2016c; Livorsi et al., 2015, 2016; Mattick et al., 2014; May et al., 2014; Rawson et al., 2016; Sedrak et al., 2017; Skodvin et al., 2015).

> *"It [antibiotic choice] depends on the time of day that you're admitting the patient, and on a lot of other factors, whether you can ask your advanced trainee or your boss…. you've kind of heard half of the story, and you haven't fully done everything yourself, and it sounds like a good going infection, so you prescribe."* – Non-consultant [junior doctor], Oncology, Female, Australia (Broom et al., 2014)

When care delivery happens 'out-of-hours', the allocation of prescribing responsibility becomes ambiguous. Although junior doctors are expected to initiate or escalate antibiotics, they are hesitant to question or change decisions of their senior colleagues, consequently reporting feelings of disempowerment (Broom et al., 2016b, 2016c; Mattick et al., 2014; Rawson et al., 2016).

> *"So, I feel quite, I wouldn't say disempowered, but I feel like the seniors make most of the decisions. So, I'm quite reluctant to make any decisions about [de-escalating] antibiotics."* – On-rotation doctor, Gastroenterology, UK (Rawson et al., 2016)

Antibiotic prescribing is a practice-based skill or craft, learned through a process of apprenticeship and everyday interactions between individuals rather than academic education (Björkman et al., 2010; Broom et al., 2014; Broom et al., 2016a, 2016b, 2016c; Eyer et al., 2016; Livorsi et al., 2015; Mattick et al., 2014; May et al., 2014; Rawson et al., 2016; Sedrak et al., 2017; Skodvin et al., 2015). However, de-escalating or stopping treatments is considered a senior medical decision-maker role as this requires professional confidence and experienced clinical judgement. Making an independent clinical judgement is viewed as unrealistic or "something of a dark art" (Broom et al., 2016c), highlighting variation in the perceived responsibility for prescribing decisions.

> *"I think there's a lot of black boxedness about antibiotics. There's a lot of, you know, people really don't understand antibiotics… you have to understand what you're doing and why you're prescribing it."* – Consultant, General Medicine, Australia (Broom et al., 2016c)

Patients transitioning between hospital wards means that the provision of care takes place in multiple hospital locations and across various professional groups, adding to the complexity. Doctors' rotations, rapid ward rounds, numbers of staff delivering care and patients being cared for 'remotely' from their primary medical team compounds this problem, leading to frustration, anxiety and, ultimately, distancing from engaging with decision making.

> *"One thing about emergency is that we treat people at their initial presentation and unless we make the effort to follow-up someone through the ward, we actually don't know what happens to them."* – Emergency Department doctor, Australia (Sedrak et al., 2017)

Lack of awareness of what ultimately happens to the patient and whether the prescribed antibiotic therapy was the correct choice denies junior doctors the opportunity to learn from occasions when their prescribing decisions had been over-ruled or changed.

> *"I don't think there's too much time for feedback... after a few months you learn that you know, no news is good news."* – Foundation doctor (FY1), Male, UK (Mattick et al., 2014)

There was a concern that some information handed over to the next shift (or clinical area) is not always acted on and prescribed antibiotics are not reviewed by the subsequent clinical team taking over patient care (Björkman et al., 2010; Broom et al., 2014; Broom et al., 2016a, 2016c; Eyer et al., 2016; Cortoos et al., 2008; Livorsi et al., 2015; Mattick et al., 2014; May et al., 2014; Rawson et al., 2016; Sedrak et al., 2017; Skodvin et al., 2015). Fast-paced clinical environments, error-prone handovers, disjointed information, and cumbersome IT systems present further challenges.

> *"Our systems do not let us check up on what tests have been obtained. You actually have to call and ask: 'Have you received the specimen so and so?' Or else, you would have to wait for the results for another two to three days."* – Consultant, ID-specialist, Norway (Skodvin et al., 2015)

Three studies highlighted that poor documentation of decisions and inconsistencies in monitoring and treatment plans compounded the problem and created a sense of anonymity or 'invisibility' of decisions (Broom et al., 2016b; Mattick et al., 2014; Rawson et al., 2016). When reasons for antibiotic prescriptions are not documented, clear, or easy to find in clinical patient notes, clinicians must guess whether initial decisions regarding antibiotic choice and rationale were accurate and justified. This incomplete patient information impacts on clinicians' ability to take ownership of antibiotic prescribing decisions.

Theme 2. Tension between individual care and broader public health concerns

In uncertain clinical situations, doctors must make decisions in the presence of multiple and often conflicting objectives. While the ethical principle of a "good doctor" is to make decisions based on what is best for the individual patient (Broom et al., 2014), at the same time, clinicians have a responsibility to consider population-level consequences of overprescribing. On the one hand, antibiotic overprescribing is recognised as a serious global concern, but, on the other hand, not treating an infection may lead to serious patient complications, even death, and loss of professional reputation.

> *"It [AMR] is always there at the back of your mind, but then sometimes when you are faced with a particular situation, you're stuck between trying to think on the global way of trying to reduce broad-spectrum antibiotic use and all that versus trying to make sure you don't miss a bug by going too narrow."* – Resident, USA (Livorsi et al., 2015)

The abstract reality of future AMR causes internal conflict for the treating clinician facing the concrete reality of the 'here and now' – the patient's clinical status and perhaps pressure from family and patients to 'do something' (Björkman et al., 2010; Broom et al., 2014; Broom et al., 2016a, 2016c; Broom et al., 2017; Eyer et al., 2016; Livorsi et al., 2015; Rawson et al., 2016;). The short-term individual costs (for patients and professionals) must be constantly weighed against longer-term societal gains.

> *"It's hard....we probably think about the global scale, but it's because our oath is to the patient, and so we have to think about them first and then everybody afterwards."* – Clinician, Australia (Broom et al., 2017)

Five studies reported that, although clinicians consider AMR and its potentially severe consequences when choosing treatment, the threat of resistance is generally perceived to be a distant or not immediate issue (Björkman et al., 2010, Broom et al., 2014; Broom et al., 2016c; Broom et al., 2017; Livorsi et al., 2015). Except for clinicians working within infectious diseases and microbiology departments (Björkman et al., 2010), most participants appeared to downgrade the importance of the problem and its potentially devastating consequences during their prescribing decision making process. For example:

> *"Yes, I have seen resistant bacteria sometimes, with, for example, Lexinor. But this is nothing I have been thinking about."* – Physician, Sweden (Björkman et al., 2010)

Long-term effects of resistance at the broader community level are not prioritised, and some degree of overuse of antibiotics to manage immediate patient risks is allowed and socially acceptable.

> *"Yes, I guess that [AMR] is never of such interest to anybody here. Or, this is a small UTI, that is – that gets treated, period, end of discussion! People don't make a big deal out of it [treating asymptomatic bacteriuria]."* – Physician, Switzerland (Eyer et al., 2016)

The risks of over-prescribing to the individual patient tend to be disregarded (Broom et al., 2017). Some clinicians consider antibiotics a "peripheral thing", of "limited concern" (Broom et al., 2014) with the threat of AMR as a theoretical problem, which, while morally and professionally important, is not necessarily practical (Björkman et al., 2010; ; Broom et al., 2016a, 2016c; Broom et al., 2017; Livorsi et al., 2015). Recognition that individual practice contributes to the emergence of AMR is generally low, and some clinicians are "desensitised" to the problem (Broom et al., 2017). Absence of feedback on juniors' antibiotic prescribing limits the opportunity to identify reasons for the knowledge deficits and improve prescribing practice.

> *"It's very unusual that anyone would actually explain to you what they're thinking. I think I've had one explanation which was like a ray of sunshine"* – On-rotation, Renal, UK (Rawson et al., 2016)

Theme 3. Evidence-based practice versus bedside medicine

Internal reasoning, or the way clinicians make sense of their decisions, plays a significant role in antibiotic prescribing. Prescribing behaviour, which may at first appear as 'non-rational' or at odds with the evidence, is, in fact, a realistic and logical choice at the bedside, where positive patient outcomes and maintaining professional reputation take a priority. Junior doctors risk facing social disapproval if their decision not to prescribe is at odds with the 'social norms' of the hospital (Broom et al., 2014).

> *"I think they [junior doctors] realise and know that they'll get into trouble if they don't treat community-acquired pneumonia appropriately on the night…"*
> – Consultant, Respiratory Medicine, Male, Australia (Broom et al., 2014)

The health of individual patients lies at the core of medical professionalism and forms part of their professional identity. Being seen by the patient and relatives to be "doing good" drives clinicians to prescribe antibiotics for their patient regardless of whether it is evidence-based or not (Rawson et al., 2016). This internalised logic of over-prescribing is driven by the desire to improve the patient condition(s) or provide a "beacon of hope" (Eyer et al., 2016). This rationale interplays with the expectations of never missing a diagnosis. Prescribing antibiotic treatment is seen as a confirmation that "at least something has been done" (Livorsi et al., 2016).

> *"We are trained to do something and fix something, so to not do anything is probably the hardest guideline to follow"* – Resident, USA (Livorsi et al., 2016)

In busy hospital environments, professional competence is being constantly evaluated. Missing a potentially treatable infection could result in serious patient harm. Therefore, decisions about whether to prescribe antibiotics are heavily influenced by fear of consequences for prescribers.

> *"Just the thought of not covering some resistant organism or more pathogenic organism, even though I do not have any definitive objective evidence, always makes me quite anxious."* – Consultant, USA (Livorsi et al., 2015)

Perception of an emotional safety net created by administering antibiotics or prolonging their use was reported in twelve studies (Björkman et al., 2010; Broom et al., 2014; Broom et al., 2016a, 2016c; Broom et al., 2017; Eyer et al., 2016; Livorsi et al., 2015, 2016; May et al., 2014; Rawson et al., 2016; Sedrak et al., 2017; Skodvin et al., 2015). Although experience helps to identify and treat the severely ill patients, "erring on the side of caution" (Broom et al., 2016c) and prescribing antibiotics "just in case" provides reassurance and is, therefore, the default option irrespective of grade or experience (Livorsi et al., 2015).

> *"I would err on the side of overtreating. In other words, more extended-spectrum, rather than undertreating in the first instance."* – Consultant, Respiratory Medicine, Australia (Broom et al., 2016c)

Junior doctors report experiences of being criticised and seen by colleagues as incompetent when deciding not to treat (Broom et al., 2016a, 2016c; Broom et al., 2017; Livorsi et al., 2015; Mattick et al., 2014). In contrast, conservative antibiotic decision making is rarely recognised as good practice (Eyer et al., 2016). Senior doctors' preferences, expectations and prescribing habits also influence junior doctors' prescribing decisions.

> *"I think juniors often model the seniors and try and work out why particular things are done and perhaps model them. Sometimes there may not be good reasons."* – General Medicine, Australia (Sedrak et al., 2017)

Patient demands, expectations of patients' families and the developing "consumerism culture" pose additional pressure resulting in a low threshold for prescribing antibiotics (Broom et al., 2016a). Fear of patient complaints and a potential lawsuit was reported in ten studies (Björkman et al., 2010; Broom et al., 2014; Broom et al., 2016b, 2016c; Broom et al., 2017; Eyer et al., 2016; Livorsi et al., 2015; May et al., 2014; Sedrak et al., 2017; Skodvin et al., 2015). This fear drives clinicians to adopt defensive medicine approaches and prescribe broad-spectrum antibiotics unnecessarily, irrespective of the healthcare system they work in (public or private).

> *"With the complaints culture, and the amount of litigation going on, I think a lot of doctors are afraid to stand up and say 'no, you really don't need antibiotics', or 'there's really no indication', or 'you're alright for now, let's just wait and see what the blood test shows', or things like that."* – Medical, Non-Consultant, UK (Broom et al., 2016a)

However, external factors, such as patient access to care in the private health system hinder doctors' ability to foster AMS. For instance, in the US, the emergency departments disproportionately provide care to low-income and uninsured patients (May et al., 2014). As a result, doctors must account for the clinical scenario and consider the patient's ability to obtain follow-up care.

> *"If it's an outpatient, usually I use the broad-spectrum antibiotics because we don't have the luxury usually of following the patients and seeing if it's working."* – Resident, Male, USA (May et al., 2014)

Prescribing according to guidelines offers some reassurance and protection, provided these are evidence-based, up-to-date, readily available, accessible, and that doctors have time to consult them. Digressing from antibiotic guidelines is rationalised by the potential discrepancies between guidelines and practice (Björkman et al., 2010; Broom et al., 2014; Cortoos et al., 2008; Livorsi et al., 2015, 2016; Sedrak et al., 2017; Skodvin et al., 2015). Clinical judgement must be applied when the individual patient case does not 'fit' readily into the guidelines (Livorsi et al., 2016).

3.3.4.2 Theme 4 - Refutational translation

Some of the individually translated findings described alternative or refutational perspectives of the same phenomenon. The contradictory concepts related to the prioritisation of different tasks by different clinical teams. This dissonance added a new dimension, and a new refutational theme was formed.

Theme 4. Diverse priorities between different clinical teams

Multidisciplinary input is essential during hospital in-patient care. However, a multitude of experts are involved in patient care, with different tasks or interventions performed by various professionals, who may have different goals for the patient. This can result in variation of care, including antibiotic use. For instance, diverse priorities are evident in the weighting given to different phases of the antibiotic decision making process between speciality groups. Despite a common overall approach, emergency department (ED) clinicians and surgical specialities emphasise immediate patient care and infection prevention, including initiating antibiotics (Broom et al., 2016a; Broom et al., 2017; Cortoos et al., 2008; May et al., 2014; Sedrak et al., 2017), whilst medical specialities focus on longer-term infection management concerns, including refining/reviewing of initial prescribing decisions and stopping antibiotics (Broom et al., 2016b; Eyer et al., 2016; Rawson et al., 2016).

> *"I think it's because the risk of a person getting an infection comes down onto them [surgeons] personally, not antimicrobial stewardship, not pharmacy, not ID, but them personally. So, if their patient gets an infection in a weeks' time, they're the one getting into trouble."* – Clinician, Australia (Broom et al., 2017)

Heightened awareness of sepsis and associated risks and complications culminates in urgency for surgeons and ED clinicians to commence antibiotics as soon as possible in anyone suspected of having an infection (May et al., 2014; Skodvin et al., 2015). In contrast, acute care medicine doctors report a common stepwise approach to the decision process surrounding acute infection management, whereby new information is constantly considered in the context of prior knowledge (Rawson et al., 2016) and the use of microbiology test results when selecting antimicrobial therapy is emphasised.

> *"You refine your likelihood of diagnoses based on every new quantum of information you get, so you start off with the physiological parameters, then your differential is refined based on blood results and further refined based on the microbiology."* – Specialist Trainee, UK (Rawson et al., 2016)

Different clinical teams can also have diverging opinions on guideline content and its requirements within the same hospital. For example, whilst surgical groups describe a strict interpretation of antibiotic guidelines (Cortoos et al., 2008), internal medicine doctors highlight that guidelines are incomplete by promoting a standardised, 'one-size fits all' approach to antibiotic prescribing (Broom et al., 2016b; Livorsi et al., 2016; May et al., 2014; Rawson et al., 2016; Sedrak et al., 2017; Skodvin et al., 2015).

> *"So, guidelines are guidelines, but at the end of the day, it still comes down to individualising patient care, and so sometimes those guidelines do not cover all the bases, and you still need to do what you think is best for the patient."*
> – Attending Physician, USA (Livorsi et al., 2016)

Most clinicians, irrespective of gender, type of setting and healthcare sectors, recognised the benefits of collaboration, including the availability of a second opinion in treating infections and support for the improved use of antibiotic prescribing guidelines. However, four studies reported that junior doctors experienced difficulties in negotiating prescribing decisions with multiple authoritative figures across various clinical teams (Broom et al., 2014, Broom et al., 2016b; Mattick et al., 2014; Rawson et al., 2016). Junior doctors perceived effective collaboration and support from other specialities as the facilitators in remedying deficiencies in practical knowledge of appropriate antibiotic prescribing. Key professional collaborators identified in antibiotic prescribing were microbiologists, infectious disease specialists and pharmacists.

> *"I find them [pharmacists] more involved in the fact of reminding you about antibiotics... I mean, there's a lot to remember, and I'm not bright enough to remember it all, so I'm quite happy for someone else to catch it for me and give me a little prod."* – Non-Consultant, Medical, UK (Broom et al., 2016a)

Infectious diseases specialists were recognised as helping hospital doctors in AMR prevention by promoting and encouraging the use of guidelines and appropriate narrow-spectrum antimicrobials during handover meetings and ward rounds (Björkman et al., 2010; Skodvin et al., 2015).

> *"Concerning antibiotic treatment, we follow a simple algorithm, but when things get complicated, we collaborate with the ID specialists and intensive care doctors, of course."* – Gastro-Surgery Consultant, Norway (Skodvin et al., 2015)

Participants in three studies reported clinical microbiology colleagues acting as an important communication channel in infection management (Mattick et al., 2015;

Rawson et al., 2016; Skodvin et al., 2015). Internal medicine doctors, in particular, described their services and advice as valuable and convenient to access.

> *"I think if it isn't clearly in the guideline or I am not sure, if it doesn't easily fit into the guideline, I am going to say [to my juniors], okay speak to microbiology and see what they think."* – Respiratory Consultant, UK (Rawson et al., 2016)

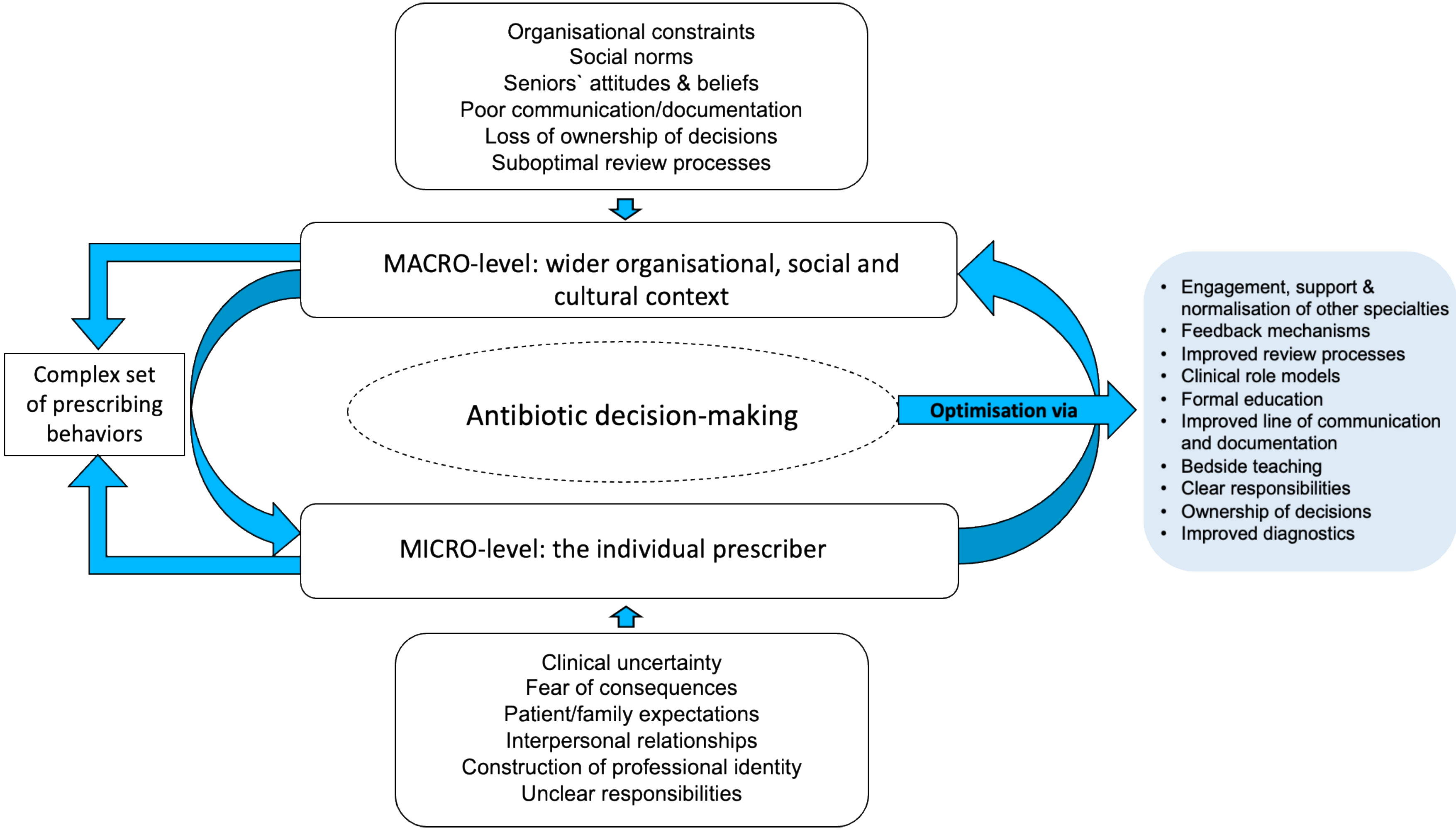
Although these experts were generally highly approved across medical and surgical fields, the relationship with them varied significantly depending on individual clinicians' interest in infectious diseases (Björkman et al., 2010; Broom et al., 2016b; Broom et al., 2017; Cortoos et al., 2008; Mattick et al., 2014). The presence of ward clinical pharmacists generated conflicting opinions. Most clinicians from medical and surgical groups (mostly male, representing different levels of seniority) described pharmacists as helpful in discussing and sharing rationales for antibiotic prescriptions and prompting antibiotic review and de-escalation (Broom et al., 2016a; Livorsi et al., 2015; Rawson et al., 2016). However, they were perceived by some participants (mainly male physicians from internal medicine) as interfering (Cortoos et al., 2008).

> *"Indeed, it is once again someone more bothering you."* – Internal Medicine Resident, Belgium (Cortoos et al., 2008)

3.3.5 Outcome of synthesis process (Phase 6)

From the translation of findings across the 15 papers, a new line of argument emerged. This final stage in the process of meta-ethnographic analysis enabled the development of a higher-order interpretation, that is, generation of a conceptual model drawn from, "but more than the sum of", the final themes (Toye et al., 2017, p. 16). Through team reflection and revisiting the original studies, it gradually became apparent that the four overarching themes overlapped. A more complex nuanced interaction between two micro- and macro-level dimensions of hospital antibiotic prescribing emerged. These two dimensions constantly and simultaneously interacted with each other producing multiple tensions for prescribers and formed the basis for the conceptual model (Figure 18).

Figure 18. Conceptual model depicting multi-dimensional nature of antibiotic prescribing in hospital settings



The model illustrates the multidimensional nature of hospital antibiotic decision making and reflects the array of pressures and dilemmas which need to be balanced by clinicians as they decide their prescribing action(s). This multidimensional nature of antibiotic decision making describes a complex dynamic. For every clinician, there will be a degree of interdependence between different factors influencing prescribing practice depending on their level of expertise and ability to tolerate risks for their patient and themselves. The illustrated elements, or factors, will form independent components on one level. However, they are not separate or discreet but constitute an integral part of a whole and will exert a degree of direct or indirect influence on prescribing decisions. These elements coexist, interact, and create a constant dynamic. Both macro (broader hospital structures, including the social norms, standards, and organisational constraints for human behaviour) and micro (individual behaviours) dimensions feature a complex interplay of influence, authority, and the pursuit of treatment goals.

The macro-level structures of hospitals provide the social and cultural setting for healthcare professionals to relate to each other, constantly shaping and influencing macro-level dimensions that drive individual behaviours and everyday practice choices and decisions. These influences go beyond guidelines and what constitutes evidence-based practice. Decisions around antibiotics are influenced by the perception of what represents an appropriate behaviour within professional hierarchies and a desire to maintain a sense of competence or professional reputation among peers. Senior colleagues are often perceived as ‘unquestionable’, and challenging their prescribing decisions is socially unacceptable. Influenced by various authoritative figures, junior doctors find negotiating antibiotic decisions difficult. These competing dynamics cause confusion and anxiety. The involvement of various clinical teams in patient care may result in a partial loss of individual accountability for collective decisions. Juggling an array of responsibilities in a busy hospital environment, lack of easily accessible and clear guidelines and scarce learning opportunities impede good antibiotic stewardship.

This unique and evolving dynamic leads to the creation of micro-structures of influence, such as the internalised logic of prescribing driven by fear of consequences (such as the patient deteriorating and losing professional credibility) that underpins antibiotic use and drives social interaction with colleagues and patients. The emerging consumerism culture and fear of patient complaints poses an additional pressure. Providing optimal care for the patient and improving their condition is a priority. Benevolence operates across all spheres of medical work and forms part of the professional identity. Prescribing broad-spectrum antibiotics is perceived as an act of kindness, and immediate patient improvement means ‘good doctoring’. The threat of AMR is an abstract or theoretical problem, which is not necessarily of imminent importance in a hospital setting. Understanding these multiple drivers of overuse on both micro- and macro-level is fundamental to developing sustainable interventions to optimise antibiotic use by hospital doctors.

3.4 Discussion

This review is the first to apply an interpretive meta-ethnographic approach and propose a conceptual model to understand the nature of medical antibiotic prescribing in acute hospitals. The exploration of the challenges to appropriate prescribing in hospitals revealed tensions and uncertainties in antibiotic decision making by doctors due to various complex organisational and cultural factors. Diversification of priorities between different specialities creates loopholes in the continuity of antibiotic care and treatment. This review indicates that the transition of patients between wards, busy work environment, high workload, poor documentation and communication, and the reluctance of junior doctors to question senior colleagues, all contribute to the partial loss of ownership of antibiotic decisions.

The concept of antibiotic decision ownership does not appear to be highlighted by previous reviews of hospital antibiotic prescribing. However, it can be argued that when health professionals have a sense of decision ownership, they become personally invested in clinical decisions made for their patients (Dubov et al., 2016). Although infection management and antibiotic decisions are inherently team-based and interprofessional in nature (Broom et al., 2015), findings from this ME show that stopping or de-escalating therapy is seen as the responsibility of the consultant or senior specialist. The disparity between expectations of junior clinicians to start but not review and/or stop antibiotics has been previously addressed in a realist review, which found there is lack of clarity around the specific roles and responsibilities that trainees undertake in relation to antimicrobial prescribing (Wong et al., 2015). Communicating an expectation for this group to gain active responsibility for prescribing decisions was suggested as a possible solution to overcome the issue. A recent observational study comparing antibiotic decision making in acute medical and surgical specialities at a London teaching hospital found that the loss of ownership occurred in the transition of care between the emergency department and inpatient teams (Charani et al., 2019). The ME findings confirm this is the case across different hospital settings and highlights the complexity that arises from each individual's responsibility for the collective problem of antimicrobial resistance being blurred.

Furthermore, this review has identified inconsistencies in the provision of information between specialities and healthcare professionals. The healthcare system heavily relies on patient medical records for communication and safe, effective care as patients move between wards and their care is handed over to different clinical teams when staff shifts change. Despite international efforts which suggest that clear documentation of decisions is a key principle in advancing patient safety and improving outcomes (CDC, 2019), the findings show poor documentation of prescriptions remains a barrier that leads to unnecessary continuation of antibiotics. The ME confirmed that clinicians often lack adequate information to make an appropriate decision as to whether to stop, continue or alter the treatment.

Some studies included in the review indicated that under clinical uncertainty, when an infection is suspected but not proven, the treating clinician will balance immediate clinical risks over long-term population risk. Although commencing antibiotics may benefit the individual, excessive use can increase future AMR and thus be detrimental to society, a situation known as "the tragedy of the commons" (Hardin, 1968, p. 1243). Considering the population implications of AMR at the bedside was viewed by clinicians as difficult. The ME demonstrated that in order to eliminate concrete clinical concerns, some clinicians adapt their behaviour accordingly to the culturally accepted norms of the hospital and choose an activity that is perceived as low risk at an individual level. This fear of consequences is heightened by the perception that being conservative in prescribing not being seen as good practice often leads to non-adherence to clinical guidelines (either broader spectrum or for longer duration than is clinically indicated), without any clinical benefit to individual patients (Krockow et al., 2019). Driven by fear of patients deteriorating, an individual's capacity to adhere to evidence-based practice may be diminished and antibiotic optimisation becomes an absent priority, whilst the risks of over-prescribing to the individual patient tend to be downgraded. This dichotomy between the care recommended in the guidelines and the care provided at the bedside has been reported in earlier works as "being on the safe side" (Walker et al., 2000, p. 275).

The ME further highlights the interpersonal nature of antibiotic prescribing and the associated difficulties in negotiating decisions with multiple authoritative figures, including the immediate clinical team and other specialties. Discord in interpersonal relationships was an influencing factor on prescribing decisions, at times leading to poor continuity of care. Inconsistent advice and misunderstanding of roles and responsibilities pertaining to antibiotic decisions posed additional barriers to successful collaboration. Challenging decisions of senior colleagues was perceived as unacceptable. The reluctance of junior doctors to question prescribing decisions can act as an obstacle to gaining a clear understanding of why prescribing choices differ (Wong et al., 2015). In such an environment, deferral to the opinion leaders can become the default mode of practice, suppressing valuable input from all members of the team. Yet, qualitative research suggests that doctors tend to feel drawn towards supportive teams and teachers who engage with or inspire them (Spooner et al., 2017). In environments where senior clinicians are approachable, trust in working relationships increases, allowing junior doctors to raise questions and thus close the communication gap (Bould et al., 2015; Friedman et al., 2015). Examples of good practice included the presence of a clinical pharmacist, infectious disease and microbiology colleagues on the ward, prompting the review of antibiotics and acting as effective communication channels.

A collaborative culture fostering a multidisciplinary approach and normalisation of the role of other specialists within the decision making process are crucial to aid improvements to antimicrobial stewardship (Chaves et al., 2014). This review demonstrates that the involvement from other specialties in decision making depends on the familiarity and acceptance of those colleagues by senior clinicians. Some junior doctors in these studies described managing interactions with other healthcare professionals as challenging. The 'unspoken' yet widely accepted rules on how to manage multidisciplinary dynamics mean that doctors face difficulties steering through the complex system of interrelationships with colleagues that could potentially provide them with assistance. Yet, turning to other specialities for advice can be a source of support outside the scope of medical hierarchy and the immediate clinical team, as junior clinicians experience less fear of appearing ignorant and attracting criticism (Papoutsi et al., 2017; Tallentire et al., 2011).

Although literature is still lacking with regards to the contexts under which junior doctors feel more able to challenge decisions effectively, quantitative evidence shows that the provision of feedback on the quality of prescribing and direct interaction with prescribers appear to have the most lasting impact on practice (Wagner et al., 2014). A recent Cochrane review on interventions to improve antimicrobial prescribing practices for hospital inpatients found that interventions that included feedback were more effective than those that did not (Davey et al., 2017). Findings of the ME complement the review by showing that creating effective feedback mechanisms and improving communication on prescribing practice has the potential to elicit behavioural change.

In addition, endorsements for the greater integration of other prescribing groups, including pharmacists and nurse prescribers within antibiotic stewardship efforts have already been highlighted by others (Olans et al., 2017). For example, lack of partnership with nurses can limit the success of antibiotic stewardship initiatives (Carter et al., 2018). Yet, this ME identified an absence of perceived or reported nursing involvement in antibiotic decision making. This may reflect perceptions about antibiotic prescribing as a process that requires increased knowledge only exclusive to medical professionals with prescribing powers (Castro-Sánchez et al., 2018), and the existing gaps in undergraduate and postgraduate education on antibiotics and AMR (Rawson et al., 2016a). Yet, it remains essential to maximise the contribution of existing professionals outside infection disease and microbiology towards appropriate use of antimicrobials (Edwards et al., 2011), especially in view of the most recent Nursing and Midwifery Council guidance highlighting that newly qualified nurses have to be prepared to undertake prescribing training soon after registration (Nursing and Midwifery Council, 2018).

Lastly, antimicrobial prescribing behaviours may vary significantly across different hospital types and be influenced by the types of patients admitted, prescribing patterns and the resources available. For example, a previous study using data gathered from a nationwide survey highlighted major differences in the available resources and implementation of AMS programmes between public and private hospitals in Australia (Cotta et al., 2016). Moreover, significant differences in antibiotic use remain across different hospital types. In adjusted models, the use of third- and fourth generation cephalosporins and anti-pseudomonal agents was lower in teaching hospitals (Goodman et al., 2020). Although doctors working in private hospitals acknowledged treating more 'aggressively' with broader-spectrum antibiotics when patient follow-up was uncertain (May et al., 2014), no major sector-specific drivers of doctors' prescribing behaviour emerged in the synthesis. These findings suggest that antibiotic prescribing across different countries and healthcare systems may be influenced by a similar set of cultural factors (Livorsi et al., 2015). However, given that most studies included in this synthesis were conducted in public teaching hospitals, such as in the UK, the developed model can only be claimed to be representative of that context.

3.4.1 Strengths, limitations and reflexivity

Locating suitable qualitative studies can be challenging (Booth, 2016) and small-scale qualitative research can be perceived as biased and lacking transferability (Trochim et al., 2016). However, the number of included studies in the synthesis (n=15) from seven countries reflecting a breadth of prescribing perspectives was sufficient for conducting ME (Campbell et al., 2011). The synthesis was carried out in a rigorous way, including a large range of databases and grey literature, with a continuous input from the experienced research team, undoubtedly reinforcing the credibility of the findings. All stages of the review were checked for accuracy and were grounded in the data by constantly checking the findings against the original studies.

The novelty of this ME is the generation of a higher translation that helps to understand the complexities of decision making in hospital antibiotic prescribing. Although the conceptual model cannot be claimed to be definitive and represent all healthcare practitioners, it offers a unique lens, through which the experiences of doctors can be considered. ME is an interpretative approach and the development of the conceptual model was informed by the review team's backgrounds and perspectives. Although the review was led by a novice researcher, the supervisory team had considerable expertise in synthesising qualitative research, including experienced health professionals and social scientists with an interest and experience in developing behaviour-change interventions, but none were medical prescribers. The main researcher (GW) had been previously involved in projects exploring hospital antibiotic stewardship, NR has extensive experience in conducting ME and is a co-author of the eMERGe ME reporting guidance. BW, CK and DW have experience in qualitative synthesis. The research was conducted in close affiliation with an NHS hospital trust with advisory input from clinicians during the project. However, it is likely that a different team may have interpreted the included studies differently.

There is currently no gold standard of appraising qualitative studies and including studies with poorly reported methods could produce ME findings which lack credibility (Toye et al., 2014). The critical appraisal was conducted using the CASP tool, but a different approach of judging the 'weight of evidence' of each paper may have been justified. To be included in the synthesis, studies needed to meet a certain degree of methodological transparency. This decision was appropriate as there were many methodologically transparent and eligible studies to review, and rigorously develop new interpretations and a line-of-argument. After creating the LOA, the developed interpretation and findings were compared against the papers excluded following quality appraisal (Almatar et al., 2014; Barlow et al., 2008). This strategy ensured that important insights have not been missed, thus eliminating potential bias. One study raised an issue relating to senior doctors' perception that inappropriate antibiotic prescribing outside guideline recommendations originates from junior doctors (Almatar et al., 2014). Although this perception did not feature in the analysis, including this paper would not have changed the final synthesis.

There is little published guidance on updating an ME and there is no set time interval after which an ME becomes out-of-date. Re-doing a new overarching ME or "knocking down and rebuilding the house" could potentially change the findings of the original ME (France et al., 2016, p. 5). To enhance the quality of the review, the database searches were updated in May 2021, identifying five papers (representing four studies) that met the inclusion criteria (Broom et al., 2018a; Broom et al., 2018b; Catho et al., 2020; Kajamaa et al., 2019; Morgan et al., 2018). However, on critically reading them, it became apparent that including these studies in the ME would have not refuted the findings but resulted in equivalent meaning. For example, these studies reported similarities in terms of concordance to guidelines (Broom et al., 2018b; Catho et al., 2020); medical hierarchy and interpersonal relationships (Broom et al., 2018a; Charani et al., 2019; Kajamaa et al., 2018); fear of consequences (Broom et al., 2018b; Charani et al., 2019), reputational risks (Broom et al., 2018a; Charani et al., 2019) and partial loss of ownership (Charani et al., 2019; Kajamaa et al., 2018). Study participants were also similar to those of the included studies – mostly internal medicine and surgery clinicians, representing a range of seniority and practising in public teaching hospitals across four countries: Australia (Broom., 2018a, 2018b), UK (Charani et al., 2019; Kajamaa et al., 2018) Switzerland and France (Catho et al., 2020).

Not all of the included studies reported details of participants' characteristics – including gender, ethnicity, level of training, length of experience – and some studies analysed data together for samples drawn from across different clinical settings and healthcare systems. Therefore, it was not always possible to fully identify disconfirming cases between papers or carry out a sub-analysis of different drivers of behaviour based on the sample characteristics and study context. Additionally, five included papers were published by the same researchers, and although the authors explored prescribing practices in two different countries (Australia and UK), the results may have inadvertently influenced the findings and synthesis (Broom et al., 2014; Broom et al., 2016a, 2016b, 2016c; Broom et al., 2017).

The exclusion of studies describing the views and experiences of healthcare professionals other than doctors, or where the study population included a mix of healthcare professionals, may be contested, and a more inclusive approach exploring more diverse perceptions across different clinical groups may have been warranted. However, given that doctors almost exclusively remain the key antibiotic prescribing group, it was vital to first understand their views and experiences of prescribing practice. The decision was also made to exclude low-income countries to ensure that the theory generated from synthesising primary studies reflected the function of ME and is relevant to the context and setting of the planned antibiotic intervention, that is, acute hospitals in well-developed healthcare systems. Including relatively homogenous studies helped strengthen the weight of the conceptual model.

Finally, to increase credibility of the review and ensure that the breadth and scope of the data were captured in the synthesis, findings were critically reflected upon through regular briefing sessions and workshops with key stakeholders (healthcare professionals involved in hospital antimicrobial stewardship and health service users), providing opportunities to develop and refine ideas and interpretations, and analysed using multiple theoretical perspectives (see Chapter 4). Although de-contextualisation of qualitative findings can be debated (Friberg et al., 2000), the quality and rigour of this review means that it is possible to apply the new conceptual model to a variety of clinical contexts and different groups of healthcare professionals.

3.4.2 Future practice and research implications

This ME highlights that there is a need to incorporate the influence of the micro- and macro-level elements in the design and delivery of future behavioural-change interventions to optimise antibiotic use in hospital settings. Addressing this complex interaction may be a contributing factor to finding future solutions to the ever-growing problem of AMR and reducing the fear of consequences from non-prescribing or stopping antibiotics. Finding new ways of discussing and questioning prescribing decisions between and within clinical teams may be one strategy to mitigate the negative impact of the loss of ownership of decisions and reduce failures in the provision of adequate information. In clinical practice, the influence of senior colleagues could be harnessed by creating role models who act as custodians of the professional agenda and create a supportive and open environment that fosters a culture of learning and feedback. The high-level findings presented in this analysis could be further developed for implementation in practice. The insights into doctors' conceptualisation of antibiotic use could also have implications for behavioural interventions in other settings, such as primary care or long-term facilities.

The findings in this study concerning the loss of decision ownership may be worth further empirical examination, with a large sample and across diverse populations. It would also be of value to investigate the diversity of opinions around the roles and responsibilities that junior prescribers should undertake in relation to antimicrobial prescribing and how to help overcome uncertainty and fear of consequences. Finding ways to communicate an expectation for this group may foster transfer of active responsibility down the hierarchy ladder. Moreover, there remains a gap in the research concerning the contexts under which junior doctors feel more able to challenge seniors' decisions effectively. Lastly, identifying and comparing inter-hospital factors associated with inappropriate prescribing across different sectors (private versus public, teaching versus non-teaching) will help direct future AMS efforts in specific settings. These areas warrant further investigation.

3.5 Conclusions

This novel ME extends the current evidence base by providing an understanding of the complexities of hospital antibiotic prescribing. The resulting conceptual framework has the potential to act as a basis for future antibiotic management interventions, exploring clinicians' internal logic of antibiotic prescribing behaviours beyond antimicrobial guidelines and evidence-based practice. Changing ingrained behaviours within a culture or an organisation is undeniably difficult. Yet, improving prescribing practices is essential to minimising the growing public health threat of AMR. It is particularly challenging in acute hospital settings due to the complex relationships between a wide range of stakeholders and multiple teams. Acknowledging this complexity and variability of the contexts and recognising the norms and the ways in which doctors learn to practise will facilitate that change. Healthcare stakeholders can draw on this evidence of how and why doctors make prescribing decisions to help design and implement more effective antibiotic stewardship interventions in secondary care.

Uncertainty is an unavoidable part of clinical practice and will inevitably persist across all the spheres of medicine. Thus, the key dilemma for policymakers and healthcare providers is how to place a higher value on non-prescribing or prescribing narrow-spectrum antibiotics, when available and efficacious, and eliminate a degree of fear while making decisions under uncertain conditions. This ME highlights the need for a more collaborative culture fostering ‘normalisation’ or routine embedding of the role of other specialists within the decision making process. The quality of inter-professional relationships between clinicians remains key to achieving this change. Reclaiming the *‘why’* may act as a positive force to shift the individual risk perceptions and have a positive knock-on effect on changing the hospital culture to open collaboration. This shift will require engagement from senior colleagues, managers, and opinion leaders to acknowledge the importance of maximising open dialogue in everyday clinical interactions.

Finally, the identified barriers and facilitators in this ME should guide the future choice of hospital antibiotic interventions to change the current practice (the ‘how’). An exploration of additional challenges not identified in the review and the description of the initial modelling of the prototype antibiotic intervention is provided in the next chapter.

Chapter 4: Exploring the views and opinions of healthcare professionals and health service users using focus groups – Study 1

4.1 Overview of chapter

The previous chapter of this thesis described a systematic review and synthesis process of qualitative evidence relating to antibiotic use in acute hospitals from the perspective of doctors. This chapter aims to fill the gaps in the existing evidence relating to the barriers and facilitators to appropriate antibiotic prescribing, validate that evidence, and thus inform the development of a behaviour-change intervention. This chapter describes a qualitative exploratory study, which forms the first empirical stage of the thesis. This qualitative study serves three purposes. First, to explore and assess healthcare professionals' perspectives of the developed theory of antibiotic prescribing derived from the meta-ethnographic work (Chapter 3). Second, to generate new ideas and model the key elements or features of a behaviour change intervention to improve antibiotic use in hospital settings. Third, to investigate the acceptability of the prototype intervention by health professionals involved in its delivery.

The first part of this chapter describes the design and conduct of the qualitative study, including study aims and questions, sampling strategy, data collection and analysis procedures. The second part forms a description of data analysis. The findings are then discussed in the context of the broader literature, and the implications for the development of an intervention to improve antibiotic use in acute hospitals are considered.

4.2 Rationale

The MRC Framework suggests that complex interventions have better chances of being effective if they are tailored to the target group and the local context (Craig et al., 2008). They should also be feasible and suitable for use in clinical practice. An active engagement with key stakeholders can help inform understanding of the human and social elements that may influence the uptake of the proposed intervention (O'Cathain et al., 2019). Therefore, a range of stakeholders were interviewed about their ideas related to the content, appearance and mode of delivery of an intervention. These were healthcare professionals (HCPs) who are the target group in delivering the intervention and health service users (members of the public) representing the target group for receiving the intervention.

To increase the study quality and ensure that it benefits patients and society, patient and public involvement (PPI) was considered crucial during the development stages. Active engagement of lay participants ensured that people with lived experiences contributed additional expertise and gave valuable and novel insights. It also enabled the identification of the strengths and weaknesses of the prototype intervention before proceeding to a full-scale evaluation. This approach ensured that the focus of the antibiotic intervention was not excessively 'academic' or purely driven by theory but has instead a practical application based on the interaction and feedback with the target group (Hoddinott et al., 2018).

4.3 Study aims and questions

This first empirical study was designed to fulfil three specific research aims. These are outlined below, along with the rationale.

Research Aim 1: To establish a conceptual foundation for the intervention

The primary aim of this qualitative study is to obtain a deeper understanding of HCPs' antibiotic prescribing processes and identify the contextual factors that influence their prescribing behaviours. This includes evaluating how HCPs conceptualise their internal antibiotic prescribing processes and the subsequent effect on their prescribing behaviours. The systematic review of this thesis (Chapter 3) has drawn robust conclusions about the barriers and facilitators to appropriate antibiotic prescribing and outlines priorities for addressing in a future intervention. However, for an antibiotic intervention to work in a real-world setting, a deeper understanding of the context in which the intervention will be used and which behaviours within that context are amenable to change was needed.

Research Aim 2: To generate new ideas around the content and delivery of the intervention

Careful development of the prototype intervention was necessary to optimise its adoption in clinical settings. This required generation of ideas regarding the intervention content, how it could be feasibly delivered and by whom. Consideration was also given to the content, format, style and the mode of delivery of the proposed intervention, behavioural influences and potential solutions to maximising its intended aims. The attitudes of clinical staff were also explored.

Research Aim 3: To explore potential issues surrounding the acceptability of a prototype intervention

O'Cathain et al. (2019) argue that in order to facilitate adoption and implementation when developing a complex intervention, it is important to explore the preferences of those delivering the intervention and the values of those receiving it. Therefore, a better understanding of the users' priorities, potential workflow challenges and interactions was needed before making final refinements.

Based on these research aims, the following questions were developed:

1. What are the barriers to, and facilitators of, appropriate antibiotic prescribing that have not been identified in the systematic review?
2. What form of delivery, content and appearance, are likely to motivate and direct behaviour change around antimicrobial prescribing?
3. What are the predicted acceptability issues of introducing a new antibiotic intervention into clinical practice?

4.4 Methods

Chapter 2 of this thesis has outlined the general considerations of carrying out qualitative research. Therefore, the following section focuses only on the methods and issues specific to this study. To ensure detailed reporting, the essential aspects of the study are reported using the consolidated criteria for reporting qualitative research (COREQ) (Tong et al., 2007), details of which are provided in Appendix 28.

4.4.1 Setting and sample

The setting for the study was two major acute adult teaching hospitals in Edinburgh, Scotland. The target group was HCPs involved in decision making around antibiotics, including doctors, pharmacists, nurses and hospital managers, and health service users (lay participants) who had received antibiotics in the past.

A purposive sampling of stakeholders was used, which involved identifying and selecting informants according to a set of different respondent characteristics (Creswell et al., 2011). Participants with varying levels, roles and responsibilities of antibiotic prescribing were recruited as they were expected to have potentially different views of prescribing practices. The sample was chosen according to the following criteria: age and years of experience, gender, speciality, education, clinical area, and level of involvement in decision making around antibiotic prescribing. Snowball sampling, also known as 'chain-referral sampling', was also employed (Silverman, 2013). Encouraging participants to share the link to the study information with potentially eligible HCPs was an efficient and cost-effective way to access people who would otherwise be very difficult to find. The inclusion and exclusion criteria for the study are outlined below.

Inclusion criteria:

- Healthcare professionals of any age, gender, speciality, discipline, or level of experience currently working in an acute hospital
- Former in-patients who had previously received antibiotics
- A researcher with prior experience of working on behaviour-change interventions
- Adults (>18 years)

Exclusion criteria:

- Individuals who have no fluency in the English language or lack the capacity to consent to research
- Other hospital workers (e.g., porters, administration staff)
- Current in-patients

4.4.2 Recruitment process

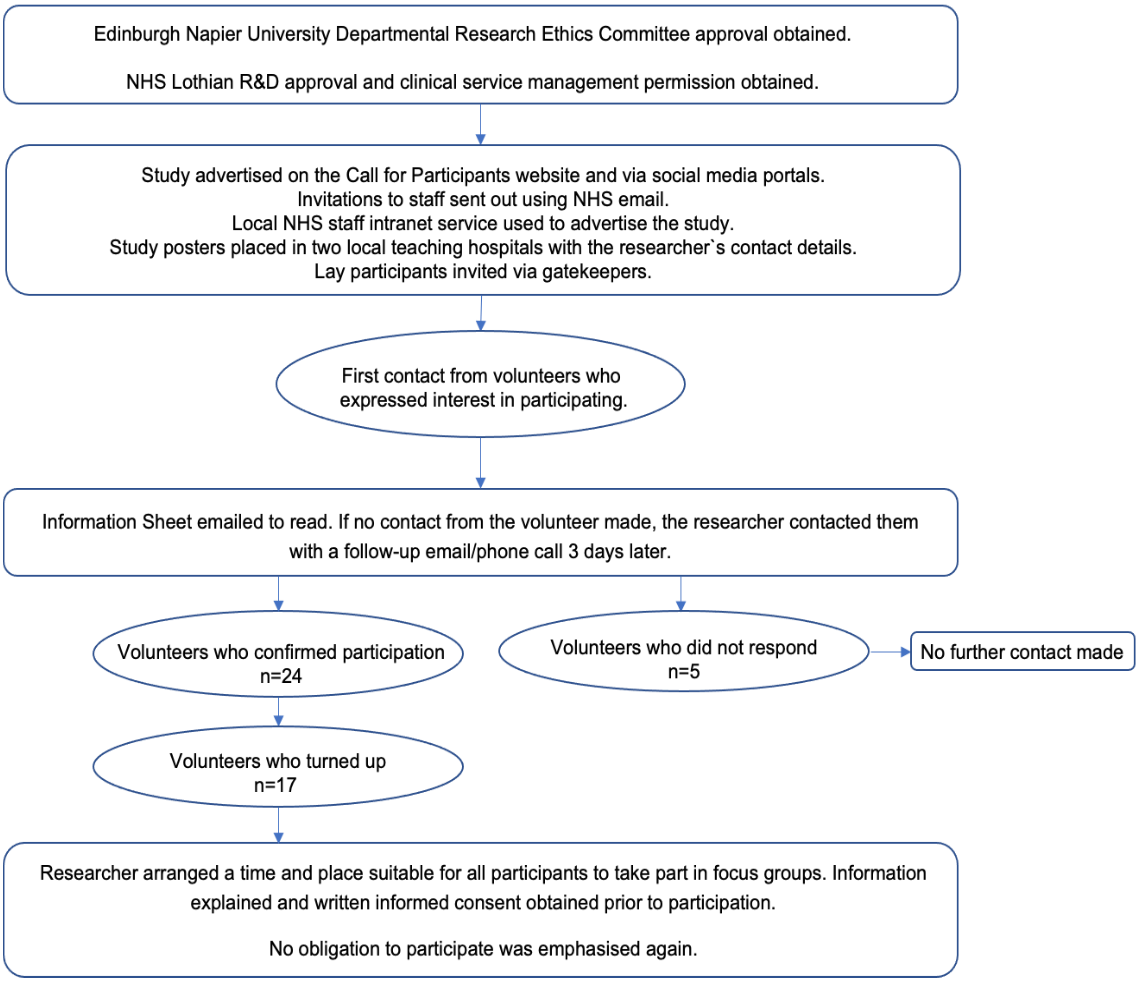
There was no direct patient contact at any stage of the study, and NHS Research Ethics Committee REC approval was not required. However, R&D Clinical Governance Board approval had to be obtained. Once the clinical service management permission, NHS R&D, and the University Research Committee approvals were granted (Appendices 2 and 3), recruitment started.

The recruitment process (illustrated in Figure 19) was initiated by first approaching and discussing the study with the clinical managers and charge nurses from two major city hospitals in Edinburgh practising in a variety of settings, including intensive care units, accident and emergency department, surgical, medical and respiratory wards. A range of recruitment approaches was employed, including NHS Intranet advertisements, mass internal emails and study posters placed in staff offices (Appendix 29). The participants were also recruited using a purposeful online method, such as antibiotic-related Twitter pages, forum groups, and other social networking sites. Lastly, the study was registered on a certified research recruitment website.

Lay participants were contacted using the gatekeeper recruitment strategy. The local hospital Patient Advisory Service representative was contacted via email and sent an overview of the research protocol. Next, the founder of the Critical Care Recovery website was approached for permission to contact potential participants. These two gatekeepers initiated contact with their network and helped the researcher arrange a convenient time for participants to take part in the study.

Volunteers who contacted the researcher and expressed interest in taking part in the study were emailed the Information Sheet with the researcher's contact details (Appendix 10). If no further contact was made from the volunteer, the researcher contacted them three days later with a follow-up email to ask if they would be willing to participate. No further contact was made with volunteers who did not respond to the follow-up email (*n*=5). Volunteers who confirmed their participation were recruited for the study (*n*=24). No financial incentive was offered for participation in the study not to influence participants' motivation for taking part (Seidman, 2019). However, there was an option for participants to be reimbursed for travel expenses.

Figure 19. The recruitment process for Study 1



Nevertheless, the recruitment process was not straightforward, and some challenges were encountered. For example, the intention was to recruit a maximum of 12 participants per focus group (FG). This sample size is representative of the FG methodology applied in other settings (Carlsen & Glenton, 2011). The initial response rate was high, and participants were overrecruited in anticipation of a 10-20% 'no show' rate (Flynn et al., 2018). However, seven out of 24 respondents who confirmed their participation in the study did not attend. There were nine and then eight participants in the first and second FG, respectively, but only four in the third FG. Although the number of participants was smaller than planned, it allowed the researcher to explore their views in more detail, resulting in the added benefit of making the discussion more meaningful.

4.4.3 Participant characteristics

A total of 17 participants took part in three focus groups held between April and July 2018 – 14 HCPs and three health service users. The sample comprised of 10 females and seven males, all between the ages of 29 and 68. Healthcare professionals were recruited from two Scottish Health Boards and had a varying level of experience from more than five to more than 30 years. All participants specified their ethnicity as white except for one, who described it as mixed (white Asian).

Sample characteristics are presented in Table 10. These were two consultant physicians, two microbiology consultants, two clinical pharmacists, three advanced nurse practitioners (ANPs), five nurses practising across a variety of disciplines, including infection prevention, surveillance and control, clinical research management, nurse prescribing and university lecturer, and three health service users. To ensure anonymity and confidentiality, all participants were assigned pseudonyms.

Table 10. Focus groups sample characteristics (Study 1)

FOCUS GROUP 1 (April 2018)				
Name	**Age range**	**Ethnicity**	**Job title / Specialty**	**Years of clinical experience**
1. Mary	40-49	White (other)	Infection Surveillance Nurse	21-30
2. Cameron	30-39	White Scottish	Advance Nurse Practitioner Critical Care	11-20
3. Lydia	30-39	White Scottish	Senior Pharmacist	5-10
4. Hannah	30-39	White Scottish	Advanced Nurse Practitioner Hospital at Night	5-10
5. Anna	30-39	White Scottish	Nurse prescriber / Lecturer	11-20
6. Julia	50-60	White Scottish	Advanced Nurse Practitioner Hospital at Night	> 30
7. Bruce	> 60	White Scottish	Lay participant – retired professional	N/A
8. James	> 60	White Scottish	Lay participant – retired professional	N/A
9. Alice	20-29	White Scottish	Lay participant – researcher	N/A
FOCUS GROUP 2 (May 2018)				
1. Douglas	30-39	White Scottish	Consultant Microbiologist	11-20
2. Joanna	50-60	White English	Clinical Research Nurse Manager	> 30

3. Warren	50-60	White Scottish	Infection Prevention and Control Senior Nurse	> 30
4. Emma	50-60	White (other)	Clinical Pharmacist	5-10
5. Paula	30-39	White English	Consultant Physician Acute Medicine	11-20
6. Julia*	50-60	White Scottish	Advanced Nurse Practitioner Hospital at Night	> 30
7. James*	> 60	White Scottish	Lay participant – retired professional	N/A
8. Alice *	20-39	White Scottish	Lay participant – researcher	N/A
FOCUS GROUP 3 (July 2018)				
1. Matt	40-49	White Asian	Critical Care Consultant	21-30
2. Daniel	40-49	White Scottish	Consultant Microbiologist	21-30
3. Olive	30-39	White English	Infection Prevention and Control Nurse	21-30
4. Joanna *	50-60	White English	Clinical Research Nurse Manager	> 30

***Participants who attended previous FG**

4.4.4 Data collection procedure

The chosen data collection method for this study was focus groups (FGs) using semi-structured interview topics, the rationale for which is provided below. To avoid repetition, a more detailed account of the methods used and the considerations involved are outlined in Chapter 2 (Section 2.7).

Focus groups have been extensively used in health service research to explore the perspectives of HCPs and patients. The methodology is most suitable when the purpose of the study is to examine factors related to complex behaviours (Barbour, 2018). As a research method, focus groups are valuable for the following reasons. They offer the researcher a means of gaining deeper insights into diverse views that people have about a specific issue and how they interact with and discuss the issue (Holloway & Galvin, 2016). The Medical Research Council recommends using FGs to explore barriers and facilitators in the preliminary phases of intervention development (Craig et al., 2008). Methodologically, FG discussions tend to involve a group of participants who come from similar social or cultural backgrounds or have similar experiences or concerns about a phenomenon of interest (Liamputtong, 2011). However, as opposed to individual interviews, FGs do not aim to reach an agreement on the topic being discussed. Still, they offer a unique opportunity to understand the participants' meanings and interpretations of the research issues (Hennink, 2014).

In total, three focus groups were conducted, each lasting about 90 minutes. Before each session, participants were given written information and briefed verbally about the nature and aims of the study. They were also informed of their right to withdraw from the study at any point. Informed consent was obtained from all participants. Each FG started with an introductory round and the setting of ground rules. With participants' permission, routine demographic data, such as their age, gender, speciality, and years of experience, were collected. The sessions were recorded using a digital voice recorder and transcribed verbatim (typed out, word for word) for the analysis. Light refreshments were provided.

For the pragmatic reason of convenience, and in anticipation of recruitment difficulties in gaining access to busy HCPs, focus groups were held at their workplace. In order to ensure that participants felt relaxed, the sessions were conducted in a quiet, private room, where the conversation could not be overheard or disturbed. The researcher assured participants that she would not reveal any information gathered during FGs and that their confidentiality and anonymity would be maintained at all times. To ensure privacy, the researcher placed an 'engaged' sign on the door but explained to the HCPs that they could still be contacted. The drawback of conducting FGs in the hospital setting was that an interview could be interrupted at any time. This posed a minor problem in the third FG as one senior clinician was called to return briefly to the clinical area.

In keeping with the reflexivity considerations (described in detail in Chapter 2, Section 2.7.3.3), the researcher wore smart casual clothes, remained calm and used her interpersonal skills to establish a rapport with participants. At the start of each session, the researcher explained her background in critical care nursing. She also assured participants that no judgement would be imposed on their answers. The researcher, who had prior experience in facilitating focus groups, acted as a moderator and her academic supervisor (CK) as an observer. The researcher encouraged interaction between the participants and ensured that their opinions and subjective experiences were explored in relation to the research objectives. The observer took notes during the discussions and ensured that the researcher did not overlook any participants trying to contribute to the discussion. A summary of participants' views was used at the end of each session to check for accuracy. The researcher and observer debriefed and exchanged their preliminary impressions after each session.

The interview topic guide (Appendix 30), piloted prior to use and subsequently modified, was designed in a semi-structured format to cover the research questions. The questions covered participants' views of the generated theory relating to the key challenges of antibiotic use in the hospital setting, their experiences of prescribing/receiving antibiotics, their opinions and preferences for the content, format/mode of delivery of a possible antibiotic intervention, and the issues surrounding its acceptability. Their views regarding behaviours and points of communication that would be most amenable to change were also discussed. Some questions from the topic guide were rephrased and adapted to the issues raised during the group discussions. For example, the discussion around de-escalation (stopping) of antibiotics highlighted participants' concerns about sub-optimal antibiotic review processes. In the subsequent FGs, the issue was explored with other participants in more detail.

To maximise each participant's contribution during FGs, the researcher employed a range of individual and group activities to encourage people to express their views and determine their priorities. She also drew on the principles of the 'premortem' approach, a simple and cost-effective technique of brainstorming, which uses prospective hindsight to guide participants to "look back from the future" and thus help identify why an intervention may fail before introducing it into the real-world setting (Klein, 2008, p. 103). The general format of the FGs was as follows: introduction and explanation (using a PowerPoint presentation), individual idea generation (using stickers), sharing ideas (using flip charts), discussing ideas, and voting and ranking ideas (a group exercise using flip charts).

4.4.5 Pilot focus group

To refine the final study design, a pilot FG was conducted. The pilot offered an opportunity to check for clarity of the research aims, test the topic guide and refine research questions, investigate procedural elements of the study to ensure its validity, and finally provide the researcher with practical experience in the role of the moderator (Wray et al., 2017).

The invitation to attend the pilot was sent within the University department using internal email. Nine people participated in the pilot, including five experienced researchers (all senior female lecturers) and four novice PhD researchers (four females and one male), all with a healthcare and/or social science background. The session took place at Edinburgh Napier University in March 2018. For the pilot to be meaningful to the participants, the topic was explained in lay terms. The session lasted approximately 60 minutes. A possible limitation is that the sample constituted academics who were not necessarily familiar with antibiotic prescribing, therefore not representative of the population studied. However, the feedback received was invaluable and facilitated a critical reflection and re-evaluation of the study design.

In terms of the methodology, the main issue that emerged was the lack of clarity around study aims and the presented theory. Subsequently, minor adjustments were made to the style and format of the discussion. The presentation length was shortened, the wording altered to increase clarity and the topic guide modified for greater efficacy whilst ensuring the objectives remained the same. The pilot also facilitated the identification of unanticipated issues, such as how to manage silences and the potential lack of engagement from participants. Undertaking this exercise provided the researcher with important experiential learning about the research process and offered an opportunity to consider the strengths and weaknesses of using the FG method.

4.5 Data analysis

This section describes the data analysis process. The data from the three FGs have been analysed together, summarised in relation to each research question, and discussed in the context of relevant literature. The future implications for developing an antibiotic intervention are also explored.

Using NVivo (Version 11) analysis software, the data were organised according to emerging categories and analysed using Framework Analysis developed inductively. Framework Analysis is a method for creating a new structure of the data through a process of grouping codes into clusters around similar concepts and ideas (Ritchie & Lewis, 2013). The purpose of this study was to identify patterns, check the meaning and potential issues of using the intervention rather than to explore clinicians' views and experiences around antibiotic prescribing inductively. Therefore, the analysis was appropriately descriptive at this stage as a more in-depth conceptual approach would not have been appropriate or useful for the purposes of intervention refinement. However, some questions required deeper analysis. Repeated reading and comparison of responses allowed identification of any emerging issues until data saturation was reached and no new information emerged. The phases of Framework Analysis (previously outlined in Chapter 2) were as follows.

Step 1. Data familiarisation

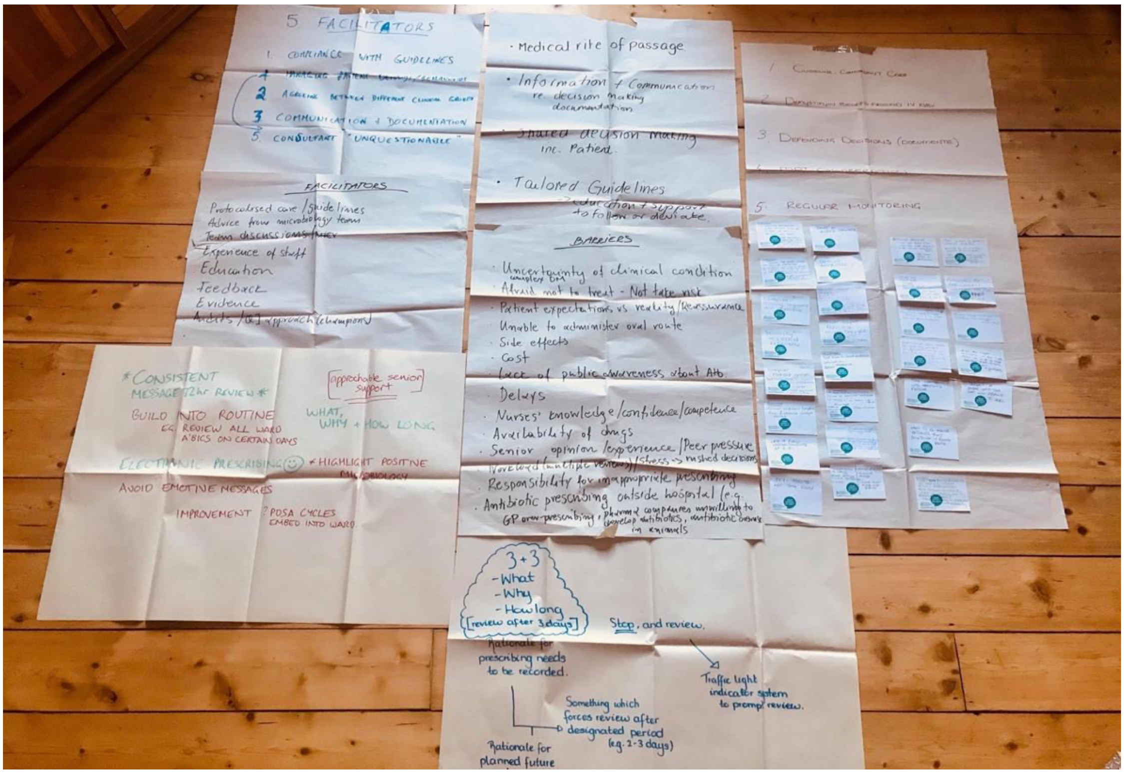
Once the recordings were transcribed verbatim, the researcher read the transcripts repeatedly to check for errors and ensure the accuracy of the transcription. This exercise allowed 'immersion' in the data. Transcripts had large margins and line spacing to facilitate later coding and noting ideas and were supplemented with notes made immediately after the FGs. Emerging concepts were presented to the supervisory team and checked to ensure that they related to the research questions.

Step 2. Identifying a theoretical framework:

After familiarisation and reading the transcripts line-by-line, the researcher applied labels (or codes) that described what she interpreted as important or relevant to the research question. These codes referred to specific behaviours (e.g., veering off guidelines), values underpinning certain statements (e.g., belief in the importance of person-centred prescribing), attitudes (e.g., defensive prescribing) and emotions (e.g., fear). This stage was predominantly focused on the classification of all the data to be compared systematically across the whole data set. Coding line-by-line alerted the researcher to consider the voices of lay participants specifically, which may have remained invisible as they did not ‘fit’ the existing set. Examining connections and deviations in the data challenged the developing analysis and consequently made it more robust.

Ideas generated during FGs were initially organised using a hands-on approach to allow the iterative development of codes (Image 2). After coding the first few transcripts, the codes were reviewed and then applied to all subsequent transcripts, and a tentative thematic framework was identified. Using NVivo was particularly useful at this stage as it sped up the process and ensured that data could be easily retrieved at later stages. Devising and refining the analytical framework was repeated several times until no new codes emerged. This process was guided by the recurrent key issues and concepts and by addressing the themes identified from *a priori* research questions.

Image 2. Initial categorisation of ideas generated during FGs



Codes were then grouped into themes and sub-themes using a tree diagram to create a working analytical framework. The purpose of this exercise was to sift and sort the data. While the development of the initial coding framework was a process of trial and error, it soon became apparent that it was a false start. Some of the initial categories, such as ‘resource constraints’, ‘poor documentation’, ‘guidelines’ and ‘suboptimal review processes’, were too specific or overlapping and needed to be broader to reflect the complexity of the data. After going back and forward, the categories were collapsed and organised under ‘barriers and enablers to appropriate antibiotic prescribing’. The developed coding framework was checked by the supervisory team, and further refined. It consisted of 12 codes (sub-themes) clustered into four categories (themes). The final version of the analytical framework used to index the data is presented in Table 11

Table 11. Coding index (Study 1)

Themes and sub-themes
1. Barriers to appropriate antibiotic prescribing
1.1 Physical environment
1.2 Social context
1.3 Individual barriers
2. Enablers to appropriate antibiotic prescribing
2.1 Organisational
2.2 Behavioral
3. Lay participants’ voice
3.1 Person-centred prescribing
3.2 Value of listening
3.3 Shared decision making
3.4 Relationship-building
4. Proposed components of the antibiotic intervention
4.1 Target population and behaviour
4.2 Key elements and features
4.3 Aspects of implementation

Step 3. Indexing

Once a thematic framework was developed, it was systematically applied to each transcript using the existing categories and codes. The researcher worked through the transcripts, highlighting a block of text and then assigning it or simply 'dragging and dropping' it into the relevant category of the framework (Table 11). The researcher worked through the entire transcript in this way. Excerpts that fitted into multiple categories or did not neatly fit were discussed with the supervisory team until agreement was reached, resulting in further refinements of the framework. A separate table was then created using Microsoft Word software, and data corresponding to the key categories were located and inserted under a specific thematic heading (Appendix 31).

Step 4 & 5. Charting, mapping and interpretation

Finally, the data were organised into a more manageable format, and a spreadsheet was used to develop a matrix of barriers and enablers to optimal antibiotic use. The descriptive summaries of the indexed data were then 'charted' into the matrix so that all data could be visualised as a whole (Appendix 32). The purpose of this stage was to go beyond organising the data to make sense and aid understanding of the developed concepts. This was a process of rearranging the data to create order and required reduction of the data while ensuring that the original meanings of the participants' words were retained. A schematic diagram was created at this stage to guide interpretation of the data (Appendix 33). Through regular meetings, findings were reviewed and discussed, providing opportunities to establish patterns and relationships between themes and subthemes and further develop and refine ideas and develop a final framework. This process was reflective and iterative, requiring continuous referring to the original data and then altering the mapping and interpretation of the data accordingly. This process went beyond surface-level description to a more in-depth conceptual analysis.

4.6 Results

This section provides a descriptive account of the results of the focus groups with HCPs and health service users. The results converged under four overarching themes summarised in Table 12 and illustrated using a concept map (Appendix 34). The discussion below focuses on these themes with exemplar quotes.

Table 12. Summary of the key findings (Study 1)

THEME	KEY FINDINGS
Barriers to appropriate antibiotic prescribing	• High workload, fragmented processes, limited resources, poor-quality documentation and patient handover, fragmented/ outdated IT systems and lack of patient follow-up pose challenges to the continuity of care. • Variability of practice between specialities/areas considered an issue. • Low priority given to antibiotics. • Lack of motivation to review antibiotics. • Transfer of patients between wards and number of HCPs involved in patient care diffuse individual responsibility for antibiotic decisions. • Taking responsibility means taking the blame. • Hierarchical structures and fear of criticism hinder open discussions about antibiotics. • Lack of feedback on prescribing barrier to learning. • Fear of litigation/patient deterioration drives defensive medicine. • Knowledge deficits due to gaps in training. • Invisibility of long-term effects of antibiotics.
Enablers to appropriate antibiotic prescribing	• Multidisciplinary approach improves communication around antibiotic decisions. • Input from other specialities (pharmacy and microbiology) considered important. • Clear documentation and a thorough antibiotic review enable continuity of care. • Evidence-based guidelines improve compliance. • Tailored recommendations considered helpful. • Need for more training/education on antibiotics in the curriculum. • Normalising questions around antibiotic prescriptions perceived as key. • Cultural change needed to open conversations on antibiotics.
Lay participants' voice	• Importance of engaging patients in decision making about antibiotic therapy. • Trust, relationship-building, communication and information provision considered crucial to shared decision making. • Active listening to patient concerns key to promoting mutual understanding/facilitating diagnosis in ambiguous situations. • Nurses viewed as best placed to establish trust with patients.
Proposed components of the antibiotic intervention	• Target population: all hospital HCPs involved in everyday antibiotic decision making. • Target behaviour: improved antibiotic review practice. • An electronic system for improving transparency, communication and documentation of decisions, integrated into routine practice. • A range of elements and features suggested, including regular prompts and triggers, traffic light system, and generation of reports (outlined in Table 13). • A system that reduces the 'hassle factor'. • Utilise Antibiotic 3+3 message: 'what, why and how long + review after 3 days'. • Discussion with the patient/family integral part of the intervention. • Engagement from senior clinicians considered essential to improve uptake and implementation. • Involvement of nursing and pharmacy staff key in intervention delivery.

4.6.1 Barriers to appropriate antibiotic prescribing

When asked specifically about any factors that, in their view, could hinder or promote appropriate prescribing behaviour in a hospital setting, participants discussed many issues that they felt created gaps in the antibiotic decision making process. The reported barriers are discussed below.

4.6.1.1 Physical environment

At the structural environmental level, the key barriers identified during the FGs were related to daily stressors. Participants spoke at length about their work schedule and time being limited in clinical practice due to high workload, fragmented processes and limited resources. As demonstrated by the excerpts, rapid patient turnover and quick ward rounds pose challenges to the continuity of patient care:

> *"They [doctors] do not have time to do anything, nothing, 'cause I've worked for them. It's not that they're ineffectual. They just do not have any time to do anything practical that would be of benefit on the care of patients."* – Mary, Infection Surveillance Nurse [ISN], FG1

> *"I want a decision. Have you got around this bay yet? We're gonna have to move this patient without you seeing them or halfway through seeing them."* – Paula, Consultant, Acute Medicine [AM], FG2

Participants in FG1 described marked differences across settings, shifts and priorities between specialities, highlighting practice variability.

> *"It's variable between specialities. Like Mary said, stroke are very good, as are respiratory. There's always a plan there. And other areas, it'll just say, 'de-escalate antibiotics' without an actual level or plan about what they want to go to. So, it's variable."* – Hannah, ANP, FG1

Another participant stated:

> *"My experience was that whoever's prescribing the antibiotics may have done a different prescription depending on how well they understood and knew the patient. And you don't really have time for that, unfortunately."* – Cameron, ANP, FG1

Some participants described that during nights and weekends, care is provided by more junior prescribers with limited senior medical cover and support. According to

ANPs, information handed over to the next shift is not always acted on or followed up by the subsequent clinical team. For instance:

> *"But it's probably the most frustrating part of it all from our role is no matter what you do at night, it's not always taken forward in the morning."* – Hannah, ANP, FG1

> *"And some of that's due to staffing levels and, you know, it's the weekend, and you don't have dedicated medical cover at your hospital at weekend team, or hospital at night team."* – Julia, ANP, FG1

There was a general agreement that frequent transfer of patients between wards and the number of professionals involved in patient care impede the individual's ability to take responsibility for prescribing decisions.

> *"One of the problems with having too many specialists involved is that sometimes, no one knows who the decision maker is. The responsibility gets diffused."* – Paula, Consultant, AM, FG2

> *"… So, who's making the decision, 'cause technically it's one team and another team. And there's that bit of, you know, kind of potentially cross purposes around do we continue, do we stop?"* – Anna, NP, FG1

Another participant added:

> *"I think there is a lack of ownership, and that often prevents a decision being made timeously."* – Julia, ANP, FG1

This 'diffusion of responsibility' can be exacerbated by poor documentation of antibiotic decisions and inconsistencies in the monitoring and treatment plans. Participants in FG2 and FG3 expressed apprehension regarding reviewing antibiotic prescriptions when the information is disjointed or the reasons for prescription are not documented, clear or easy to find.

> *"That decision is maybe not documented very well, you get to the review the next day, it's often a different team two days, three days down the line, you're on a different ward, the reasons for the decision aren't completely clear, and the downstream team have a fear then of changing that decision and being the one to make a mistake themselves."* – Douglas, Consultant Microbiologists [CM], FG2

> *"There's no documentation of what they have reviewed. Yes, we stop them, yes, we don't, yes, we change them. It's confusing!"* – Daniel, CM, FG3

Another participant commented:

> *"I think part of the confusion sometimes seems to be that the information is in various different places."* – Warren, Infection Prevention and Control Nurse [IPCN], FG2

Participants in FG1 described how others deviating from antibiotic guidelines without providing reasons for doing so generates uncertainty and ambiguity for the prescriber. Fragmented or outdated IT systems within the organisation pose additional challenges.

> *"In my experience, the barriers to that are technological. It takes so long to log on to the system as a personal user."* – Lydia, Pharmacist, FG1

> *"In software and hardware that is 15 years old, to log into a system which doesn't connect to Wi-Fi, to scroll back through 15 pages of previous people's notes to find a one-line entry which probably doesn't exist."* – Cameron, ANP, FG1

4.6.1.2 Social context

Participants in FG1 discussed the impact of interprofessional relationships on decision making and the nature of hierarchical structures in the hospital. There was an emphasis on the lack of acceptance of showing discomfort with the embedded practices. This social expectation of non-interference with colleagues' decisions hinders open discussions of antibiotic prescriptions.

> *"The hierarchy can be an obstacle, basically."* – Hannah, ANP, FG1

> *"There are places that historically a consultant will like a certain type of antibiotic. And their juniors will have to prescribe it even though they know it's off [guidelines], or they'll just get it in the necks."* – Mary, ISN, FG1

> *"These poor juniors who are just out of university and they're like, 'Ah well, I'll just do it.' Questioning's not worth their hassle."* – Anna, Nurse Manager [NP], FG1

As the excerpts below illustrate, prescribers adapt their behaviour depending on the environment and its conditions. Maintaining good relationships depends on complying with the "status quo" and respecting the social ranks in daily practice.

> *"I still hear when I'm around: 'well, I better do that just in case, 'cause so and so's on'. Continuing the trends, continuing the status quo and trying to fit in with seniors' specific preferences."* – Matt, Consultant, Critical Care [CC], FG3

The majority of senior clinicians acknowledged that it could be intimidating for junior prescribers to raise questions or override their decisions for fear of being criticised in front of their colleagues.

> *"The juniors often feel intimidated."* – Matt, Consultant, CC, FG3

> *"I don't get angry with them [junior prescribers] because they've prescribed something random, because someone has a culture that actually appears to be fine. I just explain, don't treat the culture, treat the patients."* – Paula, Consultant, AM, FG2

Participants in FG1 and FG2 pointed out that a lack of rationale sharing impedes learning and leads to bad prescribing habits. However, some ANPs and nurse prescribers believed that the issue often originates with the senior clinicians. They talked about the perpetuating lack of interest and blasé attitude towards antibiotics, with low priority status on reviewing prescriptions.

> *"Always this, 'Well we'll review it again tomorrow'. And then actually it's still not, and then you think, 'Oh well we've seen them, but we'll consider that idea over then, we'll come back to it tomorrow'. And actually, it doesn't quite always happen as timely as you want it."* – Anna, NP, FG1

In contrast, some senior clinicians highlighted that low motivation to review antibiotics is associated with the lack of feedback on prescribing.

> *"So, the motivation then is about you reviewing, and the reviewing bit shifts continuity of the care in real-time, and feedback is a major issue."* – Matt, Consultant, CC, FG3

4.6.1.3 Individual barriers

The discussions across the focus groups revealed that clinicians often practise defensive medicine to reduce the possibility of patients complaining or even taking legal action. Senior clinicians, in particular, described how fear of litigation is the primary driver of inappropriate prescribing. They talked at length about how the need to treat patients has become emotionally charged due to recent high-profile public malpractice claims.

> *"Take the Bawa-Garba case, for example. The female doctor was on her first day in a new job…and she's been hung out to dry. They didn't diagnose sepsis in time. It was the delay in antibiotic prescribing. And that sort of thing makes the junior doctors throw antibiotics around on their first day in a new job when they're too busy, and everyone else is off sick, and their consultant isn't there."* – Paula, Consultant, AM, FG2

Some participants expressed the view that the possibility of being reported to the governing body for malpractice and consequently losing the profession far outweighs the fear of a patient dying.

> *"They [junior doctors] are less afraid of the patient dying than they are of being reported to the GMC. That's just it. So, actually, fear of losing their profession is potentially even higher than losing a patient."* – Matt, Consultant, CC, FG3

> *"I think I'd more worry about a governing body, the GMC, rather than a kind of public."* – Douglas, CM, FG2

A lay participant commented:

> *"There is no longer the belief that teachers and doctors are infallible. And that's why the litigation is an issue in America, and it's becoming true here."* – James, LP, FG1

Participants in FG2 talked about how assuming responsibility for an antibiotic decision means taking the blame for the consequences.

> *"It's a big judgement call as well, isn't it? And who is willing to take this responsibility and perhaps take the blame for the decision?"* – Emma, CP, FG2

In the context of clinical uncertainty, participants across the focus groups described a tendency to be overcautious in a litigious environment and avoid unnecessary risk. Patients demands and expectations pose additional pressure. For example:

> *"I've been once threatened by a patient with a lawsuit because I didn't want to give antibiotics. He felt that he needed it."* – Hannah, ANP, FG1

This urgency to initiate antibiotics is driven by a heightened awareness of sepsis amongst the public and professionals.

> *"Sepsis publications and Sepsis 6 drivers, and sepsis campaigns, and the sepsis three definitions, they have far more press bizarrely than the antibiotic apocalypse. Plus, the effects are far more immediate."* – Matt, Consultant, CC, FG3

Listening to participants' voices across the focus groups, 'doing something' was perceived as easier in practice than watchful waiting. A senior consultant further elaborated on this point, explaining that choosing not to prescribe antibiotics creates more work for the clinician.

> *"The action of not prescribing involves two things. One, you have to justify yourself by writing even longer screeds in the notes, as opposed to clicking boxes of why you don't think you should prescribe. And two, the inaction of not prescribing probably may dictate a more frequent review."* – Matt, Consultant, CC, FG3

Stopping or de-escalating antibiotics was predominantly deemed a senior medical responsibility. It was viewed as a skill that requires knowledge and experience as it can lead to patient deterioration.

> *"It can be more difficult, I think, to stop it than to start."* – Cameron, ANP, FG1

> *"I'd say it's more of a judgement call to stop an antibiotic than to start it."*
> – Douglas, CM, FG2

> *"Yeah, sorta scaredness comes into it, 'cause you don't want to set them back by stopping it."* – Joanna, NM, FG3

While views diverged on the prescribing focus between medical and ANPs' training, there was consistency in the belief that some staff groups are "disempowered" regarding antibiotics and "struggle with the basics". The identified knowledge deficits were seen to be due to gaps in undergraduate medical training.

> *"I think it's very dependent on the group of staff that you're working with…there is hardly anything in their training about antibiotic prescribing."* – Daniel, CM, FG3

There was also a sense of the 'invisibility' of antibiotic decisions when consequences of poor practice are not directly apparent. While the majority of participants were aware that inappropriate antibiotic prescribing contributes to AMR, in practice, the long-term effects of antibiotic overuse are underplayed.

> *"Your active symptom of prescribing is your patient dies in front of you. Your passive symptom is three or five years down the line Meropenem doesn't work. People will never see the bad effect of antibiotics for years, and even when they do see them years down the line, they will never associate them."* – Matt, CC, FG3

4.6.2 Suggested enablers to appropriate antibiotic prescribing

The second theme that emerged from across the focus groups was a range of organisational and behavioural enablers or factors to sub-optimal antibiotic prescribing in hospitals. These are described below.

4.6.2.1 Organisational enablers

Participants discussed several benefits of a multidisciplinary approach (MDT) and the involvement of other specialities in antibiotic decisions. The key reported advantages were improved communication and the availability of a second opinion in treating infections. The ANPs, in particular, emphasised that an MDT approach encourages direct discussions with senior clinicians and facilitates efficient decision making, with frequent references to pharmacy and microbiology colleagues.

> *"For antibiotic decisions in critical care, a consultant microbiologist comes round every day with up-to-date results for the patients. So, in my clinical practice, it's really very multi-disciplinary decision making."* – Cameron, ANP, FG1

"I think pharmacists are really helpful, especially when it comes to complex [antibiotic] treatments. They really know their stuff." – Julia, ANP, FG1

Senior clinicians in FG2 reported that documentation is often viewed as an administrative requirement rather than a medical task. However, there was a consensus regarding the importance of clear documentation of antibiotic management decisions and treatment plans. Participants highlighted that improved continuity of care is dependent on improving the quality of prescriptions.

"If I could change one thing about how people are managed at the front door and going through the system, it would be to have those decisions about antibiotic prescribing clearly documented, state why you're giving antibiotics, what do you think the condition is you're treating, how long you plan to give it for." – Douglas, CM, FG2

"Yeah. And then somebody who's coming the next day can see that documented clearly and think, well, we've done test X, which means that it's not actually this condition, I can confidently stop or rationalise the antibiotics." – Anna, NP, FG1

A key identified enabler to appropriate antibiotic use was a thorough patient review. For example:

"Even if you are busy, I think you have to be thorough. I don't think there's an excuse not to sit and go through the notes and look at their history, to look at what micro results are available, their bloods, their chest X-ray." – Paula, Consultant, AM, FG2

Increasing compliance with antibiotic guidelines was described as a facilitating factor in the effective and safe treatment of infections. Participants in FG1 discussed how evidence-based guidelines support clinicians in making decisions.

"Compliance of guidelines, because you meet that ethical quandary, so not doing any harm, doing the best for your patient, respecting the autonomy and doing justice to the wider community. The guidelines help you with that because they're evidence-based." – Cameron, ANP, FG1

"You have a lot of junior doctors and a lot of health professionals who aren't microbiologists, and they need something to help them when they are faced with sick patients. You need guidelines; you can't be an expert in everything." – Anna, NP, FG1

Some ANPs felt that more tailored antibiotic recommendations would help with adherence:

> *"I think it would be helpful to have more tailored guidelines to the environment that people work in."* – Hannah, ANP, FG1

Senior clinicians in FG2 and FG3, including the microbiologists, suggested that appropriate training and education on antibiotic prescribing should be embedded into the curriculum.

> *"I think the thing that might be useful is bringing it forward and making this [antibiotic prescribing] much more prominent during medical school, during training."* – Douglas, CM, FG2

One of the enablers discussed was restricting certain broad-spectrum antibiotics, reinforcing the importance of reviewing treatments:

> *"In my practice, our standard practice is to only issue a three-day code for broad-spectrum antibiotics, so that forces a review to happen that can't be carried on indefinitely."* – Douglas, CM, FG2

4.6.2.2 Behavioural enablers

Participants in FG2 emphasised the importance of normalising questions around prescriptions. They felt that junior prescribers should be able to ask for clarification about antibiotics in their daily practice. Creating an opportunity to open a conversation about antibiotics with senior colleagues was identified as key to that process.

> *"I think we need something in place in our processes that could prompt a whole team to challenge the decision that has been made already, something around antibiotic prescribing that could prompt people to review and think through, and maybe allow juniors to challenge these decisions."* – Joanna, NM, FG2

> *"So, that goes back to challenging or not so much challenging, I might say, as reviewing or questioning or clarifying. It's really a clarification. Who has instructed them to do that?"* – Paula, Consultant, AM, FG2

Another participant responded:

> *"Not in the sense that they want the consultant to explain the entire antimicrobial policy, but just to say something like a urinary infection."* – Emma, CP, FG2

Senior clinicians recognised the need to address social and cultural influences on juniors' prescribing behaviours. There was consensus across the focus groups that clinicians' reluctance to speak up for fear of being embarrassed or criticised needs to be minimised by "destigmatising" some aspects of the antibiotic review. Participants in FG2 and FG3 suggested that junior prescribers should be expected to ask questions about antibiotic prescriptions:

> *"It's almost like changing our thinking about asking questions and saying it's acceptable, it's okay to ask."* – Olive, IPCN, FG3

> *"Yeah, just make sure that everybody knows. So, you know, the whole ward know that the juniors should be asking the consultant what, why and how long."*
> – Paula, Consultant, AM, FG2

Senior doctors in FG2 emphasised that discussing antibiotic prescriptions does not have to be confrontational and pointed out that most senior doctors are accustomed to being asked for answers and to share expertise. There was a sense that asking for clarification should therefore become part of routine practice.

> *"I think what should be happening actually is that the juniors should feel able to say why and for how long. And it should be routine for them to say that so that they can then write, you know, you had sepsis, review in three days."* – Douglas, CM, FG2

However, as the quotes below illustrate, it was pointed out that improvements require a cultural change.

> *"We need to create a culture whereby people welcome that kind of approach."*
> – Joanna, NM, FG2

> *"Nobody gets a carrot for not prescribing. Everybody gets a stick for not prescribing. That's it. So, the culture must change."* – Matt, Consultant, CC, FG3

Supporting and empowering less experienced prescribers in their everyday antibiotic decision making was viewed by senior doctors as key to facilitating that cultural reorientation.

> *"I think empowerment is part of it… I guess it's tapping into the knowledge that they already have and just giving them a structure by which they can realise they can answer their own question without just phone a friend and have it delivered on a plate."* – Daniel, CM, FG3

> *"I would say that senior support should be accessible or approachable. Someone approachable that you can contact for advice."* – Paula, Consultant, AM, FG2

4.6.3 Lay participants' voice

When listening to the lay voice, there was consistency in participants' views. All lay participants were interested in discussing the importance of engaging patients in making decisions around their treatment, including antibiotic therapy. Trust, relationship-building, communication and information provision were described as crucial to shared decision making. A common concern was that some clinicians do not actively listen to the patient's account.

> *"But it is very important at some point if there's an opportunity for the clinicians to take cognisance of what the patient is saying. And I think it did make a big difference, and it certainly helped my progress and my recovery."* – Alice, LP, FG1

Giving credence to patient's concerns was described as a key approach in gaining valuable information on their condition and symptoms and, as a result, open a meaningful dialogue.

> *"They [doctors] should listen. They may not have the same interpretation of it as you do but they should listen."* – James, LP, FG1

> *"We talked about dialogue with the shared decision making. I think, as you say, the person in themselves, if they feel well or if they feel worse when they're presenting, there's maybe a sort of credence in that."* – Alice, LP, FG1

Another participant added:

> *"I think we need to listen to people though, that's one thing. You know, if you don't listen to the person, it's their body."* – Bruce, LP, FG1

As illustrated, adequate explanations to the patient about their condition and the treatment plan to promote understanding are reassuring to the patient:

> *"So, I had good conversations with the microbiologist and the consultant and so on. But the consultant kinda described a path to me he was looking for before I would be discharged from intensive care. And I found that very reassuring."* – James, LP, FG2

Discussions with lay participants revealed that patient care heavily grounded in a task-oriented system poses a significant barrier to effective communication. There was a perception that quality interaction requires trust, time and patience. Nurses were viewed as best placed to establish that trust with patients. For example:

> *"I think nurses probably have better links with the patients. You'll see them regularly. There's a different kind of trust in the nursing staff. Somebody that you can see, and you relate to. Whereas you may see the consultant once every other day."* – James, LP, FG1

Patient input was viewed as necessary in ambiguous clinical situations, where there are no obvious signs of infection, and the diagnosis is uncertain. Lay participants felt that antibiotic treatment options should be routinely discussed with clinically stable patients.

> *"And then having that discussion with the patient to say: 'This is why I'm doing this'. You know, I don't think you're unwell enough to need IV, and making sure that your patient is feeding back whether or not they're happy with your plan of care."* – James, LP, FG1

> *"Interpreting the patient experience and what they think is wrong with them is very important."* – Bruce, LP, FG1

However, one lay participant pointed out that:

> *"There is a lack of encouragement for the patient to be involved in the decision making."* – Bruce, LP, FG1

There was also a perception that previous clinical experience of treating particular diseases may subconsciously influence the prescriber's decision in complex situations. Participants felt that more patient involvement in the decision making process is particularly important in those situations.

"I think it, again it kinda comes back to your making decisions and judgements from experience and your patient in front of you." – Bruce, LP, FG1

"Have they [prescribers] come up with similar cases or a new case, and they think of all the patterns they have previously experienced, and so they might not pick up any new clues that could help them in their decision making. They need to speak to the patient." – Alice, LP, FG1

4.6.4 Proposed components of the antibiotic intervention

This section presents findings from the focus groups related to the proposed components of the antibiotic intervention, including the target behaviour, practical elements and features, and some aspects of implementation. The suggestions are summarised in Table 13 and further described with exemplar quotes.

Table 13. Proposed components of the antibiotic intervention

COMPONENT	DESCRIPTION
Aim	To aid hospital prescribers in the timely antibiotic review process.
Target population	All HCPs involved in everyday antibiotic decision making in acute hospitals.
Format	An electronic prescribing system incorporating elements of a clinical decision support.
Functions	Diary entry system for monitoring decisions. Accessible and easy to use.
	Improves continuity of care.
	Prompts discussion within the team.
	No option to override the system without taking action.
	Facilitates communication and documentation: a) helps with the transitions between wards/shifts b) eliminates guesswork
Content	Links to the patient's information (history, symptoms, age, risk factors).
	Records the antibiotic dose, route, infection (rationale), time and duration, reason for deviating from guidelines.
	Links to antibiotic guidelines and microbiology results.
	Traffic light system - stop, go and review.
	Pop-up windows, prompts & triggers.
	Populates a list of antibiotics due for review.
Messages	Avoid emotive messages/images.
	No long explanatory words.
	Clear, concise and understandable.
	Use '3 + 3': what, why, how long and review after 3 days.

Timing of prompts	When an antibiotic is due for a review (3 days after initiation).
Accountability/ responsibility	Tracking documentation about the prescriber's decisions.
	End-users able to see the prescriber's signature.
Transparency	Everyone has access to the information and can see the 'journey' of the antibiotic.
Endorsement	Buy-in/support from senior clinicians required.
Knowledge and training	Utilise existing NHS antibiotic guardians for each clinical area to monitor prescribing decisions and provide feedback/face-to-face training sessions.
	Involve nursing and pharmacy staff.
Patient factors	Prompts discussion with the patient/family.

In terms of the target population, participants put an emphasis on ensuring that the intervention is applicable to all hospital professionals involved in everyday antibiotic decision making, irrespective of grade, experience or speciality. There was a consensus across the focus groups that the intervention should aim to improve the antibiotic review process.

> *"We all have accountability. We're all supposed to be working from the same spreadsheet, as it were. So, I think it should be everyone, because no matter what your background, you should be prescribing to the same standard."* – Cameron, ANP, FG1

> *"You kinda want everybody to do the same thing. We should all prescribe antibiotics the same way or for the same reasons or from the same guidelines."* – Anna, NP, FG1

Other participants commented:

> *"The intervention should be based around getting people to review what they're doing."* – Douglas, CM, FG2

> *"To review where they are and justify the decision they're making in the short and longer-term."* – Paula, Consultant, AM, FG2

There were many suggestions across the FGs related to practical elements and features of the future intervention. A system or tool promoting better documentation of decisions and integrated into routine care was one of the key suggestions.

"It's got to be based around making people document what their decision is, why they've made it, and build it into the routine of what happens as part of the patient's care." – Matt, Consultant, CC, FG3

"A system that can force even more caution because as soon as there's documentation about your decisions that you can't shy away from it." – Lydia, Pharmacist, FG1

Most participants accentuated the need to eliminate any uncertainties around record keeping. They favoured an electronic prescribing system as a means of providing more transparency.

"So you can literally go in and see the journey of antibiotics." – Paula, Consultant, FG2

"That's something electronic prescribing would be quite useful for, because then they would just take that need to fill it in out of the equation." – Alice, LP, FG2

"Get rid of the paperwork." – Bruce, LP, FG2

One of the microbiologists also highlighted the importance of documenting the reasons for deviating from guidelines.

"And then if you go off the guideline, you document why." – Douglas, CM, FG2

Participants in FG1 and FG2 pointed out that a system that prompts a review of antibiotics would encourage prescribers to take responsibility for that action. For example:

"If something pings up in the patient's chart, then somebody becomes responsible for an action." – Anna, NP, FG1

"If the system would accumulate a list of patients due for a review and it got pinged to the doctors' job list, then somebody would have to take responsibility for that. Job lists are always done 'cause the juniors end up doing it." – Mary, ISN, FG1

"Yeah, that might help with the transitions between one shift and another. At least people aren't then left then guessing." – Julia, ANP, FG2

It was also anticipated that such a system would enhance communication between clinicians:

> *"The electronic system might prompt the questions of whoever might be leading the discussion, or who's going to record something, and maybe prompt answers out of the consultant."* – Cameron, ANP, FG1

Other participants talked about the convenience of having all the information in one place as opposed to having to search through sets of notes and prescriptions charts. For example:

> *"You know, you can be like on your twelfth Kardex. And, you know, reams of notes, and then there's theatre notes that have antibiotics on them, and there's somewhere else, and there's somewhere else. It would be great if you had one place for everything."* – Mary, ISN, FG1

Additional suggested system features included populated fields for inputting patient information, such as antibiotic dose, route, infection (rationale), time and duration, with links to patient microbiology results. It was pointed out that access to supporting information, including antibiotic guidelines, should be "at the touch of a button" to reduce the 'hassle factor'. The use of "intuitive screens" was described as a practical solution in a busy context.

> *"Finding if any of the three MRSA screens they've [patients] had in the last year that were positive takes a while. But you could have something more intuitive that makes a positive microbiology pop-up more on the screen."* – Cameron, ANP, FG1

Participants also recommended incorporating a traffic-light system that provides alerts and reminders.

> *"It has to be something that is easily flagged up, even if it's just something that says stop and review."* – Paula, Consultant, AM, FG2

Participants in FG1 emphasised that such a system would act as a "safety net" for the less experienced prescribers.

> *"We need something that would help juniors sift through information or even suggest next steps for treatments, and act like a safety net almost."* – Lydia, Pharmacist, FG1

There were some reservations in FG2 and FG3 regarding the use of emotive images and messages, as they could trigger a negative response from prescribers. Participants also talked about clinicians being less receptive to long explanations due to time constraints. Instead, the use of "a clear, concise and understandable language" was considered more effective.

> *"I would probably avoid emotive because sometimes when people are making these decisions, they're actually already really upset."* – Douglas, CM, FG2

> *"You don't want explanatory words. You just want it to be clear and concise and understandable."* – Warren, IPCN, FG2

Participants in FG2 independently came up with an idea of the main message for the intervention. As illustrated below, they suggested that it should be analogous to the Surviving Sepsis Campaign, the result of which was the 'Sepsis Six', a bundle of medical therapies designed to improve management of patients with sepsis, which has been largely effective in the NHS (Levy et al., 2018; McGregor, 2014). The focus of the Sepsis Six is on making it clear for clinicians what three diagnostic and three therapeutic actions need to be initiated in the event of suspected sepsis. Drawing on the Sepsis Six bundle, the focus groups participants suggested a similar name for the future antibiotic intervention, and later called it Antibiotic 3+3.

> *"You know, similar to Sepsis 6 thinking, ask 3 plus 3: what, when, how long, and then review every three days. That can almost be quite grounding and will be easy to remember."* – Paula, Consultant, AM, FG2

> *"It's very non-hierarchical that question. So, you can ask it without feeling somebody's being put under pressure."* – Joanna, NM, FG2

To realise the anticipated benefits of the intervention, participants suggested some approaches that could facilitate its uptake and implementation. There was recognition that implementing the intervention into clinical practice may be limited if HCPs perceive it to have low relevance or view it as unacceptable. Therefore, endorsement or buy-in from senior decision makers was considered crucial.

> *"I mean, you will need the consultants to buy into it first."* – Joanna, NM, FG3

Provision of training was described as an essential element of a successful roll-out. As illustrated, participants in FG2 suggested incorporating training into the induction.

> *"Get it into inductions and things earlier in their attachment."* – Douglas, CM, FG2

> *"There must be an element of training in your induction."* – Emma, CP, FG2

There were also suggestions in FG3 regarding utilising antibiotic champions in each clinical area to provide support and face-to-face training sessions.

> *"So, I think then you need facilitators for certain clinical areas, you know, where you've maybe got your champions, your link people that can go in and spend that time, face-to-face, 'cause that's generally how most people prefer to learn."* – Olive, IPCN, FG3

> *"We have lots of antibiotic guardians, probably over a thousand. That's just off the top of my head, but there's a lot. So, you could utilise that resource."* – Daniel, CM, FG3

A lay participant stressed the importance of involving nursing and pharmacy staff in the delivery of the intervention.

> *"This kind of intervention is going to be very important. And if you get the nursing and pharmacy staff to prompt it, it's more likely to embed*." – James, LP, FG2

4.7 Discussion

This study provides important insights into the views and experiences of HCPs and health service users concerning decisions about antibiotics in the hospital setting. The exploration of the challenges to appropriate prescribing revealed gaps in antibiotic decision making due to various complex organisational and cultural factors. Daily stressors, including high workload and rapid patient turnover, frequent patient transitions between wards, and communication flaws, were cited as key barriers to the continuity of patient care. Other challenges included the social context of the hospital and the paternalistic nature of relationships within it. Reluctance to voice concerns or challenge seniors' prescribing decisions for fear of criticism, and inertia to change the current practice norms, negatively impacted antibiotic decisions. These findings reinforce previous qualitative work pointing to the concept of 'prescribing etiquette', a set of collective 'rules' of concordance with peer practice influencing prescribing behaviour (Charani et al., 2013). Interpretations of the data further revealed that junior prescribers' ability to seek advice depends on the 'approachability' of the senior clinicians, supporting other studies that highlight power relations and rules of engagement within the medical hierarchy (Broom et al., 2014; Crowe et al., 2017).

An important finding was fear of litigation due to the recent public medical court cases. These cases, the 'Sepsis Six' campaign and pressure exerted from patients and families were cited as the main drivers of broad-spectrum antibiotics overuse. Although defensive medicine is not a new concept, little attention has been paid in the literature to the possible impact of malpractice claims on antibiotic prescribing. In the UK, the number and costs of NHS litigation claims are increasing. The National Audit Office's (2017) report showed that the number of new claims for compensation in England alone doubled from 5,300 to 10,673 between 2006/07 and 2016/18, at a cost of £1.6bn (National Audit Office, 2017). Quantitative evidence shows that clinicians become overcautious when faced with the likelihood of complaints against them and adopt defensive behaviours, including overprescribing broad-spectrum antibiotics (Tebano et al., 2018). Meta-ethnography (Chapter 3) indicated that decisions about whether to prescribe antibiotics are heavily influenced by fear of consequences for prescribers. This study confirms that fear of malpractice claims and an aversion to taking unnecessary risks may at times lead to deviation from evidence-based practice. These findings reinforce the need to ensure prescribers are safeguarded and supported when choosing not to prescribe antibiotics or to stop/de-escalate therapy.

The study data further indicate that in a hospital environment, where multiple clinical teams are involved in patient care, diffusion of responsibility occurs. The structure of hospital care means that there are numerous clinical teams involved in the antibiotic decision making process. Tarrant et al. (2019, p. 1357) conceptualise this as a “problem of many hands”, where the collective boundaries for individual accountability or ‘blameworthiness’ become blurred. This dissonance was apparent in the meta-ethnography findings, highlighting the partial loss of clinical ownership of antibiotic decisions due to a lack of clarity around the specific prescribing roles and responsibilities that less experienced prescribers undertake. Earlier qualitative research has indicated that junior doctors feel discomfort related to the physical act of writing a prescription due to the perception that the accountability for prescribing decisions lies wholly with the clinical team (Lewis & Tully, 2009). This was cited to be the result of insufficient knowledge to make autonomous prescribing decisions and fearing the judgement of incompetence, suggesting that these are areas for improvement.

Reflecting on the findings, the concept pertaining to low motivation to review antibiotics due to a lack of feedback on performance is new and concerning. Evidence suggests that direct interaction with prescribers has the most lasting impact on prescribing practice (Hersh et al., 2009; Wagner et al., 2014). Moreover, the most recent Cochrane review on interventions to improve antimicrobial prescribing for hospital inpatients has concluded that interventions that include feedback are more effective than those that do not (Davey et al., 2017). This means that creating effective mechanisms to improve communication and provide real-time feedback to less experienced prescribers have the potential to elicit behavioural change. The focus groups revealed that there might be merit in re-aligning current efforts to prioritise a timely antibiotic review with performance feedback measures to improve the quality of prescribing.

It is widely recognised that the problem of AMR driven by misuse and overuse of antibiotics is a collective responsibility (O’Neill, 2016). However, although the study was conducted in hospitals with an active antimicrobial stewardship programme, data analysis shows that clinicians perceive individual contributions to the future effects of resistance as minimal and, therefore, insignificant. When the consequences of poor practice are not directly apparent (as the collateral damage to both the patient and the society only occurs in the future), it creates a perception of 'invisibility' of prescribing decisions. A recent qualitative review has found similar results, emphasising that the abstract and long-term nature of AMR leads clinicians to underplay its consequences and doubt personal accountability in antibiotic decisions (Krockow et al., 2019). Efforts to change that perception will be critical in shifting practice.

In terms of the proposed antibiotic intervention, the findings suggest that there is more scope for changing prescribers' behaviour in relation to undertaking antibiotic review rather than initiation of therapy due to clinical uncertainty. The benefits of timely review include shortening the patient's stay in hospital, reducing the incidence of adverse effects, mitigating the impact of AMR, and reducing morbidity and mortality (Matuluko et al., 2020). Since 2011, the Department of Health has advocated an active approach to reviewing antibiotic prescriptions 48–72 hours into treatment to allow an opportunity to discontinue or de-escalate antibiotics (Department of Health, 2015). However, the study shows that re-evaluating antibiotics is perceived as a low priority rather than a core clinical decision. These findings reinforce a UK-based quantitative study, which found that, in practice, few antibiotic prescriptions are reviewed and modified following initial prescription (Llewelyn et al., 2014).

The findings further illustrate some of the challenges faced by prescribers, including communication failures. The link between poor interprofessional communication and patient care in hospitals is well documented and the leading cause of preventable adverse events (Campbell et al., 2018). In keeping with other qualitative studies, unarticulated rationales for off-protocol prescribing decisions emerged as a source of frustration for junior prescribers (Mattick et al., 2014; Yon et al., 2015). Central to this concept was recognition that improvements in communication require 'destigmatising the question' around antibiotics. Removing associations of shame or blame and creating opportunities to openly discuss prescriptions may reduce the ambiguities associated with infection management. Asking three simple questions, such as 'what, why and how long for' was suggested as a critical enabler to consulting senior colleagues about antibiotic prescriptions in daily clinical work. Collective efforts are required to assist less experienced prescribers in learning the craft and help them develop confidence and expertise (Kajamaa et al., 2019).

Documentation of antibiotic decisions lacking clarity and occurring in the context of fragmented information came to the fore in focus groups. Research has previously suggested that poor-quality documentation may lead to the unnecessary continuation of antibiotics as the prescribers lack adequate information to decide whether to stop, continue, or switch the treatment (Ashiru-Oredope et al., 2012). The healthcare system relies on patient medical records for communication, and safe and effective care, especially during staff shift changes and patients transitioning between hospital wards.

However, the existing evidence shows that duration of antibiotics tends to be poorly annotated (Charani et al., 2017; McCallum et al., 2013), despite international efforts emphasising the importance of clear documentation of decisions in advancing patient safety and improving outcomes (CDC, 2019). Reducing the 'anonymity' of poor practice by creating a robust audit trail of antibiotic decisions was viewed in this study as essential in efforts to optimise antibiotic review processes. The key practical solution is to integrate electronic prescribing systems across hospitals and feasibly translate it into an intervention delivered as part of routine clinical practice workflow. Harnessing the potential of information technology to implement electronic prescribing and medicines administration systems into NHS hospitals has become part of the eHealth Strategy in Scotland (Scottish Government, 2018).

The need for person-centred prescribing in the context of hospital care emerged as a new finding. The importance of discussing antibiotic decisions with patients and the resulting reduction in antibiotic use has been well documented in primary care research (Coxeter et al., 2015). In 2016, the Scottish Government published a Health and Social Care Delivery Plan, which recognised that individuals and their families should be at the centre of decisions that affect them. This principle of patient involvement signifies a fundamental shift in practice and warrants consideration in future antibiotic interventions. However, there is a lack of data guiding patient engagement in the antibiotic decision making process in hospitals (Rawson et al., 2018). This study suggests that improving communication with patients around antibiotics may reduce the likelihood of complaints and mitigate some of the unwanted effects of malpractice liability.

Lastly, data interpretation shows that there is scope within the hospital setting for appointing antibiotic guardians or champions in monitoring prescribing decisions and providing support and face-to-face feedback. Examples of good practice include the presence of a clinical pharmacist on the ward prompting antibiotic review and engagement with nursing staff, reinforcing previous work concerning the expanding role of these professionals in governing antibiotic usage internationally (Olans et al., 2017; Pedersen et al., 2020). The need to engage nurses in antimicrobial stewardship efforts has been recently explored in a study by Carter et al. (2018), which found that nurses expressed willingness to engage in AMS programmes and perceived it as an extension of their role as the patient's advocate. These findings present an opportunity for improving current practice.

4.7.1 Comparison with the meta-ethnography findings (Chapter 3)

The study provided an opportunity to compare the identified barriers and facilitators to appropriate antibiotic use against the meta-ethnography (ME) (Chapter 3) to establish any relationships, identify refutational findings and explore key uncertainties. Similarities between the emerging themes were anticipated, as the aim of the focus groups was to evaluate the conceptual model developed from the synthesis of qualitative evidence.

Regarding the identified barriers to appropriate antibiotic prescribing, there was a degree of overlap, including organisational constraints, poor documentation and the lack of transparency of prescribing decisions. Similarly, the critical enabler was recognising that improvements in clinical practice require individual ownership of prescribing decisions. Central to good practice was feedback on prescribing decisions. The ME found that scarce feedback on performance causes frustration for junior doctors, limiting opportunities for understanding why their decisions have been overruled or changed. Although focus group participants did not directly speak of the need to create feedback mechanisms, they perceived that the lack of feedback leads to low motivation to review antibiotics. They also attributed antibiotic knowledge deficits and lack of familiarity with specific treatments to gaps in undergraduate education. This finding contradicts the ME results, which highlighted that antibiotic prescribing is more of a practice-based skill learned through a model of apprenticeship and everyday interactions between individuals rather than academic education.

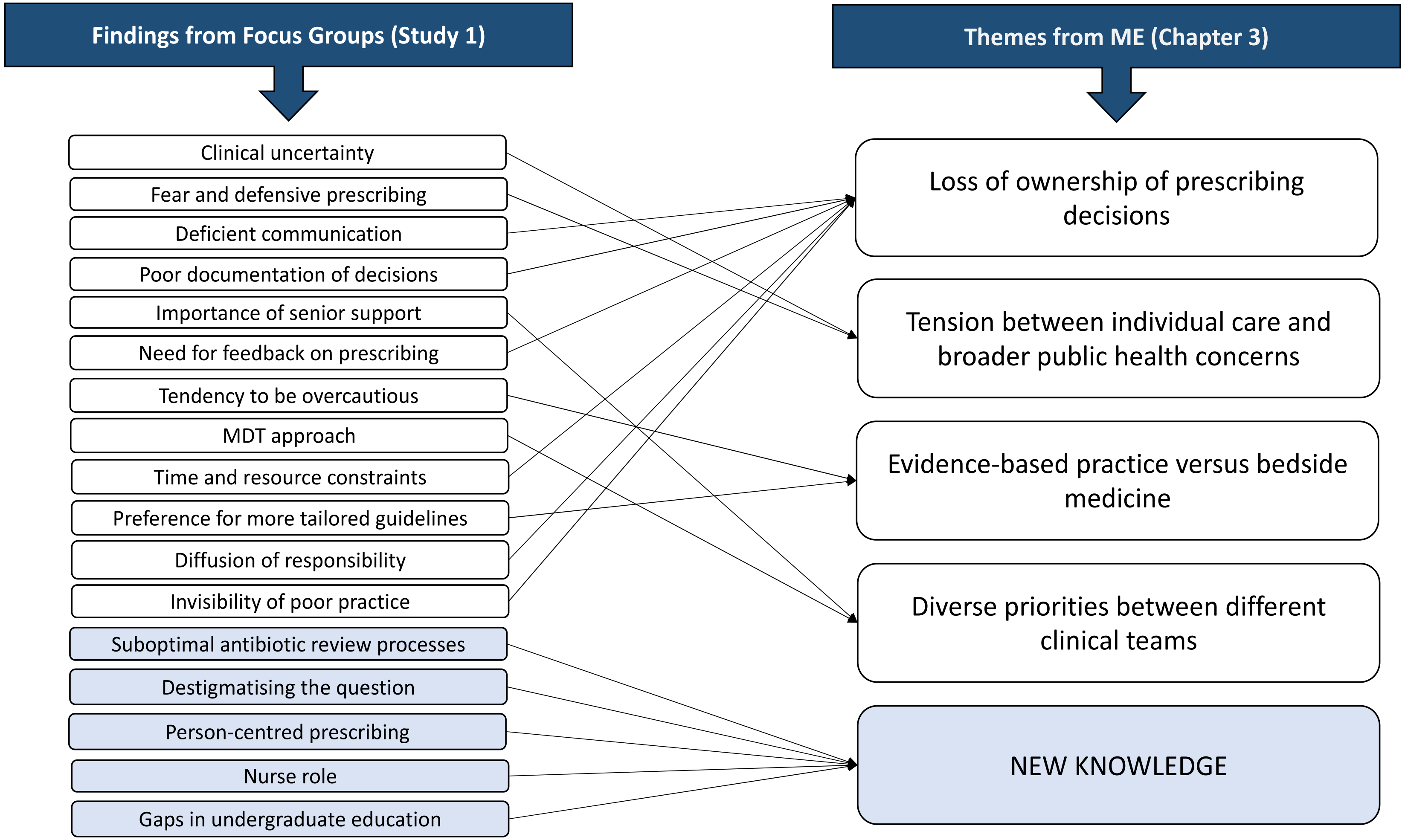
Fear of consequences driving the defensive act of overprescribing featured prominently throughout the ME. This relates to the fear of patient deterioration if antibiotics are not prescribed and the fear of patient complaints and potential litigation. Prescribing antibiotics was perceived by junior doctors as an emotionally demanding endeavour, and the 'rules of the hospital game' were reported to work against 'rational' prescribing decisions. Several studies identify a range of factors influencing prescribers' behaviour, including benevolence and the urgency to provide optimal care to the patient and the pressure to avoid clinical and reputational repercussions. The tension between safeguarding and litigation strongly connects to this study's findings, reaffirming that prescribing broad-spectrum antibiotics is perceived as low risk and a task that requires low cognitive demand. When faced with the possibility of legal challenges, avoiding unnecessary risks and a shift away from best practice may be a natural choice.

The ME further explored the concept of risk trade-offs that doctors must make when prescribing broad-spectrum antibiotics in the presence of multiple and often conflicting objectives. The review found that sound professional judgement will involve accurately weighing up immediate individual risks and the long-term consequences of AMR to the community when an infection is suspected but not proven. However, these competing priorities were downplayed in the focus groups. Participants were sceptical about the 'passive symptoms' of future AMR, stressing the importance of managing 'active' short-term patient risks.

Consistent with the ME, there was recognition that less experienced prescribers are vulnerable to senior colleagues' attitudes, opinions, and prescribing preferences, leading to the transmission of localised habits. At the core of the problem is the perception that questioning senior doctors' decisions and asking for clarification are not welcomed or even acceptable. However, beyond medical hierarchy, this theme was not further explored in the focus groups. Instead, the focus shifted to strong leadership, collaboration and role modelling. Participants talked about the need to "destigmatise the question" to help alleviate the challenges to effective communication. A multidisciplinary approach and input from other specialities were seen as key enablers to good practice. However, in contrast to the ME, which identified an absence of perceived or reported nursing involvement in antibiotic decision making, focus groups participants stressed the importance of harnessing nursing input in prompting the antibiotic review. The reason for that may be twofold. While most focus groups participants were nurses with interest in antibiotic use who were keen to discuss the topic in detail, most studies included in the ME lacked antibiotic stewardship programmes involving nurses. However, that aspect was not explored in the synthesis.

Person-centred prescribing and the need for all HCPs to adopt a more personalised and individualised approach within their practice emerged as new knowledge. However, considering the patient and public involvement in the study, recent policy changes and heightened awareness around shared decision making in NHS Scotland, these findings are not surprising. In addition, although the description of the proposed antibiotic intervention is a new finding, this is due to the nature of the research question posed. Figure 20 provides a graphic representation of the relationship between the findings of the two studies.

Figure 20. Relationships between the findings from the ME and focus groups



4.8 Implications for the intervention development

Improving the quality of antibiotic review processes emerged as the core concept. Creating a robust audit trail of prescribing decisions is crucial to increasing the transparency and quality of documentation. Reducing the 'invisibility' of poor practice by enabling all HCPs to see the 'journey of the antibiotic' is essential to the responsible use of antibiotics. Central to this concept is the recognition that improvements in practice require timely feedback on prescribing practice.

Participants' preference for integrating an electronic prescribing system delivered as part of routine clinical practice workflow could be feasibly translated into an intervention. Incorporating elements of clinical decision support to streamline workflows and take advantage of existing data sets was preferable to utilising paper checklists and medication Kardexes. Ensuring that all information is contained in one place may improve documentation of antibiotic decisions and enhance the continuity of care. It may also reduce the "hassle factor" (any time-consuming task) by highlighting any potential information gaps or uncertainty at the time of prescribing. However, creating and incorporating an intuitive, user-friendly system with effective prompts and decision making pathways with quick access to guidelines and microbiology results may be a challenge to an organisation facing significant budgetary constraints. An alternative would be to incorporate antibiotic review alerts into the existing NHS patient health records system.

Participants expressed dislike of using emotive images and messages as part of the intervention. These were believed unlikely to elicit a positive effect on behaviour. Instead, they suggested using the Antibiotic 3+3 questions ('what, why and how long plus review after three days') to reduce any communication flaws. Removing any negative associations around asking for clarifications about prescription rationales is also likely to reduce fear of consequences. Engaging patients in antibiotic decisions has the potential to increase clinicians' knowledge of patient treatment and may have an impact on minimising the likelihood of complaints. Finally, harnessing senior support, pharmacy engagement, and enhancing the professional nursing role in antimicrobial stewardship, presents an opportunity for improving current practice.

A summary of the key findings developed in ME (Chapter 3) and mapped onto the qualitative study, their potential application to an antibiotic intervention and the expected outcomes, are presented in Table 14. A detailed exploration of each component in relation to behavioural change theory is provided in the next chapter.

Table 14. Key findings and the resulting implications for the development of an intervention

KEY FINDINGS	INTERVENTION AIM	EXPECTED OUTPUT
Loss of ownership of prescribing decisions	Create an audit trail of antibiotic decisions attributed to each HCP and each drug that would be visible to all.	Transparency/visibility of antibiotic decisions is increased. Prescribers are less likely to avoid taking responsibility for antibiotic decisions.
Defensive prescribing	Promote the 'Antibiotic 3 +3' questions (what, why and how long plus review after three days). Increase shared decision making.	Destigmatising questions around antibiotics is likely to enhance communication. Fear of consequences reduces.
Disjointed information	Information contained in one place is easier to access and track.	Improved documentation of antibiotic decisions. Likelihood of improved continuity of care increases.
Lack of motivation to review antibiotics	Use prompts, triggers and cues to review antibiotics. Create feedback mechanisms on performance. Empower nursing staff to prompt review.	Prompts are likely to interrupt reflex behaviours (i.e., prescribing or continuing broad-spectrum antibiotics when not necessary). Receiving individual feedback on prescribing may address the motivation factor. Less experienced clinicians feel more empowered and are therefore more likely to make autonomous decisions.
Value of engagement and buy-in from senior clinicians	Harness leadership to show that most people perform the desired behaviour.	Spillover effect - behaviour spreads peer-to-peer. Uptake rate and sustainability increase.
Risk aversion – a tendency to avoid unnecessary risks	Provide safeguards. Use the power of defaults by restricting broad-spectrum antibiotics and applying automatic stop orders. Increase awareness of long-term AMR effects.	Restricted use of unnecessary broad-spectrum antibiotics. Increased knowledge/awareness of AMR risks.
Multidisciplinary approach	Normalise input from other specialities in the decision making process.	Support and advice from experts will increase learning opportunities and facilitate timely and optimal review.
Preference for an electronic prescribing system	Reduce the 'hassle factor' by flagging up any potential information gaps or uncertainty at the time of prescribing.	Electronic prescribing embedded into the hospital workflow is likely to increase efficiency. Confusion over handwritten interpretation or incomplete prescriptions is minimised. Compliance with guidelines increases. Prescribing error

		minimised. Enhanced transparency of decisions. Reduced paperwork. Increased user engagement and improved information retention.
Dislike of emotive images and long messages.	Use positive images and short messages.	Higher uptake of intervention (than if negative images were shown).
Preference for tailored guidelines.	Provide links to antimicrobial guidelines and policies tailored to specific groups of prescribers and clinical areas.	Easy access to evidence-based recommendations will provide a safety net and increase adherence.
Training and knowledge	Provide training on ward induction. Utilise existing NHS Lothian antibiotic guardians for each clinical area to monitor electronic prescribing decisions and provide support and face-to-face training sessions.	Enhanced understanding of the intervention. Likelihood of successful delivery and implementation increases.
Value of user experience and person-centred prescribing	Engage patients in shared decision making.	Better communication and increased knowledge of patient preferences. Reduced potential of complaints/litigation. Possible reduction of diagnostic bias.
Time constraints	Reduce time pressures by employing more efficient systems of working (e.g., electronic prescribing).	Streamlining clinical workflow and improving collaboration of care is likely to increase efficiency.

4.8.1 Implications for future research

This study provides a better understanding of the structural and behavioural drivers that shape prescribing practice in the hospital setting and reveals potential opportunities to intervene. The high-level data presented could be further developed for implementation in practice to guide the effectiveness of behaviour-change antibiotic interventions. The insights into prescribers' conceptualisation of antibiotic use could also have implications for behavioural interventions in other settings, such as primary care or long-term facilities.

The concept related to lack of motivation to review antibiotics may be worth further examination. It is widely recognised that when healthcare staff are demotivated, their work performance is diminished (Afolabi et al., 2018). Therefore, it would be of value to investigate behavioural factors that affect prescribers' motivational states in reviewing therapy – the extent to which increased responsibility for prescribing decisions affects the intention to engage in antibiotic stewardship remains uncertain and warrants further exploration.

Finally, an opportunity for further studies exists in relation to exploring prescribers' perceptions of risk underpinned by fears of professional repercussions. Patient engagement may become central as the decisions not to prescribe or discontinue antibiotics require a public understanding of prescribers' reasoning.

4.9 Strengths and limitations

A major strength of this study is the number of steps taken to ensure the quality of data collection and analysis, reported using relevant qualitative standards (Appendix 28). The pilot focus group conducted enabled testing of the topic guide and refinement of the study design. Using purposive sampling helped capture diverse views and experiences related to the phenomenon of interest, resulting in the generation of robust data. The study trustworthiness was maximised by employing a process of member checking to validate the data. Key points raised during the FGs were summarised at the end of each session, and the themes generated were presented to the subsequent groups to check and confirm for agreement. Researcher bias was minimised by avoiding leading questions that could potentially prompt participants to answer in a way that supports particular assumptions.

An inductive approach was used to strengthen the study and ensure the analysis was data-driven, with multiple quotations provided to support the findings. Disconfirming evidence was checked to identify any refutations. The interpretation of data was presented to academic supervisors to increase coherence, establish coding accuracy and achieve a high degree of clarity. In addition, although the results of the study came from HCPs and health service users in east Scotland, the robust findings may be generalisable to the rest of the UK and to other countries looking at developing antimicrobial stewardship interventions which promote behavioural change.

Having only three focus groups may be seen as a limitation. However, little guidance exists on the topic, with commonly cited recommendations that focus group research requires at least two groups (Krueger & Casey, 2014). To assess this recommendation, Guest et al. (2017) conducted a thematic analysis of 40 FGs on a health-related topic and found that more than 80% of all themes were discoverable within two to three focus groups, and three focus groups were sufficient to identify all the key themes within the data set. Moreover, the relatively small sample size in the third focus group, comprising two senior clinicians and two nurses, may also attract criticism. Although the general principle is that between six and eight participants are sufficient, some earlier studies have reported as few as four participants (Fern, 1982). One possible reason for the poor attendance in the third focus group is that it took place over a Bank Holiday weekend. Another explanation may be that the topic under investigation had a low priority for busy clinicians. However, the in-depth discussions across the focus groups and the rich information obtained allowed data saturation, where a clear pattern of themes emerged, and no new information was produced.

Despite the attempts to recruit as diversely as possible, the sample did not include any junior healthcare staff. This may reflect the complexity of the topic and the unwillingness of less experienced prescribers to voice their opinions in the presence of their senior colleagues. Moreover, although a behaviour change expert was initially recruited for the qualitative study, she could not take part due to extenuating circumstances. This was resolved by the researcher seeking expertise within the supervisory team, who have considerable experience in developing complex health interventions.

Lastly, a possible limitation of using qualitative methodology is the likelihood that participants may not express their honest and personal opinions about the topic or give socially acceptable answers (Barbour, 2018). Employing individual and group exercises to engage everyone in the discussion reduced the chances of some participants not expressing their views, especially when their thoughts opposed the opinions of another participant.

4.9.1 Reflections of the researcher

Before embarking on this PhD, I worked as an Intensive Care nurse and then as a Research Coordinator within critical care. My professional background may have potentially impacted the interactions between participants during the discussions. More specifically, I had a pre-existing professional relationship with some of the participants through my clinical practice. Although a positive working relationship helped with establishing rapport and trust with the participant, it may have inhibited them from expressing their true opinions, or the views declared may have arisen due to conformance issues and what they deemed as socially acceptable answers. To make participants feel more at ease and encourage open communication, they were asked for further clarifications when required, whilst the potential for mistrust was minimised by reinforcing confidentiality throughout the research process. However, there is also a likelihood that participants may not share my interpretation of their voices. Although member checking allowed validation of the data, the analysis should be read as one of many possible interpretations.

However, my background brought some advantages to this study. Firstly, my experience of working in healthcare enabled me to establish rapport with participants. By gaining their trust, I facilitated interpersonal exchanges between participants rather than simple statements of their opinions. Secondly, my practical and theoretical understanding of the subject enabled me to share participants' concerns related to the drawbacks of the current healthcare system, facilitating more meaningful discussions.

Lastly, I felt prepared for addressing unforeseen issues and ensured that the discussions' content was related to the context that was being explored.

Despite having conducted a pilot focus group, I felt apprehensive about my ability to manage complex group dynamics effectively. My academic supervisor acted as an observer during the focus groups, and although her input was minimal during the discussions, the presence of an experienced researcher increased my confidence. The field notes taken by the observer were helpful in that they allowed me to critically reflect on the interactions and power differences between participants. For example, it became apparent in the second focus group that some senior clinicians tended to speak with authority and appeared more dominant, 'educating' other participants on the 'real' (as opposed to more academic or derived from literature) problems of antibiotic misuse. In those situations, I found it challenging to distance myself and 'perform' the role of researcher. However, despite those difficulties and a few quiet pauses where participants did not have anything to contribute, or chose not to express their opinions, most participants were enthusiastic about discussing the topic and engaging in the process.

Although the focus groups ran smoothly, as the third focus group unfolded, I realised that the Dictaphone stopped working and, as a result, I lost half of the audio recording. This issue was addressed by writing down notes immediately after the discussion and contacting the participants to verify the accuracy of the information. Moderating focus groups provided me with an invaluable opportunity to increase my practical experience in using the methodology. In addition, I was also able to test my initial assumptions about the planned intervention. As I anticipated that some ideas would feature strongly in the discussions (e.g., electronic prescribing), I had to ensure that I did not impose my opinions on participants. Giving adequate weight to the suggestions of others enabled me to obtain in-depth information about the antibiotic intervention that later helped shape its design.

Chapter 5: Development and operationalisation of the intervention content using Behaviour Change Wheel theoretical framework

The systematic review and meta-ethnography (Chapter 3) followed by focus groups with key stakeholders (Chapter 4) resulted in the proposal of core components of an intervention to improve antibiotic review in a hospital setting. Drawing on the data generated in the previous chapters, this chapter provides a worked example of the systematic development of the behaviour change intervention using the BCW Framework.

Michie et al. (2014) propose three fundamental components of a behaviour change intervention:

- The theory underpinning the intervention (Chapter 3 & 4).
- Behaviour change techniques (BCTs) used (Chapter 5).
- Form of delivery (Chapter 6).

In this thesis, these elements are drawn together to develop the theoretical basis in conjunction with the empirical evidence. The chapter commences with a brief discussion of the importance of applying a theoretical base to complex health interventions to maximise their potential efficacy and the challenges involved in selecting and applying a suitable theory. Next, an overview of the BCW (Michie et al., 2014) is provided, and the key processes involved in developing the intervention content are described. Finally, the key findings, strengths, limitations and future implications are discussed.

5.1 Behavioural theory

Theory can be simply defined as "a set of interrelated concepts, definitions, and propositions that presents a systematic view of events or situations by specifying relations among variables to explain and predict events or situations" (Glanz et al., 2015, p. 26). For example, behavioural theory can explain why people engage in behaviours that may affect an individual's health and understand factors influencing health professionals' behaviours, such as antimicrobial guideline adherence (Davey et al., 2017). When applied to behaviour change, theories can also help predict why, when and how it occurs (or does not occur) and explain why an intervention succeeds or fails (Michie et al., 2018).

The UK Medical Research Council (MRC) advocates the application of theory as an integral part of a complex intervention design, development and evaluation (Craig et al., 2008). The reasons for it are threefold. Firstly, to identify the causal determinants of change and select relevant BCTs (Michie & Johnston, 2012). Secondly, theory-driven mechanisms of action (MoAs) can be investigated to better understand how the intervention is expected to bring about its effects (Davis et al., 2015). Finally, theory can provide possible solutions to changing behaviour across different populations and contexts. Additionally, theory-based interventions provide researchers with an opportunity to test and refine the theory and thus facilitate intervention optimisation (Michie, 2008).

There may be numerous sources of complexity within behaviour change interventions. The MRC describes these factors as:

- the number of interacting components
- the number and difficulty of behaviours required by those delivering or receiving the intervention
- the number of groups targeted by the intervention (Craig et al., 2008).

Other characteristics include the number or variability of outcomes and the degree of flexibility allowed. While not a guarantee of effectiveness, a good theoretical understanding is essential for addressing these complexities.

The importance of applying a theoretical base to behaviour change interventions to maximise their potential efficacy has been previously highlighted in the literature (Bluethmann et al., 2017; Davis et al., 2015; Dombrowski et al., 2012). In the context of antibiotic use, there is growing evidence emerging from primary care research to support the effectiveness of interventions grounded in behavioural theory and evidence (Eccles et al., 2007; Hrisos et al., 2008; Little et al., 2013; Mohebbi et al., 2018). However, more focus on behaviour change theory underpinning these interventions is still needed, particularly why and how such interventions may work in other settings.

5.1.1 Challenges of selecting and applying suitable theory

Despite the expanding evidence on the importance of using theory in behavioural change interventions, a large proportion of health interventions are still designed without reference to theory, and where theory is used, it is often not applied rigorously (Michie et al., 2014). This trend is also evident in interventions targeting antibiotic use. For example, of 20 studies included in a recent systematic review of AMR interventions carried out by McParland et al. (2018), only four reported an explicit theoretical basis to their intervention. One reason for this may be a lack of clarity regarding how to translate theory into intervention design. Another explanation could be poor reporting or lack of detailed description of the theoretical basis of interventions, as well as the use of the most prominent theories, such as the Theory of Planned Behaviour or Health Belief Model, that do not address the important roles of habit or emotional processing and may therefore not be appropriate for the intervention design (Davis et al., 2015; Michie et al., 2011).

Even when interventions have positive effects, as shown in the previous section, the causal assumptions underlying the interventions are often not explicit but hidden within a 'black box', which does little to inform how these interventions could be replicated in another context (Maindal et al., 2010). A lack of systematic process evaluation, which provides clear descriptions of intervention theory and identifies key process questions, hinders assessment of intervention mechanisms, and assessment and replication of interventions (Moore et al., 2015). Rawson et al. (2017) further argue that, within the literature describing antibiotic use interventions, there is a lack of transparency in terms of which intervention components are directly responsible for its outcome. These components or 'active ingredients' explain how an intervention brings about change, representing the proposed MoAs (Craig et al., 2008).

The lack of reported detail makes it impossible for other researchers to determine which intervention components to use to ensure effectiveness. Choosing an appropriate theory to draw on is therefore challenging. Moreover, there are many existing theories and frameworks, including multiple psychological models available for guiding behaviour change interventions. However, as Prestwich et al. (2015) explain, many are incomplete, contain the same or overlapping constructs, and most have not been tested in a healthcare setting. For instance, a review led by Michie et al. (2014) identified 83 theories of behaviour and behaviour change, which contained more than 1700 theoretical constructs.

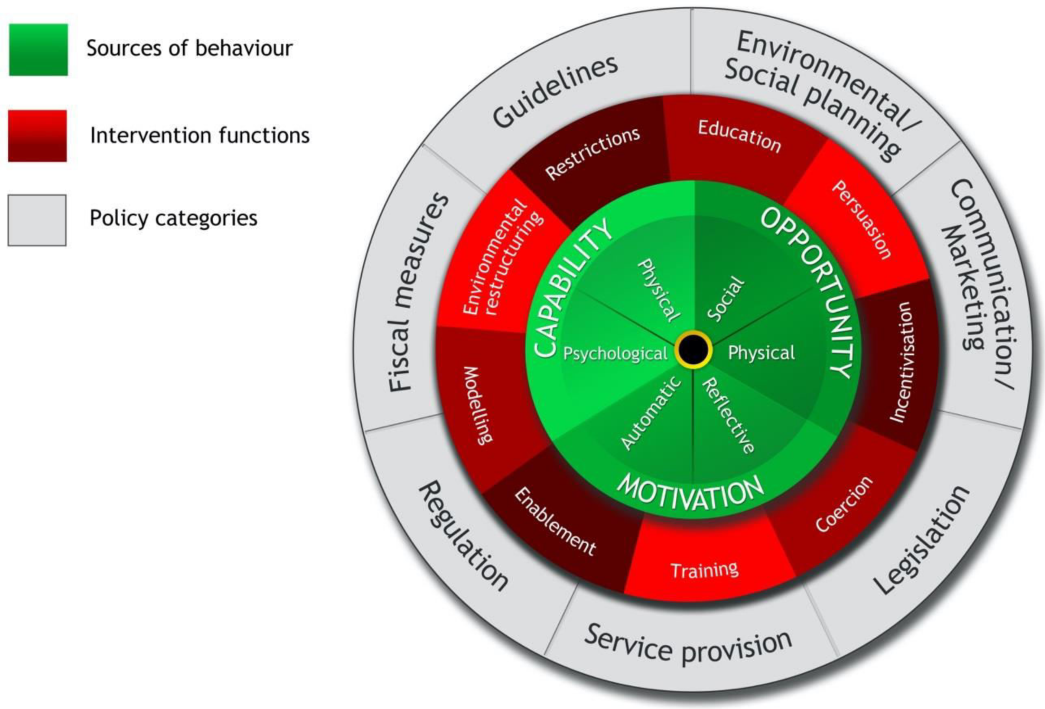
Glanz et al. (2015) provide a comprehensive review of behavioural theory and its application to real-world settings. The authors argue that there is no strong evidence for using one particular theory of health behaviour for interventions at individual, group and community levels. This suggests that theory selection should be guided by the researchers’ own informed assessment of its suitability for changing specific behaviour under the investigation.

In short, a multitude of theories, models and frameworks exists. They are all complex and originate from a variety of disciplines and backgrounds. However, different theories may be relevant to behaviour change interventions at different levels. For instance, psychological theories are more relevant to interventions targeting individuals and team behaviour, whilst organisational change theories are more applicable to interventions directed at hospitals or trusts, and so on (Walker et al., 2003). One common limitation is that they are only helpful for researchers trying to understand or predict behaviours but not change them and develop interventions (Davis et al., 2015). The Behaviour Change Wheel (BCW) was chosen to guide and inform the development of the intervention because this comprehensive framework can be used to analyse the problem in behavioural terms. The framework also recognises that behaviour change occurs as a result of an interacting system and it allows an in-depth exploration of the barriers and facilitators of change (Michie et al., 2014).

5.1.2 Using the BCW Framework to develop interventions

To address the challenges and recommendations outlined above, Michie et al. (2011) conducted a systematic review and developed the Behaviour Change Wheel (BCW) as a comprehensive approach to designing behaviour change interventions. The BCW (Figure 21) was developed from 19 frameworks for classifying behaviour change interventions, nine intervention functions and seven policy categories (Michie et al., 2011). This evidence-based framework allows the researcher to directly match intervention targets (behaviour, population and context) to specific MoAs (the processes through which behaviour change occurs) (Connell et al., 2019; Michie et al., 2014). The BCW has been examined for reliability and successfully applied in a number of contexts to address issues, such as physical activity in school children (Martin & Murtagh, 2015), promoting independent living in older adults (Direito et al., 2017), supporting parents to reduce the provision of unhealthy foods to children (Johnson et al., 2018), promoting appropriate antibiotic prescribing in primary care (Courtenay et al., 2019) and many others.

Figure 21. The Behaviour Change Wheel (Michie et al., 2011)

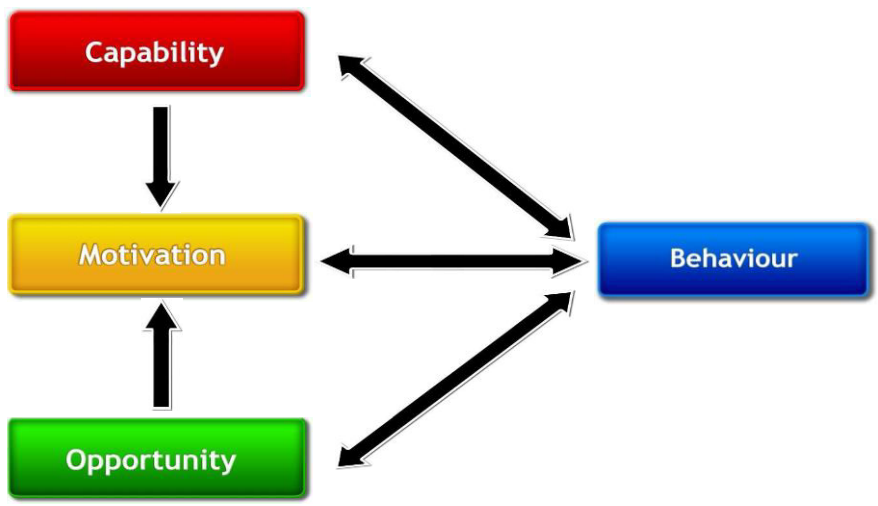


As illustrated in Figure 21, the BCW comprises three layers, and each of those layers needs careful consideration during intervention design and development to support behaviour change. At the core of the wheel are the four major influences on behaviour, which have been organised into the COM-B model (Capability, Opportunity and Motivation and Behaviour). The second layer comprises nine intervention functions that characterise the type of intervention that is required. The third and outer layer contains seven types of policy categories that can deliver those interventions. Using the BCW allows researchers to systematically and transparently identify and select evidence-based intervention functions and policy categories that could change behaviour (see Appendix 35 for definitions).

5.1.3 The COM-B Model

The starting point in the intervention development is the COM-B model (Figure 22).

Figure 22. COM-B Model (Michie et al., 2014)



Michie et al. (2014) define the COM-B components as follows:

- **Capability** is the individual's psychological and physical ability, and knowledge and skills required to engage in a particular behaviour (i.e., physical strength, stamina).
- **Motivation** is the internal drive to want to perform the behaviour over and above the alternatives (i.e., desires, impulses, intentions, inhibitions).
- **Opportunity** refers to the factors situated outside the individual that make the behaviour possible or prompt it (such as physical resources).

The authors of the model have proposed that changing behaviour will involve changing one or more of its interactive components into a new causal combination to minimise the risk of it reverting (Michie et al., 2014). Thus, for example, achieving positive changes in a prescriber's capability (e.g., increased knowledge of AMR) or opportunity (e.g., providing prompts and triggers to review antibiotics) can potentially increase their motivation to perform the required behaviour (e.g., timely antibiotic review), whilst motivation can only increase opportunity or capability through performing the behaviour itself (Michie et al., 2014).

As illustrated earlier in the BCW, each COM-B component is linked to intervention functions and policy categories (Figure 22). Intervention functions are potential ways to mitigate shortfalls in one or more of the COM components, whilst policy categories are decisions made by authorities that enable intervention functions (Michie et al., 2011). For example, physical skill development, which is the focus of training, could be used to address a lack of psychological capability, whilst legislation or service provision could enable these to occur.

Once the intervention options have been selected, the next step in intervention design involves the identification of effective BCTs and modes of delivery that can be linked back to psychological theory (Michie et al., 2014). This process is consistent with the MRC guidance on complex interventions (Craig et al., 2008). A detailed description of how the COM-B model and BCW have been applied to guide the development of an antibiotic intervention is provided in the following section.

5.1.4 Theoretical Domains Framework

To facilitate behavioural diagnosis using the COM-B model, the Theoretical Domains Framework (TDF) can be used to help identify what is most likely to bring about the desired behaviour change in the target group (Cane et al., 2012; Michie et al., 2005). This validated framework expands the capability, opportunity, and motivation elements into 14 different domains, with each considered a determinant of behaviour (Cane et al., 2012). Definitions of these domains and their component constructs are provided in Appendix 36.

The framework was developed by an international panel of behaviour change experts through a consensus approach, who identified 128 theoretical constructs from 33 theories of behaviour change and then simplified them into theoretical domains (Cane et al., 2012). In the context of research onto antimicrobial use, the TDF has been effectively used to design surveys and topic guides and analyse interview data exploring factors influencing antibiotic prescribing across various healthcare settings, including hospitals (Chaves et al., 2014; Ierano et al., 2019).

However, although it is a useful and flexible framework for examining people's experiences, attitudes, and perspectives, and identifying a range of possible barriers and enablers to behaviour change facilitating the development of targeted interventions, the TDF is not without its drawbacks. For example, a mixed-methods study exploring the use of TDF has found that researchers experienced several challenges in applying the framework, including time and resources issues and steps in operationalising TDF (Phillips et al., 2015). A recent systematic review looking at TDF-related qualitative publications, which employed health care professionals or patient/public samples, has found similar results (McGowan et al., 2020). The authors recommended less rigid use of the TDF and a more inductive aspect to analysis. These challenges and recommendations have been considered in the application of TDF in Step 4.

5.1.5 Behaviour Change Techniques Taxonomy

The key intervention components or 'content' are the active ingredients that bring about behaviour change (Michie et al., 2013). These active components are the 'what' of the intervention rather than the 'how'. With a proliferation of behavioural interventions, different labels have been used to identify the same intervention components, and the same label has described different components (e.g., behavioural counselling). The absence of standardised definitions has led to confusion, highlighting the urgent need for consensus (Michie et al., 2008). This urgency is reflected in the MRC calls for improved methods of specifying and reporting the content of interventions (Craig et al., 2008).

To address this lack of consistency, Michie and colleagues (2013) developed a taxonomy of Behaviour Change Technique (version 1) (BCTTv1), comprising 93 BCTs clustered into 16 groupings (see Appendix 37). This extensive and rigorous classification system was developed by international expert consensus and offers a systematic way of characterising the potentially active ingredients of behavioural interventions (Michie et al., 2013). Michie et al. (2013, p. 5) define the BCTs as “the observable, replicable and irreducible component of an intervention designed to alter or redirect causal processes that regulate behaviour”, which can be used either individually or in conjunction with other BCTs.

The BCW guides intervention developers to a range of options when selecting suitable BCTs, with recommendations that all options should be considered in intervention design. Michie et al. (2013) further categorised the BCTs into ‘frequently used’ and ‘less frequently used’ within each intervention function. For instance, goal setting, feedback and restructuring the physical environment are all examples of frequently used BCTs. In addition, effective BCTs have been used to identify intervention techniques across a wide range of studies, for example, to increase physical activity (Devi et al., 2014), medication adherence (Bobrow et al., 2018) and changing health professionals’ behaviour (Treweek et al., 2014).

5.2 Aims

The aim of this chapter is to identify and develop a theoretical understanding of how the intervention is likely to achieve the desired outcome, determine causal links between components and develop a prototype behaviour change intervention to improve antibiotic use in acute hospitals. The aims and objectives follow the three stages of Michie et al.’s (2014) BCW Framework. The applied approach has been adapted from Marley’s (2017) work.

5.2.1 Objectives

The specific objectives are to complete stages 1-3 of the intervention development using the BCW, such as:

Stage 1: Understand target behaviour

- Make a behavioural analysis of what underlies the problem.

Stage 2: Identify intervention options

- Identify and select intervention functions.
- Identify and select policy categories.

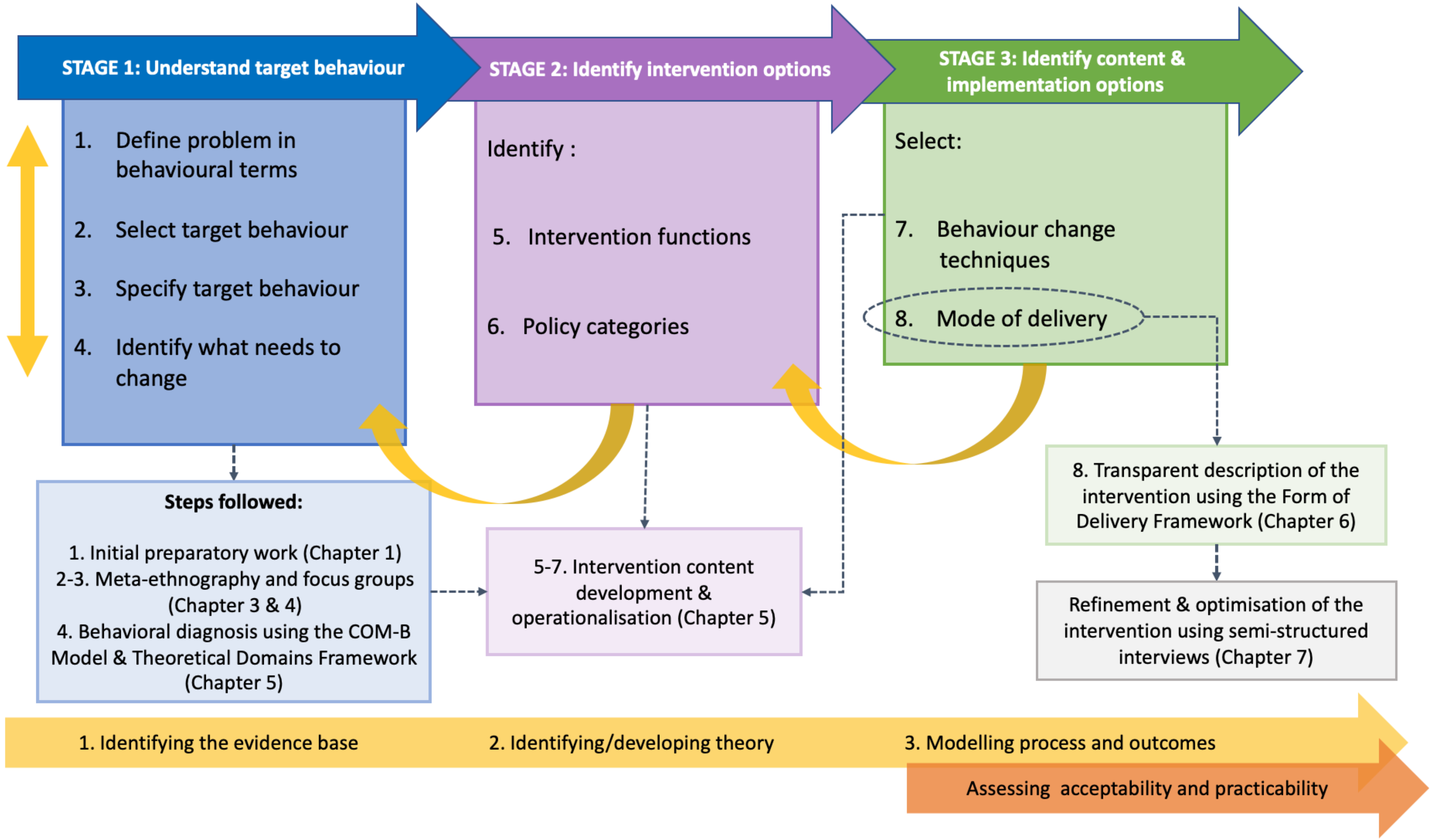
Stage 3 (BCW): Identify content and implementation options

- Identify and select BCTs to be included in the intervention.

5.3 Methods

This section presents the process involved in developing the content or 'active ingredients' of the antibiotic intervention. The operationalisation of the intervention content is described, and the created matrix displays the proposed mechanisms of action. The BCW three-stage, eight composite steps approach (Michie et al., 2014), illustrated in Figure 23, guided the intervention development.

Figure 23. The applied stages of the BCW and MRC framework mapped onto thesis chapters



5.3.1 Stage 1: Understand the target behaviour

As illustrated in Figure 23 above, the first stage in intervention development involves understanding the behaviours to be influenced by following four steps, starting from defining the health issue in behavioural terms (Chapter 1), through to carrying out a meta-ethnography (Chapter 3) and focus groups with a range of stakeholders (Chapter 4) to understand the theoretical and practical components that should be considered in a future intervention targeting antibiotic prescribing behaviours in a hospital setting. It should be noted that an inductive approach in the intervention design means that some steps in the development process overlapped and/or occurred simultaneously. Step 8 (options for mode of delivery of the intervention) is discussed separately in the next chapter. The details in each step are presented in the following sections.

5.3.1.1 Step 1: Define the problem in behavioural terms

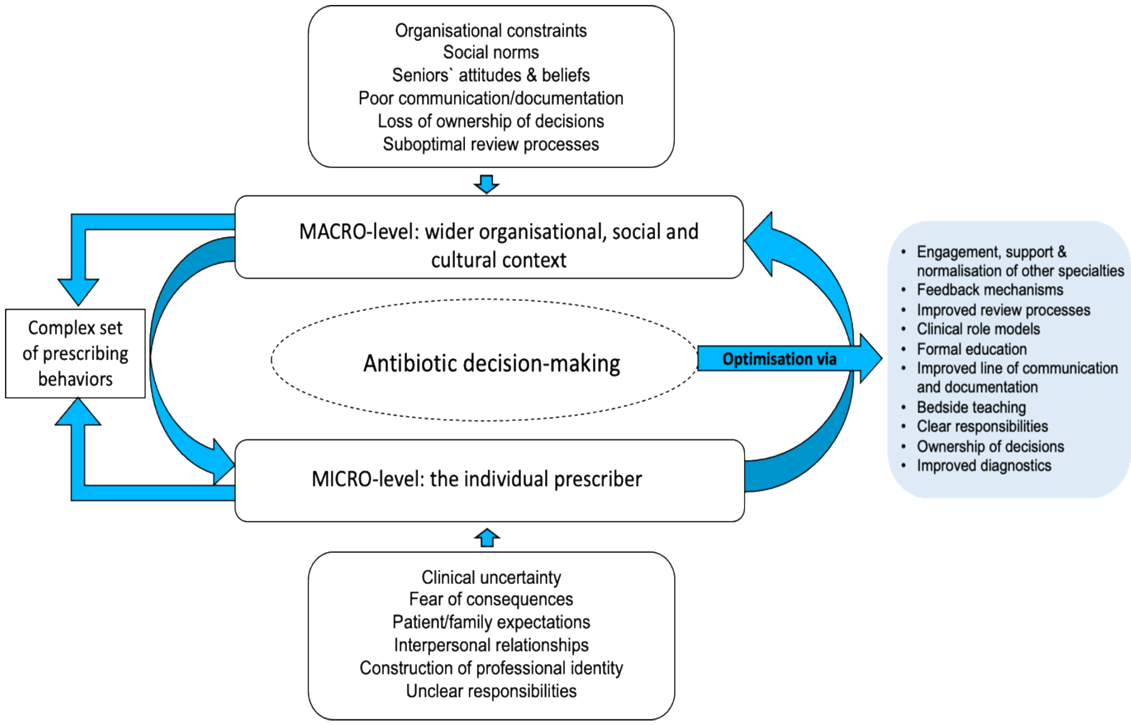
The first step in the BCW framework is to define the problem that requires intervention in behavioural terms, including identifying the problem and specifying the behaviour and target population (Michie et al., 2014). Chapter 1 of this thesis outlined the problem in behavioural terms, taking the specific context into account. Briefly, it described that antibiotics are among the most frequently prescribed and costly hospital therapies, yet 30-50% of that usage remains unnecessary or inappropriate (CDC, 2019). It further identified a gap in the evidence base on what behaviour-change strategies work in a hospital setting, how to implement them and what refinements are needed to tailor the interventions to the local context (Lorencatto et al., 2018). It concluded by suggesting that a better understanding of the wide-ranging contextual, organisational and interpersonal determinants of antibiotic decision making and their influence on hospital prescribers is needed to inform intervention development.

The problem has therefore been defined as inappropriate antibiotic use not concordant with local or national guidelines, including prescribing antibiotics when they are not clinically required (e.g., for viral illnesses); prescribing for an incorrect length of time; unnecessary prescribing (e.g., bacterial infections of the throat); or incorrect selection of therapy (mismatch between organisms, for example, prescribing a broad-spectrum antibiotic when a lower-risk narrow-spectrum agent, which is equally or more effective for treating the same illness/disease, is available); and unnecessary risk (use of intravenous antibiotics when oral forms would be suitable) (Monnier et al., 2018).

5.3.1.2 Step 2. Select target behaviour

Once the problem is defined in behavioural terms, the next step is selecting the target behaviour(s) to address it. Given that individual behaviours do not occur in isolation, it is important first to understand the context relevant to the target behaviour. This step involved carrying out a systematic review of the literature and a meta-ethnography (Chapter 3) to help decide which determinants (specifically, which barriers and facilitators) contribute to inappropriate antibiotic prescribing in acute hospitals. This process resulted in the development of a conceptual model (described in detail in Section 3.3.5), depicting the multiple determinants that influence doctors' antibiotic decision making behaviours (illustrated in Figure 24). These factors were found to have an impact at the macro level, including broader organisational, social and cultural context, and micro level, the individual prescriber. Recommendations for improving practice, including creating feedback mechanisms, distributing responsibility for antibiotic decisions to less experienced prescribers, reducing fear of consequences, and normalising input from other specialities, were provided at this stage.

Figure 24. Conceptual model developed in the meta-ethnography (Chapter 3)



The conceptual model developed in Chapter 3 requires consideration of all identified factors impacting antibiotic prescribing practice and the specific behaviours to potentially target in the intervention before narrowing these down to just a few. Michie et al. (2014, p. 48) recommend a “less is more” approach and suggest starting with small changes and building upon these gradually.

West et al. (2020) explain that every behaviour is influenced by other behaviours, including the people the intervention will target and other people’s behaviours. Identifying relationships between behaviours can therefore be challenging. To provide a better understanding of the problem and thus select the target behaviour, it was deemed necessary at this stage to include a variety of stakeholder perspectives by carrying out empirical research with the target population and health service users (see Section 4.4 for data and sampling methods). The three focus groups helped identify the context in which the intervention will be used and which behaviours are amenable to change.

The data analysis revealed many issues that the participants felt contributed to gaps in the antibiotic decision making process. For example, a recurring finding that emerged across the focus groups was the sub-optimal antibiotic review (switching or stopping of treatment), leading to a decision to primarily target that behaviour. From the subsequent data analysis, it became apparent that the intervention needed to target all healthcare professionals (HCPs) involved in antibiotic decision making regardless of the area of practice but also include patients and/or their families, in other words, to make it ‘everyone’s business’.

5.3.1.3 Step 3. Specify target behaviour

To specify the target behaviour, the BCW recommends describing the behaviour with sufficient detail and its context by considering the Who, What, When, Where, How Often and With Whom (Michie et al., 2014). As a result of decisions made in Step 2, the target behaviour has been specified within the context of a hospital environment and summarised in Table 15.

Table 15. Specifying the target behaviour (adapted from Michie et al., 2014)

Steps involved in specifying the target behaviour	Details
Target behaviour	Optimal antibiotic review
Who needs to perform the behaviour?	Healthcare professionals involved in antibiotic prescribing or administration in inpatients
What do they need to do differently to achieve the desired behaviour?	Carry out a comprehensive and timely antibiotic review
When do they need to do it?	During the ward round at 42-72 hours after initiation of antibiotics
Where do they need to do it?	In acute hospitals (including acute and general medical settings)
How Often do they need to do it?	Daily after the initial review
With Whom do they need to do it?	A multi-disciplinary approach in consultation with patients or patient guardians (person-centred)

Therefore, this intervention aims to reduce inappropriate antibiotic prescribing by improving hospital antibiotic review practice.

5.3.1.4 Step 4: identify what needs to change

Having specified the target behaviour, the next step is to understand what needs to change in individual behaviour and the environment to achieve that behaviour. West et al. (2020) recommend that this step should involve making a COM-B diagnosis of what underlies the behavioural problem to determine the best approach to address it. This means analysing whether hospital prescribers have the capability, opportunity, and motivation to carry out the behaviour. Although critical, this step is often overlooked in intervention design (Michie et al., 2014).

Behavioural diagnosis has therefore been carried out in stages. First, the meta-ethnography and focus groups provided a contextual understanding of the barriers and facilitators most important to health professionals to affect their prescribing behaviour. This information was then retrospectively mapped onto the COM-B system of the BCW and the TDF and recorded in a matrix form (see Appendix 38). This analysis allowed for each barrier and enabler influencing clinical practice behaviour to be linked to specific TDF domains.

The next step entails determining what needs to change for the target behaviour to occur – specifically, selecting and prioritising the key items from the matrix considered most relevant for intervention targeting antibiotic review. For each domain, the researcher collated all the barriers and facilitators and prioritised those considered modifiable; exerting a strong influence on antibiotic review practice; likely to be feasible and relevant at the site; and acceptable to the prescribers. The prioritised determinants were then mapped onto the COM-B model and TDF. This task of collating and prioritising items was scrutinised by the supervisory team. The outcome of this process has been recorded in a tabular form. It represents the foundations for intervention design, outlining the capability, opportunity and motivational factors that need to be addressed to create a change in antibiotic review practice.

5.3.2 Stage 2: identify intervention options

5.3.2.1 Step 5: Identify intervention functions

Once the relevant COM-B components related to prescribers' behaviour that can be targeted as potential levers for change have been identified, the next step is to explore how to address each identified area by selecting specific intervention functions. Michie et al. (2014) explain that intervention functions are broad categories that enable a change in behaviour (e.g., education or coercion). As discussed earlier, several intervention functions can be effective for more than one COM-B component (West et al., 2020). The BCW guide provides a table mapping relevant intervention functions likely to effect change in specific COM-B components (Table 16). The matrix presented below was used to identify all possible intervention functions considered likely to effect change for the TDF domains that have been selected as intervention targets.

Table 16. Matrix of links between COM-B and intervention functions (adapted from Michie et al., 2014) – refer to Appendix 35 for definitions

	Intervention functions								
COM-B Components	Education	Persuasion	Incentivisation	Coercion	Training	Restriction	Environmental restructuring	Modelling	Enablement
Physical capability									
Psychological capability									
Physical opportunity									
Social opportunity									
Automatic motivation									
Reflective motivation									

However, to select appropriate intervention functions, it was also necessary to review the behaviour change techniques to see how they align with the identified TDF domains (see Step 7). Therefore, the proposed intervention content was created through an iterative approach, where BCTs were mapped back to intervention functions. This activity is further discussed in the following sections.

5.3.2.2 APEASE criteria

When making context-related decisions on the intervention content, the BCW guide recommends assessing intervention functions and policy categories using the APEASE criteria (Affordability, Practicability, Effectiveness and Cost-effectiveness, Acceptability, Side effects/safety, Equity – see Appendix 39 for full definitions) (Michie et al., 2014). However, as this screening process heavily relies on the availability of resources, which tend to vary between developers, the responsibility to use APEASE criteria lies with individual intervention developers (Ojo et al., 2019).

Having identified all suitable intervention functions, the next step entailed applying the APEASE criteria accordingly and making judgements for each in the context of the planned intervention. The outcome of this assessment has been presented in a table format with brief statements explaining the reasons for inclusion and exclusion (see Section 5.4.2).

5.3.2.3 Step 6: Identify policy categories

Once the intervention strategy has been developed, the next step involves evaluating policies that are likely to support the delivery of the intervention functions. This step was carried out by mapping the identified intervention functions onto policy categories using the BCW matrix (see Table 17). Finally, the same cyclical process described in Step 6 was applied, and judgements were made using the APEASE criteria.

Table 17. Matrix of links between policy categories and intervention functions (adapted from Michie et al., 2014) – refer to Appendix 35 for definitions

	Intervention functions								
Policy categories	Education	Persuasion	Incentivisation	Coercion	Training	Restriction	Environmental restructuring	Modelling	Enablement
Communication/marketing									
Guidelines									
Fiscal									
Regulation									
Legislation									
Environmental/social planning									
Service provision									

5.3.3 Stage 3: identify content and implementation options

5.3.3.1 Step 7: Identify behavioural change techniques

Having selected relevant intervention functions and policies to support and enact change, the next step involves mapping these onto specific behaviour change techniques (BCTs). Specifying intervention content using the BCT Taxonomy (see

Appendix 37) requires the researcher first to identify or code BCTs. Michie et al. (2014) recommend considering all BCTs that may be suitable for use within an intervention at the earliest stage. Therefore, all 93 BCTs included in the taxonomy were checked for inclusion.

This process of categorising qualitative information was deductive and repeated several times and required making many complex interpretative judgements. Through this process, the researcher considered all relevant BCTs for each prioritised TDF domain and then selected potentially effective BCTs for delivering the intervention. This process was informed using the mapping table developed by Cane et al. (2015), which links BCTs to TDF domains (see Appendix 40). The list of all possible BCTs was narrowed down to the ones most likely to alter prescribers' behaviour. Input from the supervisory team was sought throughout the coding process, as some members had familiarity with the BCT labels and definitions. For those who were less familiar with the framework, it helped to challenge the researcher's thinking and assumptions as they had a fresh or lay perspective.

5.3.4 Operationalising content of the intervention

After the decisions were made on the appropriate intervention functions, policy categories and BCTs, the next phase of the intervention development was to operationalise the results. This process facilitated a better understanding of how the intervention would work in the context of hospital practice. This final step resulted in developing a matrix (presented in Stage 3) of the proposed intervention content, linking BCTs to intervention functions, policy categories and the TDF behavioural deficits selected as intervention targets.

5.4 Results from the application of the BCW framework

This section presents results for Objectives 1-4. A summary of each BCW stage is provided, followed by specific recommendations for the intervention components.

5.4.1 Stage 1: Understand target behaviour by conducting behavioural diagnosis (Steps 1- 4)

The behavioural diagnosis (Table 18) highlights a range of issues related to capability, both physical (e.g., competence in reviewing antibiotics and communication skills) and psychological (e.g., knowledge of current guidelines and the threat posed by AMR); opportunity, both social (e.g., increase social support from peers and other specialities in the decision making process) and physical (e.g., increase use of resources to effectively document and communicate prescribing decisions); and motivation, both reflective (e.g., confidence to challenge decisions of senior colleagues) and automatic (e.g., reduce fear of making a no antibiotic prescription or de-escalating/stopping antibiotics).

This analysis revealed 12 domains (skills, knowledge, behavioural regulation; memory, attention and decision processes; environmental context and resources; social influences; beliefs about capabilities; beliefs about consequences; social/professional role and identity; goals; reinforcement; emotion) as drivers for improving the antibiotic review process. These influencers have been further considered in the intervention development in Stage 2 and are discussed together with the strategies derived from the analysis.

Table 18. COM-B & TDF behavioural analysis of determinants influencing antibiotic review process within the context of hospital prescribing

COM-B	TDF	What needs to change for antibiotic review to improve?
Capability – physical	Physical skills	Competence in reviewing antibiotics and communication skills; Ability to engage patients in shared decision making.
Capability – Psychological	Knowledge	Increase prescriber knowledge of how to perform antibiotic review; Increase knowledge of current guidelines and the threat posed by AMR when deciding to initiate/or continue a broad-spectrum antibiotic; Increase patient and family's knowledge of the AMR, the risks of antibiotics and the rationale for a 'no antibiotic' decision.
	Memory, attention and decision processes	Increase awareness of the importance of person-centred prescribing.
	Behavioural regulation	Ability to weigh up information from guidelines, patient's pre-existing conditions and testing to inform prescribing decisions; Reduce cognitive overload on

		prescribers.
Opportunity – physical	Environmental context and resources	Increase use of resources to effectively document and communicate prescribing decisions; Increase transparency of prescribing; Provide easy access to antimicrobial guidelines tailored to specific groups of prescribers and clinical areas. Reduce time pressures; Improve collaboration of care decisions; Provide training and learning opportunities in practice; Use of triggers to review antibiotics; Facilitate discussions with patients and families about antibiotics. Increase access to rapid diagnostic tests – outwith the scope of the intervention.
Opportunity – social	Social influences	Increase social support from peers and other specialities in reviewing antibiotics; Normalise questions around antibiotics.
Motivation – reflective	Beliefs about capabilities	Empower prescribers to make autonomous decisions at review; Confidence in changing, stopping or making a 'no-antibiotic' prescribing decision; Confidence to challenge decisions of senior colleagues; Empower patients and families to ask questions about antibiotics.
	Beliefs about consequences	Reduce invisibility of consequences of poor practice.
	Social/professional role and identity	Understand personal and professional responsibilities of the role; Reduce responsibility avoidance; Harness leadership to show that most people perform the desired behaviour.
	Goals	Employ strategies to carry out a timely antibiotic review.
Motivation – automatic	Reinforcement	Monitor prescribing decisions and provide feedback to maintain an optimal level of antibiotic prescribing.
	Emotion	Reduce fear of making a 'no antibiotic' decision or de-escalating/stopping antibiotics.

5.4.2 Stage 2: Identify intervention options (Steps 5 and 6)

5.4.2.1 Identify intervention functions

Guided by the behavioural analysis carried out in Step 4 and judgements using the APEASE criteria, relevant intervention types were identified and then mapped to COM-B targets to provide a broad indication of the likely effectiveness of the intervention. Subsequently, seven out of nine intervention types described in the BCW guide were considered potential candidates for antibiotic intervention development. These functions included: education, training, persuasion, modelling, restriction, environmental restructuring and enablement (see Table 19).

Table 19. Using APEASE to judge the intervention functions for the antibiotic intervention – refer to Appendix 35 for definitions

Intervention functions	Does the intervention function meet the APEASE criteria: affordability, practicability, effectiveness/cost-effectiveness, acceptability, side-effects/safety, equity?
Education	Yes
Training	Yes
Persuasion	Yes – use persuasive communication to induce positive feelings or stimulate action.
Modelling	Yes – ideally, senior clinicians could provide an example for colleagues to aspire to or imitate. Could be videos/webinars.
Restriction	Yes – restricted access to non-first-line antibiotics already exists within some NHS hospitals.
Environmental restructuring	Yes – restructuring services within the available resources and optimising services through improved use of IT systems/decision support tools. Objects could be added to clinicians' workspace (posters, leaflets), or electronic reminders can be used as prompts to undertake a review.
Enablement	Yes – increasing means and reducing barriers to increase capability beyond training education and beyond environmental restructuring. Cognitive behavioural approaches and increased collaboration to restructure thinking around AMR to address the fear of consequences.
Incentivisation	Not thought to be practicable within the scope of service, or affordable, cost-effective or equitable to healthcare professionals.
Coercion	Not thought to be practicable or acceptable in this context.

Education pertains to the provision of information in order to increase knowledge about current antibiotic guidelines, and the critical role prescribers can have on reducing AMR and its long-term effects. Training clinicians on appropriate prescribing behaviour and enabling learning opportunities may facilitate the target behaviour. Persuasion was selected to reinforce the potential of the intervention to encourage and advise prescribers undertaking an antibiotic review. For instance, persuasive communication could be used to emphasise the importance of long consequences of overprescribing. Modelling was selected based on the premise that the antibiotic review process could be improved by providing an observable sample of the required behaviour for prescribers to aspire to or imitate. Restriction could be applied by limiting access to non-first-line antibiotics. As the intervention also requires the individual's physical and social context to be adjusted, environmental restructuring was selected for that reason. Creating an audit trail of decisions by utilising IT systems is one way of achieving this. Finally, enablement was selected because reducing barriers to increase capability beyond training, education and environmental restructuring and increasing collaboration between health professionals is vital for the intervention to be successful.

In addition, incentivisation was not selected as this intervention type did not relate to any BCTs and is unlikely to be practicable, affordable, cost-effective or equitable to staff. Coercion was also judged to be not practicable on a larger scale and not acceptable to staff.

5.4.2.2 Identify policy categories

The seven intervention functions chosen for delivering the intervention were then mapped onto the policy categories. However, only three policy levers were deemed likely to support the intervention delivery (Table 20). These included guidelines (e.g., informing clinicians of antimicrobial guidelines); communication to influence organisational practice by communicating a vision for change (examples of which include using verbal and electronic communication or flyers to generate awareness of AMR/consequences of overprescribing antibiotics or benefits of a timely antibiotic review), and environmental/social planning (e.g., designing and utilising an automated system for reminding hospital prescribers to review antibiotics).

Guidelines around the appropriate use of antibiotics currently exist within the NHS, and rather than develop new guidelines, this intervention aims to increase current guideline awareness and adherence. Regulations could be harnessed at a later stage if the intervention proves effective. Changes to fiscal measures and legislation are outside the scope of this project or the researcher's ability and could potentially lead to problems with acceptability, practicality, and patient safety if antibiotic decision making is made too restrictive.

Table 20. Using APEASE to judge the policy categories for the antibiotic intervention – refer to Appendix 35 for definitions

Policy categories	Does the policy category meet the APEASE criteria: affordability, practicability, effectiveness/cost-effectiveness, acceptability, side-effects/safety, equity?
Communication/ marketing	Yes
Guidelines	Yes – guidelines to support prudent use of antibiotics and AMS initiatives in this context currently exist. Increase current guideline awareness and adherence.
Fiscal measures	Not possible to access in the context of this intervention.
Regulation	Not possible in this context. Potential for new regulation if effectiveness is shown.
Legislation	Not possible in this context.
Environmental/ Social planning	Yes – changes can be made to the physical and social environment by increasing the use of IT resources and utilising a decision support tool.
Service provision	Not applicable (or possible) in the context of this intervention.

5.4.3 Stage 3: Identify content and implementation options (Step 7)

A total of 25 out of the 93 BCTs were identified, including instruction on how to perform the behaviour; demonstration of the behaviour; information about health consequences; credible source; add objects to the environment; goal setting (behaviour); action planning; problem solving; discrepancy between current behaviour and goal; behavioural practice/rehearsal; restructure the physical environment; feedback on behaviour; feedback on outcome(s) of behaviour; demonstration of the behaviour; prompts and cues; social support (unspecified); social comparison; focus on past success; habit reversal; habit formation; identification of self as role model; information about emotional consequences; reduce negative emotions; information about social and environmental consequences, and verbal persuasion about capability. These are presented in Table 21.

As recommended by Michie et al. (2014), the selected BCTs can be used either individually or in combination with others. However, it should be noted that the number and effectiveness of specific BCTs or BCT combinations for a given behaviour in each context remains uncertain (Michie et al., 2018). The following section discusses these strategies derived from the analysis for each COM-B component and provides recommendations on the intervention content.

5.4.4 Operationalising the BCTs

Operationalisation involved describing how each selected BCT could be potentially used in practice for each COM-B component. Matrices were developed to display the proposed mechanisms of action (MoAs) and provide recommendations on the content. The initial version of the intervention comprises 25 BCTs, delivered across seven intervention functions, using three policy levers that aim to address deficits in twelve TDF domains (see Table 21 – shading highlights each COM-B component).

Table 21. Matrix of the proposed intervention content mapped from COM-B to the TDF (based on Cane et al., 2012 and Michie et al., 2014), intervention functions and policy categories, with BCTs selected as the most appropriate targets for the proposed intervention drawn from meta-ethnography and focus groups

COM-B	Theoretical domain	What needs to happen for the target behaviour to occur?	Potential intervention function	Policy category	BCTs (selected)	Recommendations on intervention content
↑ **CAPABILITY** (physical)	**Skills:** An ability or proficiency acquired through practice.	• Competence in reviewing antibiotics and communication skills. • Ability to engage patients in shared decision making.	Training Enablement	Guidelines Environmental/ social planning	1.2 Problem solving 4.1 Instruction on how to perform the behaviour 6.1 Demonstration of the behaviour	• Identify and discuss barriers to undertaking a timely antibiotic review. • Demonstrate how to undertake antibiotic review using a decision support tool and communicate effectively with peers and patients. • Provide instructions for how to use the decision support tool (e.g., using clinical examples).
↑ **CAPABILITY** (psychological)	**Knowledge:** An awareness of the existence of something.	• Prescriber's knowledge of how to perform a timely antibiotic review. • Knowledge of current guidelines and the threat posed by AMR when deciding to initiate/or continue a broad-spectrum antibiotic. • Patient and family's knowledge of the AMR, the risks of antibiotics and the rationale for a 'no antibiotic' decision.	Education Training Enablement	Communication Guidelines Environmental/ social planning	4.1 Instruction on how to perform the behaviour 5.1 Information about health consequences 5.3. Information about social and environmental consequences 9.1 Credible source 12.5 Add objects to the environment	• Provide a rationale for undertaking a timely review and changing, stopping/de-escalating antibiotics. • Provide instructions on how to perform a timely antibiotic review. • Provide information about competing priorities (e.g., patient's immediate health needs vs long term effects of AMR) and existing guidelines (e.g., training during induction, patient leaflets and posters). • Provide easy access to guidelines. • Embed formal education related to antibiotic stewardship within the curricula (outwith the scope of the intervention).
	Behavioural regulation: Anything aimed at	• Be aware of the importance of person-centred prescribing.			1.1 Goal setting (behaviour) 5.1 Information about	• Information on person-centred prescribing behaviour and its • importance.

	managing or changing objectively observed or measured actions.				health consequences 1.4 Action planning	• Prompt communication with patients about their antibiotic treatment (or decision not to prescribe).
	Memory, attention and decision processes: The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives.	• Ability to weigh up information from guidelines, patient's pre-existing conditions and testing to inform prescribing decisions. • Reduce cognitive overload.			1.2 Problem solving 4.1 Instruction on how to perform the behaviour 1.6 Discrepancy between current behaviour and goal 8.1 Behavioural practice/ rehearsal 12.1 Restructure the physical environment	• Provide instruction on how to change, stop/de-escalate antibiotics (e.g., using clinical examples). • Outline deviations from guidelines/ evidence-based practice. • Prompt prescribers to practice referring to the guidelines in daily practice. • Utilise a decision support tool to help prescribers make decisions based on guidelines. • Utilise IT solutions to effectively document and communicate prescriptions' rationale.
↑ OPPORTUNITY (physical)	**Environmental context and resources:** Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and adaptive behaviour.	• Increase use of resources to effectively document and communicate prescribing decisions. • Increase transparency of prescribing. • Provide easy access to antimicrobial guidelines tailored to specific groups of prescribers and clinical areas. • Reduce time pressures. • Improve collaboration of care decisions. • Facilitate discussion with patients about antibiotics. • Provide training and learning opportunities in practice. • Use of triggers to review	Training Restriction Environmental restructuring Enablement	Guidelines Environmental/ social planning	4.1 Instruction on how to perform behaviour 5.1 Information about health consequences 7.1 Prompts/cues 9.1 Credible source 12.1 Restructure the physical environment 12.5 Add objects to the environment	• Employ more efficient ways of documenting and communicating prescribing decisions. • Utilise IT systems to create a robust audit trail of decisions. • Advise how resources can be used (e.g., electronic prescribing system, posters, etc.) to communicate prescribing decisions effectively. • Provide patient information (e.g., posters, leaflets) to facilitate discussion with clinicians re stopping antibiotics. • Provide easy access to credible sources of information. • Enable better collaboration between health professionals. • Engage patients in discussions about antibiotics (e.g., using a leaflet).

		antibiotics. • Increase access to rapid diagnostic tests (outwith the scope of the intervention).			4.1 Instruction on how to perform behaviour 1.4 Action planning 2.2. Feedback on behaviour 6.1 Demonstration of the behaviour 7.1 Prompts and cues 8.1. Behavioural practice / rehearsal 8.3. Habit formation 12.5 Add objects to the environment 12.1 Restructure the physical environment	• Train prescribers on how to undertake a timely review and enable learning opportunities. • Encourage prescribers to ask questions (e.g., utilise the Antibiotic 3+3) and provide feedback on prescribing. • Utilise existing NHS antibiotic champions to demonstrate behaviour, provide training and feedback on performance. • Prompt use of decision support tool at review. • Introduce environmental stimulus (e.g., electronic triggers and prompts, posters) to prompt or cue timely antibiotic review. • Restrict access to non-first-line antibiotics.
↑ OPPORTUNITY (social)	**Social influences:** Those interpersonal processes that can cause individuals to change their thoughts, feelings or behaviours.	• Increase social support from peers and other specialities. • in reviewing antibiotics. • Normalise questions around antibiotics.			3.1 Social support (unspecified) 4.1 Instruction on how to perform the behaviour 7.1 Prompts and cues 6.2 Social comparison 12.2 Restructuring the social environment 1.4 Action planning 12.1 Restructure the physical environment	• Draw attention to others' prescribing performance to allow comparison. • Provide guidance on how senior colleagues should be involved in decisions to change or de-escalate/stop antibiotics at review. • Enable prescribers to seek advice about antibiotics from peers and other specialities. • Engage other health professionals (e.g., nurses and pharmacists) in prompting the antibiotic review. • Ensure the availability of local champions to provide advice. • Provide social support of leadership to aid prescribers in antibiotic decision making. • Utilise IT solutions to prompt questions about antibiotics to facilitate target behaviour.

↑ **MOTIVATION** (reflective)	**Beliefs about capabilities:** Acceptance of the truth, reality or validity about an ability, talent or facility that a person can put to constructive use.	• Empower prescribers to make autonomous decisions at review. • Confidence in changing, stopping or making a 'no-antibiotic' prescribing decision. • Confidence to challenge decisions of senior colleagues. • Empower patients and families to ask questions about antibiotics.	Education Persuasion Training Environmental restructuring Modelling Enablement	Communication Guidelines Environmental/ social planning	1.1. Goal setting (behaviour) 5.1. Information about health consequences 15.3 Focus on past success 6.1 Demonstration of the behaviour 4.1 Instruction on how to perform the behaviour 1.2 Problem solving 9.1 Credible source 7.1 Prompts and cues 8.4 Habit reversal 12.1 Restructure the physical environment 12.5 Add objects to the environment 15.1 Verbal persuasion about capability	• Discuss clinical uncertainty and provide a rationale for de-escalating/stopping antibiotics at review. • Advise a reflection on positive outcomes of prescribing decisions. • Using a credible source, provide instructions (e.g., using clinical examples) on when and how to change, stop or make a 'no-antibiotic' decision. • Utilise an automated system (e.g., electronic prompts) for reminding prescribers to review antibiotics and motivate independent decision processes. • Interrupt reflex behaviours by • introducing environmental stimulus to prompt questions about antibiotics (e.g., electronic reminders, posters).
	Beliefs about consequences: Acceptance of the truth, reality or validity about outcomes of behaviour in a given situation.	• Reduce invisibility of consequences of poor practice.			5.1 Information about health consequences 9.1. Credible source 12.1 Restructure the physical environment 2.2 Feedback on behaviour	• Use persuasive communication of information on AMR and negative consequences of overprescribing or continuing antibiotics longer than necessary, supported by consultant microbiologists. • Utilise IT systems to create an audit trail of prescribing decisions and providing feedback on performance.
	Social/professional role and identity: A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting.	• Understand personal and professional responsibilities of the role. • Reduce responsibility avoidance. • Harness leadership to show that most people perform the desired behaviour.			6.1 Demonstration of the behaviour 13.1 Identification of self as role model 4.1 Instruction on how to perform the behaviour 6.1 Demonstration of the behaviour 9.1 Credible source 12.1 Restructure the	• Provide an observable sample of the performance of the behaviour using clinical examples, directly in person or indirectly (e.g., via film, webinar, pictures) for the prescribers to aspire to or imitate. • Clarify individual responsibilities • Provide information about the important role prescribers can have in reducing AMR and its

					physical environment	effect on the broader health of society, in addition to the duty towards the patient. • Engage medical leaders in demonstrating the target behaviour. • Create an audit trail of prescriptions to increase the visibility of antibiotic decisions.
	Goals: Mental representations of outcomes or end states that an individual wants to achieve.	• Employ strategies to carry out a timely antibiotic review.			1.1 Goal setting (behaviour) 6.1 Demonstration of the behaviour	• Create timely review goals and engage senior clinicians in performing the target behaviour.
↑ MOTIVATION (automatic)	**Reinforcement:** Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus.	• Monitor prescribing decisions and provide feedback to maintain an optimal level of antibiotic prescribing.			2.2 Feedback on behaviour 2.7 Feedback on outcomes of behaviour 4.1 Instruction on how to perform the behaviour 5.1 Information about health consequences 12.1 Restructure the physical environment	• Create feedback mechanisms on prescribing. • Provide information about how to give feedback • Provide advice for how to embed feedback mechanisms into practice (e.g., ward rounds) • Utilise IT systems to create an audit trail of decisions.
	Emotion: A complex reaction pattern involving experiential, behavioural and physiological elements, by which the individual attempts to deal with a personally significant matter or event.	• Reduce fear of making a 'no antibiotic' decision or de-escalating/stopping antibiotics. • Employ strategies to manage patient expectations for an antibiotic and the negative emotion it creates for the prescriber.			5.6 Information about emotional consequences 11.2 Reduce negative emotions 4.1 Instruction on how to perform the behaviour 5.1 Information about health consequences 5.3 Information about social and environmental consequences 6.1 Demonstration of the behaviour	• Provide information (e.g., written, verbal, visual) to increase positive beliefs about the consequences of performing the target behaviour. • Providing strategies to meet the target behaviour without inducing prescriber's negative emotion. • Demonstrate how to perform the target behaviour and communicate effectively with peers and patients.

5.4.1.1 Links between BCTs and the mechanisms of action

Despite the growing number of behavioural interventions in healthcare, their effects continue to be small, variable, and often not maintained long-term (Carey et al., 2019; Kwasnicka et al., 2016). Moore and Evans (2017) suggest that developing a better understanding of the MoAs (the process through which behaviour change occurs) could facilitate the design of more effective interventions. More specifically, the identification of the links between BCTs and the MoAs that interventions could target may enable researchers to design interventions that include components more likely to be effective.

Carey et al. (2019) aimed to identify such links by conducting a series of binominal tests. From 277 published behaviour change intervention articles, the researchers extracted a total of 2,636 BCT-MoA links, including 70 BCTs linked to at least one MoA. Of these, 87 links between 51 BCTs and 24 MoAs occurred more often than by chance due to the overall frequency of BCTs and MoAs (i.e., $p < .05$) (Carey et al., 2019). The full results of the analysis are represented using ‘heat maps’ of the findings, providing a useful resource for identifying the BCTs that have the potential to target relevant MoAs when developing theory-based interventions.

Connell et al. (2019) further explored the links between BCTs and MoAs. One hundred and five international behaviour change experts participated in three consensus stages, rating, discussing and re-rating links between 61 commonly used BCTs and 26 MoAs. The study shows that, of 1,586 possible links, at least 51 BCTs had a definite link to one or more MoAs (Connell et al., 2019). To examine concordance between the hypothesised BCT–MoA links obtained in the two studies (Carey et al., 2019; Connell et al., 2019), Johnston et al. (2021) triangulated the findings using multilevel modelling. Uncertainties and differences between the two studies were reconciled using consensus development methods, and the results were presented using a matrix of links between BCTs and MoAs, providing detailed evidence for each MoA available online via the Theory and Technique Tool (TATT) (see Appendix 41) (Johnstone et al., 2021).

Using the online TATT tool, the intervention content developed in the preceding stages (Table 21) was then mapped onto the matrix of possible BCT–MoA links, displaying explicit pathways through which behaviour change is likely to occur (Table 22). The results of this exercise have shown that of the 68 possible BCT–MoA links proposed in this thesis to change prescribers' behaviour, nine combinations are unlikely to be effective (highlighted in orange in Table 22). For example, the *Information about health consequences* technique is unlikely to influence the *Environmental Context and Resources*, suggesting that this link should not be targeted or evaluated in the intervention (Johnston et al., 2021). Similarly, to increase prescribers' *Physical Capability* (i.e., *Skills*), of the three proposed BCTs, only the *Instructions on How to Perform the Behaviour* technique is likely to produce a change in behaviour. Notably, for the four BCTs techniques selected to increase *Psychological Capability* (i.e., *Memory, Attention and Decision Processes*), there is absence of evidence on the effectiveness of these behavioural pathways. More research is therefore needed to resolve this ambivalence about the BCT–MoA links, and to explore the potential pathways that appear to be currently underused.

Table 22. Intervention content mapped onto the matrix of BCT-MoA links (using the online Theory and Technique Tool)

COM-B	Theoretical domain	BCTs (selected)	Links between BCTs and MoAs
↑ **CAPABILITY** (physical)	**Skills**	1.2 Problem solving	
		4.1 Instruction on how to perform the behaviour	
		6.1 Demonstration of the behaviour	
↑ **CAPABILITY** (psychological)	**Knowledge**	4.1 Instruction on how to perform the behaviour	
		5.1 Information about health consequences	
		5.3. Information about social and environmental consequences	
		9.1 Credible source	
		12.5 Add objects to the environment	
	Behavioural regulation	1.1 Goal setting (behaviour)	
		1.4 Action planning	
		5.1 Information about health consequences	
	Memory, attention and decision processes	1.2 Problem solving	
		4.1 Instruction on how to perform the behaviour	
		1.6 Discrepancy between current behaviour and goal	
		8.1 Behavioural practice/ rehearsal	
		12.1 Restructure the physical environment	
↑ **OPPORTUNITY** (physical)	**Environmental context and resources**	1.4 Action planning	
		2.2. Feedback on behaviour	
		4.1 Instruction on how to perform behaviour	
		5.1 Information about health consequences	
		6.1 Demonstration of the behaviour	
		7.1 Prompts and cues	
		8.1. Behavioural practice / rehearsal	
		8.3. Habit formation	
		9.1 Credible source	
		12.1 Restructure the physical environment	
		12.5 Add objects to the environment	
↑ **OPPORTUNITY** (social)	**Social influences**	1.4 Action planning	
		3.1 Social support (unspecified)	
		4.1 Instruction on how to perform the behaviour	
		6.2 Social comparison	
		7.1 Prompts and cues	
		12.1 Restructure the physical environment	
		12.2 Restructuring the social environment	

↑ MOTIVATION (reflective)	**Beliefs about capabilities**	1.1. Goal setting (behaviour)	
		1.2 Problem solving	
		4.1 Instruction on how to perform the behaviour	
		5.1. Information about health consequences	
		6.1 Demonstration of the behaviour	
		7.1 Prompts and cue	
		8.4 Habit reversal	
		9.1 Credible source	
		12.1 Restructure the physical environment	
		12.5 Add objects to the environment	
		15.1 Verbal persuasion about capability	
		15.3 Focus on past success	
	Beliefs about consequences	2.2. Feedback on behaviour	
		5.1 Information about health consequences	
		9.1 Credible source	
		12.1 Restructure the physical environment	
	Social/professional role and identity	4.1 Instruction on how to perform the behaviour	
		6.1 Demonstration of the behaviour	
		9.1 Credible source	
		12.1 Restructure the physical environment	
		13.1 Identification of self as role model	
	Goals	1.1 Goal setting (behaviour)	
		6.1 Demonstration of the behaviour	
↑ MOTIVATION (automatic)	**Reinforcement**	2.2 Feedback on behaviour	
		2.7 Feedback on outcomes) of behaviour	
		4.1 Instruction on how to perform the behaviour	
		5.1 Information about health consequences	
		12.1 Restructure the physical environment	
	Emotion	4.1 Instruction on how to perform the behaviour	
		5.1 Information about health consequences	
		5.3 Information about social and environmental consequences	
		5.6 Information about emotional consequences	
		6.1 Demonstration of the behaviour	
		11.2 Reduce negative emotions	

Legend:

No evidence **Links** **Inconclusive** **Non-Links**

5.4.1.2 Capability

Guided by the application of the BCW framework (Michie et al., 2014) and the recent evidence on the links between BCTs and MoAs (Johnston et al., 2021), the mapping exercises undertaken in this chapter have shown that for the intervention to be successful in improving antibiotic review in a hospital setting, prescribers would be required to increase their *Physical Capability*. In addition, the ME and focus groups highlighted issues around prescribers' skills in antibiotic use, whilst engaging and communicating with staff and patients were also perceived to be a concern in a hospital setting. This perceived difficulty resulted from a lack of confidence in discussing antibiotics, from senior clinicians' preparedness (or lack of) to listen to the concerns of junior colleagues, and previous experiences. Therefore, greater emphasis on *Skills* training (such as demonstrating and providing instructions on how to perform the target behaviour and discussing barriers to undertake a timely review) may increase competence in reviewing antibiotics and improve communication with peers and patients, in addition to increasing the ability to engage patients in shared decision making.

Drawing on the identified barriers and facilitators to appropriate prescribing (Appendix 38), the identified lack of knowledge of the current guidelines and threat posed by antimicrobial resistance (AMR) was one of the key factors influencing decisions to initiate or continue broad-spectrum antibiotics. Clinical uncertainty was described to arise in situations of insufficient knowledge about the effectiveness of treatment and its potential outcomes, influencing the interpretation of patients' conditions. This could sometimes lead to minimising the long-term effects of using broad-spectrum antimicrobials.

Fear of consequences stemmed from knowledge deficits, with participants discussing how clinicians tend to adopt defensive prescribing behaviours in uncertain clinical situations. Thus, an emphasis on *Knowledge* of current guidelines and the threat of AMR may enhance prescribers' *Psychological Capability* by providing information about competing priorities (e.g., patients' immediate health needs vs long term effects of AMR), providing a rationale for and instructions on how to perform a timely review and ensuring easy access to guidelines. Consideration must also be given to the patient and/or their family's knowledge of AMR, the risk of antibiotics, and the rationale for a 'no antibiotic' decision. Information provision using leaflets and/or posters could enhance awareness of these issues. Although outwith this intervention's scope, the mapping exercise has shown that psychological capability can also be addressed by embedding formal education related to antibiotic stewardship within the curricula. This research could be undertaken as part of the post-doctoral work.

Conducting behavioural diagnosis has shown that TDF domains of cognitive and interpersonal skills, memory, attention and decision processes, and behaviour regulation are closely linked. For example, the focus groups carried out in Stage 1 have identified a lack of shared decision making with patients as a potential barrier to appropriate antibiotic use. Therefore, addressing the area of *Behavioural Regulation* may, in turn, increase awareness of the importance of person-centred prescribing. This change in behaviour could potentially be achieved through action planning, such as prompting communication with patients about their antibiotic treatment, although there is currently a lack of conclusive evidence demonstrating the effectiveness of the link between this BCT and MoAs (Johnston et al., 2021). Furthermore, adherence to evidence-based antibiotic guidelines was inconsistent due to the complex nature of treatments and drug intolerances. Therefore, an emphasis on prescribers' *Memory, Attention and Decision Processes* (e.g., providing instruction on how to change, stop/de-escalate antibiotics by using clinical examples; or outlining deviations from guidelines), may enhance their ability to weigh up the available information and thus inform better prescribing decisions.

Additionally, poor prescribing decisions were perceived to result from cognitive overload caused by busy working patterns, time constraints and cumbersome IT systems. Although tackling organisational constraints is difficult, applying a BCT such as 'restructuring physical environment' and utilising a decision support tool to help prescribers make decisions based on the guidelines, for example, could potentially alleviate the problem of compromised decision making when undertaking the antibiotic review.

5.4.1.3 Opportunity

Conducting the behavioural diagnosis has shown that both health professionals and patients/families require improvements in their *Physical Opportunity*. System barriers, such as organisational constraints (e.g., variations in practice) and fragmented processes (e.g., disjointed information), were frequently mentioned in the ME and focus groups. Feedback on prescribing was considered essential, with a lack of continuity of care and scarce learning opportunities making it difficult for clinicians to voice their concerns and ask questions. Lack of timely review and competing priorities of care between different specialities were also discussed. Creating the opportunity through employing more efficient ways of documenting and communicating prescribing decisions, providing easy access to credible sources of information and, if cost is not a concern, utilising IT systems to create a robust audit trail of decisions may influence the *Environmental Context and Resources* domain.

Additionally, utilising BCTs such as providing ‘instructions on how to perform behaviour’ (e.g., train prescribers on how to undertake timely antibiotic and enable learning opportunities) and enabling better collaboration between health professionals (e.g., encouraging prescribers to ask questions) may help prescribers to improve in this area. Other BCTs that could be utilised include ‘feedback’ on and ‘demonstration of the behaviour’ (e.g., using existing NHS antibiotic champions to demonstrate behaviour, provide training and feedback on performance) and providing ‘prompts and cue’s (e.g., introduce an environmental stimulus, such as electronic triggers to prompt or cue timely antibiotic review). In addition, applying the BCT ‘adding objects to the environment’ by providing patient information on the importance of timely review (e.g., in the form of posters or leaflets), is likely to facilitate discussion with patients/families regarding stopping antibiotics.

In terms of *Social Opportunity*, lack of rationale sharing for prescribing decisions and the unacceptability of contesting seniors’ decisions were the main barriers to improving antibiotic review. However, support from senior colleagues and other specialities was perceived to encourage prescribers to seek help and advice. It was pointed out that the availability of approachable senior clinicians is paramount to building a supportive culture within the hospital. Therefore, greater emphasis on engagement from peers, and practice based on the normalisation of questions around antibiotics, may be achieved through addressing the *Social Influences* domain. For example, drawing attention to others' prescribing performance to allow comparison, enabling prescribers to seek advice about antibiotics from colleagues, ensuring the availability of local champions to provide advice, and engaging nurses in prompting antibiotic review may increase social opportunity. Moreover, providing social support of leadership in the form of additional resources that aid prescribers in antibiotic decision making, and utilising IT solutions to prompt questions about antibiotics may also facilitate the target behaviour. Overall, cooperation between HCPs and working toward a common goal was highlighted as key to enhancing the opportunity to improve the antibiotic review.

5.4.1.4 Motivation

Mapping findings onto the BCW framework has indicated that *Reflective Motivation* is a necessary component to target in the intervention. This could include 'goal setting', by advising prescribers to reflect on the positive outcomes of prescribing decisions; providing instructions and demonstrating how to make a no-antibiotic decision, utilising an automated system for reminding prescribers to review antibiotics and motivate independent decision processes; and interrupting reflex behaviours by introducing environmental stimulus to prompt questions about antibiotics, are all examples of the strategies to enhance *Beliefs About Capabilities*. Discussing clinical uncertainty and providing a rationale for de-escalating/stopping antibiotics at review may help to increase clinicians' confidence in changing, stopping or making a 'no-antibiotic' decision. Targeting this domain would help empower prescribers to make autonomous decisions, increase their confidence to challenge the decisions of senior colleagues, and encourage patients/families to ask questions about antibiotics.

Motivation to improve antibiotic review can also be facilitated by addressing the *Beliefs About Consequences* domain. Utilising IT systems to create an audit trail of prescribing decisions and providing feedback on performance by a 'credible source' (e.g., consultant microbiologists) may reduce the invisibility of poor practice and its long-term effects. Applying BCT, such as 'identification of self as role model' (e.g., providing an observable sample of behaviour, directly or indirectly via webinar or pictures) for the prescribers to imitate may enhance *Social/Professional Role*; whilst setting *Goals* may help employ strategies to carry out a timely review of antibiotics.

Lastly, enabling *Automatic Motivation* may be achieved by using a cluster of BCT's, including 'information about emotional consequences', 'information about social and environmental consequences' and 'demonstration of the behaviour'. Greater emphasis on *Reinforcement* (e.g., creating feedback mechanisms on prescribing) may facilitate monitoring of prescribing decisions. In addition*, Emotions* were found to influence a motivation to review antibiotics. Automatic emotional responses such as fear of making a 'no antibiotic' prescription or de-escalating/stopping antibiotics were thought to influence prescribers' decisions. Fear of consequences and losing professional reputation were highlighted as an emotional barrier, especially among less experienced clinicians. Increasing positive beliefs about the consequences of performing the target behaviour may reduce that fear and thus enhance automatic motivation.

5.5 Discussion

Little guidance exists on the design and implementation of interventions grounded in conceptual frameworks to improve antibiotic prescribing in a hospital setting. Moreover, there is a considerable lack of evidence about interventions targeting antibiotic review specifically (Walker et al., 2019). For example, of the 221 hospital antimicrobial stewardship interventions evaluated in a Cochrane review, only 15 aimed to change patients' exposure to antibiotics by targeting the treatment's decision or the duration of therapy (Davey et al., 2017). Yet, the only sustainable way to reduce the global threat of AMR is to reduce antibiotic use (WHO, 2017).

As exposure to antibiotics increases the risk of AMR, it is essential to reduce their overuse (Almagor et al., 2018; Costelloe et al., 2010). In primary care, avoiding and delaying antibiotic prescriptions are two successful strategies which target overuse (Butler et al., 2012; Little et al., 2014; Paterson & Black, 2019). However, employing these strategies in hospitals is not appropriate as delaying antibiotics could be life-threatening in patients with bacterial infections. In fast-moving hospital environments, clinicians, therefore, need to balance the risks to the individual patient by administering early and effective antibiotic treatment and the long-term risks to society by reducing unnecessary antibiotic use.

The UK hospital antimicrobial stewardship strategy, such as ‘Start Smart, Then Focus’, promotes prompt initiation of an effective antibiotic treatment followed by active review of the continuous need for antibiotics within 48-72 hours, encouraging five actions – stop, change (narrow or broaden), switch from intravenous to oral, continue and review again at 72 hours, or move to outpatient parenteral antimicrobial therapy (OPAT) (Ashiru-Oredope et al., 2012; Department of Health, 2015). However, evidence suggests that although often started appropriately, few antibiotic prescriptions in hospitals get reviewed and modified after making the initial prescription (Llewelyn et al., 2014). Findings from the empirical research carried out as part of this thesis have shown that this is due to a complex combination of behavioural and organisational factors. The key barriers identified to performing antibiotic review were lack of ownership of prescribing decisions due to insufficient documentation and communication of prescriptions, including the lack of information about the original prescriber’s rationale for the antibiotic, lack of feedback on prescribing and a reluctance to question and/or change prescriptions made by others.

There is no one multi-purpose behavioural solution for improving antibiotic use. However, the behavioural and social sciences provide a range of theories, models and frameworks to draw on in the design of behaviour change interventions (Hulscher & Prins, 2017). Yet, a report published by the Department of Health has indicated that behavioural and social influences are often not considered in the design and evaluation of interventions aiming to improve antimicrobial prescribing (Pinder et al., 2015; Tonkin-Crine et al., 2015). As antibiotic use involves a complex set of human behaviours, it can be understood through the application of theory previously used to predict or explain behaviour in the general population (Hrisos et al., 2008; Michie et al., 2014).

A large number of existing theories, which often overlap in content, makes the selection of one framework over another challenging. To reduce complexity, increase the accessibility of theory and help researchers identify effective interventions, Michie and colleagues (2014) synthesised a core set of 19 behaviour change frameworks and developed the BCW (Michie et al., 2014). By addressing the gap of theory-led research in antibiotic use, this study is the first to apply the BCW, qualitatively analyse sources of behaviour using the COM-B/TDF model and provide recommendations on the intervention content to improve hospital antibiotic review. Drawing on the barriers and facilitators to appropriate prescribing identified in the ME and focus groups (Chapter 3 & 4), the interlinked components of the COM-B model and TDF were systematically followed to determine what needed to change for the target behaviour to occur and identify potential behaviour change techniques. Conducting the behavioural diagnosis of the factors that drive prescribers' behaviour provided a means of delineating the 'active ingredients' of the intervention that is tailored to the context (West et al., 2020).

Mapping the salient TDF domains onto the COM-B model of behavioural change indicated that all aspects were relevant for improving antibiotic review in hospitals – prescribers' capability to review, their opportunity to review and their motivation to perform a timely review. Prior research has shown similar results. The above-mentioned studies, which applied the TDF to explore factors influencing antibiotic prescribing have identified at least one barrier or enabler across all 14 TDF domains (Chaves et al., 2014). This means that addressing a single COM-B component will not bring about the desired behaviour change. For instance, the analysis has shown that for the intervention to be successful, it is vital to target Psychological Capability.

Addressing prescribers' and patients' deficit in *Knowledge* was found necessary to achieve change. However, enhancing knowledge is not enough to change behaviour. Evidence shows that providing people with information or merely increasing knowledge, has little potential to bring about change and can undermine the effectiveness of future interventions (Kelly & Barker, 2016). The behavioural diagnosis has demonstrated that optimising the antibiotic review process extends beyond knowledge, emphasising the importance of the hospital's broader social and environmental context.

To achieve the targeted change, it is therefore critical to create Opportunity, such as providing clinicians with *Social Support* (e.g., enable prescribers to seek advice about antibiotics from peers and other specialities), engage other health professionals (e.g., nurses and pharmacists) but also patients and their families in prompting antibiotic review or ensuring the availability of local champions to provide advice); improve the *Environmental Context and Resources* (e.g., utilise IT systems create a robust audit trail of decisions) and increase Motivation (e.g., providing regular and timely feedback on prescribing) to drive the required improvements in performing a timely antibiotic review. In addition, reducing negative *Emotions,* such as the fear associated with not prescribing an antibiotic and managing patient expectations, are essential in future interventions.

These findings are in keeping with prior research showing that stopping antibiotics 'early' (before the course is completed) is perceived as a risky behaviour and that junior prescribers, in particular, may lack confidence and the required competence in undertaking this task (Scott et al., 2019; Walker et al., 2019). This was a consequence of inadequate experience and limited education regarding the de-escalation of antibiotics within training programmes. The perceived need to continue the antibiotic course has been previously reported in the literature and discussed in Chapter 3. The clinicians perceived that fear of litigation or complaints, and the structure of medical teams limit the opportunity for de-escalating antibiotics (Broom et al., 2016a, 2016b). Others reported scepticism regarding guidelines for stopping antibiotics (Livorsi et al., 2016). Although defensive medicine is a widely reported phenomenon, little attention has been paid to clinicians' fear of consequences, with a lack of interventions targeting that area. Harlé et al. (2013) argue that emotions have a powerful impact on behaviour and beliefs. Therefore, an intervention should target prescribers' *Emotions* and *Beliefs About Consequences* to alter their perceptions of the relative risks and benefits of undertaking a review and subsequently discontinuing or de-escalating antibiotics.

The behavioural diagnosis further highlighted the need to ensure support and engagement of other specialities to improve the review process. Research carried out by Charani et al. (2017) supports this notion by highlighting the importance of engaging specialities outside infectious diseases and microbiology and involving senior clinicians and opinion leaders to facilitate a cultural shift in practice norms. However, despite the urgent need to maximise the contribution of all HCPs in AMS interventions (Tonkin-Crine et al., 2015), previous evidence has identified a perception that an antibiotic review is solely the responsibility of prescribers, with a lack of clear roles for pharmacists and nurses (Broom et al., 2015; Broom et al., 2017a). There may be many drivers for such a limiting perspective, from perceptions about antibiotic prescribing as a process that requires increased knowledge only exclusive to professionals with prescribing powers (Castro-Sánchez et al., 2018) to existing gaps in undergraduate and postgraduate education about antibiotics and AMR (Rawson et al., 2016a). Incorporating an understanding of the socio-cultural influences on prescribing into a hospital context has the potential to support interventions which target individual practice, such as the antibiotic review.

Challenges to a timely review in the hospital setting included limited and disjointed information (e.g., why the antibiotic was prescribed and for how long). Workload implications, existing working patterns, diverse priorities and the time required to access electronic medical records were reported to limit prescribers' opportunity to assume an active role in undertaking a review. The issue of incomprehensive patient records across all healthcare settings has been previously reported, prompting calls for clear documentation of indications and intended duration of prescription (Pike, 2018). Therefore, the *Environmental Context and Resources* domain, through restructuring the environment, needs to be targeted to facilitate prescribers' working patterns and employ more efficient ways of documenting and communicating prescribing decisions. This could be achieved by utilising IT systems to create a robust audit trail of decisions, utilising a decision support tool to streamline working processes. Additionally, part of the national Quality and Innovation (CQUIN) indicators for acute care settings is to ensure that prescriptions are reviewed within 72 hours of starting an antibiotic (NICE, 2018). Targeting the 'Goals' domain to raise the priority of undertaking a timely review may also be an appropriate solution.

Modelling the determinants of prescribers' behaviour has enabled the selection of suitable intervention functions and policy categories, and finally, the identification of the BCTs for improving antibiotic review in hospitals. Evidence on the effectiveness of specific BCW options applied in the design of AMS initiatives is scarce. However, a Cochrane review of interventions to improve hospital antibiotic prescribing applied the BCTTv1 to identify and characterise the components of included interventions (Davey et al., 2017). Analysis of effect modifiers in 29 RCTs and 91 interrupted time series studies found that interventions which included 'enablement' or 'restriction' functions were associated with more significant improvements in outcomes, and interventions that included both functions, had cumulative effects (Davey et al., 2017). Moreover, 'enabling' interventions that also included the BCT 'feedback on behaviour' were more effective than those that did not. However, it remains unclear which specific intervention components are linked to increased effectiveness as only a few studies included BCTs, such as 'goal setting' or 'action planning' (Davey et al., 2017). To maximise the potential of effective intervention, these functions and BCTs have been included in its design.

Finally, there is a dearth of evidence to guide the development of patient-centred interventions that support patient involvement in antibiotic decisions in hospitals. However, given the previous observations gathered in the focus groups of desire among patients for shared decision making, and research suggesting the potential impact of information provision about antibiotics on patient attitudes and behaviours (Rawson et al., 2016b), using a person-based approach and actively engaging patients in discussions around antibiotics is essential.

5.5.1 Future implications

Evidence suggests that only about half of the original intervention components are explicitly described in published studies (Glasziou et al., 2014; Lorencatto et al., 2013). Therefore, using the BCW and building up evidence in behavioural terms (who needs to do what differently, to whom, where and when), permitted effective and detailed mapping of the determinants of prescribers' behaviour to improve antibiotic review in a hospital setting. The sequence of mapping exercises undertaken in this chapter provides a useful resource for identifying BCTs that have the potential to target relevant MoAs for changing prescribing behaviours in acute hospitals, including 59 potentially effective BCT–MoA links. Targeting these likely determinants may enable policymakers and intervention designers to develop and optimise effective theory-based antibiotic interventions.

Although a rigorous and systematic process was applied to the development of the initial draft of the intervention, further refinements and iterations may be needed to enhance the content and future implementation. One intervention is unlikely to fit all contexts or address all needs. However, a practical solution might be to explicitly design a strategy that addresses local barriers and facilitators to timely antibiotic review. The intervention proposed in the thesis fits well with this approach.

While using the BCW framework and creating specific recommendations that can be implemented in a local context does not guarantee success, it does increase the likelihood of an intervention being successful. Optimising or 'refining' the intervention and determining its acceptability with key stakeholders is likely to provide an indication of the transferability and generalisability of the results (see Chapter 7).

5.6 Strengths and limitations

This is the first intervention developed using the BCW to address sub-optimal antibiotic review behaviours in HCPs working in acute hospitals. The design process has been described in a transparent way, allowing reproducibility. The preliminary version of the intervention can be adapted or modified in the implementation stages to address weaknesses without losing methodological rigour. In addition, the development of a solid theoretical basis was guided by the MRC recommendations, emphasising the importance of using an appropriate theory in the intervention design (Craig et al., 2008).

The application of the BCW has shown that the COM-B model and TDF can be systematically applied to the determinants (barriers and facilitators) of appropriate antibiotic prescribing in a hospital setting. The researcher has also demonstrated how primary data (derived from focus groups) and secondary data (meta-ethnography) can be retrospectively applied to the BCW to guide intervention development and refinement. Use of the BCW allowed triangulation of the findings from these sources and enabled the development of recommendations on the intervention content by considering the barriers and facilitators to the target behaviour. Additionally, this approach was useful in ensuring that the intervention reflects the needs of the target population.

The findings also offer a range of potentially effective BCTs and indicate which BCTs are unlikely to influence MoAs (i.e., what to avoid), thus providing a solid basis for designing and evaluating future theory-based antibiotic interventions. The 59 BCT–MoA links specified may also be helpful in suggesting alternative theoretical explanations of the effects of BCTs on behaviour in antibiotic intervention studies conducted without an explicit theoretical basis (Johnston et al., 2021). Nevertheless, for a large number of identified links (i.e., 46 BCT–MoA links), the evidence of effectiveness is either absent or inconclusive, possibly reflecting the recent developments in this field of research (Johnston et al., 2021). Further empirical work is needed to ascertain whether the specific BCTs can influence the selected MoAs and bring about a change in behaviour.

While the BCW provides a systematic and theory-guided approach for identifying the behaviour change techniques which are expected to be effective, the authors acknowledge that it does not provide a detailed blueprint for designing specific behavioural change interventions (Michie et al., 2014). Moreover, there is ambivalence in the literature regarding the links between BCTs and MoAs that appear to be currently underused.

Thus, the application of the BCW requires subjectivity and drawing inferences based on the identified components. Although the deductive mapping of the determinants of behaviour onto the COM-B and TDF was relatively straightforward, several barriers and facilitators were closely related and could be categorised under more than one domain. For example, ‘cultural inhibitors’ (e.g., lack of rationale sharing for prescribing decisions and unacceptability of contesting colleagues’ decisions) form part of *Social Opportunity* and affect *Automatic Motivation*. Judgements also had to be made regarding how and where to categorise these determinants to best reflect participants' views related to the timely antibiotic review. However, the issue of subjectivity was minimised by involving the supervisory team in the process.

Moreover, coding data into a matrix (Steps 5-7), including the identification and selection of the intervention functions, policy categories and associated BCTs, required a cyclical approach that was complex and time-consuming. In contrast, defining the content of the intervention based on the key determinants required some creativity as some elements did not map simply onto a single dimension. For instance, in terms of Capability, prescribing includes the interplay of physical and psychological (e.g., in communication/talking). This approach resulted in a degree of overlap of the mapped BCTs on multiple domains (e.g., instruction on how to perform the behaviour, information about health consequences, demonstration of the behaviour). Therefore, the proposed intervention content (Table 21) should be used with some flexibility.

5.7 Conclusions

This chapter has highlighted the importance of using behavioural theory in the design, development and evaluation of complex health interventions; described the challenges of selecting a suitable theory and provided a worked example of applying the Behaviour Change Wheel for developing the content of a theory-based intervention to improve antibiotic review in a hospital setting.

The proposed intervention incorporates 25 BCTs that can be delivered through seven intervention functions and levered by three policy categories. Although using the BCW was labour-intensive, this comprehensive framework enabled a transparent development of a theoretically sound intervention. Conducting behavioural diagnosis and drawing on the BCT taxonomy helped develop a proposed mechanism of action. If effective, the intervention could potentially be tailored or modified for use in other settings.

Finally, the set of recommendations on the intervention content developed in this chapter, including descriptions of the BCTs and which causal processes they target, demonstrates how theory can be operationalised within appropriate intervention components. It also provides a replicable set of hypothesised BCT–MoAs links that other researchers may wish to test. The next chapter explores the form of delivery for the intervention suited to the organisational setting.

Chapter 6: Exploration of a form of delivery for the antibiotic intervention

6.1 Overview of chapter

Previous chapters of this thesis have explored two broad groups of interconnected components of the proposed intervention: 1) *theory* (the processes through which the intervention is thought to influence behaviour) and 2) *behaviour change techniques* (the content of the intervention). This chapter discusses the *form of delivery* (FoD) by which the intervention can be delivered in relation to the chosen behaviour change techniques. The rationale behind the decision to use the selected FoD is provided and methods for maximising the effectiveness of each component are described. Finally, the prototype intervention's key elements and features are summarised using the Form of Delivery framework (Dombrowski et al., 2016).

6.2 Aims and objectives

The overall aim of this thesis is to develop a theory-based behaviour change intervention to improve antibiotic use in a hospital setting. This chapter aims to:

1. Provide the rationale for the most appropriate form of delivery likely to be effective in motivating and directing behaviour change.
2. Outline how the theoretical underpinnings generated in Chapters 3- 5 have been embedded in the chosen forms of delivery.
3. Describe methods for maximising the effectiveness of chosen components.
4. Provide a transparent account of the intervention elements using the Form of Delivery framework (Dombrowski, 2016).

6.3 Form of delivery

Michie et al. (2014) describe behaviour change interventions as having two broad components: behaviour change techniques (BCTs) and the FoD, or the way the intervention is delivered to its target population. As outlined in Chapter 5, a BCT is defined as "an observable and replicable component designed to change people's behaviour", which can be used alone or in combination with other BCTs (Michie et al., 2013, p. 5). However, there is a lack of agreement in the literature as to how FoD should be defined, what it comprises, and how researchers should be reporting it (Marques et al., 2020).

Dombrowski et al. (2016) suggest that form of delivery is an umbrella term used to refer to multiple intervention delivery components that can either enhance or undermine its effectiveness, ranging from delivery elements to delivery features. The term 'element' refers to the broad FoD components (e.g., delivery format), whilst the term 'features' covers the subcomponents of the FoD elements. For example, 'delivery format' includes the mode of delivery, delivery method, channel and route. Behaviour change interventions typically include many BCTs and FoD elements. However, as some BCTs have a delivery form integrated into them (e.g., goal setting), each BCT included in the intervention may have a different composition of FoD elements and features (Michie et al., 2014).

Therefore, the FoD components must be sufficiently specified so that the intervention can be fully operationalised and replicated. A clear description of the FoD is also helpful in assessing intervention fidelity during the implementation process. Effective interventions rely on fidelity, or simply "the degree to which an intervention or procedure is delivered as intended" (Breitenstein et al., 2012, p. 407). As discussed in Chapter 5, developing the intervention entailed making considerable judgements and decisions. Conducting behavioural diagnosis using the Behaviour Change Wheel (Section 5.4.1) facilitated operationalisation of the intervention by linking BCTs and intervention functions to address the identified behavioural deficits.

Similar to selecting appropriate BCTs, Dombrowski et al. (2016) recommend considering the full range of options when selecting the FoD. In line with the template for intervention description and replication (TIDieR) of Hoffmann et al. (2014), Dombrowski et al. (2016) propose an FoD framework through which the behaviour change intervention content can be conveyed (see Appendix 42). Data extracted in the meta-ethnography (Chapter 3), focus groups (Chapter 4), the coding matrix displaying the proposed mechanism of action of the intervention (Chapter 5), together with evidence of effectiveness, were used to inform and guide the FoD options for the intervention. The FoD framework was used to specify the intervention delivery elements and features.

The specific FoD proposed and discussed in this chapter has been developed into a toolkit consisting of four components: 1) Webinar; 2) Online Interactive Tool; 3) Antibiotic Review Tracker (including feedback mechanisms); and 4) Patient Information Materials. These were selected in discussion with academic supervisors during the intervention development and with the stakeholders, including HCPs and health service users (Chapter 4). The four components were considered to best translate the theory developed in previous chapters, into concrete intervention elements, designed to change prescribers' behaviour using seven intervention functions supported via three policy categories (described in Chapter 5, Section 5.4.4). The four components have been chosen to target behavioural deficits which relate to the 12 domains identified as influencers on antibiotic review in a hospital setting. The components were also judged to be practical and acceptable to the target group for delivering each identified BCT. *How* this FoD can be used to maximise the adoption and implementation of the intervention is described in the next chapter.

6.3.1 Why is the FoD important?

The Consolidated Standards of Reporting Trials (CONSORT) 2010 statement suggests that researchers should report an intervention with sufficient details to enable others to replicate it (Schulz et al., 2010). However, the quality of published descriptions of intervention remains poor, including how and where they were administered. For example, a study of 137 papers published in leading medical journals reporting 133 non-drug interventions showed that only 39% were reported adequately (Hoffmann et al., 2013). This increased to 59% by contacting authors for additional information, a task that only a few researchers can afford to carry out. A more recent retrospective cross-sectional data analysis of 119 randomised controlled trials found that 15 years after implementing the CONSORT statement, a median of only 61% of the checklist items was reported (Stevanovic et al., 2015). Without complete published information on the intervention's key features, clinicians and other developers cannot reliably reproduce or build on the research findings (Hoffmann et al., 2014).

Dombrowski et al. (2016) further argue that FoD can be essential for operationalising several theories or translating theoretical concepts (i.e., the distinction between abstract and concrete) into intervention components. For instance, a study investigating which features of graphic warnings predict their perceived effectiveness in discouraging smoking found that as images were moved from cartoon form (abstract) to a photograph (concrete), the likelihood of the impact was significantly higher (Cameron & Williams, 2015).

Moreover, FoD can influence intervention engagement and adherence. For example, health service commissioners may only be prepared to implement an intervention that staff and patients perceive as acceptable to them (Dombrowki et al., 2016). Lack of engagement with the intervention may also impact its effectiveness. A study investigating adherence to a self-monitoring diet found that the adherence was higher and significantly affected weight loss in a group that received a personal digital assistant rather than a paper record (Wang et al., 2012). The findings suggest that the materials offered as part of behaviour change techniques can also influence engagement. Lastly, FoD may be essential for the implementation and sustainability of the intervention beyond the initial research study. Therefore, selecting an appropriate FoD at the outset may increase the chances of the intervention having a population impact (Dombrowski et al., 2016).

6.4 Identifying the FoD and implementation options

This section provides an overview of the proposed key intervention elements and features informed by combining theory and evidence and integrating elements of a person-based approach. It also stresses the importance of considering the views of the people who will use the intervention (Yardley et al., 2015). Chapter 3 of this thesis has synthesised and examined the literature which enabled the researcher to generate the theory behind the *content* of the intervention, whilst the focus groups carried out with the HCPs and health service users (Chapter 4) helped fill the knowledge gap and explored the intervention's *mode of delivery.* The intervention components were then chosen in discussion with the supervisory team, who have expertise in intervention development. These components were judged to best support the theoretical basis developed in previous chapters for three reasons – their capacity to influence target behaviour, their applicability to the target population, and their potential for effectiveness.

Furthermore, the development of intervention components was informed by reviewing the current evidence. However, as the existing research into methods to successfully reduce antibiotic use in hospitals is limited, previous studies targeting an antibiotic reduction in primary care had to be drawn on instead (Tonkin-Crine et al., 2011; Yardley et al., 2013). Given the complexity of hospital antibiotic prescribing and the reported reluctance of clinicians to modify prescriptions made by others (Charani et al., 2013), the challenge was to develop a feasible and sustainable intervention that will aid HCPs in successfully tracking antibiotic decisions and carrying out a timely review.

6.4.1 Selecting the mode of delivery

The TIDieR framework (item 6: 'How') emphasises the need for researchers to clearly specify the mode of delivery of behaviour change interventions (Hoffmann et al., 2014). Nevertheless, the lack of a shared definition or a universal framework to describe it makes it challenging for researchers to systematically delineate the interconnections between the mode of delivery and other intervention elements (Dombrowski et al., 2016). Similar to making context-based decisions on intervention content, a range of options should be considered when identifying the most suited mode of delivery (Michie et al., 2014). In their recent publication, Marques et al. (2020, p. 5) define it as "the attribute of a behaviour change intervention delivery that is the informational or physical medium through which a behaviour change intervention is provided". For example, an intervention could be delivered face-to-face (e.g., a nurse providing a patient with information about the health consequences resulting from a particular behaviour), remotely, via email, or through a digital device (e.g., a mobile phone application).

The appropriate mode of delivery choice should be based on the target behaviour, target population, and setting (Michie et al., 2014). Given the lack of published guidance on the effectiveness to inform the selection of mode of delivery of an intervention to improve antibiotic use in hospitals, a basic taxonomy adapted from

Marques et al.'s (2020) mode of delivery classification system was developed for the proposed intervention. Data extracted from the three focus groups (Chapter 4) was used to inform and guide the development of the basic taxonomy (Table 23), which was refined with input from the academic supervisors. For example, the participants identified electronic clinical decision support as favourable, which was considered a key finding when selecting a potential mode of delivery. The chosen mode of delivery also had to accommodate the limited time that HCPs have due to their high work demands. A pragmatic approach was therefore considered essential. Moreover, evaluating the existing antibiotic interventions and their likely effectiveness in changing HCPs' behaviour was important. As recommended by the Behaviour Change Wheel guide, the APEASE criteria (Affordability, Practicability, Effectiveness and Cost-Effectiveness, Acceptability, Side effects/safety, Equity – see Appendix 39 for complete definitions) were then applied to aid judgements and the selection process (Michie et al., 2014).

Table 23. Using APEASE to select the modes of delivery for the intervention

Mode of delivery			**Does the mode of delivery meet the APEASE criteria (affordability, practicability, cost-effectiveness, effectiveness, acceptability, side effects, safety, equity)?**
Face-to-face	Individual		Yes
	Group		Possibly – need to consider practicability and affordability
	Combined (individual and group)		Possibly – as above
Distance (individual level)	Printed material	Printed publication (e.g., leaflet, booklet, manual, worksheet)	Yes
		Letter	Unlikely – but possible (effectiveness and practicability)
		Public notice (e.g., poster, sign)	Yes
	Phone	Service delivered via audio call	Unlikely – but possible (acceptability, effectiveness, safety, practicability)
		Text messaging e.g., automated reminders)	Yes
		Mobile phone app	Possible – need to consider cost-implications, effectiveness and acceptability
	Web-based	E-learning	Yes – but need to consider equity and practicability
		Digital support system	Yes – may be issues with acceptability and cost-implications
		Virtual reality	Unlikely – lack of evidence for these approaches

		Playable electronic storage (e.g., Webinar)	Yes
		Live video call	Yes – need to consider practicability and affordability
		Website	Yes
		Email (e.g., automated reminders)	Yes
Combined (face-to-face and distance)	Individual/group/combined with one of the distance options		Yes – need to consider acceptability and cost-implications

Applying the APEASE criteria helped to identify several modes of delivery as a potential format through which the content of the intervention could be delivered. These were discussed with the supervisory team and judged to be of similar merit. As a result, a blended approach including a range of individualised, remote and group-based elements was selected to deliver the intervention. For instance, although printed materials, such as a manual, poster or patient leaflet, were considered affordable, acceptable and practical, a letter was not judged to change the target behaviour effectively. Similarly, a webinar was deemed affordable, cost-effective, likely to be acceptable and highly equitable with a potential for face-to-face contact. Therefore, combining printed materials with a web-based element was judged as the most effective way to target the behavioural deficits identified in Chapter 5. The rationale for choosing specific modes of delivery and evidence of their effectiveness is discussed in the next section.

6.4.1.1 RE-AIM Framework as a planning tool

As the APEASE criteria did not adequately cover reach and engagement considerations, the RE-AIM (Reach, Effectiveness, Adoption, Implementation, Maintenance) framework was used to address these critical issues and increase the intervention's chances of success (see Chapter 2, Section 2.4.3 for details). The RE-AIM framework is a valuable tool designed to aid the translation of research into practice and estimate the impact of public health interventions (Glasgow et al., 1999). As a planning tool, the RE-AIM can assist researchers to systematically consider a range of factors or dimensions that could influence the effective dissemination of an intervention, programme or policy (Glasgow et al., 2001). These dimensions encompass both individual-level and organisational-level factors (see Appendix 43 for complete definitions). For instance, for an intervention to be maintained, individuals need to engage with it continually, and organisations need to develop appropriate mechanisms to support its delivery.

Guided by the research findings generated in the preceding stages of this thesis, the APEASE criteria and team discussions, the following decisions were made (Table 24).

Table 24. Maximising RE-AIM criteria in the intervention development

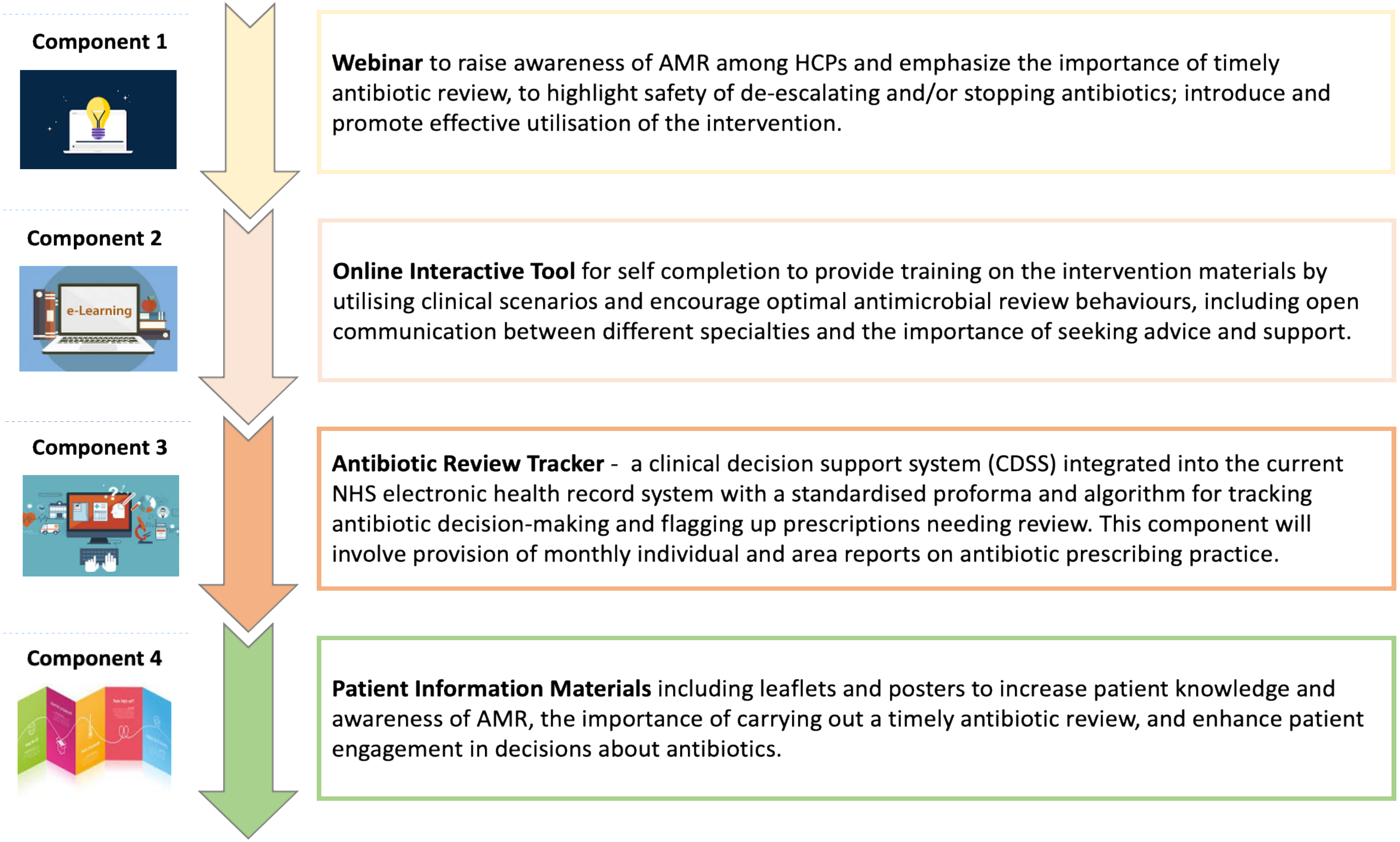
RE-AIM DIMENSION	HOW IT WAS MAXIMISED
REACH	• Develop an intervention that will create an opportunity for HCPs to engage with peers and patients/families. • Incorporate the intervention into the busy workflow, so it is more appealing to staff. • Use internal communication networks and staff meetings to let HCPs know about the intervention and how it can help improve the use of antibiotics. • Use posters and leaflets in the waiting rooms to promote the intervention and encourage people to ask questions about antibiotics.
EFFECTIVENESS	• Consider using multiple delivery channels. • Ensure that the HCPs know how to use the intervention materials and seek advice to improve compliance. • Determine the required individual or environmental-level changes (e.g., equipment demands). • Ensure consistency in the intervention delivery. • Discuss the intervention progress and impact on practice with the HCPs (e.g., during team meetings). • Tailor the intervention to the local needs (e.g., increase support and feedback as required).
ADOPTION	• Engage clinical leaders and the local antimicrobial stewardship team in intervention delivery. • Consider a combined approach, for example, incorporating technology with group-based discussions and/or individual feedback. • Ensure provision of ongoing training and support for the HCPs who will deliver the intervention. • Utilise clinical champions who can engage and support HCPs during the adoption, implementation and maintenance of the intervention. • Ensure practicality, acceptability and usability of the intervention across different settings.
IMPLEMENTATION	• Create a manual to support intervention fidelity, clearly describing the components and processes involved. • Ensure that the intervention materials for patient/families follow accepted health literacy recommendations. • Build-in a team approach to intervention delivery (e.g., engage clinical pharmacists). • Ensure buy-in from local opinion leaders.
MAINTENANCE	• Ensure ongoing promotion of the intervention. • Use reminders to encourage long-term maintenance (e.g., via text and/or emails). • Ensure ongoing contact and support to keep HCPs motivated to use the intervention (e.g., through webinars or team discussions). • Provide a certificate for HCPs to encourage completion of training. • Consider assessing the cost-effectiveness of the intervention so that continued funding can be secured.

Having assessed wider implementation and dissemination issues, the most appropriate mode of delivery to target behavioural deficits identified as influencers to antibiotic prescribing in a hospital setting (see Chapter 5) was then selected. The chosen method of delivery is described in the following section.

6.5 Proposed intervention components

Guided by the theory generated in the preceding chapters, mode of delivery taxonomy, and the APEASE and RE-AIM criteria, the Digital Antibiotic Review Tracking Toolkit (DARTT) was designed, a complex, multifaceted behavioural intervention primarily targeting HCPs involved in hospital antibiotic prescribing or administration (illustrated in Figure 25). DARTT can be used flexibly, either as standalone components or as part of an integrated toolkit, with recommendations for using all materials if this is feasible and appropriate. The following section describes the methods for delivering each component. For the purpose of this thesis, the components are defined as the informational or physical mediums through which the behaviour change intervention can be provided. These components or 'active ingredients' have been considered as integral to DARTT, designed to increase attention to antibiotic decisions and streamline clinical workflow.

Figure 25. Components included in the DARTT intervention



6.5.1 Component 1: Webinar

The term webinar refers to a web-based seminar, using a video and audio content over the internet to a particular audience with the purpose of training (Zielinki et al., 2020). A webinar can either be delivered live or be recorded and delivered 'on-demand' from multiple remote locations, allowing flexibility and convenience. The on-demand ability to share and distribute recorded webinars means that the content is readily available to trainees, and unlimited playback is possible (Buxton et al., 2012). On the other hand, an advantage of using a live online presentation is its interactive format, as participating viewers can submit questions and comments. Additionally, as this innovative method delivers via video stream rather than download, such as a video podcast, it does not require any hard drive space nor management of media files (Zielinki et al., 2020).

6.5.1.1 Evidence of effectiveness of webinars

Over the past decade, online-based educational sessions, such as webinars, have become a popular method for training in the field of health sciences (McKinney, 2017). In 2020 alone, the Centers for Disease Control and Prevention (CDC) website listed more than 170 webinars covering an array of topics, including vaccines, sexually transmitted infections, blood disorders and many others (CDC, 2020).

Many healthcare disciplines have employed web-based options for continuing education. For instance, a plastic surgery residency programme in Ireland offering webinar teaching as an alternative to traditional classroom teaching noted that the approach enabled better "interaction, active participation and immediate feedback" (Martin-Smith et al., 2015, p. 1324). Moreover, Prunuske (2010) carried out a comparison study using a web-based approach for orientating medical students for their community medicine rotation. It found that classroom and web-based formats were comparable and equally effective for presenting orientation materials for a required clinical rotation. Similarly, a series of research webinar presentations was developed to engage nurses in discussions about evidence-based practice. Evaluation of the programme indicated that 90% of participants found the sessions helpful to their practice and planned to attend future webinars (Black et al., 2013).

A study assessing the effectiveness of web-based education from 15 randomised controlled trials (RCTs) has found that multicomponent electronic-based interventions effectively change HCPs' practice patterns and improve their knowledge (Lam-Antoniades et al., 2009). More recently, a multicentre quality improvement project, which focused on sharing antimicrobial use reports among hospitalised children using collaborative learning opportunities provided through monthly webinars, has successfully promoted the development of 36 distinct and innovative stewardship interventions (Newland et al., 2018). The method has also been used successfully in complex interventions targeting a reduction in antibiotic use. For example, a parallel-group, cluster RCT evaluating a multicomponent intervention conducted in 79 GP practices in the UK, which included a webinar for self-limiting respiratory infections (RTIs), has found that the delivery of this electronic intervention led to a reduction of overall antibiotic prescribing for RTIs (Gulliford et al., 2019). Overall, the evidence strongly suggests that this technique is equivalent to conventional educational techniques and better than no intervention (McKinney, 2017).

6.5.1.2 Webinar main features in relation to BCTs

This section outlines the main features of the Webinar, the first component of DARTT. This component has been designed to address barriers which relate to the domains identified in Chapter 5 as influencers on antibiotic prescribing behaviour, including *Knowledge, Social/Professional Role and Identity, Social Influences, Beliefs About Capabilities, Beliefs About Consequences, Goals,* and *Emotion.*

The 'credible source' technique will be employed to present verbal and visual communication. The Webinar will therefore be narrated by a practising hospital clinician (e.g., a member of the local AMS team, an infectious disease specialist or a clinical microbiologist) and recorded in a hospital setting. Feedback on the initial version of the webinar content will be sought from key stakeholders prior to implementation. The link to the final version of the recorded Webinar will be included in the DARTT-supporting documentation. Clinicians will be encouraged to watch the Webinar during their staff meetings. However, an option for a live presentation will be offered to stimulate open discussion (e.g., BCTs 'goal setting' and 'problem-solving').

Incorporating a Webinar into the antibiotic toolkit using a range of BCTs (e.g., 'information about social and environmental consequences', 'information about emotional consequences', 'focus on past success'), is anticipated to serve several functions. The primary purpose is to bring attention to and discuss the misuse of antibiotics in hospitals, which contributes to the increasing problem of antimicrobial resistance (AMR), for example by referencing the government report and most recent resistance data (O'Neill, 2016). The need for evidence-based interventions to change prescribing behaviours and the importance of carrying out a timely antibiotic review will be highlighted. The Webinar will also provide a forum for introducing DARTT, explaining how and by whom it was developed (highlighting input from health service users), providing a summary of its aim and explaining the intervention's components and tools and how to implement them.

To help inform and motivate appropriate prescribing behaviours, the safety of stopping or de-escalating antibiotics will be highlighted by drawing on the current evidence base. An emphasis will also be put on incorporating DARTT into the clinical workflow with no anticipated increase in workload. To optimise the effect, information on local AMR data, coupled with education on the timely review, will address the *Knowledge* and *Beliefs About Consequences* domains identified in Chapter 5.

Finally, the value and potential benefits of using the intervention in clinical practice will be explained, including improved documentation of antibiotic prescribing decisions and provision of patient education using a leaflet. It will also be pointed out that the provided feedback on prescribing practices could be used in performance appraisals. A summary of the Webinar features and related BCTs is provided in Table 25.

Table 25. Summary of the Webinar content and delivery

Intervention component	Content	Delivery	BCTs
Webinar (recorded and/or live stream)	Professionally delivered by a relevant practising hospital clinician (e.g., a member of local AMS team, infection control specialist or microbiologist), lasting no more than one hour, and summarising: • Importance of AMR & timely review. • Introduction to DARTT. • Safety of stopping/de-escalating antibiotics. • Local AMR data. • Promote action planning. • No increase in workflow. • Potential benefits of DARTT.	Webinar delivered through an electronic link embedded in the DARTT supporting documentation. Clinicians offered a live stream option and encouraged to present the Webinar in staff meetings.	Goal setting (behaviour); Problem-solving; Information about health consequences; Information about social and environmental consequences; Information about emotional consequences; Credible source; Reduce negative emotions; Focus on past success.

6.5.2 Component 2: Online Interactive Tool

According to Wang et al. (2019), educational methods are changing rapidly due to the considerable technology adoption among a new generation of learners, who tend to be more accustomed to using digital media. Digital tools, devices and media, including computers, tablets, mobile phones and smartphones installed with various applications, have changed people's lifestyles, including communication and education methods. Several definitions of e-learning exist, all reflecting different perspectives. Ghirardini (2011, p. 3) defines it as using "computer and Internet technologies to deliver a broad array of solutions" to enable learning and improve performance.

There are two primary approaches to e-learning. The first is self-paced (e.g., learners are alone and completely independent) and the second is instructor led (Wang et al., 2019). Both approaches can use online learning resources, interactive e-activities, electronic simulations and job aids, such as checklists or technical glossaries. The advantages of using online tools include reduced long-term costs, flexibility (e.g., time and geographical location), reusability, portability and shareability of the content (Wang et al., 2019). Ghirardini (2011) explains that most e-learning tools and courses are designed to build cognitive skills. As these skills are learned better 'by doing', they require more interactive e-learning activities. Online tools incorporating interactive elements with feedback are useful tools in changing people's attitudes and behaviours (Vignati et al., 2017). However, using online tools for education relies on users' motivation, digital literacy and the available technology's ability to handle a large amount of multimedia content (Wang et al., 2019).

6.5.2.1 Evidence of effectiveness of e-learning

This component strongly links to the evidence gathered in the preceding chapters. Whilst the meta-ethnography (Chapter 3) found that the theoretical knowledge learned during undergraduate training does not always fully equip junior doctors with the necessary skills to make complex and multifactorial prescribing decisions in clinical practice competently, participants in the focus groups (Chapter 4) pointed out that practical training is essential to the successful implementation of the intervention and could be provided at induction.

Traditional tools may be inadequate to deliver training to meet the complex demands of HCPs. Therefore, an increasing number of health disciplines have adopted a wide range of e-learning approaches, due to their flexibility, low-cost, easy access and user-centred learning (Ruggeri et al., 2013). Several studies have examined e-learning effectiveness in various contexts, including healthcare education and continuous professional development. A meta-analysis evaluating the effect of internet-based instructions for health professions learners has found a significant positive impact compared with no intervention (Cook et al., 2008). More recently, a meta-analysis assessing the effect size of e-learning in nursing education has shown that, on average, online learning leads to higher knowledge and skill scores than conventional learning methods (Voutilainen et al., 2017). Similarly, a feasibility study assessing the impact of e-learning on gastroenterologists and surgeons in training found that their knowledge on criteria for referral to genetic counselling for colorectal cancer and the comprehension of communication skills improved (Douma et al., 2017).

Online learning has also played an important role in antimicrobial stewardship education. An online internet training for antibiotic use (INTRO) trialled in five European countries was acceptable and feasible among GPs in multiple countries (Anthierens et al., 2012). However, despite its reported success, it stressed the importance of tailoring the intervention to HCPs' learning needs and the contexts in which they work. To address these caveats, the massive open online courses (MOOCs) offer novel opportunities (e.g., a weekly video-based lectures accompanied by questions, homework, assignments and case discussions) to deliver relevant information to a wide range of people (Rocha-Pereira et al., 2015). Evidence shows that these online courses have been useful in supporting postgraduate medical education (Subhi et al., 2014) and continuing professional development (Aboshady et al., 2015).

Furthermore, a recent prospective controlled intervention study evaluating the effects of a short, interactive e-learning course has shown long-term effectiveness in improving medical students' performance of an antibiotic therapeutic consultation (Sikkens et al., 2018). Similarly, a quantitative process analysis of an RCT, which evaluated a web-based intervention to reduce antibiotic prescribing for lower respiratory tract infections in six European countries, showed positive effects on GPs across all countries (Yardley et al., 2013). Given the revolutionary advances offered by this technology, successful implementation of e-learning in health interventions has a great potential to help trainees develop the necessary knowledge and skills.

6.5.2.2 Online Interactive Tool main features in relation to BCTs

The second component of the DARTT intervention is an Interactive Online Tool, which employs a combination of BCTs to target behavioural deficits related to the following domains: *Skills, Knowledge, Behavioural regulation, Memory, Attention and Decision Processes, Environmental Context and Resources, Beliefs About Capabilities, Beliefs About Consequences, Social/Professional Role* and *Identity, and Emotion.*

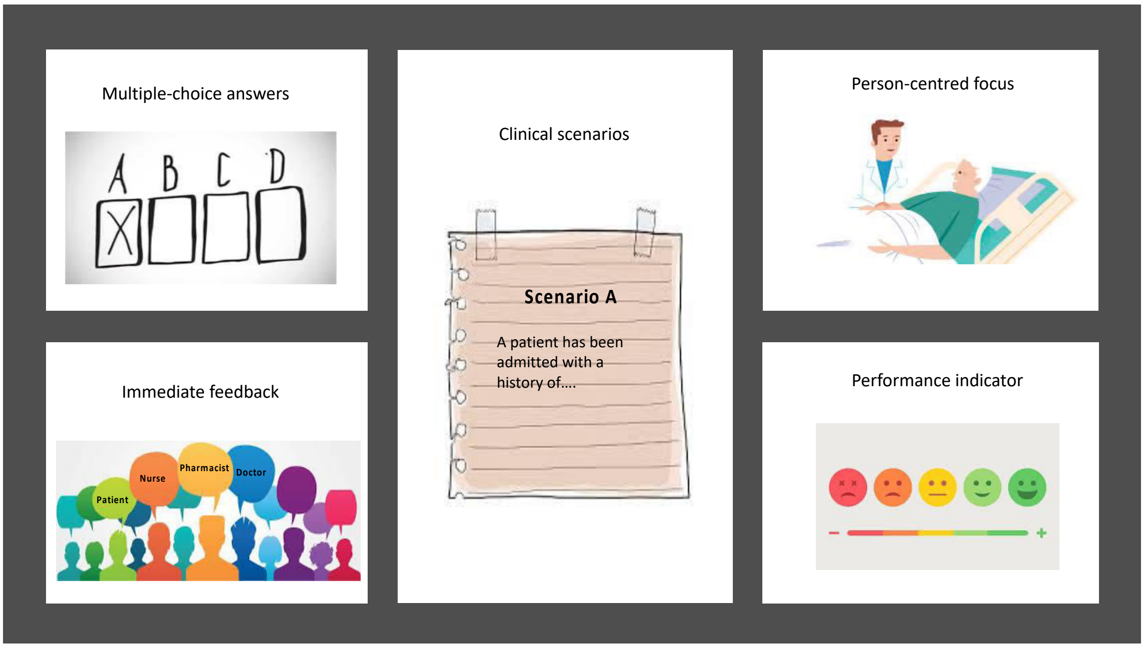
Healthcare professionals will be sent a weblink to the intervention that will be accessible on any internet-enabled device to make it possible for them to play 'anywhere, anytime'. Clinicians will be encouraged to complete the online activity during their induction, or ideally as part of ongoing learning and development. Up to three email reminders and text messages will be sent to potential participants. The Interactive Online Tool aims not to teach HCPs about specific antibiotics or their appropriateness to treat a given infection but to encourage optimal antimicrobial review behaviours by employing BCTs, such as ‘prompts/cues’ and ‘habit formation’. The online tool will first introduce a brief background on AMR (e.g., BCTs ‘credible source’, ‘information about health consequences); the importance of reviewing and stopping/de-escalating antibiotics (e.g., BCTs ‘discrepancy between current behaviour and goal’, ‘instruction on how to perform the behaviour’); and the role of HCPs in antibiotic review (e.g., BCT ‘identification of self as a role model’). Based on the evidence, a ‘no antibiotic’ option will be highlighted. A short demonstration of how to use the DARTT tools will be provided (e.g., BCT ‘demonstration of the behaviour’).

The interactive element of the e-learning activity will comprise of two clinical scenarios, and the participating HCPs will be asked to engage with the activity by watching and answering case-related questions (e.g., BCTs ‘behavioural practice/ rehearsal’, ‘habit formation’, ‘habit reversal’). This activity will provide training on using the Antibiotic Review Tracker, the main component of DARRT (described in more detail in Section 6.5.3.2). For example, clinicians will be given two clinical scenarios and be prompted to populate the relevant fields within the Tracker (BCT ‘prompts/cues’). To encourage the completion of the e-learning activity, the participants will be informed that they will receive a CPD certificate.

The first scenario will depict a patient treated for suspected pneumonia whose clinical status is slowly improving. Prompts and cues to reassess, tailor and/or stop antibiotics after the third day of treatment, when the causative organism(s) can be identified, will be provided. Using the BCT of ‘behavioural practice/ rehearsal’, the second scenario will focus on reaching a ‘no antibiotic’ decision, whereby a patient with a suspected urinary tract infection (UTI) is no longer showing any signs of infection, and it is, therefore, safe to discontinue antibiotics. In both scenarios, the HCPs will be prompted to discuss the antibiotic treatment plan with the patient and/or their family.

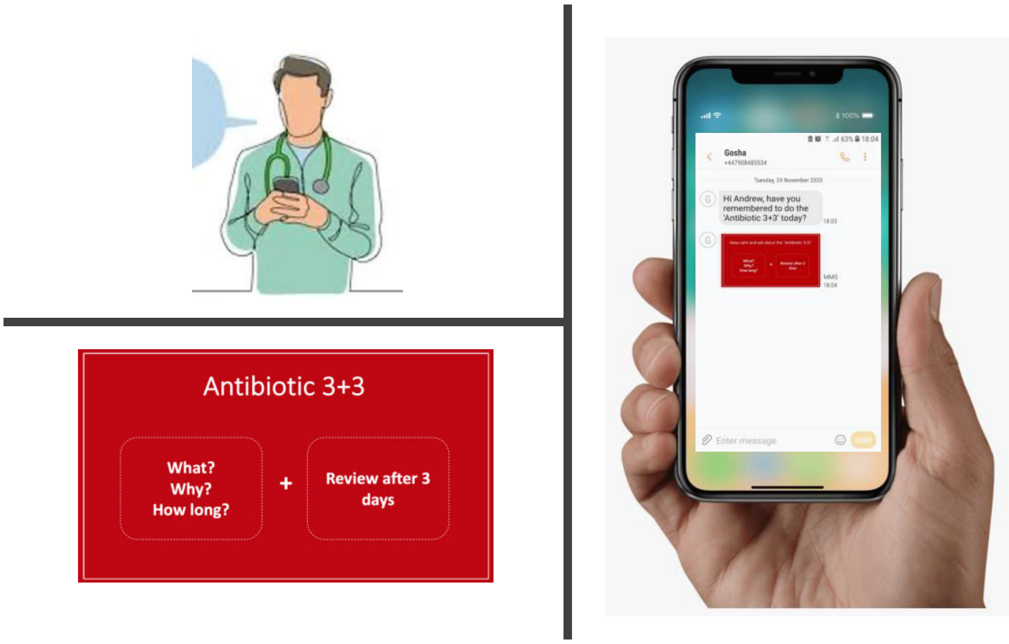
Once the therapeutic decision is made, HCPs will be given automated feedback about their performance from different professionals involved in antibiotic decisions (e.g., senior clinician, clinical pharmacist, nurse) and patients (e.g., BCTs ‘credible source’, ‘feedback on behaviour’ and ‘habit reversal’). By employing techniques such as ‘action planning’ and ‘problem solving’, emphasis will be put on communication with other specialities, highlighting the importance of seeking advice and support from more experienced colleagues. An example of the Interactive Online Tool's main features is presented in Figure 26.

Figure 26. Online Interactive Tool main features



Discussions with focus group participants (Chapter 4) showed a need to address social and cultural influences on prescribing practice and their impact on junior prescribers' behaviour. There was consensus that a reluctance by clinicians to speak up for fear of being embarrassed, intimidated or criticised needed to be minimised by "destigmatising" some aspects of the antibiotic review. To address this reticence to ask questions, they suggested an idea of the Antibiotic 3+3 (what, why and how long, and review after three days), which would prompt prescribers to discuss prescriptions openly (e.g., BCTs 'prompts/cues', 'habit formation'). Therefore, at the end of the online training, HCPs will be asked whether they would like to receive antibiotic review reminders via automated text message containing the Antibiotic 3+3 message, an example of which is illustrated in Figure 27.

Figure 27. An example of text message reminders



A summary of the Interactive Online Tool features and the BCTs chosen to deliver this component is provided in Table 26 below.

Table 26. Summary of the Online Interactive Tool content and delivery

Intervention component	Content	Delivery	BCTs
Interactive Online Tool	Evidence-based educational e-learning activity for self-completion to increase motivation and competence to review antibiotics, lasting no more than 30 minutes, and including: • Background on AMR. • The role of HCPs in antibiotic review. • Demonstration of DARTT tools. • Two clinical scenarios with prompts and questions. • Emphasis on fostering optimal prescribing behaviours. • Individual feedback given. • CPD certificate provided after completing the e-learning.	HCPs will be sent a weblink to the e-learning activity, which will be accessible on any internet-enabled device. Up to three email and text reminders will be sent to complete the activity. An option for receiving antibiotic review text reminders will be offered.	Problem solving; Action planning; Discrepancy between current behaviour and goal; Feedback on behaviour; Instruction on how to perform the behaviour; Information about health consequences; Information about emotional consequences; Demonstration of the behaviour; Social comparison; Prompts/cues; Behavioural practice/ rehearsal; Habit formation; Habit reversal; Credible source; Identification of self as a role model.

6.5.3 Component 3: Digital Antibiotic Review Tracker

Focus groups carried out in Chapter 4 highlighted the need to develop a system for tracking and monitoring decisions. Participants indicated that the new intervention should address poor documentation and promote better communication between different clinical teams and areas. An electronic tool and the convenience of having all the information in one place were favoured and viewed as providing more transparency in the decision making process. Participants also suggested that an electronic tool would facilitate workflow changes, enhance the communication of an antibiotic prescription, and support clinicians in selecting potentially appropriate treatments using patient-specific and other supporting local data.

Digital technology plays an important role in reducing the pressures and challenges faced by healthcare staff. In 2018, the Scottish Government published a new integrated Digital Health and Care Strategy, which sets out the key priority areas for development to fully maximise the potential of digital technology, including improving the quality of care (Scottish Government, 2018). This strategy also places innovation at the forefront of its agenda. It recognises a real opportunity for researchers in Scotland to create a digital healthcare system and support improvement in the safety, effectiveness and efficiency of healthcare services.

In terms of medicine management, digitalising the entire prescription service remains one of the key areas for improvement in the UK (Tolley, 2012). Although more prevalent in primary care, electronic prescribing and medication administration systems are increasingly being used in the hospital setting (Bell et al., 2019). More advanced systems incorporate the clinical decision support system (CDSS), which is intended to aid clinicians in prescribing safely, including drug dictionaries, default dose suggestions, and warnings to the prescribers (e.g., drug interaction, drug allergies and relevant laboratory results alerts) (Kawamoto et al., 2005). Computerised CDSS, particularly as an adjunct to electronic health records, charting or order entry systems, could lead to patient care improvements.

Clinical decision support systems, built of software designed to assist with clinical decision making, are mainly used at the point of care today, aiding clinicians in combining their knowledge and patient information with the system suggestions (Sutton et al., 2020). The most basic forms of CDSS include assessment, monitoring, and informative tools such as automated alerts, reminders and electronic links to clinical guidelines, whilst more advanced diagnostic tools tend to rely on statistics and machine learning to provide therapy advice or risk assessment (Hernandez et al., 2017).

6.5.3.1 Evidence of effectiveness of CDSS

Clinical decision support systems have been widely used to improve specific aspects of patient care, including prescribing, by promoting behaviour change among clinicians (Rawson et al., 2017). The range of functions provided by CDSS is extensive, including diagnostics, prompts and alarms, disease management, drug control, and many more (Sutton et al., 2020). They can take the form of computerised alerts and reminders, order sets, computerised guidelines, patient data reports, feedback, documentation templates and clinical workflow tools. For example, decision aids designed for improving the quality of diabetes care have shown many advantages. A recent review of RCTs of medical records powered by a CDSS for diabetes care has shown a significant improvement in measures of quality (Ali et al., 2016). Similarly, an RCT evaluating the effectiveness and safety of a CDSS to manage the treatment of patients with gestational diabetes found that the intervention generated safe advice about therapy adjustments, reduced the clinicians' workload and helped them identify patients who required a more urgent or a more comprehensive examination (Caballero-Ruiz et al., 2017).

In terms of medication management, CDSSs are commonly used to reduce drug errors. They are designed with a drug safety software and measures for safeguarding the dosing, duplication of therapies, interaction checking, intravenous to oral antibiotic conversion opportunities, drug-pathogen mismatches, and discontinuation or de-escalation prompts (Helmons et al., 2015). These systems have also been shown to aid clinicians in selecting appropriate antibiotic treatment for various infections and to improve the overall quality of care (Blumenthal, 2010). Clinical decision support tools in the form of electronic warnings and reminders can also prevent inappropriate prescriptions. For example, a study evaluating an impact of CDSS on receipt of antibiotic prescriptions for acute bronchitis and upper respiratory tract infection in ambulatory care has shown a 19% reduction in the likelihood of receiving an antibiotic, controlling for patient, provider and practice characteristics (McCullough et al., 2014).

Alerts generated by CDSSs are among the most utilised type of decision support. However, evidence suggests that there is a high level of variability in prioritisation depending on how the alerts are displayed (e.g., passive or active/disruptive). A comparative, retrospective, multinational study investigating alert warnings for high- and low-priority drug-drug interactions (DDIs) found that they existed for most of the high-priority DDIs but overriding them was straightforward in most systems (Cornu et al., 2018). An earlier meta-regression of 162 RCTs to identify factors of an effective CDSS has shown that odds of success were greater for systems that required HCPs to provide reasons when overriding advice (Roshanov et al., 2013).

Moreover, a systematic review carried out by Moxey et al. (2010) identified reasons for overriding repeatedly shown alerts, such as clinicians' perceptions of their seriousness or relevance. This means that the risk of users ignoring or overriding important reminders rises with the frequency of seeing less relevant alerts. Kwok et al. (2009) have shown that CDSSs can also improve adherence to clinical guidelines. This is important as the implementation of traditional clinical guidelines is difficult with low clinician adherence (Leone et al., 2012). However, the guidelines can be encoded into a decision support tool in various forms, including standardised order sets, alerts with links to a specific protocol for the patients, and reminders for testing (Sutton et al., 2020).

Although there are many benefits of using a CDSS in clinical practice, the system is not without its drawbacks. For example, the technical complexity of CDSSs related to integrating large sets of data means that the system may not always be accurate or fast (Belard et al., 2017). Other factors, such as the lack of sufficient technical support and adequate user training, may compound the challenge of widespread implementation of a CDSS. The literature highlights the variability in the uptake of recommendations generated by CDSSs for prescribing decisions. A systematic review found that the uptake of CDSSs depends on a variety of factors, including the availability and accessibility of hardware, how well the system is integrated into clinical workflow, and the relevance and timeliness of the clinical prompts provided (Moxey et al., 2010). Other challenges include clinicians' acceptance of the system and the perceived threats to professional autonomy. These findings suggest that issues beyond software and content must be considered for successful implementation of a CDSS.

6.5.3.2 Antibiotic Review Tracker main features in relation to BCTs

The digital Antibiotic Review Tracker, the main component of the DARTT intervention, is a CDSS with a standardised proforma and algorithm for tracking decision making and flagging up prescriptions which need to be reviewed. This component has been designed to target barriers related to a range of domains, including *Skills, Knowledge, Behavioural Regulation, Memory, Attention and Decision Processes, Environmental Context and Resources, Social Influences, Beliefs About Capabilities, Beliefs About Consequences, Goals, Reinforcement* and *Emotion* (see Chapter 5, Section 5.4.4 for more details).

To change the implementation of behaviour, techniques, such as 'restructure the physical environment' and 'add objects to the environment' will be utilised. The system will be integrated into the current NHS electronic health record system, supporting patient progress notes, including laboratory reports and other patient descriptors. The majority of the existing NHS systems can be modified to include free-text entries. Clinicians will access the Tracker dashboard template by selecting a designated progress note (e.g., 'ANTIBIOTIC TRACKER'). To enable easy access, the graphical user interface will run on different internet browsers and be designed based on clinicians' routine workflow. The main section will facilitate real-time antimicrobial prescribing information input, taking into account patient laboratory culture and sensitivity testing results and response to antibiotic therapy. The program inbuilt into the Tracker will recognise the need to initiate broad-spectrum treatment during periods of clinical uncertainty and prompt a more specific therapy after the laboratory results become available.

The system will incorporate the principles of the UK national Start Smart then Focus strategy for hospitals, such as:

- Do not start antibiotics unless there is clear evidence of infection.
- For antibiotics prescribed, document clinical indication, dose, route, duration and the review date.
- Obtain cultures first where possible.
- Comply with the local antimicrobial guidelines.
- Prescribe single-dose antibiotics for surgical prophylaxis where antibiotics are effective.
- Review the clinical diagnosis and continuing need for antibiotics by 48-72 hours and make a clear prescribing decision (i.e., stop, switch, change, continue or refer to outpatient parenteral antibiotic therapy (Department of Health, 2015).

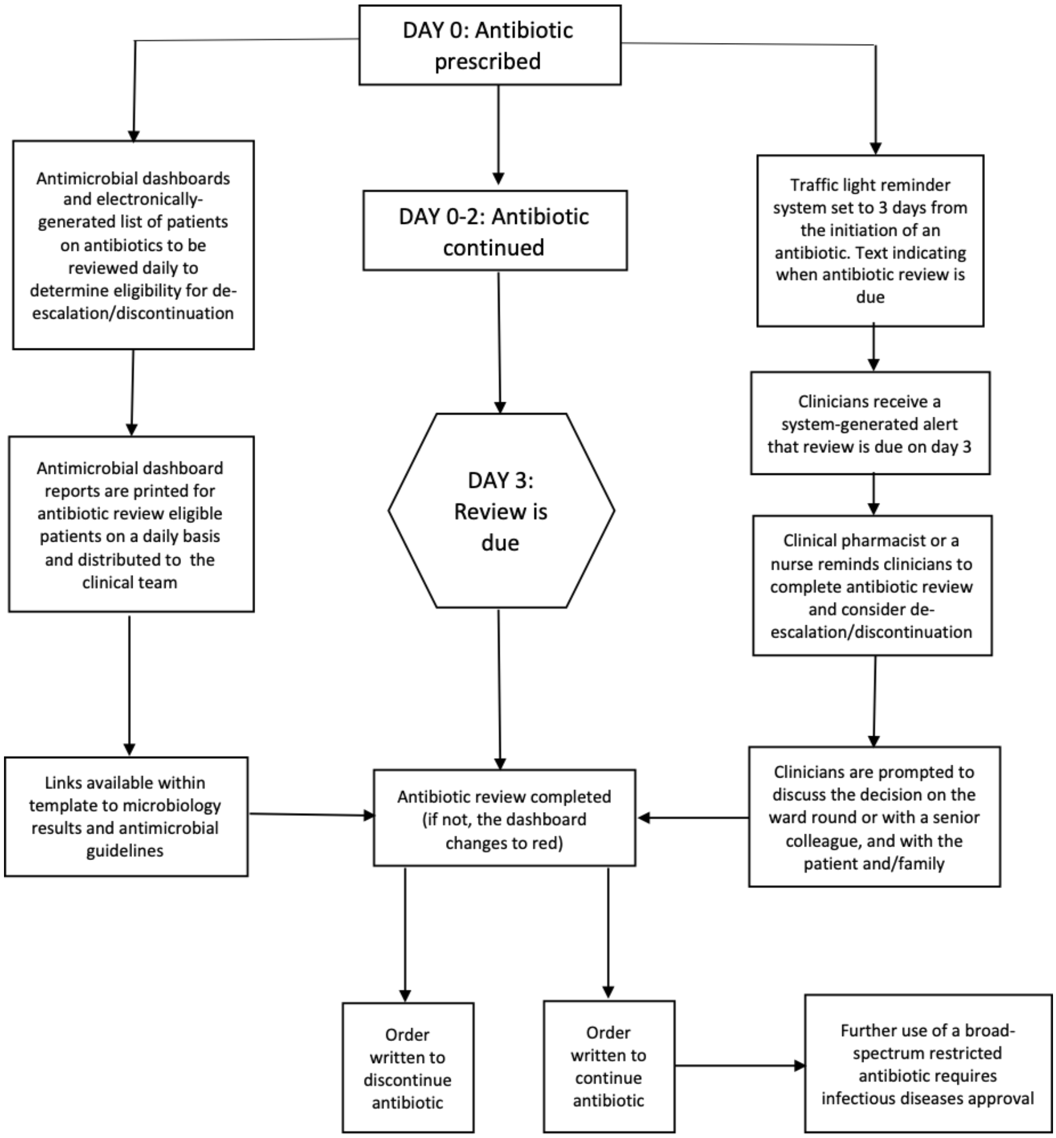
Similar to Graber et al.'s (2015) antibiotic time-out intervention, the Tracker's structured data fields will focus on several questions – 1) Is a bacterial infection present?; 2) Have cultures been obtained?; 3) Has the site of infection been determined?; 4) Has the causative bacterial pathogen(s) been identified?; 5) Is the patient clinically stable?; 6) Has the right drug and dose been prescribed to cover the pathogen?; 7) Can the antibiotic be stopped or changed to oral or a narrower-spectrum agent?; and 8) How long do the antibiotic guidelines recommend treatment for? The purpose is to prompt clinicians to consider an alternative course of action (i.e., a 'no antibiotic' decision) and replace the unwanted behaviour by applying techniques, such as 'action planning' and 'habit reversal'.

An integrated 'traffic-light' function will alert clinicians to review the antibiotic therapy on the third calendar day of treatment (e.g., BCT 'prompts/cues', 'restructure the physical environment'). To promote a timely, team-based assessment, the data fields will also include questions about whether the antibiotic decision made during the review was discussed on ward rounds or with a senior clinician (BCT 'social support'). The Tracker will have an inbuilt basic logic tree for correct dosing regimens (i.e., frequency and duration of antibiotic) and free text fields for explaining the rationale for deviating from the guidelines. Prompts to clearly document the plan of action and discuss the decision with the patient or their family will be provided (BCT 'habit formation'). Hyperlinks to online resources, such as antibiotic guidelines, will be embedded within the Tracker's template. Engagement with clinical pharmacists will be essential at this stage, and their expertise, clinical knowledge and input will be maximised by employing a combination of techniques, such as 'social support', 'goal setting', 'action planning', 'instructions on how to perform the behaviour' and 'feedback on behaviour'. They will be briefed and encouraged to remind clinicians to complete an antibiotic review and consider de-escalation/discontinuation of treatment (if appropriate).

For the continuation of restricted broad-spectrum antibiotics, infectious diseases input will be required. The Tracker dashboard will also allow the user to generate reports for patients who are eligible for a review (e.g., BCTs 'prompts/cues', 'habit formation'). These reports will be distributed to the clinical team daily. Overall performance reports on individual clinician decisions, but not containing any patient data, will be generated and emailed to prescribers (e.g., 'in the last month, you've reviewed X number of prescriptions, de-escalated Y number of antibiotics, and accessed guidelines Z number of times'). The BCTs deemed useful for the delivery of this element, include 'social comparison', 'discrepancy between current behaviour and goal' and 'feedback on behaviour'.

A diagram of how the Tracker will be integrated into the clinical workflow is presented in Figure 28. The diagram has been adapted from the study by Graber et al. (2015), which successfully pilot-tested an antibiotic time-out programme at an acute US hospital, where continuing two broad-spectrum antibiotics (vancomycin and piperacillin-tazobactam) after day three had previously required infectious diseases specialist approval. The time-out strategy has also been endorsed in the UK (Ashiru-Oredope et al., 2012).

Figure 28. The Antibiotic Review Tracker workflow schematic



6.5.3.3 Feedback mechanisms

The meta-ethnography (Chapter 3) highlighted that scarce feedback on prescribing decisions, and poor communication pathways cause frustration for junior doctors, leading to a lack of understanding of the rationales for why their decisions have been over-ruled or changed, limiting opportunities for developing further knowledge and skills in the area. Focus groups carried out in Chapter 4 further support these findings. Although participants did not directly speak of the need to create feedback mechanisms, they reported a lack of motivation to review antibiotics due to the lack of feedback on performance.

Audit and feedback have been used successfully in healthcare to improve HCPs' performance. Feedback can be used as a standalone intervention or in conjunction with other approaches, such as educational meetings (Ivers et al., 2012). Many behavioural theories exist explaining how feedback may lead to improvements in patient care. For example, Grol et al. (2007) suggest that giving feedback may change the individuals' awareness, their beliefs about current practice, affect self-efficacy and direct their attention to specific tasks. The provision of feedback can also be used for learning. Enabling discussion and reflection on an individual's practice compared with evidence-based practice or peers may motivate HCPs to improve the quality of care.

Providing feedback has been shown to produce significant changes in HCPs' behaviour in general. For instance, a systematic review has shown that feedback provision may be more effective when baseline performance is low, when it is provided by a supervisor more than once, delivered in verbal and written formats, and when it includes both clear targets and an action plan (Ivers et al., 2012). However, substantial improvements in antibiotic prescribing practice have been noted in more complex interventions that included a feedback component rather than feedback provision alone (Drekonja et al., 2014). John et al. (2015) argue that social norm feedback, that is, presenting information to individuals to show them that they deviate from the social norm, may influence them to adjust their behaviour accordingly.

The Department of Health has suggested that there is potential to actively give detailed prescribing data feedback to primary care prescribers to improve practice (Pinder et al., 2015). Using a randomised factorial trial, Hallsworth et al. (2016) used publicly available databases to identify and recruit 1581 GP practices whose prescribing rate for antibiotics was in the top 20% for their NHS local area. Every GP in the feedback intervention group received a letter from the Chief Medical Officer stating that their practice prescribed more antibiotics than 80% of practices in its local area. The study found that social norm feedback from a high-profile figure can significantly reduce antibiotic prescribing at a low cost and on a large scale (Hallsworth et al., 2016).

The 2016 Infectious Diseases Society of America's guidelines for Implementing an Antibiotic Stewardship Program recommend both pre-prescription authorisation (PPA) and post-prescription review with feedback (PPRF) as core approaches for reducing antibiotic use in the healthcare setting (Barlam et al., 2016). In their quasi-experimental crossover trial, Tamma et al. (2017) evaluated approaches for optimising antibiotic use and found that PPRF may have more impact on decreasing overall days of antibiotic therapy compared with PPA. Similarly, a prospective audit which measured the clinical impact of intervention with feedback within 48–72 hours of antibiotic administration on hospitalised patients in the intensive care unit found positive effects on antimicrobial use, duration of therapy and length of stay (Khdour et al., 2009). Given its clear advantages, the prospective audit and feedback remains one of the most widely implemented strategies to curtail inappropriate antibiotic usage in hospitals compared to other settings. Wilkinson et al. (2019) suggest that this might reflect the ease of monitoring in hospital settings and the availability of local experts, such as infectious disease specialists, microbiologists, or clinical pharmacists, to perform critical supportive roles within the interventions.

The information regarding feedback delivery will be sought from the target population through the next stage of this thesis (Chapter 7). The knowledge gathered will provide ideas about who should deliver feedback to prescribers, how (in what form) and when best to deliver it. For instance, focus group participants (Chapter 4) suggested that utilising already existing NHS antibiotic guardians (BCT 'credible source') to monitor prescribing decisions and provide support and face-to-face training sessions would be fundamental to the success of the intervention. These antibiotic guardians could be nominated within each clinical area (e.g., a member of the local AMS team or a clinical pharmacist) to ensure that new staff complete the training (e.g., BCTs 'verbal persuasion about capability', 'prompts/cues') and also provide practical advice on the use of the Tracker for all antimicrobial prescriptions (e.g., BCTs 'instructions on how to perform the behaviour', 'problem solving').

The antibiotic guardians could act as role models by giving explicit feedback to prescribers and encouraging expert advice-seeking behaviours using reports generated by the Tracker. The reports would then be emailed to prescribers and presented by the antibiotic guardian during brief face-to-face discussions. The following BCTs have been selected as the most suitable to facilitate behaviour change – 'feedback on outcome of behaviour', 'discrepancy between current behaviour and goal', 'reduce negative emotions', 'focus on past successes'.

The generated reports would provide individual prescribing data, including the number of antibiotic prescriptions for each month together with information on incomplete or inappropriate information (e.g., incorrect dosing regimen). An emphasis would be put on the proportion of agents that were stopped or de-escalated. Data would be presented in a table or bar chart for comparison with peers (BCT 'social comparison'). A brief accompanying narrative would explain the numerical data in the table and include a reminder on how to access the antibiotic guidelines and where and how to seek expert advice (BCT 'social support'). The local area performance reports would be circulated to management for discussion during team meetings. A summary of the Antibiotic Review Tracker main features, including the feedback component and the chosen BCTs, is provided in Table 27.

Table 27. Summary of the Antibiotic Review Tracker content and delivery

Intervention component	Content	Delivery	BCTs
Digital Antibiotic Review Tracker (+ feedback on performance)	Professionally designed CDSS for electronic implementation in clinical practice, including: • A standardised proforma and algorithm for tracking decisions. • Antibiotic review traffic-lights reminder system. • Creates trail of decisions. • Allows generation of reports for review-eligible patients. • Basic logic tree for correct dosing regimens. • Creates individual performance reports. • Prompts discussion with the clinical team and the patient. • Infectious diseases input required for continuation of restricted broad-spectrum therapy. • Hyperlinks embedded to	The Tracker will be integrated into the electronic record system, accessible on NHS-enabled devices and delivered at the point of care. The interface will run on all internet browsers.	Goal setting (behaviour); Problem solving; Action planning; Discrepancy between current behaviour and goal; Feedback on behaviour; Feedback on outcome of behaviour; Social support (unspecified); Instruction on how to perform the behaviour; Information about health consequences; Information about social and environmental consequences; Information about emotional consequences; Social comparison; Prompts/cues; Behavioural practice/rehearsal; Habit formation; Habit reversal; Credible source; Reduce negative emotions; Verbal persuasion about

	online resources (e.g., antibiotic guidelines). • Monthly individual and area reports on antibiotic-prescribing practice provided by antibiotic guardians. • The reports will include aggregated data for the number of initiated antibiotics, streamlined prescriptions and incomplete/incorrect information. • Presented as a table and/or bar chart in a PDF file. • Comparison with peers. • Accompanied by a narrative with links to antibiotic guidelines.	Delivered by email to prescribers and discussed with the 'clinical champion'. Local area reports encouraged to be discussed in team meetings.	capability; Focus on past success; Restructure the physical environment; Restructuring the social environment; Add objects to the environment.

6.5.4 Component 4: Patient information materials

Patient information materials (PIMs), such as leaflets and posters, have been used in healthcare for many decades to reinforce, illustrate, or simply remind people of previously received information. Although most information can be accessed through the Internet, patients continue to ask for more written information to supplement verbally provided facts and instructions (Sustersic et al., 2017). Information materials are a useful resource in health education and promotion as they can help patients understand the purpose of tests, interventions, treatments, and procedures (Protheroe et al., 2015). The UK Government has emphasised the importance of providing patients with good quality health information so that they can take an active part in decisions about their care (Department of Health, 2010). Although PIMs can be found across various healthcare facilities, one of the most common places for patients to access them is in the waiting room of their general practice or in a hospital.

6.5.4.1 Evidence of effectiveness of PIMs

Patient-centred prescribing is a strong focus of DARTT, driven by findings from the focus groups conducted with HCPs and health service users, as well as evidence from primary care suggesting that engaging patients in antibiotic decisions can reduce unnecessary antibiotic use (Coxeter et al., 2015). Providing patients with information helps empower them to make informed choices about their health and care. However, to be effective, PIMs must first be noticed, read and understood (Protheroe et al., 2015). A questionnaire survey assessing the use of PIMs has suggested that patients value and read health information materials found in waiting rooms and that such materials can improve patient-clinician interaction, health knowledge and self-management (Moerenhout et al., 2013).

Evidence from primary care suggests that using PIMs can facilitate a reduction in antibiotic use. For instance, a systematic review assessing the effectiveness of written information used during GP consultations has shown similar findings by providing evidence that it can effectively reduce antibiotic prescriptions for common infections (De Bont et al., 2015). Another example is a non-blinded cluster RCT that aimed to improve the management of infections in 272 community pharmacies in England (Ashiru-Oredope et al., 2020). The intervention arm received a webinar-based training on AMR and a patient leaflet about a respiratory tract infection (RTI) to be used for four weeks. The use of the leaflet was associated with a better provision of self-care advice and lowered referrals to GPs for certain RTIs compared to the control group ($p < 0.05$) (Ashiru-Oredope et al., 2020).

Although evidence exists that both patients and clinicians want a person-centred focus on prescribing in a hospital setting (Rawson et al., 2018), there is little research showing that the use of PIMs could lead to similar changes in behaviour and reductions in antibiotic use. However, a recent Australian study showed positive results (Ritchie et al., 2019). Inpatients from across general medical, surgical and orthopaedic wards were asked to look at one of three randomly selected posters, which highlighted either the futility of antibiotic treatment for colds, the risk of adverse drug reactions from antibiotics or the issue of AMR. The study found that using simple educational materials emphasising antibiotic futility led to a reduction in patient expectations of receiving antibiotics for common colds (Ritchie et al., 2019).

Furthermore, a recent qualitative study investigating the acceptability of a patient leaflet about antibiotic prescribing decisions made during a hospital stay, introduced as part of a complex health behavioural intervention to minimise antibiotic overuse, reported that patients found it an accessible and valuable source of information (Mowbray et al., 2020). Importantly, participants expressed a desire to be involved in antibiotic prescribing decisions and highlighted the importance of open communication and engagement with clinicians. This finding is in keeping with an earlier qualitative study carried out in five European hospitals, showing that inpatients place trust in clinicians to take the best prescribing decisions for them (Zanichelli et al., 2019). However, communication regarding their antibiotic treatment was found to be insufficient due to time constraints. Both studies highlight the importance of patient engagement in decisions around prescribing.

However, while there is evidence that hospital inpatients want an increase in shared decision making around prescribing (Rawson et al., 2018), there is an absence of research informing the design and use of PIMs to support the antibiotic review process. Therefore, although the researcher has provided some ideas regarding the mode of delivery and the main features, more detailed information will be gathered in qualitative interviews conducted in Chapter 7.

6.5.4.2 Main features of PIMs in relation to BCTs

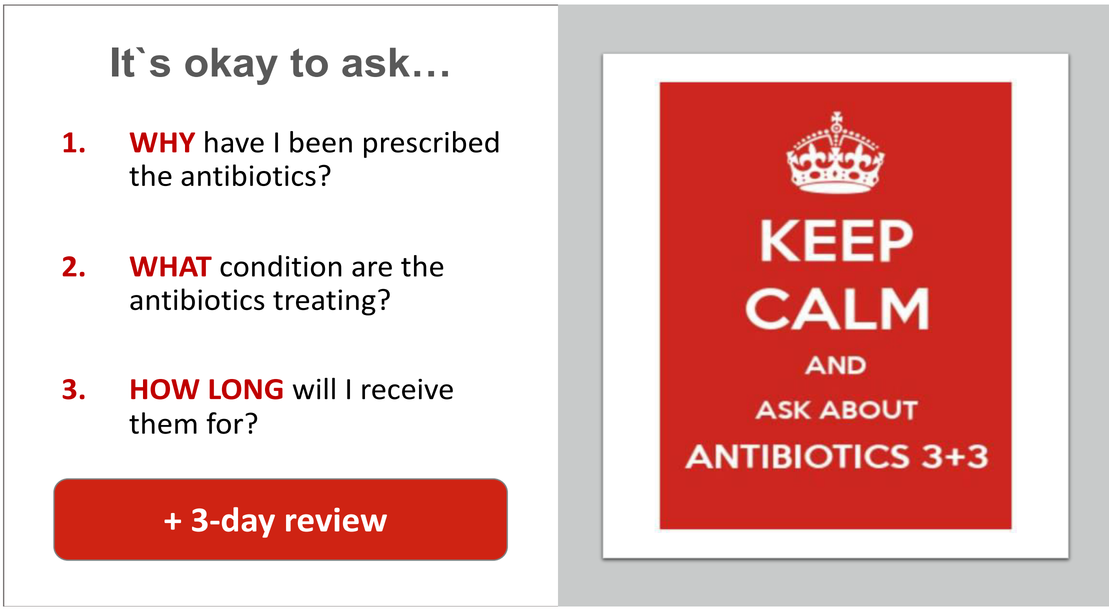
This component has been designed to address the following behavioural domains: *Knowledge, Environmental Context and Resources, Beliefs About Capabilities, Beliefs About Consequences*, and *Emotion*. The purpose of the PIMs component is to provide individualised practical information and increase patient understanding about AMR and the risks of antibiotics (e.g., side effects) and the importance of carrying out a timely antibiotic review, point towards reputable information sources, and enhance patient engagement in decisions about antibiotics (e.g., BCTs 'add objects to the environment', 'prompts/cues', 'habit formation' and 'instruction on how to perform the behaviour').

The leaflets will first be piloted and then presented in a simple layout in a double-sided A4 format and incorporate engaging images. It will provide brief but relevant and easily accessible information in a health literate format to improve patient knowledge and awareness about antibiotics (BCTs 'information about health consequences', 'information about social and environmental consequences'), and encourage engagement and open communication with HCPs. The leaflet will have links to reputable websites and cover the following four areas:

1. What are antibiotics, and why do we use them?
2. What is antibiotic resistance?
3. Why is antibiotic review important?
4. Can I ask my doctor or nurse about antibiotics?

Information encouraging patients and their families to ask HCPs about the antibiotics using the Antibiotic 3+3 principle (what, why, how long and review after three days) will be provided on a poster, an example of which is illustrated in Figure 29.

Figure 29. An example of the antibiotic poster



The summary of the content of the PIMs component chosen for delivering each BCT is presented in Table 28 below.

Table 28. Summary of patient leaflet content and delivery

Intervention component	Content	Delivery	BCTs
Patient information materials	Professionally designed PIMs, including: • Patient leaflet to improve patient knowledge and enhance shared decision making. • Presented in a double-sided A4 format and written in plain English. • Explaining the risks of antibiotics	Patient information leaflets and posters placed in the hospital waiting rooms provided in a health literate format.	Instruction on how to perform the behaviour; Information about health consequences; Information about social and environmental consequences; Information about emotional

	(e.g., AMR and side effects) and the importance of a timely review, stopping or narrowing down antibiotics. • Poster encouraging patients to ask HCPs about antibiotics – use of Antibiotic 3+3.		consequences; Prompts/cues; Habit formation; Reduce negative emotions; Add objects to the environment.

6.6 Translating theory into intervention components

The MRC framework for complex interventions highlights the benefit of theory-driven instead of theory-inspired approaches for designing and evaluating interventions (Craig et al., 2008). The guidance also suggests that modelling an intervention prior to a full-scale trial can provide useful information, strengthening its design. However, Michie and Prestwich (2010) argue that despite many interventions stating their theoretical basis, they rarely make an explicit reference to how the theory informed the design of the intervention. Therefore, researchers need to become more transparent in outlining *how* the theory was applied within the intervention and then implemented in practice. By explicitly describing how to translate theory and evidence into an intervention, researchers can demonstrate the reliability of the development process, and intervention fidelity in practice (Breitenstein et al., 2012; Michie et al., 2018).

This theory-based intervention has used an explicit causal pathway to address these concerns, which enabled the researcher to avoid making any assumptions which lacked evidence. Developing the theoretical basis for the intervention required a clear understanding of the processes through which individual BCTs have their effects (i.e., their mechanisms of action). Chapter 5 of this thesis carefully describes the procedure for selecting relevant BCTs using the Behaviour Change Technique Taxonomy v1 and how they were mapped to each of the identified behavioural determinants (Michie et al., 2014). Table 29 below demonstrates which BCTs have been incorporated into the intervention components and their mechanism of action.

Table 29. Intervention content and mechanisms of action

Intervention component	Incorporated BCTs	Mechanism of action	
		↑ COM-B	TDF
Webinar	Goal setting (behaviour); Problem-solving; Information about health consequences; Information about social and environmental consequences; Information about emotional consequences; Credible source; Reduce negative emotions; Focus on past success.	Psychological Capability; Social Opportunity; Reflective Motivation; Automatic Motivation.	Knowledge; Social/professional role and identity; Social influences; Beliefs about capabilities; Beliefs about consequences; Goals; Emotion.
Online Interactive Tool	Problem solving; Action planning; Discrepancy between current behaviour and goal; Feedback on behaviour; Instruction on how to perform the behaviour; Information about health consequences; Information about emotional consequences; Demonstration of the behaviour; Social comparison; Prompts/cues; Behavioural practice/ rehearsal; Habit formation; Habit reversal; Credible source; Identification of self as a role model.	Physical Capability; Psychological Capability; Physical Opportunity; Social Opportunity; Reflective Motivation; Automatic Motivation.	Skills; Knowledge; Behavioural regulation; Memory, attention and decision processes; Environmental context and resources; Beliefs about capabilities; Beliefs about consequences; Social/professional role and identity; Emotion.
Antibiotic Review Tracker (+ feedback on performance)	Goal setting (behaviour); Problem solving; Action planning; Discrepancy between current behaviour and goal 2.2 Feedback on behaviour; Feedback on outcome of behaviour; Social support (unspecified); Instruction on how to perform the behaviour; Information about health consequences; Information about social and environmental consequences; Information about emotional consequences; Social comparison; Prompts/cues; Behavioural practice/rehearsal; Habit formation; Habit reversal; Credible source; Reduce negative emotions; Verbal persuasion about capability; Focus on past success; Restructure the physical environment; Restructuring the social environment; Add objects to the environment.	Psychological Capability; Physical Capability; Psychological Capability; Physical Opportunity; Social Opportunity; Reflective Motivation; Automatic Motivation.	Skills; Knowledge; Behavioural regulation; Memory, attention and decision processes; Environmental context and resources; Social influences; Beliefs about capabilities; Beliefs about consequences; Goals; Reinforcement; Emotion.
Patient Information Materials	Instruction on how to perform the behaviour; Information about health consequences; Information about social and environmental consequences; Information about emotional consequences; Prompts/cues; Habit formation; Reduce negative emotions; Add objects to the environment.	Psychological Capability; Physical Opportunity; Reflective Motivation; Automatic Motivation.	Knowledge; Environmental context and resources; Beliefs about capabilities; Beliefs about consequences; Emotion.

6.7 Mapping of the form of delivery elements

Hoffman et al. (2014) suggest that intervention description involves more than providing a list of the 'active ingredients'. Details of key features, including duration, dose or intensity, mode of delivery, essential processes, and monitoring, are needed for each intervention component. Therefore, to increase the quality of reporting and enable future replicability, the intervention content and mode of delivery described in the previous section have been mapped onto Dombrowski et al.'s (2016) Form of Delivery framework (Table 30) (adapted from Hoffman et al.'s TIDieR checklist (2014)).

Table 30. Form of delivery elements of the DARTT complex behaviour change intervention

Delivery elements *Delivery features*	**Description**
Provider (Who delivers, facilitates, or is behind the intervention?)	
Provider Characteristics	The DARTT Research Team will provide the intervention. Hospital sites will be responsible for the local implementation, a process led by a local Clinical Champion.
Professional background	Clinicians, researchers and behaviour change experts.
Professional experience	The Research Team comprises PhD level-trained nurses and social scientists who have vast experience in developing behaviour change interventions. Two experienced clinicians (e.g., microbiologist, infectious disease specialist or clinical pharmacist) and a senior doctor will be recruited to join the team.
Number of providers	Two nurses, three social scientists, and two doctors.
Training in intervention facilitations	Half day workshop will be provided to the new members of the Research Team. Local Clinical Champions will be given access to the relevant online elements before implementation.
Training in intervention delivery	Group facilitation training.
Intervention relevant competence	Professionals trained in using DARTT tools.
Continuity	Same provider.
Delivery Format (What are the methods of intervention administration)	
Mode of delivery	The intervention includes both face-to-face and remote online components, supported by written information.
Delivery method	The Webinar will be delivered during team meetings or staff inductions. Individual feedback will be provided to prescribers and discussed in staff meetings.
Delivery channel	Webinar, Online Interactive Tool, Clinical Decision Support System, verbal and written feedback for prescribers, text and email.
Delivery route	Video, picture and text.
Materials (What are the physical or virtual materials that the intervention consisted of?)	
Participants' materials	E-learning activity, Antibiotic Review Tracker, Patient Leaflets and Posters.
Providers' materials	DARTT supporting documentation, email and mobile phone reminders, CPD certificate provided after completion of the E-learning activity.
Intervention materials	DARTT intervention manual.

Setting (Where is the intervention being delivered?)	
Location	Secondary care.
Venue	Acute and general medical wards in hospitals (e.g., respiratory wards). The online components will be accessed via computers and phones.
Intensity (What is the intensity with which the intervention is being delivered?)	
Duration of intervention	Application of the Antibiotic Review Tracker should occur at the initial prescription, with review reminders occurring 48-72 hours after the initial prescription. Individual feedback and team discussions around the Tracker-generated prescribing reports should occur monthly.
Number of contacts	Individual feedback and team discussions around the Tracker-generated prescribing reports should occur monthly.
Length of contacts	20 min for individual feedback and 60 min team discussions.
Frequency	Monthly
Spacing	Constant for team discussions and variable and more frequent for face-to-face feedback.
BCT sequencing	Variable order.
Contact form	Scheduled (regular maintenance visits) and reactive (responding to issues when they occur with reactive maintenance, e.g., when requested by prescribers or the clinical team).
Tailoring (Does the intervention delivery differ between participants?)	
Intervention variation	One size for all with personalised feedback sessions.
Tailoring source	Modifications will be made to the DARTT tools and materials by the Research Team following qualitative feedback from an acceptability study and after the initial pilot. Verbal feedback to prescribers will be tailored accordingly to individual needs.
Standardisation	Automated (e-learning, texts and emails) and personal feedback.
Style (What was the overall style of the intervention?)	
Delivery style	HCP and patient-centred. DARTT targets primarily prescribers (senior and junior doctors and advanced nurse practitioners) and other clinicians involved in decisions around antibiotics and patients.
Communication style	Practitioner led feedback sessions.
Communication techniques	Listening, questioning, reflecting.
Visual style	A graphic designer will be consulted to help with intervention design elements such as layout, look and colour scheme of the materials and a web development agency recruited to help with the web-based aspects of DARTT.
Complexity	DARTT is a complex, multifaceted intervention. The depth of information provided will be appropriate for healthcare professionals. The reading level and layout of patient leaflets will be provided in a simple and health literate format. A language specialist will be consulted for input on the patient materials.

6.8 Chapter summary

The literature review (Chapter 3) and analysis of the focus groups with stakeholders (Chapter 4) identified barriers related to antibiotic use in a hospital setting. An electronic reminder system with a decision tracking mechanism was a favourable form of delivery suggested by the participants. Using a theoretical framework combined with empirical findings and guided by judgements made by applying the APEASE criteria, the Digital Antibiotic Review Tracking Toolkit (DARTT) has been proposed. DARTT is a complex, multifaceted, behavioural intervention targeting HCPs and patients/families, which can be used flexibly, either as standalone components or a toolkit.

The proposed intervention aims to improve antibiotic review practice, increase prescribers' confidence to make autonomous decisions, enhance communication between clinicians, and involve patients in shared decision making about their antibiotic treatment. Steering prescribers toward the desired behaviour by providing electronic prompts and reminders will assist them in making better antibiotic decisions. The explicit steps undertaken to design the intervention and its main features and elements have been described and presented using Dombrowski et al.'s (2016) Form of Delivery framework. The development process was not linear but comprised of several stages, including full engagement from the supervisory team to revise ideas before the draft of the intervention emerged. The DARTT components and their mode of delivery have been chosen to target barriers related to the 12 theoretical domains identified in Chapter 5 as influencers to antibiotic prescribing behaviour. Evidence of the effectiveness of each component in clinical practice has been provided. The Antibiotic Review Tracker, the main component of DARTT, was designed to alert clinicians to carry out a timely antibiotic review, help make appropriate de-prescribing decisions and provide a useful antibiotic data summary while fitting into clinical workflow.

6.9 Strengths and limitations

The strength of this intervention is its theoretically driven developmental process. Integrating published literature with the primary data derived from the focus groups provided rich data to support theory generation and content for the intervention. Making explicit the steps undertaken in the intervention development improved its transparency and replicability. The advantage of choosing a web-based mode of delivery is the great diversity of available features and formats for presenting information online and thus ensuring user engagement (Lustria et al., 2009).

Although the chosen intervention components, aims and delivery mode are evidence-based, finding literature to guide intervention design elements, such as layout, look and functions, was challenging. Limited research identifying the design features most likely to bring about behavioural change has been conducted to date.

Therefore, prior to pilot testing, a consultation with a graphic designer and a web developer will be required to ensure the intervention is attractive, practical, accessible and easy to use. Additionally, due to the dearth of research reporting an explicit theoretical basis to interventions designed for hospital use, a large proportion of the presented evidence relating to the effectiveness of individual components has been derived from primary care (i.e., patient leaflets). Thus, thorough exploration of the topic is required with potential users. The next challenge will be moving from intervention development to practical decisions about its implementation and further tailoring the components and specific BCTs to ensure effectiveness.

6.10 Conclusions

This chapter has highlighted the importance of selecting the appropriate form of delivery in the design and delivery of complex health interventions and described the chosen delivery methods of the DARTT intervention, underpinned by evidence, theory and context. A summary of its main elements and features in relation to the chosen BCTs (i.e., active ingredients) has been presented to allow full operationalisation, comparison and future replication. The evidence gathered in the preceding chapters was systematically brought together to demonstrate the intervention content and the proposed mechanisms of behaviour change. An overview of the intervention components and the chosen mode of delivery, including face-to-face and remote (online) components, supported by written information was provided.

As the uptake of information technology within healthcare settings is increasing and the barriers against using such methods are rapidly reducing, web-based systems within antibiotic stewardship interventions are warranted. The idea of implementing the Antibiotic Review Tracker for the main component of the DARTT intervention is novel. However, as discussed in this chapter, the clinical decision support system chosen to deliver the key component is a tried and tested method that has shown effectiveness in reducing unnecessary antibiotics in secondary care. It can therefore be concluded that it is an appropriate mode of delivery for this purpose. The modes of delivery proposed for other components, including e-learning activities, feedback, and patient information leaflets, are more common in AMS activities, and the evidence of their effectiveness has been demonstrated. As the intervention components are a prototype version of the final product, further refinements will benefit from seeking the expertise of other disciplines, including a graphic designer, web development agency and a co-design with end-users to refine the intervention into the most effective FoD. The next chapter presents qualitative interviews with the target population to assess the intervention acceptability and practicability and thus enable its optimisation.

Chapter 7: Refinement and optimisation of the intervention using interviews with healthcare professionals and health service users – Study 2

7.1 Overview of chapter

Chapter 6 described the developed intervention's key elements and features, which were summarised using the Form of Delivery framework to allow full operationalisation and future replication (Dombrowski et al., 2016). This chapter describes the second empirical phase of the project and discusses the evaluation of the proposed Digital Antibiotic Review Tracker Toolkit (DARTT) intervention. Healthcare professionals (HCPs) and health service users were asked to provide preliminary feedback on the appearance, mode of delivery and content of the prototype intervention. The implications of the results for the intervention, suggestions for refinement and the adaptations made are discussed in this chapter.

7.2 Rationale

The UK Medical Research Council's (MRC) influential guidance for the development and evaluation of complex interventions emphasises the importance of an early assessment of their feasibility and acceptability using prototypes (Craig et al., 2008). This approach can highlight aspects that can be adapted based on the end-user feedback without a full pilot trial. Testing the feasibility and acceptability of the prototype intervention can also ensure that it is appropriate for the context in which it is planned to be delivered (Craig et al., 2008). The purpose of the interviews is threefold. Firstly, to gather information about how the target group reacts to the intervention design, content and form of delivery. Secondly, to capture participants' perceptions of the usefulness and practicality in terms of application to practice, and finally, to identify any engagement and implementation issues.

Patient and public involvement (PPI) in the research process has been widely recognised in the last decade as best practice on the premise that it may improve its quality and relevance and reduce research waste (Wicks et al., 2018). User engagement offers an opportunity to learn about people's needs and preferences and to apply these to the design process at an early stage (Owens et al., 2011). Engaging healthcare professionals (HCP) and health service users in refining the intervention ensures that it is “usable, clinically effective and appropriate to cultural context” and increases the chances of more successful implementation (Ram et al., 2008, p. 64; Vale et al., 2012). Testing the prototype intervention with HCPs and health service users is in line with the MRC’s guidance for complex intervention, which recommends that key stakeholders should be involved in each stage of the design process (Craig et al., 2008).

7.3 Study aims and questions

The aim of this study is to assess the interpretation of the DARTT intervention components and their potential impact, determine their broad acceptability, and explore the options to refine the intervention’s design, content and delivery. User feedback is required to determine the DARTT intervention’s strengths and areas for improvement to limit future implementation failure (Levati et al., 2016). The empirical study forms the last part of an iterative intervention development process undertaken in this thesis and aims to answer the following research questions:

1. Do healthcare professionals and health service users find the proposed DARTT intervention acceptable and practical?
2. What refinements, modifications and adjustments are needed to increase the uptake and effectiveness of DARTT?
3. What are the anticipated barriers to the implementation of DARTT?
4. How can DARTT be successfully delivered and maintained in clinical practice?

7.4 Methods

This section describes the sampling and recruitment strategy and participant characteristics, as well as data collection and analysis methods. As the study methods resemble those previously described in Study 1 (Chapter 4, Section 4.4), the researcher will refer to the specific sections of that chapter to avoid repetition. The general considerations of carrying out qualitative research are outlined in Chapter 2. The study aspects are reported using the COREQ guidelines for qualitative research (Tong et al., 2007), details of which are provided in Appendix 44.

7.4.1 Setting and sample

A purposive and snowball sampling method (see Chapter 4, Section 4.4.1) was used to maximise diversity. Participants were selected according to the following criteria: professional background (clinical area and speciality including medical, nursing and allied health professionals), years of clinical experience, gender and geographical location (different Health Boards/Trusts within the UK). Similar to Study 1, participants with varying levels, roles and responsibilities in antibiotic decision making were recruited to gather a wide range of views and preferences on the intervention content and design. The inclusion and exclusion criteria were as follows:

Inclusion criteria:

- Healthcare professionals involved in everyday decision making around antibiotic use for hospital in-patients
- Former in-patients who had previously received antibiotics
- Adults (aged > 18 years)

Exclusion criteria:

- Individuals who have no fluency in the English language or lack the capacity to consent to research
- Other hospital workers (e.g., porters, administrative staff)
- Current in-patients

The interviews were carried out online, and participants chose the interview setting, either in their workplace (an acute hospital) or at home. Although data saturation was reached after conducting 15 interviews, an unanticipated interest in the DARTT intervention and a high number of volunteers for the study enabled the researcher to maximise her sample, providing an opportunity to capture potentially diverse views. As a result, a total of 18 participants were interviewed between December 2020 and January 2021.

7.4.2 Recruitment process

The same recruitment strategy outlined in Study 1 (Section 4.4.2, Figure 19) was used, including access to specific professional forums, such as the Advanced Clinical Practitioners, NHS Intranet advertisements, internal mass emails, study posters placed in staff offices and social media such as Twitter. The participants who took part in Study 1 and expressed their interest in participating in future research on antibiotic use were contacted directly and offered an opportunity to participate in Study 2. From 11 volunteers contacted, four agreed to be interviewed (three HCPs and one lay participant – highlighted in bold in Table 30). Several participants volunteered to forward the study information to colleagues with a particular interest in antimicrobial stewardship. All participants were emailed the Study Information Sheet (Appendix 11), and those who agreed to take part were asked to sign the electronic version of the Consent Form (Appendix 9).

As the study recruitment occurred during heightened COVID-19 pandemic restrictions, challenges were anticipated. However, the recruitment coincided with the initial roll-out of the hospital electronic prescribing and medicines administration (HEPMA) system in Lothian hospitals, and there was significant interest in the intervention. Consequently, the recruitment process was fast, and no barriers to study recruitment were encountered.

7.4.3 Participant characteristics

Eighteen participants were recruited for the study: 15 HCPs and three health service users (lay participants). The sample consisted of nine females and nine males, aged between 20 and 66 years, practising in various disciplines in four Scottish Health Boards and two English Trusts. Healthcare professionals had a varying level of experience from under five to more than 30 years. All participants except one specified their ethnicity as white.

Sample characteristics are presented in Table 31. These were two consultant physicians, two consultant microbiologists, one infectious disease (ID) consultant, one mid-level doctor (trainee), two junior doctors (FYs), two clinical pharmacists and one lead pharmacist, three advanced nurse practitioners (ANPs), one senior infection surveillance nurse, and three health service users, including a high school teacher, a retired teacher and a Scottish Government Policy Officer. To ensure anonymity and confidentiality, all participants were assigned pseudonyms.

Table 31. Semi-structured interviews sample characteristics (Study 2)

PARTICIPANT CHARACTERISTICS					
Name	**Age range**	**Ethnicity**	**Job title**	**Clinical area/speciality**	**Years of clinical experience**
1. **Mary***	40-49	White Irish	Infection Surveillance Nurse	Critical Care	21-30
2. Anna	40-49	White Scottish	Advanced Nurse Practitioner	Critical Care	21-30
3. Caroline	50-60	White Scottish	Advanced Nurse Practitioner	Cardiothoracic Surgery	> 30 years
4. **Hannah***	30-39	White Scottish	Advanced Nurse Practitioner & Clinical Facilitator	Hospital at Night	5-10
5. Alex	30-39	White Scottish	Senior Pharmacist	Care of the Elderly	5-10
6. Kirstin	50-60	White English	Medicines Optimisation Pharmacist	General Medicine	21-30
7. Jane	50-60	White Scottish	Principal Pharmacist	Project Lead for Antimicrobial Prescribing Group	> 30 years
8. Maya	20-29	White British	Junior Doctor	General Medicine	< 5 years
9. Matthew	20-29	White Scottish	Junior Doctor	Acute Medicine & Medicine for the Elderly	< 5 years
10. Wesley	20-29	White English	Internal Medicine Trainee	Gastroenterology	< 5 years
11. Robert	40-49	White Scottish	Consultant Physician	Critical Care	21-30
12. Tom	50-60	White English	Consultant Physician	Acute and general medicine	21-30
13. **Daniel***	40-49	White Scottish	Consultant Microbiologist	Acute and general medicine	21-30
14. Peter	50-60	Black African	Consultant Microbiologist	Acute medicine, surgery and paediatrics	21-30
15. Miles	40-49	White English	Infectious Disease Consultant	Infectious disease and general medicine	21-30
16. **James***	> 60	White Scottish	Lay participant – retired	N/A	N/A

			professional		
17. Sophie	30-39	White Scottish	Lay participant – Scottish Government Policy Officer	N/A	N/A
18. Veronica	30-39	White Scottish	Lay participant – High School teacher	N/A	N/A

***Participants who took part in Focus Groups (Study 1)**

7.4.4 Data collection procedure

To ensure participants' involvement in the refinement and optimisation of the DARTT intervention, various data collection methods were considered, including consultation approaches (workshops and focus groups) and face-to-face semi-structured interviews and surveys. Semi-structured interviews were considered the most suitable option as they provided an efficient method of gaining more in-depth information about participants' perceptions, likes and dislikes regarding the DARTT intervention and eliciting their views to specific questions about the intervention's acceptability. The main advantage of using interviews is the opportunity to clarify individual answers and the ability to capture non-verbal language and cues, such as enthusiasm or disinterest regarding the proposed components of the intervention (Bell & Waters, 2018). A more detailed description of the considerations taken into account in semi-structured interviews is provided in Chapter 2 (Section 2.7).

Although face-to-face interviews were initially planned, the study required changes to the data collection approach due to the pandemic. The interviews had to be undertaken entirely online or via telephone to minimise any detrimental impact on NHS staff (see Chapter 2, Section 2.7.2 for study amendment details). The researcher contacted interested participants to arrange a suitable time and mode of interview. Seventeen participants agreed to be interviewed online using a secure Microsoft Teams platform, and they were shown images of the DARTT intervention using a brief PowerPoint presentation (see Appendix 45). One lay participant was interviewed via telephone and was sent a Word document containing intervention details prior to the interview. Using low-fidelity paper prototypes, which can help to visualise high-level design concepts into a tangible product in a quick and easy way, enabled participants to offer their views on the generated ideas (Wiklund et al., 2016). A semi-structured interview topic guide was used, which was piloted with a lay participant during a brief online meeting to check for understanding and clarity of the presented information (Appendix 46). The interview questions explored the five dimensions of the RE-AIM framework (reach, effectiveness, adoption, implementation and maintenance – described in detail in Chapter 2, Section 2.4.3), to guide pragmatic early-stage intervention planning and help understand what improvements were needed (Glasgow et al., 1999).

Each interview lasted approximately 60 minutes. Pre-interview, all participants were briefed verbally about the nature and aims of the research. They were also informed that they could withdraw from the study at any point without giving the reason for doing so. With participants' permission, routine demographic data, such as their age, gender, speciality, level and years of experience, were collected. The interviews were recorded by the researcher using a digital voice recorder and then transcribed verbatim (typed out, word for word) for analysis purposes.

In keeping with the reflexivity considerations outlined in Chapters 2 and 4, the researcher introduced herself, provided a brief background to the study, remained calm and used good interpersonal skills to establish rapport with participants. The intention was to make participants feel comfortable and at ease. The participants were assured that the data obtained would be kept confidential and anonymised. Reflective notes were made after each interview to assist with analysis and record any other information, such as non-verbal cues, for example, those not gathered during the recorded interview.

7.5 Data analysis

Data gathered during the interviews were analysed using the five interconnected stages of the framework analysis, including data familiarisation, the development of a theoretical framework, indexing, charting, mapping and interpretation (Ritchie & Spencer, 1994). This process has been already described in detail in Chapters 2 and 4 (Section 4.5).

Briefly, in stage one, the researcher became familiarised with the data set by listening to the recorded interviews, transcribing word for word, and reading the transcripts line by line. Key ideas and recurrent themes were noted at that stage. The next step involved identifying a thematic framework. One of the framework analysis benefits is that the method is flexible and allows researchers to adopt inductive, deductive, and combined approaches to qualitative data (Gale et al., 2013). Given that this study's purpose was to explore specific issues and assess the DARTT intervention's initial acceptability and usability, a 'hybrid' approach was deemed appropriate. This study was designed around a priori issues, and these issues guided the thematic framework. Therefore, the researcher began with a deductive coding system, starting with a pre-defined set of codes using the RE-AIM Framework (Glasgow et al., 1999), but kept an open mind to allow for new and unexpected concepts to emerge.

The researcher then tested the codes' suitability by applying two transcripts to the coding index, and some changes were made following discussion with the academic supervisors. For example, the initial categories 'reach' and 'effectiveness' derived from the RE-AIM Framework did not capture participants' comments regarding their likes and dislikes of the intervention. Subsequently they were modified, and new codes of 'acceptability' and 'usability' were created for more clarity and to ensure that the original research questions were being fully addressed. Using NVivo (Version 11) qualitative data analysis software aided the data's initial organisation, ensuring efficiency. To enhance the quality of the analysis process, the initial coding was carried out by two independent researchers. After reading and coding the first few transcripts (*n*=3), the researcher met with her academic supervisor to compare the emerging codes and agree on a final set of codes to apply to the subsequent transcripts. Codes were subsequently grouped into categories. The final version of the coding framework, comprising 14 codes (sub-themes) clustered into six categories (themes), is presented in Table 32.

Table 32. Coding index (Study 2)

Themes and sub-themes
1. Acceptability
1.1 General impressions
1.2 Perceived benefits
1.3 Suitability
2. Usability
2.1 Design and functionality
2.2 Impact on daily practice
3. Adoption
3.1 Enablers to adoption
3.2 Barriers to adoption
4. Implementation
4.1 Implementation strategy
4.2 Technological infrastructure
4.3 Support
5. Maintenance
5.1 Improvements
5.2 Tracking the success
6. Suggestions for improvement
6.1 Practical adaptations
6.2 Aspirational features

In the third stage, indexing, each transcript was systematically applied to the framework using the existing categories and codes. Ritchie and Lewis (2013) recommend generating a matrix or table in which columns are codes and rows represent cases. This matrix was then populated with summarised data drawn systematically from coded interview transcripts. This process was applied to all of the textual data gathered, an example of which is provided in Appendix 47. During charting, the fourth stage, the descriptive summaries of the indexed data were re-arranged and reduced into a chart to create order (presented in Appendix 48). The purpose of this process was that all of the data could be visualised as a whole. It was necessary at this stage to preserve the original meaning of the transcripts. The charts contained headings and subheadings drawn from a priori Form of Delivery framework (described in Chapter 6), which was judged to best report the research findings (Richie & Spencer, 1994).

The last stage, mapping and interpretation of the data, was carried out by comparing cases within the matrix. A schematic diagram was created to guide the finding of connections and explore the relationship between the categories (Appendix 49). This exploration of the developed thematic framework enabled the researcher to better understand the issues being explored. The nature of the research questions did not demand an in-depth conceptual analysis but that it was more descriptive of the key issues. The following section provides the results of that process.

7.6 Results

This section describes the results of the interviews conducted with HCPs and lay participants with reference to the study research questions. The results from the interviews are reported, the suggestions for the intervention adjustments discussed, and the adaptations made are outlined. Lastly, the final version of the DARTT intervention is presented. Table 33 below provides a summary of the key findings, which are described in more detail in the next section. Suggestions for improvement are reported separately in Section 7.6.6.

Table 33. Summary of the key findings (Study 2)

THEME	KEY FINDINGS
Acceptability	• DARTT is acceptable, important, visually appealing and has a clear clinical value. • Broadly applicable to all hospital areas. • Potentially transferable to other settings (e.g., primary care). • Anticipated benefits include improving the quality of prescribing, communication around antibiotic and patient outcomes, increasing patient knowledge of antimicrobial resistance, minimising the NHS costs. • Regular face-to-face feedback and text message reminders not acceptable. • PIMs considered less important by senior doctors.
Usability	• General optimism about the design, functionality and potential effectiveness of the Tracker.

	• The Tracker offers a safety net for prescribing decisions that would fit well into clinical workflow. • Monitoring and auditing of prescribing patterns viewed as key for benchmarking performance. • Visual prompts (e.g., traffic lights system) particularly useful for flagging the antibiotic review. • The simplicity of the Antibiotic 3+3 reminder endorsed.
Adoption	• Adoption dependent on organisation-wide support and securing buy-in from senior decision makers but also strong engagement with front-line staff. • Habits, pre-existing work routines, time constraints, lack of familiarity and resistance to change cited as potential barriers to uptake. • The Webinar and Online Interactive Tool components considered necessary for promotion and raising awareness. • Computer literacy and fear around electronic prescribing perceived as an issue – need to ensure users are sufficiently trained and competent to use the Tracker.
Implementation	• Implementation strategy and a project management team required for successful implementation. • Need to link with local antimicrobial stewardship teams, raise awareness and obtain support from permanent members of staff. • Piloting of the Tracker viewed as key. • The difference in opinions regarding the simultaneous and incremental rollout. • Limitations of the NHS technology and system compatibility potentially problematic during implementation. • Technical support considered critical.
Maintenance	• General optimism about the self-sustainability of DARTT. • Need for progress monitoring and process evaluation (i.e., long-term follow-up). • Continuous and robust collection and analysis of data critical to informing future decisions. • Flexible approach, system re-iterations and keeping in contact with the end-users integral to effective maintenance.

7.6.1 Acceptability

This theme included an exploration of issues related to user comfort with the DARTT intervention to ensure it reaches and benefits the right audience. The general reaction to the intervention was very positive. Collectively, all HCPs endorsed the idea of DARTT and reported that it was important, comprehensive, visually appealing and had a clear clinical value, as the following quote illustrates:

"I think if you've got it really polished and it looks great. What you've produced is very visually appealing. I think your imagery is beautiful, and it's quite impactful, it's simple, it's obviously very thought out." – Tom, Consultant

Lay participants also found the intervention interesting and logical:

"When I first saw it, I thought the package was excellent. It was very logical and easy to follow. You have clearly taken account of all the various people at all the various stages likely to be involved in the monitoring and the administering of antibiotics." – James, Lay Participant

All participants perceived the intervention to be hugely beneficial to clinical practice. When asked about the anticipated benefits, they provided many examples, including improving the quality of prescribing and communication around antibiotics, improving patient outcomes, increasing patient knowledge of antimicrobial resistance and minimising the NHS costs. For example:

"I think the overall goal is hopefully reducing antimicrobial resistance and improving outcomes for patients, but an important secondary gain from that is improving education around prescribing." – Maya, Junior Doctor

There was general optimism about the future application of the intervention. Participants agreed that the timing of DARTT was ideal in the current climate of heightened interest in curtailing antimicrobial resistance.

"I think in the current climate, where antimicrobial resistance is such a pressing issue, the timing of it is really, really good." – Kirstin, Medicines Optimisation Pharmacist

Some senior clinicians were particularly enthusiastic at the prospect of introducing DARTT alongside the hospital electronic prescribing and medicines administration (HEPMA) system, which was recently rolled out across Scotland.

"I think what's really exciting is that it's all happening at the right time because as you probably know, we're about to start going live with HEPMA, here at the front door." – Peter, Consultant Microbiologist

In terms of site suitability, most participants felt that the intervention would be broadly applicable to all hospital settings. They pointed out that having the tool available across all clinical areas would improve continuity of care and prevent administration of unnecessarily prolonged and excessive antibiotic treatments as a result of therapy not being reviewed, especially when patients are moved between different wards.

> *"I think for continuity, it would be better if it was rolled out everywhere so that everyone's aware of it and everyone's using it. It's when patients are moved between wards, that's when these reviews get missed."* – Caroline, ANP

Some doctors suggested that it would be particularly suitable for specific areas within their hospital, such as haematology, where the use of broad-spectrum antibiotics is high and the de-escalation rates low, making it a 'hot spot' for certain infections occurring. Others felt that it would be of most importance in medical and surgical specialities, where gaps in the antibiotic review process exist or in areas where the review does not occur daily.

> *"I think where it would potentially have the most impact is in areas where there's not necessarily the daily review of the Kardex. So, in some non-acute specialities, there might not be a medical ward round every day."* – Daniel, Consultant Microbiologist

Four participants, including all junior doctors and an infection surveillance nurse, believed that DARTT would have the greatest effect in care for the elderly wards:

> *"Where I see it being particularly impactful is in places like care for the elderly wards where patients are presenting with delirium and people are like: 'Oh, maybe it's a UTI, let's give them these antibiotics', but then 10 days later they're still on them, and nothing is improving."* – Maya, Junior Doctor

Three participants commented that the intervention could potentially be suitable for primary care and community settings:

> *"I think potentially it could be expanded into community services. That would be really, really quite beneficial if it was a model that can be used across something wider than just acute services."* – Kirstin, Medicines Optimisation Pharmacist

In terms of the target audience, there was a general consensus that DARTT was applicable to all clinicians irrespective of the level of experience as "even the experienced clinicians don't always get it right". However, participants pointed out that it would be of a particular benefit to less experienced prescribers:

> *"For people who are new to prescribing, the prompts and everything I think is good, and it would give them clarity, and that confidence to then challenge things."* – Hannah, ANP

Some senior clinicians felt that microbiologists and infectious diseases specialists, in particular, would favour the intervention as they would be able to instantly see the decision making trail when junior doctors call them for advice.

> *"So, I can guarantee all the ID consultants will love it, the microbiologists will love it. When juniors phone them for advice, they can instantly see who started what, why, and why it was escalated and what cultures were taken."* – Tom, Consultant Physician

However, there were differences in terms of which intervention components were valued most. All participants liked that all components of DARTT interlinked and complemented one another. They were particularly enthusiastic about the Antibiotic Tracker and praised the idea of creating feedback mechanisms. Some commented that "not to receive any feedback on prescribing is frustrating". They indicated, however, that regular face-to-face feedback on prescribing could be perceived as criticism. There was a perception that if the feedback offered is unsolicited, some prescribers might feel "persecuted". Three participants also raised concerns about providing feedback based on comparative data due to variation of practice across specialities. As one participant highlighted, feedback on performance has to be contextualised:

> *"I think for individual feedback, it has to be contextualized and fairly diplomatic because if it's not done carefully, I think it could be perceived as criticism."* – Wesley, Trainee Doctor

Instead, participants focused on wanting unit or hospital-level feedback that could be discussed in team meetings. Junior doctors and ANPs felt that individual feedback was appropriate as part of the annual assessment or appraisal unless a prescriber is identified as an "outlier". In those instances, "someone who is sufficiently knowledgeable of the treatment", such as a clinical pharmacist or a senior clinician, would be an appropriate person to speak to the prescriber. In contrast, the idea of receiving anonymised feedback via automated emails was welcomed by all.

> *"I like the idea of getting an anonymised email with an overview of what you've done with the following guidelines, even highlighting if there were any concerns in there. It certainly would be handy to know."* – Matthew, Junior Doctor

The proposed monthly individual reports on antibiotic prescribing practice were perceived to be particularly helpful by the ANPs as they could use it as "evidence" for their professional portfolios and re-validation.

> *"As a non-medical prescriber, it's really good because we have to evidence prescribing, so I think it's actually quite useful for us just to put in our portfolios."* – Anna, ANP

Three senior clinicians perceived the patient information materials (PIMs) to be a less important component, an "add-on" or a "standalone element" that was more applicable to primary care. They also perceived little value in using posters. One consultant described "poster blindness", explaining that people unconsciously tend to ignore poster-like information. For others, PIMs were viewed as important and crucial as the Tracker itself, a valuable source of information that would help raise awareness of resistance and reinforce positive messages. As one senior doctor suggested:

> *"I like that you advocate patient engagement. You know, often they want to ask somebody, but they're not quite sure what to ask, and if they've got a script that they can ask from, it fits nicely into that kind of health literacy piece."* – Robert, Consultant Physician

Another participant emphasised the significance of involving patients in health interventions and described the new generation of patients who want to actively participate in decisions about their health:

> *"That traditional patient is like: 'The doctor's prescribed it, so I'll just take it.' We're not seeing that as much anymore. We are seeing that new generation of patients coming through and saying: 'Why am I getting that?' So having them involved and giving that bit of ownership to them as well is fantastic."* – Hannah, ANP

Lay participants also endorsed the idea of PIMs:

> *"I do think that the patient leaflet side of it is almost as important as the Tracker, and it would take a lot less effort, but it's completely worth doing."* – Sophie, Lay Participant

However, they expressed some concern regarding the It's Okay to Ask patient poster by noting that with rising expectations comes a certain responsibility. There was consensus that not being able to answer patients' or their families' questions may have negative consequences and cause unnecessary distress.

> *"I think it's very important that if you raise awareness and then people don't get an answer to what they've been alerted to, that can cause more concern than not knowing, particularly if they're already distressed, so you have to ensure that that expectation is met."* – James, Lay Participant

There were also a few misgivings about the use of text messaging for sending antibiotic review reminders to clinicians. Most felt that text reminders would be "too intrusive" or even "annoying", especially when the prescriber is not on shift. Other disadvantages of using text alerts included "reminder fatigue", meaning that many reminders are ignored. Some described it as "not the most reliable method". However, one senior clinician disagreed with that view, saying that only personalised messages have an impact on practice:

> *"Although I'm very sceptical about posters, emails and banners being a good solution, I think personalised communication is much more likely to be useful."* – Miles, ID Consultant

Although the Webinar and Interactive Online Component tool were generally seen as acceptable, the proposed communication strategies received a mixed response. Some participants were sceptical about the use of email notifications and reminders. There was a perception that, due to the sheer volume of emails that busy clinicians receive every day, unless antimicrobial stewardship is an important issue for them "they will just delete it". Using NHS Intranet banners was suggested as an alternative solution.

7.6.2 Usability

All participants endorsed the potential effectiveness of the Antibiotic Review Tracker and discussed the perceived functionality of the decision support tool in the context of hospital prescribing. For example:

> *"I guess the first thing that strikes me is how useful the functionality is because there's nothing like this in use at the moment."* – Daniel, Consultant Microbiologist

Lay participants also found the proposed functionality of the Tracker reassuring:

> *"From a patient's perspective, for me to know that all of my separate clinicians are able to access that one single review tracker and communicate from the same thing, it's really reassuring."* – Veronica, Lay Participant

The majority of participants liked the Tracker's proposed online set-up and its user-friendly interface, including a number of functions such as a standardised algorithm for tracking decisions and integrated links for accessing antibiotics guidelines. Being able to audit prescribing patterns and track non-adherence to guidelines was reported as helpful for benchmarking performance:

> *"I think getting data as a unit would be really helpful. I don't need to know who consultant X or consultant Y is, but actually seeing that there's a real outlier and somebody who's prescribing a huge amount of antibiotics or prolonging courses, then it can be really helpful."* – Tom, Consultant Physician

They also found the visual prompts built into the Tracker particularly useful, more specifically, the traffic lights system for identifying, flagging up and alerting users when an antibiotic is due for a review.

> *"That's such a kind of clear prompt that people understand really easily, and that's way easier to get a message across just with a change in colour."* – Caroline, ANP

Some participants described DARTT as a mechanism which fosters communication and discussion on prescribing practice. For instance, the pharmacists acknowledged that it is often challenging to have conversations about unnecessary antibiotics during clinical encounters. They said that having an external tool such as DARTT would encourage open communication about treatments and reduce the risk of confrontation during these difficult discussions:

> *"Having something external that could red-flag antibiotics for review would mean that everybody feels entitled to query it. I would feel like it's appropriate for me to query it with a doctor, or a nurse could do it as well."* – Alex, Clinical Pharmacist

The Tracker was seen as a helpful tool for improving the continuation of care. "Keeping everything in one place" assumed high prominence. The senior clinicians in particular praised the possibility of auditing and monitoring the prescribing trends and patterns of individual clinicians, and also compliance with the guidelines within specialities. As one microbiologist commented:

> *"Auditing individual prescribing trends and compliance within specialities has been something that we've tried to do for years, but this sounds much more focused and easier to do."* – Daniel, Consultant Microbiologist

Other practical features of the Tracker included its computer default status. There was recognition that the inbuilt proforma would guide HCPs and steer them onto making guideline-concordant decisions.

> *"It's that concept of making it easier to do the right thing, creating things like defaults in there and steering people in that path*." – Robert, Consultant

Others described it as "a safety net" for stopping antibiotics:

> *"We often just have to stop antibiotics overnight, but it feels unsafe at times as you're doing it with minimal information, whereas the Tracker would just give you so much more so that you can actually say it's okay not to prescribe as well. That stands out as almost a safety net to say that I'm not prescribing and I'm going as per guideline."* – Hannah, ANP

Most HCPs viewed the function which would allow them to generate a list of patients who are due for review as especially useful:

> *"Having a list for everyone to see would be ideal. That's exactly what is needed in the context of patient safety."* – Jane, Lead Pharmacist

The clinical value of the intervention was reported as crucial. Senior clinicians in particular felt that any new intervention should provide a specific benefit for them in their daily practice. They commented that use of the Tracker would fit well into the workflow. Most participants believed that DARTT would not make additional work, but rather it would support current clinical practice and their usual daily activities by guiding specific prescribing actions. However, one senior doctor said that the Tracker was "complicated" and there were too many data fields, which some clinicians may find "burdensome".

> *"I just I'm worried about the complexity of it, missing out on the really key things are that would actually change how we use antimicrobial stewardship, how we use antimicrobials. I think it has to be simpler."* – Miles, ID Consultant

Additionally, the Antibiotic 3+3 reminder was described as simple. However, this was not perceived negatively – rather, the simplicity of it was held to be effective. Participants reported that in a busy hospital environment, only messages that are short and snappy would "stick" and spread quickly to other areas:

> *"I like the fact that it falls along with the Sepsis 6 sort of thinking, it's nice, simple, and I think it'll stick. We've got the 3 plus 3 – what, why, how long and review after 3 days. I love the simplicity of that. And again, that's a huge thing for any intervention."* – Robert, Consultant

One infection surveillance nurse felt that the Antibiotic 3+3 might potentially help with involving nurses in antibiotic review:

> *"I would really like to see more nurse involvement, and I think that the 3 plus 3 thing will help with that quite a bit."* – Mary, Infection Surveillance Nurse

7.6.3 Adoption

Another important theme was the adoption of the intervention, specifically the enablers and barriers related to a decision to take up DARTT. The issues discussed were strongly related to engagement, including gathering support and persuading decision makers.

> *"Don't just put it out there and expect it to be taken up because it won't be. It needs to be engaged with and sold basically."* – Mary, Infection Surveillance Nurse

Participants felt that securing high-level support and buy-in from key stakeholders was key to endorsement:

> *"I think you'll need executive involvement to promote it. If you had the medical director, director of nursing and director of pharmacy all saying: we support this, I think people are much more likely to get on and use it because there isn't really anyone higher than that for them to complaint to."* – Daniel, Consultant Microbiologist

However, ensuring a top-down and bottom-up approach, including engagement from staff "on the floor", was seen as equally important:

> *"It has to be both, engagement from the top down who are at the higher level in management and are very strategic and from people on the floor, like, the junior doctors and the nurses who are actually physically there because you can't succeed without it."* – Tom, Consultant Physician

Lay participants also highlighted the importance of patient and public involvement to help endorse the value of the intervention.

> *"Engage some of the patients as well because that obviously helps endorse the value of the whole project."* – James, Lay Participant

Some believed that the adoption of DARTT should not be a problem as it was "pushing against open doors" due to high awareness of antimicrobial resistance. Others acknowledged that ingrained behaviours, such as habits and resistance to change, may pose a challenge to effectiveness. Here, participants spoke about the hospital's social structures and how they could shape the ways things are done. Prioritisation of other tasks and habitual practice or the "old ways of doing things" were cited as obstacles. The anticipated resistance was strongly linked to pre-existing work routines, time constraints or lack of familiarity.

> *"I think there's always early adopters and late adopters and people that will be resistant, to begin with, until they're more familiar with it and don't feel threatened by it."* – Daniel, Consultant Microbiologist

That resistance was also linked to the complex social dynamics within each department.

> *"Every department is so different and has different dynamics, and sometimes there are engaged individuals who pull along the rest of their colleagues and sometimes the door is so shut."* – Miles, ID Consultant

To overcome these barriers, participants talked about the benefits of "opening up conversations within a department" and promoting "visibility" of DARTT across the hospital. They suggested various strategies to ensure effective adoption, including awareness-raising sessions to communicate the vision and invite feedback, and advertising using posters and the NHS Intranet to create recognition. It was highlighted that this work should therefore begin as early as possible in the process. Some suggested presenting DARTT at team meetings, grand rounds and advance practice forums.

> *"If there are things like hospital-wide grand rounds or the advanced practice forums, it can be quite useful to present things on that level so that people aren't completely confused when something's being added to their department."* – Maya, Junior Doctor

Insufficient or ineffective communication about the intervention was perceived as a factor that could potentially hamper adoption. The Webinar was reported as beneficial for "setting the scene" and promoting uptake.

> *"The Webinar about raising awareness, you know, absolutely crucial and trying to get that mandated would be a great first step to make sure everybody was aware of this."* – Jane, Lead Pharmacist

Lay participants were of the same opinion:

> *"You can't really carry on with something if people don't know why they are doing it. I think the Webinar, where you are getting it out to members of staff during a staff meeting to explain the process would be useful."* – Veronica, Lay Participant

However, competing priorities within the NHS were cited as potential obstacles to the promotion of DARTT.

> *"I would say communication and dissemination of information are going to be one of your massive hurdles. In such a large organisation with so many competing priorities, we continue to push the importance of antimicrobial resistance higher up the agenda, but it's really, really tough."* – Miles, ID Consultant

Other barriers identified included a lack of technical knowledge and competence. Anticipated lack of uptake was associated with computer literacy and a general fear around electronic prescribing. As exemplified by the following quote, there was a perception that some HCPs are not comfortable with using IT systems and find it difficult to navigate online:

> "*There's a massive fear around electronic prescribing. I certainly work with a lot of practitioners who have IT issues, shall we say, who find it really difficult to navigate online and on TRAK, and I think unfortunately that's probably an issue that needs to be dealt with before."* – Hannah, ANP

To increase DARTT uptake, the vast majority of participants, including lay people, agreed that training for users who will interact with the Tracker was essential. The Interactive Online Tool was reported as being helpful in providing a skill set to use the Tracker and "help people get on board with it".

> *"I think the e-learning component is a really good idea because we're constantly given new tools or TRAK changes, and we get no training on it. You come in, and something's changed, and you just have to kind of find your way around it and hope for the best."* – Wesley, Trainee Doctor

However, two participants reasoned that for user-friendly and intuitive interventions, training is not necessary. For instance:

> *"Have you read the iPhone manual? There isn't one. So why, when we produce electronic systems, do we always try and write a manual to go with them? The system should be intuitive, and the idea should be to get rid of any manual training for the system."* – Robert, Consultant

There was a consensus that online training should be made mandatory, and most participants felt that it should be incorporated into LearnPro, an on-line learning platform for the NHS, which hosts a range of compulsory modules.

"I think the way to do it is having it through the kind of standard LearnPro stuff. I think if you were to say, well, you can volunteer for this e-learning, you might find that a lot of people won't do it." – Matthew, Junior Doctor

Many participants liked the idea of being able to complete the training at home, away from the busy hospital environment. Receiving a CPD certificate upon completion was received particularly well by ANPs:

"I really like the CPD certificate. As an ANP, trying to get things for our portfolios is so difficult. We have to demonstrate that we're learning our prescribing, so to have that in there would be fantastic." – Anna, ANP

Aspects of the Tracker itself were found to be central in the process of adoption. Participants reflected on the existence of other interventions trialled within their Health Boards with good evidence of efficacy. Testing the intervention was seen as central in the adoption phase to ensure that it is "simple" and "as user-friendly and straightforward as possible". Participants emphasised the importance of exploring workarounds that prescribers may employ to get around perceived difficulties in the system.

"The Tracker has to be straightforward and simple to use and as least clunky as possible. If people can find a workaround that they perceive is quicker, they will do it." – Tom, Consultant Physician

One senior doctor pointed out that "junior doctors tend to vote with their feet", meaning that if the tool is not user-friendly or adds unnecessary or burdensome steps, HCPs will stop using it. Therefore, the Tracker has to be integrated so that it is not onerous or adding additional difficulties to the prescriber at the point of use.

"It's like your smartphone. If the screen is cluttered with too many things, you're less likely to respond to all of them, whereas if it's much simpler, just a few prompts, people are more likely to engage with it." – Peter, Consultant Microbiologist

7.6.4 Implementation

Developing an implementation strategy was reported as essential to putting the intervention into operation. Participants spoke about the importance of ensuring a project management team is in place to map and coordinate future work processes.

They reported that a range of HCPs needs to be actively involved in the process, including doctors and nurses. Linking it into antimicrobial stewardship teams in the hospital environment was also seen as key. Engaging clinicians who are enthusiastic and respected and who could provide leadership featured highly in interviews.

> *"Have a core team of enthusiastic people so they could mention things to the antimicrobial team, support it and drive it forward. If you've got them on board, then they could kind of spread it out."* – Alex, Clinical Pharmacist

Seven participants felt that DARTT should be implemented simultaneously throughout the whole hospital. Others talked about the need to pilot the Tracker, phasing it in "on a small scale first" in a limited number of wards/speciality areas (e.g., critical care, infectious diseases, general medical wards) and then rolling out throughout the hospital incrementally was reported as advantageous.

> *"Roll it out incrementally in appropriate wards, maybe in even more than one Health Board. Once you've got your proof of concept, it could be rolled out on a wider scale."* – Jane, Lead Pharmacist

Piloting DARTT in fast-paced areas was preferred to minimise any issues and facilitate diffusion of knowledge of the system.

> *"Start at the front door, sort out the glitches and get more junior doctors using it in a small area because lots of them come in and go out and work elsewhere, and then they take their knowledge of using it to another area. And that's great for spreading stuff."* – Tom, Consultant Physician

Initial support from permanent members of staff to propagate the intervention was mentioned by most as key to effective implementation.

> *"I think it would be quite important to get permanent members of the staff on board and have them sort of championing it in the local departments...so, I suppose, ANPs and consultants will come into that."* – Kirstin, Medicines Optimisation Pharmacist

Some participants identified barriers to implementing DARTT within the contexts in which they worked. The safety of technological infrastructure and system compatibility was mentioned as a potential issue.

> *"A lot of thought has to be put into the safety of it. Having information moved from one system to another system requires lots of harmonisation. I think it could only work if it's integrated and coded into current practice."* – Miles, ID Consultant

There were some concerns regarding the required information technology within the NHS (e.g., software, hardware and wireless infrastructure) to support implementation of the Tracker. Some pointed out the deficiencies of current IT operating systems, such as obsolete technology and outdated or inefficient software and hardware, which is not fit for purpose. For example:

> *"Tech will be the biggest stumbling block just because IT in the NHS, in general, is really difficult, and it doesn't work for what you need. The computer in my office is 20 years old! The problem is also Wi-Fi here. We have upload speeds of like one."* – Mary, Infection Surveillance Nurse

As illustrated by the quote, some questioned the configuration with existing prescribing charts (e.g., paper-based Kardex) and felt that the Tracker could only be implemented in areas where electronic prescribing was already in use:

> *"The difficulty here [Scottish hospital] we would have, I think, we don't have electronic prescribing yet, but I think it is certainly on the horizon, and you get the feeling that it needs to be key before this could be implemented."* – Matthew, Junior Doctor

Lay participants cited a lack of sufficient technical support for staff during the implementation phase as a potential barrier. They identified the availability of staff with the appropriate skill sets as facilitators to implementation.

> *"For me personally, I would like a named person to be able to get further information from, so if I'm sitting going through the Tracker and I come across something I'm not sure about, I would like someone to call for advice to say: 'What is this about? How do I deal with this?' "* – Veronica, Lay Participant

Some participants suggested identifying HCPs who would support the intervention and provide expertise during implementation and beyond. The staff identified as best suited for that role were junior doctors or ANPs. It was suggested that having a designated person to "champion" DARTT would facilitate disseminating it to a broader audience.

7.6.5 Maintenance

One of the key topics explored was the maintenance of the intervention. Participants discussed their confidence in the self-sustainability of DARTT due to AMR being a high-profile public health issue.

> *"I think as long as we've got AMR issues which we have, and it's so high profile, I think that's going to keep it at the forefront of everybody's mind."* – Kirstin, Medicines, Optimisation Pharmacist

Another participant commented:

> *"I don't think you need to worry about sustainability because you've got a good product, and it's got a clinical value."* – Tom, Consultant Physician

However, lay participants pointed out that the sustainability of the intervention would depend on its practicality.

> *"In terms of sustainability, I guess it will depend on the use of the data, I would think, so if people on the wards are finding it useful, they're going to keep using it."* – Sophie, Lay Participant

Central to the maintenance of DARTT was progress monitoring to track the intervention's successes and identify any issues. There was recognition that process evaluation would be essential to assess whether the anticipated benefits were being achieved. Follow-up, and continually exploring and addressing unintended consequences and system errors, were also identified as necessary. Some participants suggested a range of techniques, such as data quality monitoring and clinical audits.

> *"I guess you have to audit it after a period of time to see if it's making a difference and see if there is a clinical benefit because if it's about patient safety and the patient's outcomes are better, then you have to prove that that's making a difference."* – Caroline, ANP

However, senior clinicians pointed out that the current lack of routine prescribing data may hinder efforts to measure outcomes at the outset.

> *"The outcomes will be hard to capture because nobody's actually measuring it pre-intervention, so you're not going to be able to quantify the benefit."* – Tom, Consultant Physician

Maintaining a certain degree of flexibility to "ease out the glitches" was reported as essential in the context of sustaining the long-term effects of DARTT. Integral to this process were system iterations, including software upgrades and functionality improvements. Participants highlighted that responding to end-user feedback was essential to ensure further buy-in and dissemination of innovative ideas.

> *"Once people start to use it, get feedback from them on the benefits that you could then share with others, and if something is not right, you need to be open to the fact that you are going to review and change it based on feedback."* – Jane, Lead Pharmacist

Finally, participants noted the benefits of ensuring ongoing support and regular meetings with staff, believing these efforts would keep the intervention on track. Keeping in contact with end-users, as well as providing hospital managers and other staff with regular up-to-date information, emerged as key.

> *"I think it would be good to present some data at team meetings, maybe compare performance to other Health Boards or hospitals, just to keep it fresh and keep the benefits alive."* – Alex, Clinical Pharmacist

7.6.6 Suggestions for improvement

Participants were asked to suggest any enhancements that they considered important. They identified many aspects of DARTT that would benefit from refinements, either directly or by inference. Among these key suggestions were the intervention content, design and functionality. These have been grouped into practical and aspirational adaptations. Among the practical suggestions was the need to ensure that the Tracker interface is intuitive and user-friendly and that the design fits well into the clinical workflow. Participants also suggested reducing the length of time of the Webinar and providing two versions (e.g., pre-recorded and live) to incorporate the short version into team meetings.

> *"I think the commitment of time is probably quite an important one in this day. So maybe having two versions, a shorter and a longer one would probably work better."* – Kirstin, Medicine Optimisation Pharmacist

Other suggestions included minimising the number of data fields on the Tracker.

> *"There are too many data fields, and I'm not sure if having all of those questions, you know if the impact of doing that is sufficiently high for it to be worthwhile."* – Miles, ID Consultant

Due to the challenges in delivering training to large numbers of staff, the need for easy access and minimal training were highlighted as essential requirements. Mandatory training that covers the critical aspects of how HCPs may need to interact with a system was perceived as crucial. Healthcare professionals favoured web-based style approaches such as a video including a 'run through' demonstration of DARTT and practical or 'hands-on' exercises as the preferred format to receive training and familiarise themselves with the system.

> *"I recently did my online HEPMA training, and I actually found that online video training really quite helpful and useful, just actually seeing the functionality."* – Tom, Consultant Physician

Another practical suggestion was the need to change the terminology from 'broad-spectrum' to 'access, watch, reserve', in keeping with the World Health Organization's AWARE classification of antibiotics.

> *"I would probably prefer to not use broad-spectrum but change terminology to think more Access, Watch, Reserve. PHE [Public Health England] standardised it, and we've adopted it in Scotland."* – Jane, Lead Pharmacist

Participants also recommended providing a project development opportunity to the junior prescribers to 'champion' the intervention. They highlighted the need to create clinical link roles to prompt review and provide feedback. Infection prevention nurses and antimicrobial pharmacists were perceived as best suited for these roles.

> *"I would say that that is potentially a role for an antimicrobial pharmacist or a nurse, who can actually go along and be that clinical link person."* – Wesley, Trainee Doctor

It was also suggested that more focus should be placed on creating support tools and mechanisms, such as help boxes within the Tracker, as well as online manuals and flow charts. Lay participants emphasised the need to ensure the availability of technical assistance throughout the implementation phase and beyond.

> *"If you are on one ward and you've got a designated person per ward, an online interactive tool guru who maybe filters it down to everybody else in their specific area, and they become a go-to for that."* – Veronica, Lay Participant

Enhancing the visibility of the Antibiotic 3+3 logo (e.g., using stickers in patients' notes and providing posters at bed spaces) was viewed as helpful to promoting the visibility of DARTT but also to opening a conversation around antibiotics:

> *"That information needs to be immediately available at the patient bedside so that everybody can see it. My antibiotic should be reviewed on the 7th of January. Is anyone looking at that?"* – Robert, Consultant

Most of the other practical improvements related to the clinical decision support included the need to minimise spurious alerts, which should be prioritised by clinical importance, ensuring instant access to the antibiotic prescribing guideline (MicroGuide), and offering guidance on recommended therapeutic options for the condition being treated. Creating authorisation codes for restricted antibiotics was also seen as important.

> *"So, we know in Fife, the antibiotics are locked down to a much greater degree, and you need an authorisation code by the on-call microbiologist to prescribe something."* – Jane, Lead Pharmacist

The 'aspirational' adaptations identified included many desired software features and interface requirements, such as creating individualised dashboards, applying the algorithm to the patient's clinical data to generate an action, creating pop-up windows for microbiology results and outstanding action reminders.

> *"And then maybe a pop-up reminder that you've got that outstanding action or a message from micro, so you have to do something about it."* – Peter, Microbiology Consultant

Other suggested enhancements included allowing users to review prior activities, creating default options, and embedding an online calculator.

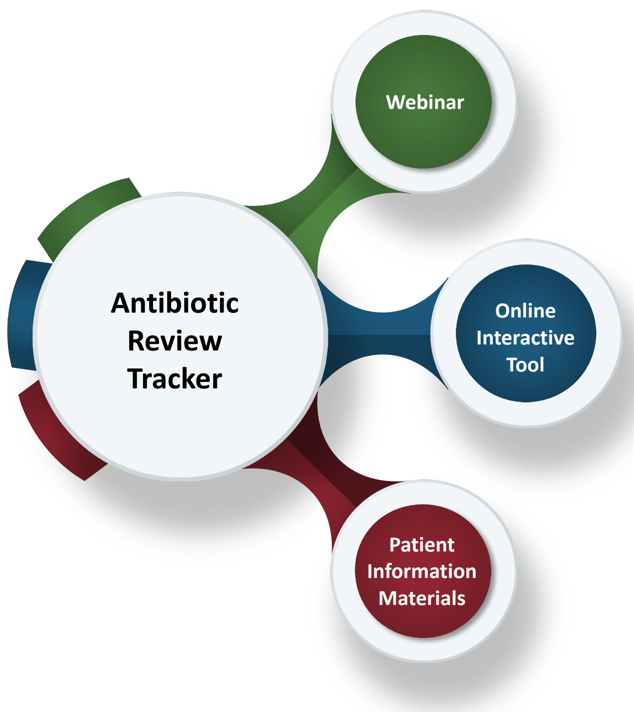
> *"Could you have a calculator on another tab for things like Vancomycin and Gentamicin? You can then click on it and if it's easier to input it and calculate it on the Tracker."* – Mary, Infection Surveillance Nurse

All these suggestions were considered in the optimisation of DARTT, and the changes made are described in the following section.

7.7 Optimised version of DARTT

Although the intervention was initially depicted in a linear manner, the interviews revealed that the Tracker was perceived as the key component, whilst the Webinar, Online Interactive Tool and PIMs were seen as complementary elements (Figure 30). This finding is important as the proposed components target different behavioural deficits (outlined in detail in Chapter 5).

Figure 30. Perceived importance of the DARTT components



Using participants' suggestions as outlined in section 7.6.6, the prototype version of DARTT was subsequently optimised. The recommendations were evaluated in relation to the theory generated in the preceding chapters, ensuring that the proposed adaptations aligned with the key behavioural deficits identified (Chapter 5, Section 5.4.4). For example, the improvement suggestion related to Component 4 (PIMs), to create the option to print out personalised patient information about the antibiotics they have been prescribed, did not link to the mechanism of action or any of the behaviour change techniques discussed. The use of personalised leaflets is common in primary care, also following specific procedures in secondary care. However, it was judged impractical in a busy hospital setting and it was decided that it may cause unintended consequences for patients, such as information overload. This suggestion was subsequently excluded from the list of adaptations made.

Based on the feedback gathered, some adjustments were made, a description of which is provided in Table 34. It is suggested that this version of DARTT is most suitable for use in hospital settings. Future acceptability and feasibility considerations have been reported using a priori Form of Delivery framework (Dombrowski et al., 2016) (see Appendix 48).

Table 34. Description of refinements made

Component 1: Webinar	
Intervention features	**Adaptations made**
Duration	Ensure the Webinar is short (e.g., 20 min) and integrate it into staff meetings.
Flexibility	Provide two versions of the Webinar: pre-recorded and live.
Component 2: Online Interactive Tool	
Intervention features	**Adaptations made**
Accessibility	Ensure HCPs can access online training from home.
Format	The training needs to be mandatory to ensure completion.
	Embed training into induction packages and continuous professional education.
Content	Create a short video as part of the training.

	Ensure the training provides an opportunity to use the Tracker.
Component 3: Antibiotic Review Tracker	
Intervention element	**Adaptations made**
Accessibility	Provide tablets to improve access.
Language	Change terminology from broad-spectrum to AWaRe classification of antibiotics.
Format	Enhance the visibility of the Antibiotic 3+3 logo (e.g., use stickers in patients' notes, Drug Kardex, antibiotic prescription pages, and electronically on TRAK system). Poster to be available at bed spaces.
Design	Create individual dashboards with a menu of outstanding actions.
	Minimise frequent/spurious alerts and ensure they are prioritised by clinical importance.
	Create microbiology recommendations/outstanding action reminders and allow them to override the system.
	Allow import of microbiology results or create a pop-up window with the summary of results.
	Ensure all required data fields are mandatory (e.g., indication, stop dates). If the source is unknown, provide a free text box.
	Create a log of the user's last activity.
	Create an antibiotic review icon on the bed plan.
Functionality	Allow users to review prior activities.
	Build in an online calculator.
	The system applies the algorithm to the patient's clinical data to generate an output or action, which is then presented to the prescriber.
	Create instant access to the MicroGuide and offer the prescriber information on recommended therapeutic options for treating specific conditions (e.g., drug strength, form and dosage).
	Create default options that automatically disable the 3-day reminder (e.g., Erythromycin for gut-motility or surgical prophylaxis).
	Minimise the number of mandatory data fields to complete a review.
	Create an authorisation code for restricted antibiotics.
	Option to audit frequency of prescriptions made without any sampling.

Clinical roles	Create a clinical link role to prompt review (e.g., Band 6 or 7 or infection prevention nurse) and provide feedback (e.g., antimicrobial pharmacist or nurse).
Support	Create an online manual and Tracker support tools (e.g., inbuild help boxes) for users.
	Provide a flow chart.
	Ensure users have access to technical support.
Incentives	Introduce an element of competition between wards.
	Send individual emails highlighting good practice
	Create 'AMR champion' roles or offer the role as a development project.
	Frame DARTT as part of the patient safety initiative.
Component 4: Patient Information Materials	
Format	Creating the option to print out personalised patient information about the antibiotics (excluded).

7.8 Discussion

The purpose of this study was to explore intervention acceptability and to refine its content. Overall, the proposed intervention was well-received by participants despite variations in age, gender, experience and speciality. They considered DARTT to be acceptable, important, visually appealing and to have a clear clinical value. Most found it broadly applicable to all hospital areas, and some suggested that it could be transferred to other settings, such as primary care. This is in keeping with the recent guidance built on published evidence, which widely advocates transitioning to e-prescribing systems as soon as the infrastructure is in place to support prescribers in the safer use of medicines (Royal College of Physicians, 2017). The interviews also provided significant insights into the anticipated benefits of DARTT, including reduction of inappropriate antibiotic prescribing and improvement of patient outcomes, which are part of the UK's national action plan to tackle AMR (Department of Health, 2019).

Creating feedback mechanisms were well-received by all participants. There has been growing interest in the literature regarding the use of social norm feedback as a promising strategy for adjusting behaviour towards the social norm (Tonkin-Crine et al., 2015). However, most participants, particularly less experienced prescribers, disliked the idea of receiving individualised feedback on a regular basis, highlighting that such encounters could be perceived as social disapproval. This finding strongly relates to the results of the meta-ethnography (Chapter 3), which found that junior doctors fear confrontation and punitive responses from senior colleagues. This preference needs to be considered carefully in future interventions as there is robust evidence suggesting that face-to-face verbal feedback may result in a moderate to a large improvement in HCPs' performance (Johnson et al., 2020).

An important aspect to consider is the approach taken to influencing prescribing practice behaviours. More specifically, rather than highlighting errors and deficits through negative feedback, overlooking the opportunity to learn, future interventions need to focus on ensuring the provision of positive feedback (e.g., through excellence reporting) as a potentially effective stimulus for learning and improved motivation (Jones et al., 2019). Central to participants' concerns was that feedback should be provided by someone experienced who they respect, such as a clinical supervisor or a pharmacist. An intuitive argument can be made that most people prefer to receive feedback from people they value (Hardavella et al., 2017).

In terms of the proposed DARTT components, participants' views were broadly similar except for the perceived importance of the patient information materials. Whilst health service users found them essential, some senior clinicians believed that they were less relevant despite the wealth of evidence suggesting their effectiveness in reducing inappropriate prescribing (De Bont et al., 2015; Ashiru-Oredope et al., 2020). The meta-ethnography (Chapter 3) has found that antibiotics continue to be prescribed for longer than is clinically necessary, leading to an increase in hospital length of stay and placing patients at risk. This is partially due to the emerging consumerism culture and patient expectations of receiving antibiotics. Although more evident in primary care, patient expectations of being prescribed antibiotics due to lack of understanding of their use are also key modifiable factors influencing hospital practice (Broom et al., 2016a; May et al., 2014). Addressing these factors, particularly increasing patient knowledge and understanding of AMR, is crucial in future antibiotic interventions (Rawson et al., 2018). Placing importance on shared decision making is also in line with the UK Health and Social Care Delivery Plan (Scottish Government, 2016).

Moreover, all participants endorsed the design, functionality and anticipated effectiveness of the Antibiotic Tracker. A user-friendly interface was considered an essential requirement. Poorly designed IT systems have been shown to create cognitive overload (Zahabi et al., 2015) and disrupt clinical practice (Hayward et al., 2013). Visual prompts (e.g., traffic lights system), the Tracker's key feature, were found particularly useful for flagging the antibiotic review, and participants endorsed the simplicity of the Antibiotic 3+3 reminder. The existing literature advocates using short, clear and memorable messages to aid familiarity and effective assimilation of information (Heath & Heath, 2008). However, central to the effectiveness of the prompts in changing behaviour was ensuring that they do not cause 'reminder fatigue'. The literature shows that the risk of ignoring or overriding important reminders rises with the amount of less relevant alerts (Moxey et al., 2010). Minimising spurious alerts and ensuring they are prioritised by clinical importance was considered in the optimisation of DARTT.

The study's findings show that both organisation-wide top-down (e.g., securing buy-in from senior decision makers) and collaborative bottom-up (e.g., strong engagement with frontline staff) approaches are equally important in adoption of the intervention. However, greater nursing engagement was seen as an important driver to successful change. The number of non-medical prescribers is steadily increasing worldwide and there is growing recognition of the need for active professional involvement from nurses within antimicrobial optimisation efforts (Maier, 2019; Manning et al., 2016). Moreover, evidence shows that inadequate engagement contributes to the unsuccessful uptake of projects within the NHS (De Silva, 2015). This is in keeping with the study findings, which show that harnessing key stakeholder engagement is essential in the process of uptake of a digital intervention through promotion and awareness-raising (e.g., during staff meetings, grand rounds and advance practice forums), fostering a sense of local staff ownership, and increasing support from top management.

The issue of computer literacy and fear around electronic prescribing came to the fore in the interviews. Participants discussed the need to ensure that users are sufficiently trained and competent to use the Tracker. Mandatory online training incorporated into the LearnPro, which is an online recording and assessment system for NHS users, was considered essential in providing the required skill set. Although little evidence exists on the effective strategies used to train healthcare staff on using e-prescribing systems (Brown et al., 2017), web-based training strategies utilised in medical and nursing education have been found to be effective and offer a convenient and efficient way of training large numbers of staff (Douma et al., 2017; Voutilainen et al., 2017). In addition, as IT systems may be utilised in ways unintended by developers, either to overcome design or technical difficulties (Brown et al., 2017), participants emphasised the need to eliminate any system workarounds that users may employ. This prioritisation was considered in optimising DARTT.

Considering the future implementation and sustainability of health interventions have been acknowledged as crucial in intervention development literature (Craig et al., 2008; Erwin & Krishnan, 2016). Designing a robust implementation strategy and putting a project management team in place to map and coordinate future work processes were found in this study to be key priorities to successful implementation. This finding is consistent with the practical recommendations included in the toolkit developed to support and promote the implementation of e-prescribing systems (Cresswell et al., 2014).

Moreover, as Kellermann and Jones (2013) argue, the approach used to implement technological interventions in healthcare is as important to achieving anticipated benefits as its features and functions. This study showed that piloting the Tracker in fast-paced areas to eliminate any potential issues was considered essential to that process. However, opinions differed regarding the simultaneous (the whole hospital goes live at once) and incremental (phasing in a limited number of wards) rollout of DARTT. Despite a dearth of evidence evaluating the effects of these approaches on patient outcomes, the suggested phased, pilot-based approach is in line with recommendations and best practice as it allows an opportunity to build momentum, engage with experts and carry out system iterations based on emerging issues (Health Information and Quality Authority, 2018).

A systematic review has shown that digital health interventions have proved challenging to implement due to various factors, including system interoperability, lack of fit with existing systems, disruption caused to interactions between health professionals, and poor implementation planning (Ross et al., 2016). These findings are in line with this study which found that deficiencies in the NHS technological infrastructure and system compatibility may be problematic during the implementation phase and impede the quality of prescribing and clinical workflow. One of the suggested approaches to address the challenges identified included a continued training and technical support provision. Similarly, a recent study describing the development of a digital self-management intervention for people with Type 2 diabetes found that training and education was a key success factor in its implementation (Ross et al., 2018).

Finally, the implementation literature has increasingly recognised the importance of ongoing monitoring, evaluation, and systems adaptation to ensure anticipated benefits are realised (Ross et al., 2018). Although there was general optimism about the self-sustainability of DARTT, participants in the study indicated the need for progress monitoring and process evaluation for the success of the intervention. Evidence shows that fully functioning technology can increase productivity, improve patient care and transform the working lives of NHS staff (British Medical Association, 2019). However, if end-user improvement requests are not actively addressed, the value of the system is not likely to be achieved (Cresswell et al., 2017). Jeffries et al. (2017) further explain that the success or failure of new IT systems is strongly linked to the adaptations of systems to fit existing work practices and reduce workload. The key strategies identified in this study to ensure the sustainability of DARTT were a long-term follow-up (e.g., using data quality monitoring and clinical audits) and system reiterations (such as software upgrades and functionality improvements) based on end-user feedback. In addition, detecting unintended consequences and system errors that could not be observed in the initial testing is in keeping with the MRC guidance.

7.9 Strengths and limitations

A key strength of this study is the steps taken to maximise its trustworthiness. Firstly, the researcher made sure that she had the required knowledge and research skills to interview participants. Secondly, study transferability was increased by using purposive sampling to capture a range of opinions and experiences related to the phenomenon of interest (Lincoln & Guba, 1985). The researcher recruited a wide range of participants from various specialities and from across several NHS Boards. A relatively large sample of 18 participants allowed data saturation, whilst including different groups of HCPs in the study ensured that a greater diversity of feedback was gathered, increasing the transferability of the findings. Moreover, involving both HCPs and health service users in refining the intervention's content is anticipated to increase the likelihood of DARTT being acceptable and effective.

Another strength was the use of the RE-AIM Framework for guiding the interviews and supporting the planning process. Although themes were allowed to emerge inductively during data analysis, the framework provided a systematic approach for considering critical aspects of the intervention planning that can improve its sustainable adoption and implementation. The use of open-ended questions increased the opportunity for participants to share their points of view and gain a richer understanding of the topics discussed. Objective and comprehensive recording of data, and findings representative of the data gathered and evidenced by including direct quotations from participants, provided a means of ensuring that the findings are repeatable. To increase coherence and achieve a high degree of clarity, the data interpretation was checked for accuracy by the academic supervisors. Where there was ambiguity, further discussion of the concepts resulted in consensus. Disconfirming evidence was also checked to identify refutational findings and ensure that developed themes resulted from the data. Additionally, a detailed description of the data collection and analysis process was provided to ensure replicability.

A potential limitation of the study may be that the sample did not include any junior nurses. Junior nurses do not currently have prescribing privileges in the UK. Therefore, there is a likelihood that the opinions of this group of HCPs may not have been representative of others due to limited experience of working in healthcare. This factor may have also impacted this staff group's interest in taking part in the study. On the other hand, it could be argued that a contribution from junior nurses would perhaps have strengthened the results by providing divergent views on the topic.

Participation in this study was voluntary and therefore the sample may represent those HCPs who were more interested in the topic of antibiotic use. There is also the likelihood that some participants may have been either hesitant to express their views about the topic or may have given socially acceptable answers (Barbour, 2018). The likelihood of this was minimised by ensuring that participants felt relaxed during the interview and explaining that their views were important for improving future intervention. Participants were also encouraged to talk about aspects of the intervention that they did not like.

7.9.1 Reflections of the researcher

Conducting the study during the COVID-19 pandemic presented me with some unique challenges. Social distancing measures and restrictions meant that traditional face-to-face data collection was not possible. A flexible approach was required and I had to seek alternative methods of connecting with research participants. As a result, the study design transitioned to a 'socially distant' online method, such as secure videoconferencing (Lobe et al., 2020). However, I had some concerns about the use of technology, specifically the security of internet platforms. Participants, whether they chose to be interviewed at home or at their workplace, could be potentially overheard in their environment. Another issue was equipment logistics, such as a working microphone and camera, while also relying on a good internet connection to capture the transcript, which was challenging at times. Despite these challenges, online interviewing via videoconferencing provided me with a valuable opportunity to recruit from a more geographically diverse population in Scotland and England. The unexpectedly fast recruitment allowed me to continue my efforts to complete my thesis.

7.9.2 Future research

Prior to the submission of this thesis, the prototype intervention underwent an internal peer review by the Edinburgh Napier University Innovation Panel, for feedback and also funding opportunities. The feedback received was very positive and the panel suggested several viable commercialisation strategies and entrepreneurial opportunities to further develop the intervention.

As a result of the peer review process, the researcher was successful in securing an internal fund to carry out further research on the intervention and develop a digital wireframe of DARTT in close collaboration with the developers Top-Level Studio. The purpose of the wireframe is to facilitate communication with stakeholders, generate more design ideas, conduct further testing and gather meaningful feedback from end-users. The involvement of a graphic designer, a web development agency (i.e., digital healthcare partner) and data sharing agency will be crucial at later stages to build the Antibiotic Review Tracker and design the Interactive online training for it, while also ensuring the compatibility of the proposed system with NHS technological infrastructure. The prototype will be developed in parallel with the university Stage-Gate Innovation Panel process where the concept and business opportunity will evolve to progress to a decision making stage. The scope for obtaining trademark and/or copyright protections will also be explored. The next steps involve carrying out consultations with GPs to check for the suitability and acceptability of DARTT in primary care settings.

7.10 Conclusions and contributions to knowledge

This study has demonstrated the acceptability and perceived usefulness of the DARTT intervention in a hospital setting. Healthcare professionals and health service users found the intervention to have a clear clinical value, discussed adoption, and identified ways in which DARTT could be modified to better reflect the hospital context. Overall, the findings provide clear recommendations on the intervention’s content, design and functionality, and it is expected to improve the antibiotic review process’s safety and quality. Policymakers could use the suggested software features to enhance the existing e-prescribing systems and as guidance for healthcare software developers. The findings could also be applied by clinicians to assist them in evaluating the suitability and functionality of new e-prescribing systems and anticipate potential challenges. In addition, researchers planning similar interventions in other settings can use these findings to guide the development process.

The findings of this study have important implications as they complete efforts to address gaps in knowledge that were identified in Chapter 1 – specifically, the dearth of information regarding how to develop a theory-based behaviour change intervention to improve antibiotic use in acute hospitals and the lack of effective interventions that can be translated and embedded, in a sustainable way, into routine clinical practice. This research adds to the body of literature by emphasising the necessity to fully explore the individual-level requirements and the cultural context when designing health interventions. Without determining whether the intervention is acceptable to the target audience, the likelihood of effective adoption and implementation would be minimised.

Finally, this study reinforces the view that patient and public involvement in the research process can strengthen the development and design of health interventions (Muller et al., 2019). Health service users were involved from the initial planning stages of the intervention and throughout each subsequent development phase. The interviews enabled participants to critically discuss the intervention content and identify any perceived weaknesses in the design. It is therefore hoped that involving both HCPs and health service users in the intervention development will increase the chances of its successful implementation in future research.

Chapter 8: Discussion and conclusions

This thesis has described a systematic review and meta-ethnography followed by two qualitative studies that have resulted in the development of a complex theory-informed behaviour change intervention to optimise antibiotic use in acute hospitals. An in-depth discussion of each study undertaken in this thesis, and consideration of the existing literature, was provided in the preceding chapters. This final chapter summarises the research undertaken in this thesis, draws together the key findings in relation to the overall research aims, and outlines the novel contributions to knowledge that this work has made. The methodological strengths and limitations are discussed in depth, the implications for clinical practice and future research are outlined, and key recommendations for developing complex health interventions are provided.

8.1 Overall research summary

The overall aim of this thesis was to develop a prototype behaviour-change intervention to optimise antibiotic use in acute hospitals, underpinned by a strong theoretical basis, acceptable to the target group (antibiotic prescribers), and suitable in clinical practice. These research aims were achieved using pragmatic MRC guidance for developing and evaluating complex interventions (Craig et al., 2008) and by drawing on the Behaviour Change Wheel (BCW) framework (Michie et al., 2014) to ensure that the intervention development was guided by relevant theory and evidence. This work involved using a staged approach and active engagement from key stakeholders, including those who would deliver the intervention (nurses, doctors, pharmacists and advanced nurse practitioners) and the recipients (health-service users).

The work carried out in this thesis is comprised of four distinct research phases:

- A systematic review and a meta-ethnography to identify the evidence base and develop theory (Chapter 3)

- Study 1 (focus groups) to explore the developed theory derived from the meta-ethnographic work and to model the key elements of the future behaviour change intervention (Chapter 4)
- Operationalisation of the intervention content and selection of implementation options using the BCW framework (Chapters 5 and 6)
- Study 2 (interviews) to gather opinion and feedback from the target group on the proposed intervention and thus refine and optimise its content (Chapter 7)

Details and justification of the adopted methods were provided throughout the research process. The following section describes the overall research findings in the wider context of antibiotic use.

8.2 Key findings in relation to the research aims

This section outlines the key findings of the thesis in reference to each research aim developed in Chapter 2 (Section 2.5).

8.2.1 Research Aim 1

To identify the essential components required for a successful intervention to improve appropriate antibiotic use in hospital settings.

This aim was fulfilled by carrying out a systematic review and meta-ethnography (Chapter 3) and a qualitative study (Chapter 4). The introduction chapter of this thesis described the background to the problem of antibiotic resistance (AMR) in behavioural terms and identified a gap in the evidence base relating to the wide-ranging contextual, organisational and interpersonal determinants of antibiotic prescribing practice in acute hospitals. The meta-ethnography examined and synthesised the existing qualitative evidence to close that knowledge gap and explored how this information could be used to inform the development of a future behaviour change antibiotic intervention. The knowledge generated provided a contextual understanding of the key barriers and facilitators to appropriate antibiotic use and helped to draw robust conclusions and recommendations for improving practice.

The findings identified four areas which collectively represented multiple challenges to appropriate antibiotic medical prescribing in hospitals – 1) loss of ownership of prescribing decisions; 2) tension between individual care and public health concerns; 3) evidence-based practice versus bedside medicine; and 4) diverse priorities between different clinical teams. This resulted in a new line-of-argument and conceptual model that reflected how these challenges operate on both the micro and macro-level. For example, for every clinician there will be a degree of interdependence between different factors which influence prescribing practice, depending on their level of expertise and ability to tolerate risks for their patient and themselves. These factors will form independent components on one level. However, they are not separate or discreet but constitute an integral part of a whole and will therefore exert a degree of direct or indirect influence on prescribing decisions. These elements coexist, interact and create a constant dynamic. Both macro (wider social structures, including the norms, standards, social and organisational constraints for human behaviour) and micro (individual behaviours) dimensions feature a complex interplay of influence, authority and the pursuit of treatment goals. These challenges highlighted key areas for improving current prescribing practice, such as creating feedback mechanisms, normalising input from other specialities and reducing variation in responsibility for antibiotic decisions. This conceptual model was a starting point for understanding what works and why and served as the basis for identifying potential targets for an intervention to improve antibiotic use.

Qualitative methods using three focus groups were then applied to explore key uncertainties not identified from the literature, to refine the model and stimulate new ideas around the mode of delivery, content and appearance of future antibiotic interventions (see Chapter 4). The focus groups identified that the target behaviour which needs to be optimised is the antibiotic review process (timely switching or stopping of therapy) and they proposed many possible ways to achieve it. The data analysis revealed that the intervention needs to target all HCPs involved in antibiotic decision making, regardless of their area of practice, but also to include patients and their families. The key finding was a need to increase the transparency of antibiotic decisions, including the reasons for prescriptions, and thus reduce the ‘invisibility’ of the consequences of poor practice, using prompts and triggers to interrupt reflex behaviours, such as the habits and prescribing preferences of senior clinicians. The participants envisioned harnessing the potential of information technology to create a robust audit trail of prescribing decisions and feasibly translate it into an intervention delivered as part of routine clinical practice workflow.

8.2.2 Research Aim 2

To develop a prototype behaviour change intervention to optimise antibiotic use in acute hospitals underpinned by a robust theoretical basis.

This aim was achieved by conducting behavioural analysis (Chapter 5) and describing the form of delivery (Chapter 6). Drawing on the theoretical basis generated in Chapters 3-4, the intervention content was developed, operationalised and transparently reported using the BCW framework. Use of the BCW allowed triangulation of the findings by taking into account barriers and facilitators to the target behaviour. This information was retrospectively mapped onto the COM-B system of the BCW and the Theoretical Domains Framework (TDF) (Michie et al., 2014) and recorded in a matrix form. This analysis allowed for each barrier and enabler which influences clinical practice behaviour to be linked to specific TDF domains. Operationalisation involved describing how each selected behaviour change techniques (BCTs) could be potentially used in practice for each COM-B component. Matrices were developed to display the proposed mechanism of action and provide recommendations on the content. The proposed intervention incorporated 25 BCTs, delivered across seven intervention functions, using three policy levers, aiming to address behavioural deficits in 12 TDF domains. Mapping the salient TDF domains onto the COM-B model of behavioural change indicated that all aspects were relevant for improving antibiotic review in hospitals, prescribers’ capability, and their opportunity and motivation to perform a timely review.

The theory generated in the preceding chapters, mode of delivery taxonomy, and the APEASE and RE-AIM criteria were then used to inform and guide the Form of Delivery options for the intervention (Chapter 6). Justifications for the decision to use the selected forms of delivery were provided and methods were described for maximising the effectiveness of each component. The prototype intervention elements and features were then summarised using the Form of Delivery framework, an extended version of the TIDIER checklist, to allow future replicability (Dombrowski et al., 2016). The Digital Antibiotic Review Tracking Toolkit (DARTT) which was developed is a novel multifaceted behavioural intervention, targeting HCPs involved in antibiotic prescribing in hospitals and involving patients and their families. The DARTT is comprised of four components: webinar, online interactive tool, antibiotic review tracker and patient information materials, which can be either used as standalone components or together as a toolkit.

8.2.3 Research Aim 3

To assess the acceptability, practicability, and suitability of the DARTT intervention in clinical practice.

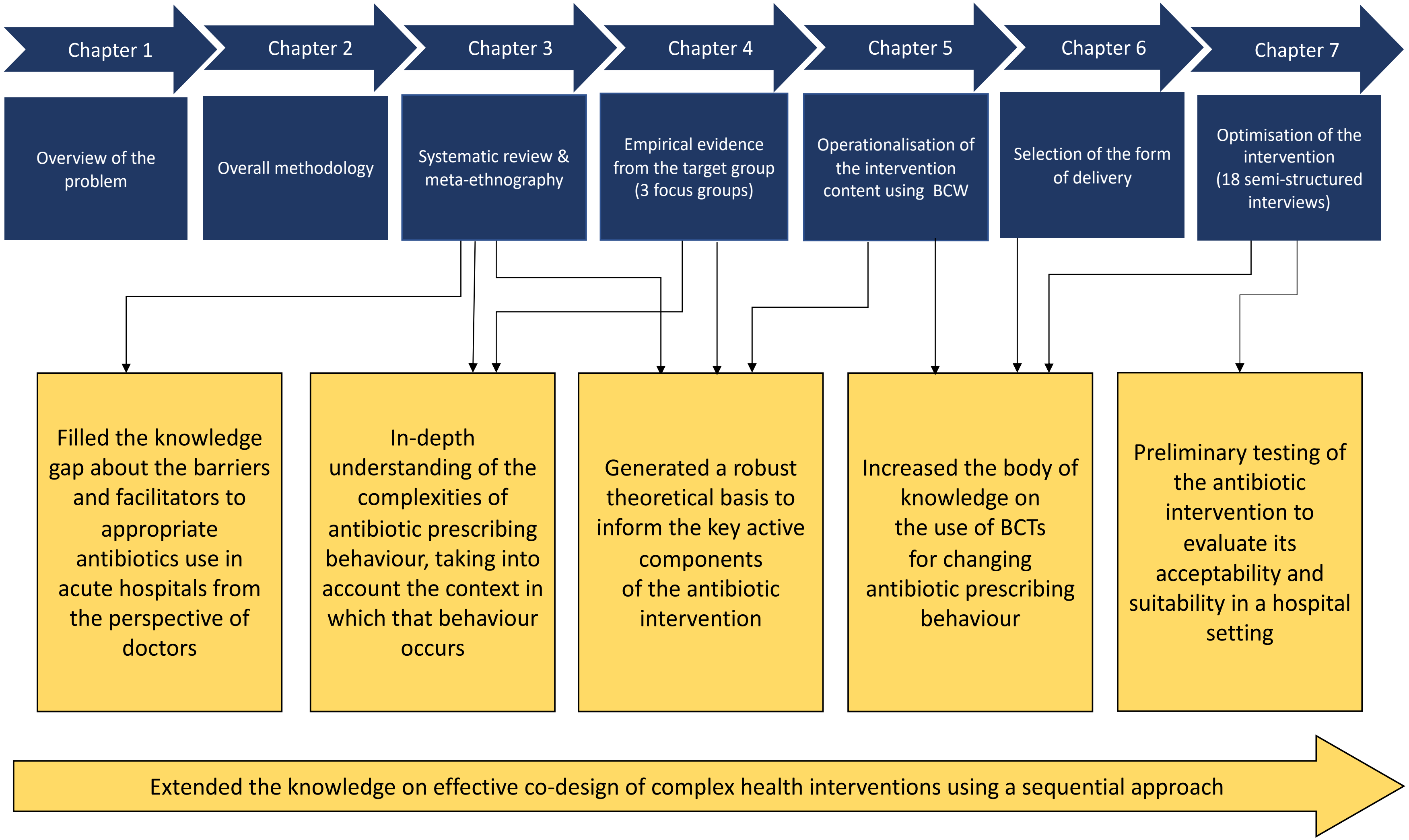
This aim was accomplished by conducting a qualitative study with healthcare professionals and health service users (see Chapter 7). Using prototypes of the intervention, participants were asked for their feedback on its proposed content, design and functionality. The findings suggest that the DARTT intervention is acceptable and suitable for the target group (multi-professionals). Potential weaknesses in the design and further adaptations which were needed were also identified, which would help increase the chances of it being successfully adopted and implemented in future research. Key suggested improvements were grouped into aspirational and practical modifications. The practical suggestions included reducing the length of time of the webinar, providing minimal training, use of standard clinical terminology, minimising the number of data fields on the Antibiotic Tracker, creating clinical link roles to prompt review, and authorisation codes for restricted antibiotics. The aspirational adaptations which were identified included software features and various interface requirements, such as individualised dashboards, links to or pop-up windows for microbiology results, microbiology outstanding action reminders, and many more. Overall, the clear recommendations generated are expected to improve the safety and quality of the antibiotic review process.

8.3 Knowledge Contribution

The work undertaken in this thesis has made a number of contributions to the body of knowledge, which are summarised below, mapped onto the thesis chapters (Figure 31) and then discussed:

- Addressed a gap in the literature concerning the behavioural determinants (barriers and facilitators) to appropriate use of antibiotics in acute hospitals from the perspective of doctors.
- Provided an in-depth understanding of the complexities of antibiotic prescribing behaviour, taking into account the context in which that behaviour occurs.
- Used the evidence base to generate a robust theoretical basis and thus inform the key active components of the antibiotic intervention.
- Increased the body of knowledge on the use of BCTs for changing antibiotic prescribing behaviour.
- Conducted preliminary testing of the antibiotic intervention to evaluate its acceptability and suitability in a hospital setting, which can inform a future trial and post-doctorate work.
- Extended the knowledge on effective co-design of complex health interventions using a sequential approach.

Figure 31. Key knowledge contributions mapped onto thesis chapters



Previous research on ‘how’ to develop effective interventions to reduce antibiotic use in acute hospitals was limited. This thesis addresses this gap by describing how the DARTT intervention has been developed by prospectively targeting identified barriers and facilitators to appropriate antibiotic prescribing. Prior to undertaking the systematic review and meta-ethnography (Chapter 3), the most recent Cochrane review of 221 studies provided recommendations on the effectiveness and safety of interventions to improve antibiotic prescribing to hospital inpatients (Davey et al., 2017). However, guidance on how to contextually design and implement interventions with end-users in mind was lacking (Charani et al., 2019). A large number of qualitative studies had explored hospital doctors’ antibiotic prescribing experience, but it was not systematically searched for and integrated within a robust qualitative synthesis. There was also limited knowledge of the key determinants of antimicrobial prescribing behaviour in hospitals. An in-depth exploration of the determinants that drive prescribing behaviour within a specific context was therefore required to change that behaviour and enhance the chances of planned interventions working in a real-world setting (Nielsen & Miraglia, 2017).

The systematic review expands the knowledge base as it is the first comprehensive meta-ethnography that provides detailed insights into the wide range of factors which influence antibiotic use in a hospital setting from the perspective of doctors. The review also outlines lessons learned and can serve as a worked example for other researchers wishing to undertake a meta-ethnographic synthesis. Findings demonstrate that social navigation of medical prescribing is an emotionally fuelled endeavour often performed with the fear of consequences. The identified themes suggest that ‘appropriate’ prescribing is a complex, context-dependent, fluid and intangible process that may often appear at odds with the evidence and therapeutic guidelines. This process is influenced by multiple factors and tensions, including uncertainty, interpersonal relationships, scarce healthcare resources and fear of the patient deteriorating, losing professional credibility and increased antimicrobial resistance. These findings complement a qualitative systematic review by Krockow et al. (2019), published after completion of the meta-ethnography. Drawing on the Health Belief Model developed by Rosenstock (1974), the review showed that efforts to tackle antimicrobial resistance must consider the tensions between immediate individual risks and long-term population risks, reinforcing the findings of the meta-ethnography.

Despite robust evidence reinforcing best AMS practice, antibiotic prescribing remains sub-optimal in many settings, including in hospitals (Charani & Holmes, 2019). Prior to undertaking this thesis, a UK report indicated that behavioural and social influences were often not considered in the design and evaluations of interventions aiming to improve antimicrobial prescribing (Pinder et al., 2015). An understanding of these determinants was therefore necessary for the successful design, adoption, and implementation of quality stewardship interventions to improve practice. The novel meta-ethnography extends the current evidence base by providing an in-depth understanding of the context-specific complexities of hospital antibiotic prescribing behaviour. Although the resulting conceptual and clinically applicable model cannot be claimed to be definitive and represent all healthcare practitioners, it offers a unique lens, through which the experiences of hospital doctors can be considered in future antibiotic management interventions.

There was also limited clarity in the literature as to what makes an antimicrobial stewardship intervention effective. Many existing interventions to change HCPs' behaviours have been designed without an explicit reason for selecting a specific strategy or a detailed description of the predicted mechanism of action (Michie et al., 2018). A recent systematic review (Matuluko et al., 2020), which synthesised current evidence for the effectiveness of interventions to ensure timely antibiotic review in acute hospitals, has found that only one of the 14 studies evaluated highlighted the use of theory (Rizan et al., 2017). One potential approach to address that gap was to apply a behavioural science framework to specify and synthesise the content and delivery of future antibiotic intervention (Lorencatto et al., 2018). Retrospective application of the Theoretical Domains Framework to results gathered from the meta-ethnography in Chapter 3, and the focus group study described in Chapter 4, identified 12 domains of behaviour that should be targeted within the intervention (see Chapter 5). This cohesive framework informed the key 'active ingredients' of the initial version of DARTT and addressed criticisms that complex interventions often lack a robust theoretical basis for the likely process of change (Craig et al., 2008).

Furthermore, little was known about which BCTs are effective in changing prescribing behaviours. The behavioural analysis of 'what needs to change' undertaken in Chapter 5 allowed the selection of specific BCTs which target relevant behavioural deficits, linking them to mechanisms of action without making any assumptions. The following BCTs were found to be crucial for changing antibiotic prescribing behaviours in a hospital setting:

- problem solving
- goal setting
- habit formation
- credible source
- instructions on how to perform a behaviour
- information about health consequences
- information about emotional consequences
- demonstration of the behaviour
- prompts/cues
- feedback on behaviour
- social support
- adding objects to the environment.

To the best of the author's knowledge, this is the first application of the BCT taxonomy to develop the content of a behaviour change intervention designed to improve the antibiotic review process in acute hospitals. However, the updated search identified a study by Walker et al. (2019), which evaluated a multifaceted 'review and revise' behavioural intervention (see Chapter 5). The majority of BCTs identified are congruent, which further strengthens this work. However, the behavioural diagnosis conducted in this thesis expanded this evidence base by identifying a replicable set of hypothesised pathways through which behaviour change is likely to occur, such as links between BCTs and mechanisms of action (MoAs). The results offer a range of potentially effective BCTs and indicate which techniques are unlikely to influence MoAs (i.e., what to avoid), thus providing a solid basis for designing and evaluating future theory-based antibiotic interventions.

Evidence shows that many complex intervention trials fail to show effectiveness, which can be due to a genuine lack of intervention effect, or sub-optimal design (Levati et al., 2016). To reduce research waste, the MRC framework recommends addressing any uncertainties and issues concerning the acceptability, optimisation, and delivery of the intervention before the effectiveness study stage (Craig et al., 2008). This includes the refinement of content delivery or method and assessment of implementation strategies.

Findings of a preliminary evaluation of DARTT were reported in Chapter 7. The gathered feedback allowed exploration of key areas, such as acceptability, usability, adoption, implementation and maintenance issues and also refinements to optimise the content of DARTT. Initial findings were encouraging. Key stakeholders, including a range of HCPs (prescribers and non-prescribers) and health service users, found the intervention acceptable and suitable for the target audience and identified ways in which DARTT could be modified to better reflect end-user needs.

This research adds to the body of knowledge by highlighting a need to fully explore the individual-level requirements and cultural context – such as habits, social norms, pre-existing work routines, time constraints, and the IT infrastructure – when designing complex health interventions. Without addressing these important issues, the likelihood of effective adoption and implementation would be minimised. In addition, guidance on how to optimise complex health interventions and which strategies to use is still lacking (Levati et al., 2016). This work is novel as it extends the use of prospective qualitative approaches in assessing theoretical acceptability issues during the optimisation phase of intervention development. It also extends the knowledge on system optimisation efforts, including refining advanced system functionalities and usability issues, to maximise the benefits of using digital technology for safe delivery of care.

Finally, although stakeholders' input has long been recommended as a method for ensuring health interventions are acceptable and feasible in the real-world setting (Clemensen et al., 2007), little evidence exists of how it can be used in practice (O'Brien et al., 2016). The key contribution of this thesis is that it provides an explicit description of a sequential approach used to integrate a body of evidence from a systematic review and meta-ethnography, two qualitative studies, and end-users' expert knowledge and perspectives to co-design and develop a novel theory-informed complex health intervention. A worked example of *how* to apply pragmatic research methods to integrate this evidence with stakeholders' engagement was described. This can be modified and adapted to suit different contexts and populations. The implications of the findings are further discussed in Section 8.5.

8.4 Methodological strengths and limitations

This section outlines several methodological strengths, and limitations, of the work carried out in this thesis. These must be considered when evaluating the findings.

8.4.1 Strengths

The key strength of this thesis is a comprehensive approach taken to the careful development of the DARTT intervention, guided by the well-established MRC Framework (Craig et al., 2008). The series of studies carried out in this thesis closely follow the key phases of the development stage identified by the MRC guidance:

- Identifying the evidence base.
- Identifying/developing theory.
- Modelling process and outcomes to increase the chances of the intervention being effective and adopted in clinical practice.

Application of the framework enabled the incorporation of both pragmatic and empirical methods and systematic mapping of the various research activities, demonstrating how it can be successfully operationalised. The framework also helped with selection of the most suitable methods to answer the research questions, which have been transparently and thoroughly reported. Using a phased approach enabled the identification of issues and aspects of the intervention that required further development and refinement. The optimisation stage was guided by the pragmatic application of the RE-AIM Framework (Glasgow et al., 1999) to understand what improvements were needed and indicated that the intervention was well received by clinicians, providing support for future feasibility testing.

The UK Medical Research Council advocates the application of theory as an integral part of a complex intervention design, development and evaluation (Craig et al., 2008). In keeping with the MRC guidance, the focus throughout this thesis has been on developing a robust theoretical understanding. A multi-method inductive approach was employed, incorporating existing evidence (findings from a systematic review and meta-ethnography), supplemented by new primary research (a qualitative study), and a behavioural analysis carried out using the BCW framework (Michie et al., 2014). The BCW, linked to the COM-B (capability, opportunity, motivation and behaviour) model of behaviour and the TDF, was originally used to help researchers rigorously apply theory and evidence to characterising and designing behaviour change interventions before clinical trials (Michie et al., 2011; Michie et al., 2014). This comprehensive and theory-derived process was articulated well in text and visuals, and was extremely useful in identifying what needs to change to help operationalise the intervention content.

Whilst the application of BCW prompted consideration of the full range of intervention options, the use of APEASE criteria helped to structure this process and make context-based decisions (Michie et al., 2014). Drawing on the BCT taxonomy ensured consistent classification of intervention content, and development of a proposed mechanism of action. Several techniques selected for inclusion in the DARTT were not identified in other published works. This approach has added to the body of knowledge regarding the use of BCTs to target key influences on antibiotic prescribing and the application of these techniques. Although the remit of this thesis does not allow for an evaluation of the individual techniques and their effect, the findings provide a solid evidence base for the BCTs required to change antibiotic prescribing behaviour in hospital settings. Applying transparent and systematic methods in the development process ensures that it is replicable and could be modified in implementation stages without losing methodological rigour. Also, application of the BCW allowed triangulation of the findings in this thesis, which in turn strengthened the design, minimised bias and created more comprehensive research (Mertens & Hesse-Biber, 2012).

The series of studies conducted in this thesis is another important strength. A transparent and reproducible systematic review and a meta-ethnography have produced new insights into doctors' experiences and the multiple challenges to appropriate antibiotic prescribing in acute hospitals. The reviewing process was carried out in a systematic way, including a large range of databases and grey literature. The qualitative evidence identified was screened, critically appraised by two independent reviewers, and synthesised using rigorous methods. Findings were reported using the eMERGe guidance for meta-ethnography, reinforcing the transparency and credibility of the review (France et al., 2019). The meta-ethnography findings provided an original and valuable understanding of current practice and highlighted the complexity of the antibiotic decision making process. Carrying out the meta-ethnography also enabled the generation of a conceptual model, which reflects how these challenges operate on both a micro and macro-level, highlighting key areas for improving current prescribing practice. The developed conceptual model provided a unique framework for discussion during the focus groups (Study 1) and enabled further exploration of barriers and facilitators to appropriate prescribing which were not identified in the literature.

The empirical qualitative studies conducted (Chapters 4 and 7) used robust methods for sampling, recruitment, data collection and analysis, and were reported following the consolidated criteria for qualitative research (COREQ) (Tong et al., 2007). Using qualitative methods as part of the development process was a strength. The qualitative findings from focus groups and interviews with healthcare professionals and health service users helped to establish a conceptual foundation for the intervention, generated new ideas around the content and delivery of the intervention, and investigated potential issues surrounding its acceptability. In addition, qualitative data interpretation can be debated on the grounds of the process being subject to bias (Polit & Beck, 2014). However, the depth and breadth of exploration and the number of steps taken to ensure the trustworthiness of the research processes mean that it is possible to generalise the findings to a broad range of clinical contexts, different groups of HCPs and many AMS interventions promoting behavioural change.

Integral to this work was the involvement of healthcare professionals and health service users throughout all stages of the research process, from the initial planning of the study protocol development, assessing whether the participant information sheet was written in lay language, and testing the interview topic guide, to sharing their unique knowledge and expertise in the intervention development (Chapter 4) and optimisation (Chapter 7). A strength of using this approach is that it draws on the diverse knowledge and expertise of a range of multidisciplinary professionals to stimulate innovative ideas (O'Brien et al., 2016). Patient and public involvement (PPI) played a pivotal role in the development of DARTT by ensuring that the research was relevant to health user needs and therefore more likely to have a beneficial impact. Giving lay participants a voice in aspects of the research design increased the quality of the intervention content and encouraged the co-production of healthcare (Vale et al., 2012).

8.4.2 Limitations

One of the limitations of the overall work is that it constitutes an exploratory stage in the design of a complex health intervention. Therefore, it is not possible to draw any conclusions regarding its efficacy in clinical practice. Although a collection of research approaches was used to ensure the needs and wants of end-users were met, the true impact of the intervention cannot yet be established. Future research should focus on evaluating the intervention's effectiveness.

There is also an argument around the complexity and time required in using the BCW to analyse behaviours. The retrospective mapping of barriers and facilitators derived from the meta-ethnography onto the TDF framework, and coding findings onto the BCT taxonomy, was carried out by one researcher and reviewed by the academic supervisory team. However, given the widely recognised complexity of the TDF language and BCT taxonomy, and the uncertainties in interpreting the domains and categorising associated psychological constructs (Phillips et al., 2015), coding by two independent reviewers or input from a health psychologist trained in the use of TDF may have further strengthened the methodological rigour of the developed coding matrix (Chapter 5) and added to the body of knowledge evaluating the effectiveness of the framework in understanding behaviour. This limitation does not diminish the credibility of the research – rather, it emphasises the need for more clarity and practical guidance on the application of the framework to make it more useable by wider audiences.

Although the MRC framework emphasises the importance of building a "cumulative understanding of causal mechanisms" so that the researcher can "design more effective interventions and apply them appropriately across group and setting" (Craig et al., 2008, p. 7), little empirical evidence exists in the literature on the effectiveness of the 59 BCT-MoA links identified in this thesis. This lack of reported links in the literature may reflect recent developments in this field of research, authors' assumptions that such links do not exist, not considering specific links when designing interventions, excluding links that are too difficult to operationalise, or not providing sufficient detail when reporting (Carey et al., 2019; Johnston et al., 2021). Further empirical work is needed to systematically test whether the identified BCTs can influence the selected MoAs and bring about a change in behaviour.

Attention also needs to be given to the sample of the two qualitative studies. A possible limitation to the focus groups (Study 1) was that the sample was drawn from only two Scottish Health Boards, with most healthcare professionals practising in NHS Lothian at the time of study participation. Although participant recruitment to focus groups may be hindered by geographical proximity to the venue and people's unwillingness to travel long distances (Flynn et al., 2018), some critics may argue that findings drawn from a homogenous setting may not be representative of all HCPs.

Moreover, the sample size of the third focus group in Study 1 was relatively small (n=4). Despite the attempts to recruit as diversely as possible, the overall sample did not include junior HCPs. This may reflect the complexity of the topic and the unwillingness of less experienced prescribers to discuss their views in front of senior colleagues. Although this limitation was minor, it was addressed in Study 2 by recruiting from a variety of Scottish Health Boards and English Trusts and making sure that the sample included junior prescribers.

Another possible limitation may be the author's background. A nursing perspective may have had potential implications for the process of data analysis, which should be read as one of many possible interpretations. However, a non-medical background brought some advantages to this work and offered a new lens to consider the complexity of antibiotic prescribing decisions. The researcher's prior experience of working in the hospital environment facilitated the discussions with participants, while her understanding of the drawbacks of the current healthcare system helped with the interpretation of findings and enabled her to take a truly pragmatic approach in development of the intervention.

Finally, the intervention development process took place over a five-year period, which could have potentially reduced the relevance of findings to current clinical practice. The iterative process adopted was time-consuming and although it increased the rigour of the research, it slowed down the intervention development at certain points. The COVID-19 pandemic had an effect on the progress of the intervention development as some research activities had to be temporarily suspended. The restricted budget available for undertaking a PhD work meant that seeking professional input from a web developer and graphic designer in the development of DARTT was not possible. Nevertheless, the outlined limitations are not significant and do not undermine the work carried out in this thesis.

8.4.2.1 Contemporisation of the MRC Framework

This research was carried out between 2016-21, and the thesis was submitted at the time when the National Institute for Health Research (NIHR) and the Medical Research Council commissioned an update of the complex intervention research framework due to significant conceptual, methodological and theoretical developments that have occurred since 2006 (Skivington et al., 2021). The new 2021 MRC framework provides an updated definition of complex interventions, emphasising the dynamic relationship between the intervention and its context. At each phase, the updated guidance suggests that six core elements should be considered, including:

1. How does the intervention interact with its context?
2. What is the underpinning programme theory?
3. How can diverse stakeholder perspectives be included in the research?
4. What are the key uncertainties?

5. How can the intervention be refined?
6. Do the effects of the intervention justify its cost?

By addressing the weaknesses and gaps of the 2006 MRC framework (Craig et al., 2008), this thesis provides a worked example of how some of the core elements could be successfully incorporated into the intervention development, capturing the dynamic interaction with the context. More specifically, it addresses the recognised lack of clarity on how context should be considered (i.e., the conceptual model developed in Chapter 3 depicting the multi-dimensional nature of antibiotic prescribing in hospital settings, including the broader organisational, social and cultural context and its influence on individual practice) and operationalised within the intervention development stage (see Chapter 5).
This research also reinforces the new recommendations by adopting diverse stakeholders` perspectives throughout the research process to identify the key uncertainties about the complex intervention and thus provide evidence useful to decision makers. Meaningful engagement with those targeted by the intervention (health service users) and those involved in its development and delivery, or whose professional interests are affected (healthcare professionals) facilitated pragmatic design and conduct of the research and offered a flexible approach to exploring research questions. This inclusive and deliberative process helped improve prospects of achieving changes in practice.

Much of the criticism of the previous MRC guidance focused on the need for a greater understanding of how and under what circumstances interventions bring about change (Greenhalgh & Papoutsi, 2018; Moore et al., 2015). The work carried out in this thesis does not use programme theory or a logic model to describe how the intervention under development is expected to produce its effects and under what conditions (Davidoff et al., 2015). However, the multi-method inductive approach employed, which incorporates triangulation of the existing evidence and primary data, supplemented by a behavioural analysis carried out using the BCW framework, means that the developed intervention is underpinned by an explicit theoretical basis, illustrated in a visual model and carefully articulated in full. For example, it provides detailed descriptions of the contextual factors that determine and shape prescribing decisions in acute hospital settings (Chapters 3–4) and of the mechanisms of change, including the identified BCTs and which causal processes they target (Chapters 5–6). In addition, particular attention is given to the intervention refinement and optimisation using an iterative process and taking into account the issues around its acceptability, usability, and implementation in the real world.

One area of this thesis that does not match the updated guidance relates to the economic considerations, particularly whether the effects of the intervention justify its cost. Skivington et al. (2021) suggest that economic evaluation – formally assessing the costs and consequences of a health intervention compared to alternatives – should be a core component of all phases of intervention research. Collaboration with health economists can help decision-makers ensure that limited resources achieve maximum gain (Barnett et al., 2020). If precious resources are spent on interventions that are not cost-effective, the population as a whole gains fewer benefits (NICE, 2014). The most common types of health economic analysis, which seek to capture the full range of health and non-health costs and benefits across different sectors and are therefore more suitable for an economic evaluation of a complex intervention, include cost-benefit analysis and cost-consequence analysis (NICE, 2014). Although undertaking economic evaluation was beyond the scope of this thesis, this area provides an exciting opportunity for future post-doctoral research.

8.5 Implications of findings

The findings of this research have implications for clinical practice, research and the development of interventions for changing antibiotic prescribing behaviour in acute hospitals.

8.5.1 Implications for clinical practice

Incorporating an understanding into local policy and practice of the socio-cultural influences on prescribing derived from this thesis has the potential to support interventions which target individual practice, such as antibiotic review. The behavioural analysis conducted in this thesis has identified the complexities inherent in the development of an intervention for optimising antibiotic use in hospitals, requiring the targeting of prescribers' capability, opportunity and motivation to prove effective in this context. The implications of this research are that antibiotic prescribing is a complex behavioural problem, likely to be influenced by a range of factors at the individual (personal to prescribers), social (or cultural, determined by colleagues) and organisational level (determined by the environment). To trigger a change, a complex behavioural intervention that considers the COM-B elements, fosters collaborative culture and breaks up pre-existing prescribing habits using focused behavioural planning is required.

The findings of this thesis suggest that the developed intervention was acceptable to the target group, given the positive feedback. Particularly well received was the proposed functionality of the Antibiotic Review Tracker and the potential benefits of improving the quality of antibiotic prescribing decisions and patient safety. This indicates that user-friendly digital tools for reviewing antibiotics which are incorporated into current routine clinical workflows show potential for a successful implementation in hospital settings. This presents an exciting opportunity for intervention developers to focus on harnessing the potential of health information technology to drive the required improvements in antibiotic use. The recommendations on required software features could be used by policymakers and healthcare software developers to optimise the existing e-prescribing systems.

Realising the potential for digital technology to transform healthcare delivery within the NHS has become an urgent policy initiative in the UK (Scottish Government, 2018). However, as the findings from this thesis show, for a digital intervention like DARTT to become part of routine practice, the interoperability of novel systems and pre-existing IT infrastructure must be addressed first. The main concern is how DARTT can be fitted into the existing health technology landscape so that the new system enables staff to deliver excellent care. Although the implementation of DARTT may require a transition from paper-based processes to digital infrastructures, the findings from the acceptability study are encouraging, in that it may be possible to integrate the intervention within the new UK Hospital Electronic Prescribing and Medicines Administration (HEPMA) system, which, at the time of writing, is being rolled out across a small number of Scottish Health Boards.

Prior to the implementation of HEPMA, major improvements were carried out to the IT infrastructure within Health Boards to support the electronic flow of information in which HEPMA was to be used, improving the chances of future system interoperability. However, resources may need to be allocated to support a range of activities, including workforce planning, continuous leadership and training of new staff, and the availability of technical support. Broad engagement and staff buy-in will also be vital to the intervention's success. Future research plans should prioritise exploration of funding opportunities and involvement of computer software specialists to support further development of DARTT from a prototype into a product that can be tested in the real-world clinical setting.

Finally, guided by the MRC framework in the development of complex health interventions (Craig et al., 2008), the involvement of key stakeholders, including health service users, aided the identification of any anticipated challenges to the adoption and implementation of the intervention, and facilitated its refinement. Such an approach ensured that the content and delivery of DARTT was adapted during the development stage to accommodate a range of users' needs and ensured that future implementation would be person-centred.

8.5.2 Implications for research

This thesis has advanced the understanding of how to develop complex behavioural health interventions and future work can draw on the sound theory and evidence it has generated. Although the intervention content and implementation considerations described are specific to hospital contexts, the body of evidence gathered could apply to a wide range of behavioural interventions and clinical areas, such as primary care or long-term facilities.

Firstly, the systematic review and meta-ethnography enhanced knowledge around clinicians' internal logic in antibiotic prescribing behaviours, that goes beyond antimicrobial guidelines and evidence-based practice. Without fully taking into account participant characteristics and exploring the cultural context, the intervention, as originally envisaged, may have not considered the social norms of hospital practice to facilitate that change. As indicated by the results of the meta-ethnography, addressing the complex interaction of a wide range of influences on the micro and macro-level may contribute to finding future solutions to the ever-growing problem of AMR and reduce fear of consequences from non-prescribing or stopping antibiotics.

Secondly, the high-level findings presented in this thesis could be further developed for implementation in practice. The results of the focus groups with key stakeholders may have the potential to inform future behaviour change interventions to promote optimal antibiotic use in hospitals and increase their effectiveness. The findings concerning the loss of decision ownership may be worth further empirical examination, with a large sample across a diverse population, such as including nurse prescribers and pharmacists in both primary and secondary care. It is suggested that future research on promoting effective hospital AMS should focus on exploring the 'invisibility' of prescribing decisions and responsibility avoidance.

Specifically, it would be of value to investigate the diversity of opinions around the roles and responsibilities that junior prescribers should undertake in relation to antimicrobial prescribing, and how to help overcome uncertainty and fear of consequences. Finding ways to communicate an expectation for this group may foster the transfer of active responsibility down the hierarchy ladder. Such an improved understanding of the role of interprofessional support and the normalisation of other specialities in the decision making process may highlight the importance of a multidisciplinary approach. In addition, there remains a gap in research concerning the contexts under which junior doctors feel more able to challenge seniors' decisions effectively. This area was beyond the scope of this thesis and warrants further investigation.

Finally, by integrating published and empirical evidence, the work undertaken in this thesis has demonstrated a rigorous method of developing a solid theoretical foundation for health interventions. The exploratory sequential method applied, which incorporated the views of key stakeholders and linked these onto the COM-B model and the BCW, allowed effective intervention operationalisation and development. Guided by the MRC framework, the systematic approach taken – starting from problem identification to designing the intervention content – presents an appealing case for applying to research funding bodies. This work also provides a sequential description of the methods used to integrate the evidence and theory required for the development of a complex intervention, which could be reproduced by other researchers planning to investigate health behaviours across different setting or contexts. Drawing on the findings, future research can use the described modelling process and the generated insights to assess the effectiveness of a behaviour change intervention.

In summary, further research is needed to:

a) empirically test the identified BCT-MoA links in effecting behaviour change in the context of optimising antibiotic review.
b) evaluate the DARTT components using a pilot or feasibility study, taking into account the uncertainties identified in the design of the intervention.
c) establish the extent to which the findings are transferable to other settings.

8.5.2.1 Options for future evaluation

The updated MRC guidance places emphasis on shifting the primary focus of evaluation from minimising bias towards assessing the "usefulness" of information for decision making (Skivington et al., 2021, p. 7). It highlights the importance of asking a range of questions, including identifying how the intervention works, what other impact it has, how it interacts with the context or how it contributes to system change. Skivington et al. (2021) further explain that the key aspect of evaluation design should focus on the choice of outcome measures or evidence of change. For instance, outcome measures could capture changes to a system rather than individuals. Drawing on the conceptual model developed in Chapter 3, this could include changes in social norms (e.g., minimising medical hierarchy by distributing responsibility for prescribing decisions to more junior clinicians) or normalisation of practice (e.g., an acceptance, engagement and support from other specialities in antibiotic decision making process).

A range of research methods can be used successfully for evaluating complex health interventions, and different designs are suited to different research questions and different intervention features, including complexity. For example, while standard experimental designs, such as RCTs, help establish the effectiveness and cost-effectiveness of interventions, non-randomised designs and modelling approaches may be more suitable in circumstances where randomisation is not feasible (e.g., in systems evaluations) (Minary et a., 2019). Additional approaches, such as a process evaluation using qualitative or mixed methods, may also be needed to answer questions around implementation fidelity, causal mechanisms, and the contextual factors (Moore et al., 2015). Process evaluation can also help identify any unanticipated consequences, additional activities or adaptations that had to be made to an intervention in a given context (i.e., changes to the content), and thus provide essential information necessary for further development of the intervention programme theory (Bonell et al., 2012).

In terms of a digital health intervention (DHI), such as DARTT, traditional approaches to evaluation in healthcare may not work well. The challenges include the rapid change of the digital technology landscape, which can be difficult to align with the time it takes to carry out some evaluations; the complexity of digital health products, with many different functionalities and features; or the lack of clarity on the best current practice for evaluating digital technologies (Public Health England, 2020). Murray et al. (2016) suggest that the efficient development of safe and effective DHIs requires innovative research methods to generate a knowledge base that can guide decision making and propose a set of research questions as the basis for an appraisal of a DHI. Drawing on these research questions, Table 35 provides a summary of the research method options for evaluating DARTT.

Table 35. A research question-driven approach for future evaluation of DARTT (adapted from Murray et al. 2016)

Research Question(s)	**Proposed research approaches for evaluation**
1. Is the intervention likely to reach the target population, and if so, is the population likely to use it?	Human-centred design for establishing and optimising potential reach and uptake, including: • concept sketching • co-design strategies • low-fidelity or "Wizard-of-Oz" prototyping • user experience testing
2. Which intervention components impact the predicted outcome, and how do they interact with each other?	For evaluating the performance of individual components of the intervention and how the presence, absence, or setting of one component impacts the performance of another: • Multiphase Optimisation Strategy (MOST) Approaches for optimisation: • full or fractional factorial experiments

	• the sequential multiple-assignment randomized trial (SMART) • system identification techniques
3. What strategies should be used to support tailoring the intervention to participants over time?	For tailoring the intervention to participants over time (e.g., non-responders, or daily adjustments reflecting changing needs or context): • SMART design (factorial experiment involving randomisation at several stages) • micro-randomised trial • system identification experiment
4. What is the likely direction and magnitude of the effect of the intervention or its components compared to a comparator that is meaningful for the stage of the research process? 5. What is the extent to which the intervention is implemented as intended, the causal mechanisms and contextual factors associated with variation in outcomes?	An RCT to establish the magnitude of the effect (effect size) of the intervention compared to a meaningful comparator, with consideration given to: • the trade-off between external and internal validity • specification of the intervention and delivery platform • choice and specification of the comparator • establishing separate data collection methods from the intervention itself A process evaluation alongside the RCT, including: • mixed methods • qualitative approaches • realist process evaluation
6. Has the possibility of harm been adequately considered, and has the likelihood of risks or adverse outcomes assessed?	Identification and quantification of expected harms can be undertaken as part of an RCT, but unexpected harms will require alternative strategies, including: • those emerging during the development and optimisation work • long-term observational studies during implementation
7. Has cost been adequately considered and measured?	For undertaking a formal health economic analysis: • cost-utility analysis • cost-effectiveness analysis • cost-consequence analysis • economic modelling
8. What is the overall assessment of the utility of this intervention, and how confident are we in this overall assessment? 9. Should research priorities and clinical practice change?	Answers to the previous questions should enable an assessment of the overall utility of the intervention, including: • balancing its effects • usage • scalability • costs and safety • sustainability

8.6 Reflections, critique and suggestions

The author of this thesis, who has had a 14-year nursing career, first in clinical practice and then in education, designed and carried out the studies and created the initial draft of the DARTT intervention. Although her background brought many advantages to undertaking this research, she investigated medical practice using an interpretive approach in a profession where the positivist paradigm is considered superior. While all research paradigms are valuable and informative when used appropriately to answer a specific research question, medical science has traditionally focused on experimental design research methods, such as RCTs (Bunniss & Kelly, 2010).

Using methodologies which were less familiar and accepted to those educated in the positivist medical tradition was problematic. Inductive approaches did not always fit with others' sets of beliefs and assumptions. This created some challenges for the researcher, particularly when trying to get a 'buy-in' from local opinion leaders during the project without trial evidence, even though a positivist stance is not appropriate for studying human behaviour and complex social change, where data rich in depth of insight and meaning is required (Berwick, 2008). Undertaking this research in keeping with the 2006 MRC guidance as a driver for change raised an additional challenge. Although useful, the framework is derived from experimental research conducted in disciplines firmly situated in the positivist paradigm (Bonell et al., 2018). The emphasis on aggregate effectiveness does not offer pragmatic guidance for researchers striving to uncover 'what works for whom and in which circumstances' and thus jointly construct knowledge with participants.

A variety of methods and approaches exist that can be used to inform and maximise the likelihood of complex health interventions being effective and sustainable. For example, qualitative research methods are best suited to provide vital insights into the design of an intervention, ensuring it is acceptable to end-users and suitable for the context in which it will be embedded (Muller et al., 2019; Yardley et al., 2015). Using qualitative methods enabled the researcher to explore the complexities of antibiotic prescribing behaviours, including the perspectives, behavioural needs and challenges of the target group (both HCPs and health service users) and the social context in which the behaviour change is to be maintained. Nevertheless, their use in intervention development and evaluation remains scarce and underdeveloped (Thirsk & Clark, 2017).

The lack of published and detailed guidance on how to methodologically apply these research methods to intervention development presented another challenge.

Although the MRC framework provides general guidance on the use of non-experimental methods (Craig et al., 2008), there is little practical detail on applying specific qualitative methods, with suggestions for researchers to consult other sources. Therefore, additional knowledge and guidance were required to develop the DARTT intervention and ensure that it was underpinned by strong evidence and a theoretical base. Given the limitations of the existing MRC recommendations and the pace of methodological developments, new and more up to date guidance is required that takes account of the contribution of a range of research methods, with specific guidance on their practical application to enhance the development process.

Moreover, the conceptual model generated by the meta-ethnography describing the multidimensional nature of antibiotic prescribing in hospital settings was one of the critical outcomes of this thesis. However, making the results easily accessible for the target audience by publishing in a leading medical journal proved difficult and finding alternative ways to present the results in a form accessible to healthcare professionals and policymakers without impacting the quality of the research was challenging. Although qualitative methods make an important contribution to healthcare research, the acceptable word counts for most reviews tend to be a better 'fit' for a statistical meta-analysis and not interpretive synthesis, which requires an in-depth clarification of the methodology and detailed reporting (Atkins et al., 2008; France et al., 2019).

Peer-reviewed medical journals which exclude qualitative research on the grounds of their limited word counts, exploratory results which are considered low priority and traditional reporting formats is undoubtedly "yesterday's war" and requires new solutions (Greenhalgh et al., 2016, p. 4). Without recognising the important contribution that qualitative evidence makes in helping to understand the behaviours of healthcare professionals, how patients experience care and why health interventions do not always work in the real-world setting, it will not be possible to address many challenges faced by healthcare systems worldwide, including the threat of AMR.

In addition, the importance of intervention components that fit the delivery context and the information on how to effectively select the 'active ingredients' (i.e., BCTs) that are most likely to bring about the desired behaviour change remains ambiguous. The hierarchically structured BCT taxonomy offers a systematic method for reliably describing the behavioural aspects of complex interventions using an agreed terminology (Michie et al., 2013). However, although the utility of the taxonomy is indisputable, it is not without its drawbacks. For example, achieving good levels of reliability in BCT selection requires skill and training in using the taxonomy (Wood et al., 2016). Due to a degree of overlap across some BCT labels and ambiguity of definitions, the process of coding for an untrained user raised some issues. For example, finding a 'perfect fit' for some BCTs and operationalising the less frequently used techniques within a digital behaviour change intervention was not straightforward. The absence of formulated techniques to guide the development of digital health interventions highlights current gaps in the field of behaviour change. Given these limitations, the question arises as to whether the current BCT taxonomy needs to be expanded by a range of experts beyond the field of health and psychology to enable more precise and transparent reporting of the intervention content using a shared language, while including other BCTs to better reflect recent technological developments.

Although it is widely recognised that effective replication and testing of complex health interventions relies on adequate reporting, sufficient details of the development process or effects reported in publications is lacking (Glasziou et al., 2014). This can potentially lead to a failure to effectively translate research into practice and policy (Candy et al., 2018). The lack of detailed descriptions of the determinants targeted by current interventions presented a practical challenge for the researcher. It was difficult or even impossible at times to identify the causal mechanisms of interventions and judge whether appropriate methods had been selected to influence behaviour. Therefore, comprehensive reporting is essential to better understand how complex behaviour change interventions work for a particular population and setting. This includes details of the causal mechanisms, a clear rationale for the choices made, and interaction with the context. More guidance is needed to address these elements during the development stages (Moore & Evans, 2017).

Drawing on these reflections and the lessons learned in this thesis, the suggestions for developing complex health interventions are summarised in Table 35.

Table 36. Key recommendations for developing complex health interventions

- Meta-ethnography is a novel methodology that can provide an in-depth understanding of context-specific behaviours and thus inform the development of complex health interventions.

- More practical guidance is required on how to systematically apply qualitative research methods to intervention development and maximise its effectiveness.

- There is a need to expand BCT Taxonomy (v1) and link it with technological progress to better guide the development of digital health interventions.

- PPI should play a key role in developing and designing health interventions to ensure the research is relevant to user needs and enhances their acceptability.

- Comprehensive reporting of behaviour change interventions is essential to allow replication and effective translation of research into practice and policy. This should include the details of:

    a) the causal mechanisms
    b) the explicit rationale for the choices made
    c) interaction with the context.

8.7 Final conclusions

This thesis has described how the MRC guidance, the BCW and the RE-AIM framework were systematically applied to develop a theory-informed, complex behaviour change intervention that is innovative and practical. By working closely with a range of healthcare professionals and health service users, an inductive sequential research approach was used to gather and validate evidence, generate new ideas, and develop the DARTT intervention to improve the antibiotic review process in hospital settings. Initial exploration of DARTT using cost-effective and efficient methods has indicated that the developed behaviour change intervention is acceptable to the target audience, suitable for clinical practice, and potentially effective in improving the quality of the antibiotic review process. The work described has advanced the meta-ethnography methodology and made a novel contribution by drawing on the high-quality evidence base and linking it with primary data to generate theory and model a multicomponent health intervention. It has also highlighted the need for systematic and transparent reporting of both the predicted mechanism of action and the intervention content to facilitate future evaluation and replication.

Given the lack of information in the literature on the underlying mechanisms of how and why current AMS interventions work on changing prescribers' behaviour, the most significant contribution to knowledge is the conceptualisation of the intervention content and identification of the predicted mechanism of action. Drawing on the results of the systematic review and meta-ethnography (Chapter 3) and the qualitative study using focus groups (Chapter 4), the BCW was used to triangulate the findings and operationalise the developed theory. This included the application of APEASE criteria to select the most suitable intervention functions, subsequent policy categories, appropriate modes of delivery and a range of BCTs that could be used to deliver the intervention (Chapters 5 and 6). Attention was paid to ensuring the reliability of the development process by explicitly delineating how theory and evidence were translated into the intervention. The detailed descriptions provided have a replication value and can serve as a basis for future research.

Finally, the overall strength of the developed intervention lies in the application of a person-centred approach to gain a depth of understanding of the target group's needs, current context, and potential implementation challenges. Providing the key stakeholders with an opportunity to influence the development allowed identification of the behaviour that needed changing, selection of preferred intervention solutions, and ensured that the intervention will be relevant and useful for clinical practice.

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Appendix 1: Characteristics of UK studies in the Cochrane Review (Davey et al., 2017)

Study	Design	Provider & settings	Participants	Clinical problem	Intervention components	Deliverer	Use of theory?
Aldeyab 2012	Interrupted time series analysis (ITS)	All physicians in 1 university hospital	All adult patients	Patients requiring therapeutic or prophylactic antibiotics.	Audit and feedback; restrictive – expert approval.	AMT	No
Aldeyab 2014	ITS	All physicians in 1 university hospital	All adult patients	Patients requiring therapeutic or prophylactic antibiotics.	Audit and feedback; restrictive – expert approval.	AMT	No
Ansari 2003	ITS	All physicians in 1 university hospital	All patients	Antibiotics dispensed to hospital wards for administration for therapy or prophylaxis.	Educational meetings; dissemination of educational materials; educational outreach by review and recommend change.	AMT	Unclear – lack of sufficient details
Barlow 2007	Controlled ITS	All physicians in 2 acute hospitals in Scotland	All patients presenting with pneumonia	Adults with community-acquired pneumonia.	Audit and feedback; educational meetings; dissemination of educational materials; reminders – physical by posters and email.	AMT	No
Bell 2014	Unintended consequences, ITS	All physicians in general, gynaecological, orthopaedic, urological, and vascular surgery wards in 1 hospital	12,883 patients undergoing elective surgery	Risk of postoperative AKI following policy change to gentamicin for prophylaxis.	Audit and feedback; educational meetings; dissemination of antibiotic policy; reminders (physical – posters in operating theatres).	AMT	No
Bradley 1999	ITS	Physicians in an adult haematology unit in 1 university hospital	All patients with clinical problem	Adult patients receiving treatment for haematological malignancy.	Restrictive	Specialist physician (microbiologist)	No
Dancer 2013	ITS	All physicians in 1 district general hospital in	All patients	Requiring antibiotic prophylaxis or treatment.	Restrictive	AMT	No

		Scotland					
Fitzpatrick 2008	ITS	All physicians in 1 hospital	All patients	Prescribing of cefuroxime and quinolones.	Dissemination of guidelines.	Pharmacists	No
Fowler 2007	ITS	Physicians in 3 acute medical wards for the elderly in 1 university hospital	Patients 80 years and older	Clostridium difficile infection in the elderly.	Audit and feedback, dissemination of guideline; reminders (physical, laminated pocket version of guidelines).	AMT	No
Khan 2003	ITS	All physicians in a non-teaching hospital	All patients	Clostridium difficile-associated diarrhoea.	Restriction with educational meetings and dissemination of guidelines.	Specialist physician	No
Lawes 2012	ITS	All physicians in 1 university hospital in Scotland	All patients	Staphylococcus aureus bacteraemia and use of antibiotics considered to be high risk for Clostridium difficile infection.	Dissemination of new antibiotic policy 3 months before the structural intervention; restrictive: the new antibiotic policy included requirement for expert approval; structural: introduction of universal screening for MRSA.	AMT	No
Liebowitz 2008	ITS	All physicians in 1 general hospital	All patients	Incidences of MRSA.	Educational meetings with dissemination of guideline; reminders, verbal on rounds.	AMT	No
Marwick 2013	ITS	All physicians in medical and surgical wards in 1 university hospital in Scotland	All patients in medical and surgical wards	Suspected sepsis (systemic inflammatory response and clinical suspicion of infection).	Audit and feedback; educational meetings with dissemination of guidelines; reminders (physical, posters in the wards and monthly email to doctors).	AMT	Unclear – lack of sufficient details
McElnay 1995	ITS	All physicians in a district hospital	All patients	All patients receiving antibiotics.	Educational meetings and dissemination of new antibiotic policy; educational outreach of junior medical staff by academic detailing; restrictive by compulsory order form and removal.	Department physician	No

McLaughlin 2005	ITS	All staff from 12 medical wards in 1 university hospital	All patients in the medical wards	Adults requiring IV antibiotic therapy.	Educational meetings with dissemination of protocol for IV to oral switch; educational outreach by academic detailing; reminders (circumstantial, sticker in charts of patients receiving IV antibiotics and physical, posters in wards and at nursing stations).	AMT	No
McNulty 1997	ITS	All physicians in the elderly care unit in 1 non-teaching district general hospital	All patients in the elderly care unit	Clostridium difficile in the elderly care unit.	Dissemination of new antibiotic policy; restrictive by removal and by review and make change.	Pharmacist	No
Patel 1989	ITS	All physicians in 1 hospital	All patients	Patients requiring antibiotic treatment.	Educational meetings with dissemination of guidelines; educational outreach by review and recommend change; reminders (physical and verbal, posters and intervention promoted at weekly ward meetings).	Pharmacist	No
Price 2010	ITS	All physicians in 1 university hospital	All patients	Requiring antibiotic treatment or prophylaxis.	Dissemination of guidelines; restrictive by removal and expert approval.	AMT	No
Stevenson 1988	ITS	All physicians in 1 hospital	All patients	Receiving antibiotics.	Dissemination of antibiotic policy.	Pharmacist	Yes
Talpaert 2011	ITS	All physicians in 1 hospital	All patients	Patients receiving fluoroquinolones, cephalosporins, clindamycin, amoxicillin, and co-amoxiclav for prophylaxis or treatment.	Educational meetings with dissemination of guidelines; educational outreach by review and recommend change; reminders (verbal (on rounds) and physical (laminated pocket cards and posters)); restrictive by removal of target drugs from	AMT	No

					clinical areas.		
Wilson 1991	ITS	All physicians in 3 hospitals	All patients	Patients receiving amoxicillin or pivampicillin.	Dissemination of newsletter to all prescribers.	Pharmacist	No
Wyatt 1988	Cluster RCT, hospital level	25 district general (non-teaching) hospitals, 13 control and 12 interventions	1318 episodes of care in 1318 patients, 25 clusters (hospitals)	Administration of prophylactic antibiotics to women undergoing Caesarean section. The intervention also targeted 3 other care processes.	Educational meeting with dissemination of guideline and slides.	Obstetrician	No

Appendix 2: Edinburgh Napier University letter of ethical approval

Edinburgh Napier University
School of Health and Social Care
Research Integrity Ethical Approvals Committee
9 Sighthill Court
Edinburgh
EH11 4BN

03/01/2018

Dear Gosha,

Project Title:	**Development of a theory-based behaviour change Intervention to Promote optimal antibiotic use in ACute hospiTals: The IMPACT Study**	
***Project start date*:**	**January 2018**	
Project end date:	**January 2020**	
Project reference:	**SHSC/0003**	***Version:* 2**

Further to your application for Ethical approval to undertake a research study at Edinburgh Napier University, I am pleased to inform you that the committee has approved your application and we wish you all the best with your study. It is your responsibility to inform the SHSC ethics when you study has completed.

Data from your study should be held securely for a period of ten years after the completion of the research project or longer if specified by the funder as per the data management policy: http://staff.napier.ac.uk/services/research-innovation-office/Documents/Research%20Data%20Management%20Policy.pdf

May I also remind you of the need to apply to the Research Integrity Committee prior to making any amendments to this study or of any changes to the duration of the project. Any proposed changes in the protocol should be submitted for reassessment as an amendment to the original application. If required please request the Amendments to an Approved Application form (contact: ethics.shsc@napier.ac.uk). All documents related to the research should be maintained throughout the life of the project, and kept up to date at all times.

Please bear in mind that your study could be audited for adherence to research governance and research ethics.

Yours sincerely,

Dr. Anne Rowat
Chair

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Appendix 3: NHS R&D letter of approval

University Hospitals Division

NHS
Lothian

Queen's Medical Research Institute
47 Little France Crescent, Edinburgh, EH16 4TJ

FM/CF/approval

26 January 2018

Research & Development
Room E1.16
Tel: 0131 242 3330

Email:
accord@nhslothian.scot.nhs.uk

Director: Professor Tim Walsh

Miss Gosha Wojcik
Edinburgh Napier University
Sighthill Campus
9 Sighthill Crescent (room 1.B.27)
Edinburgh
EH114BN

Dear Miss Wojcik

Lothian R&D Project No: 2018/0007 **REC No:** N/A

Title of Research: Development of a theory-based behaviour change Intervention to Promote optimal antibiotic use in ACute hospiTals: The IMPACT Study

Participant Information Sheet:
Version 1.0, dated 24 October 2017 (Interviews)
Version 1.0, dated 24 October 2017 (Group Consultation)

Consent Form:
Version 1.0, dated 24 October 2017 (Interviews)
Version 1.0, dated 24 October 2017 (Lay Participants)
Version 1.0, dated 24 October 2017 (HCP)

Protocol: Version 2.0, dated 22 November 2017

I am pleased to inform you this letter provides Site Specific approval for NHS Lothian for the above study and you may proceed with your research, subject to the conditions below.

Please note that the NHS Lothian R&D Office must be informed of any changes to the study such as amendments to the protocol, funding, recruitment, personnel or resource input required of NHS Lothian.

Substantial amendments to the protocol will require approval from the ethics committee which approved your study and the MHRA where applicable.

Please keep this office informed of the following study information, **which is a condition of NHS Lothian R&D Management Approval:**

1. Date you are ready to begin recruitment, date of the recruitment of the first participant and the monthly recruitment figures thereafter.
2. Date the final participant is recruited and the final recruitment figures.
3. Date your study / trial is completed within NHS Lothian.

I wish you every success with your study.

Yours sincerely

Fiona McArdle

Ms Fiona McArdle
Deputy R&D Director

CC: Ms Michelle Carr, Service Director DATCC, ST John's Hospital

STA014

Appendix 4: Edinburgh Napier University amendment approval for Study 1

Edinburgh Napier University
School of Health and Social Care
Research Integrity Ethical Approvals Committee
9 Sighthill Court
Edinburgh
EH11 4BN

15/05/2018

Dear Gosha,

Project Title:	**Development of a theory-based behaviour change Intervention to Promote optimal antibiotic use in ACute hospiTals: The IMPACT Study): Amendment Approved** 19/04/2018
***Project start date*:**	**08/01/2018**
***Project end date*:**	**08/01/2019**
Project reference:	**SHSC/0003 Version: 2 Amendment**

Please note that the amendment to your project :**Development of a theory-based behaviour change Intervention to Promote optimal antibiotic use in ACute hospiTals: The IMPACT Study)**has been approved.

It is your responsibility to inform the SHSC ethics when you study has completed.

Data from your study should be held securely for a period of ten years after the completion of the research project or longer if specified by the funder as per the data management policy: http://staff.napier.ac.uk/services/research-innovation-office/Documents/Research%20Data%20Management%20Policy.pdf

May I also remind you of the need to apply to the Research Ethics Committee prior to making any amendments to this study or of any changes to the duration of the project. Any proposed changes in the protocol should be submitted for reassessment as an amendment to the original application. If required please request the Amendments to an Approved Application form (contact: ethics.shsc@napier.ac.uk). All documents related to the research should be maintained throughout the life of the project, and kept up to date at all times.

Please bear in mind that your study could be audited for adherence to research governance and research ethics.

Yours sincerely,

Dr. Anne Rowat
Chair

Appendix 5: Edinburgh Napier University amendment approval for Study 2

Edinburgh Napier University
School of Health and Social Care
Research Integrity Ethical Approvals Committee
9 Sighthill Court
Edinburgh
EH11 4BN

Date of letter: 05/11/2020

Dear Gosha,

Project Title: Development of a theory-based behaviour change Intervention to Promote optimal antibiotic use in ACute hospiTals: The IMPACT Study
Start Date original January 2018
End date original January 2020 (Amendment 30/04/2022)
Project reference: SHSC 0003 Amendment November 2020

Further to your amendement application to the study ref SHSC 0003, I am pleased to inform you that the amendement has been approved by chair's action with the following conditions:

- Noted that you plan you must only collect data as per University guidelines during the pandemic using remote methods (see guidance at: https://staff.napier.ac.uk/services/research-innovation-office/Pages/Research-Integrity.aspx). Please contact the committee as amendment for any future changes to data collection methods.

Researchers are also responsible for obtaining all necessary licences or copyright agreements needed to use any data collection tools, diagnostic tools or software platforms used in the research project. Failure to do so may impact your ability to publish data collected without an appropriate licence from the licence owner.

Data from your study should be held securely as per the institution's data protection policy. Please adhere to data management policy for the storage and destruction of data, including identifiable data as per your data management plan, please see: http://staff.napier.ac.uk/services/research-innovation-office/Documents/Research%20Data%20Management%20Policy.pdf.
All documents related to the research should be maintained throughout the life of the project, and kept up to date at all times.

Please bear in mind that your study could be audited for adherence to research governance and research ethics.

If this is a funded project a copy of this letter should also be uploaded on worktribe.

We wish you well with your study.
Yours sincerely,

Dr. Anne Rowat, SHSC RIC convenor

INVESTOR IN PEOPLE

Appendix 6: NHS R&D amendment approval for Study 1

University Hospitals Division

Queen's Medical Research Institute
47 Little France Crescent, Edinburgh, EH16 4TJ

NHS Lothian

RESEARCH & DEVELOPMENT
Room E1.16
Tel: 0131 242 3330
Email:
R&DOffice@nhslothian.scot.nhs.uk

Director:
Professor Tim Walsh

KS/LM

2 July 2018

Miss Gosha Wojcik
Edinburgh Napier University
Sighthill Campus
9 Sighthill Crescent (room 1.B.27)
Edinburgh
EH114BN

Dear Miss Wojcik

REC No:	N/A
R&D Project ID No:	2018/0007
Amendment:	Amendment No.1 dated 28 March 2018
Title of Research:	Development of a theory-based behaviour change Intervention to Promote optimal antibiotic use in ACute hospiTals: The IMPACT Study

I am writing in reply to recent correspondence in relation to an amendment(s) to the above project and the subsequent updated documents as follows.

- Protocol Version 3.0, dated 28 March 2018

We have now assessed any consequential changes and can confirm that NHS Lothian management approval is extended to cover the specific changes intimated.

Yours sincerely

Kenneth D Scott

Mr Kenneth Scott
NRS Generic Review Manager

Appendix 7: NHS R&D amendment approval for Study 2

NHS Lothian –
University Hospitals Division

NHS Lothian

Queen's Medical Research Institute
47 Little France Crescent, Edinburgh, EH16 4TJ

RESEARCH & DEVELOPMENT
Room E1.16
Tel: 0131 242 3330
Email:
R&DOffice@nhslothian.scot.nhs.uk

Director:
Professor Tim Walsh

KS/LS

21 December 2020

Miss Gosha Wojcik
Edinburgh Napier University
Sighthill Campus
9 Sighthill Crescent (room 1.B.27)
Edinburgh
EH114BN

Dear Miss Wojcik

REC No:	N/A
R&D Project ID No:	2018/0007
Amendment:	Minor amendment dated 3 November 2020
Title of Research:	Development of a theory-based behaviour change Intervention to Promote optimal antibiotic use in ACute hospiTals: The IMPACT Study

I am writing in reply to recent correspondence in relation to an amendment(s) to the above project and the subsequent updated documents as follows.

- Consent Form Version 2.0, dated 2 November 2020
- Participant Information Sheet Version 2.0, dated 2 November 2020
- Privacy Notice Version 1.0. dated 2 November 2020
- Protocol Version 4.0, dated 2 November 2020

We have now assessed any consequential changes and can confirm that NHS Lothian management approval is extended to cover the specific changes intimated.

Yours sincerely

Mr Kenneth Scott
NRS Generic Review Manager

Appendix 8: Consent Form for Study 1

NHS Lothian   Edinburgh Napier UNIVERSITY

PARTICIPANT CONSENT FORM

Development of a theory-based behaviour change Intervention to Promote optimal antibiotic use in ACute hospiTals: The IMPACT Study.

Participant study number: ☐☐

Please initial the boxes

1. I confirm that I have read and understood the information sheet (version 1.0, 24th October 2017) for the above study and have had the opportunity to consider the information, ask questions and have had these answered satisfactory. ☐
2. I understand that taking part is voluntary and that I am free to withdraw at any time, without having to give a reason. ☐
3. I understand that if I change my mind about taking part, the researchers would like to continue to use the information I have provided for the purposes of this project. I give permission for them to do so. ☐
4. I understand that all information will be kept strictly confidential, will not be traceable to me and will only be used for the purposes of this research. ☐
5. I agree to consent to my conversation being audio recorded. ☐
6. I agree to consent to anonymised quotes of my conversation being used in any publication or presentation of the research. ☐
7. I give permission to be contacted about taking part in an interview as part of this study. ☐
8. I agree to take part in the above study. ☐

______________________________	_____________	_____________________
Name of participant (please print)	Date	Signature
____________________________	________________	______________________
Name of researcher	Date	Signature

Participant Consent Form – Focus Groups. Version 1.0 (24th October 2017)

Appendix 9: Consent Form for Study 2

PARTICIPANT CONSENT FORM

Development of a theory-based behaviour change Intervention to Promote optimal antibiotic use in ACute hospiTals: The IMPACT Study.

Participant study number: ☐☐

Please initial the boxes

I have read and understood the participant information sheet (Version 2.0, dated 2nd Nov 2020) and this consent form.	☐
I give consent for this form to be stored electronically on the Edinburgh Napier University secure research computer drive.	☐
I have had an opportunity to ask questions about my participation.	☐
I understand that I am under no obligation to take part in this study.	☐
I understand that I have the right to withdraw from this study at any time and without giving any reason until the data have been published.	☐
I understand that if I decide to withdraw from the study prior to publication of results, my data will be destroyed.	☐
I understand that an anonymised quotes will be shared with researchers at Edinburgh Napier University.	☐
I understand that data collected for the study may be shared with other researchers (on an anonymous basis). Data sharing will only be conducted as per the General Data Protection Regulations (2016/679).	☐
I have read and understood the Privacy Notice that provides information about how my personal data will be processed for this study.	☐
I agree to participate in this study.	☐
I give permission for the audio recording of the telephone interview and possible use of anonymised quotes using my exact words.	☐

Participant's Signature ________________ Date ________________

Researcher's Signature ________________ ________________

NHS Lothian

Edinburgh Napier UNIVERSITY

PARTICIPANT INFORMATION SHEET

Development of a theory-based behaviour change Intervention to promote optimal antibiotic use in acute hospitals. The study is called IMPACT.

You are being invited to take part in a research study, which is being undertaken as part of an academic doctoral qualification. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. Talk to others about the study if you wish. Contact us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Introduction

Antibiotics are powerful medicines used to treat bacterial infections. However, bacteria can find different ways to overcome the effects of an antibiotic. This is called “antibiotic resistance”. The current high levels of antibiotic resistance are occurring worldwide and have been largely driven by inappropriate use of antibiotics; in other words, the more antibiotics are prescribed, the less effective they become, and the more difficult it is to treat infections. This is a major patient safety issue in hospitals, because it increases the length of stay in hospital and the risk of death.

What is the purpose of the study?

There are two important ways to tackle the global crisis of antibiotic resistance: the first is to develop new antibiotics, the second is to improve the use of the existing antibiotics. With the lack of new antibiotics currently in development, promoting optimal antibiotic use is the only option available to slow the spread of resistance. Therefore, we want to develop and test a new intervention to promote appropriate antibiotic use for hospital inpatients. We consider your input valuable to the development of this intervention, and we would like to speak to you and gather advice and feedback about the content and look of the intervention during its developmental stage.

Why have I been asked to take part?

You have been asked to take part because you are either:

- a health professional involved in everyday decision-making around antibiotic use for hospital inpatients, or
- a health service user aged over 18 who has received antibiotics in the past, or
- a behaviour change expert who has experience developing complex health interventions.

Do I have to take part?

No, participation in the study is entirely voluntary and it is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and we will ask for your contact details (phone number or email) so that we can arrange a suitable time to speak to you. You will also be asked to sign a consent form on the day of the group discussion. Even if you decide to take part, you can still withdraw at any time and without giving a reason. The researcher will analyse all data collected from you up until this point unless informed otherwise. Deciding not to take part or withdrawing from the study will not affect your employment, the healthcare that you receive, or your legal rights.

What will happen if I take part?
If you decide to take part in the study, a member of the research team will contact you to arrange a time for you to attend one of the group discussions. The session should take no longer than 90 minutes and will take place in one of Edinburgh`s major hospitals. A maximum of 12 participants will take part and refreshments will be provided. The group will be presented with various options available for the antibiotic intervention and we would like your help in deciding the way forward. We will ask you for your ideas, opinions and advice about the look and content of the intervention. The group discussions will be audio recorded with your permission to allow us to analyse the data.

What are the possible benefits of taking part in the study?
There are no direct benefits to you by participating in this study. However, you will be providing valuable input into the intervention development, which could potentially improve antibiotic prescribing practice and thus have direct impact on future healthcare of patients. You will be reimbursed for your travel expenses.

What are the possible disadvantages and risks of taking part?
There are no obvious risks in participating in the group discussion. However, some people may find talking about their experiences difficult or a little upsetting. Please be reassured that the researcher will be sensitive to your feelings and concerns. You would be free to pause, postpone or withdraw from the discussion at any time, without having to give a reason for doing so.

What if there is a problem?
If you have a concern about any aspect of this study, please contact the researcher, Gosha Wojcik, who will do her best to answer your questions. Please see her contact details at the end of this sheet.

Will my taking part in the study be kept confidential?
Yes. All the information we collect during the course of the research will be anonymised and kept confidential and there are strict laws which safeguard your privacy at every stage. If you agree to take part in the study, you will be assigned a study number (or pseudonym), which will be used to ensure your anonymity. All written data collected will be kept in a locked filing cabinet at Edinburgh Napier University, to which only the main researcher will have access. All digital data will be password protected and encrypted. The password will be known only by the main researcher and the research team.

Computers used to store and analyse the data will have limited access measures via user names and passwords. The recording will be destroyed after the interview is typed into a transcript and checked for accuracy.

What happens when the study is finished?
We will securely hold the electronic and written data for a period of ten years after the completion of the research project. After then, all data that could identify you will be destroyed as per Edinburgh Napier University policy.

Will there be any attempts to contact me after the study is complete?
No. There is no follow-up once the study is complete.

What will happen to the results of the study?
Once the study is complete, the information will be analysed and the study will be written up as part of a PhD thesis. In addition, the study will be reported in academic journals and may also be presented at conferences for healthcare professionals and researchers. You will not be identifiable in any published results. At the end of the study, if you wish to read a general summary of findings, it will be available to you if you contact Gosha Wojcik.

Who is organising the research and why?
This study is being funded by Edinburgh Napier University.

Who has reviewed the study?
The study proposal has been reviewed by the Edinburgh Napier University Ethics Committee and study documentation approved by the NHS Lothian Research and Development (R&D) Office.

What are my rights?
If you would like to discuss the study details with someone outside the research team, or make a complaint, please contact Janyne Afseth, who is a lecturer and an independent advisor at Edinburgh Napier University. Her contact details are: j.afseth@napier.ac.uk or 0131 455 5703.

If you have any further questions about the study, please contact Gosha Wojcik at the address below:

Edinburgh Napier Univerisy
9 Sighthill Crescent
Room 1.B.27
Edinburgh
EH11 4BN
Tel: 07908485534
Email: G.Wojcik@napier.ac.uk

Thank you for taking the time to read this Information Sheet and for considering taking part in this study.

Appendix 11: Participant Information Sheet for Study 2

NHS
Lothian

Edinburgh Napier
UNIVERSITY

PARTICIPANT INFORMATION SHEET

Development of a theory-based behaviour change Intervention to promote optimal antibiotic use in acute hospitals. The study is called IMPACT.

You are being invited to take part in a research study, which is being undertaken as part of an academic doctoral qualification. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. Talk to others about the study if you wish. Contact us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Introduction
Antibiotics are powerful medicines used to treat bacterial infections. However, bacteria can find different ways to overcome the effects of an antibiotic. This is called "antibiotic resistance". The current high levels of antibiotic resistance are occurring worldwide and have been largely driven by inappropriate use of antibiotics; in other words, the more antibiotics are prescribed, the less effective they become, and the more difficult it is to treat infections. This is a major patient safety issue in hospitals, because it increases the length of stay in hospital and the risk of death.

What is the purpose of the study?
There are two important ways to tackle the global crisis of antibiotic resistance: the first is to develop new antibiotics, the second is to improve the use of the existing antibiotics. With the lack of new antibiotics currently in development, promoting optimal antibiotic use is the only option available to slow the spread of resistance. To help solve this problem, we have been working on developing a new intervention to promote appropriate antibiotic use for hospital inpatients and we would like to speak to you and gather your feedback about the design and content of the intervention.

Why have I been asked to take part?
You have been asked to take part because you are either:

- a health professional involved in everyday decision-making around antibiotic use for hospital inpatients, or
- a health service user aged over 18 who has received antibiotics in the past.

Do I have to take part?
No, participation in the study is entirely voluntary and it is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and we will ask for your contact details (phone number or email) so that we can arrange a suitable time to speak to you. You

1

PIS (Interviews) Version 2.0 (2nd Nov 2020) will also be asked to sign a consent form on the day of the interview. If you decide to take part, you can still withdraw at any time and without giving a reason until the data collected have been published. Should you decide to withdraw from the study prior to publication of results, your data will be destroyed. Deciding not to take part or withdrawing from the study will not affect your employment, the healthcare that you receive, or your legal rights.

What will happen if I take part
If you decide to take part in the study, a member of the research team will contact you to arrange an interview at a time convenient for you. The interview should take no longer than 60 minutes and it will be conducted either online using a secure online platform (i.e. Microsoft Teams) or via telephone. During the interview, you will be presented with pictures of an intervention designed to improve antibiotic use in a hospital setting. You will be asked questions about your opinions and to provide feedback on the practicality, design and content of the intervention, and its suitability for hospital use. You will then be asked to express how much you agree or disagree with a particular statement. This approach will help us understand whether our intervention is likely to work in real practice. We will also ask about your advice on how the intervention could be improved. The interview will be audio recorded with your permission to allow us to analyse the data. If you prefer not to be audio recorded, notes can be taken.

What are the possible benefits of taking part in the study?
There are no direct benefits to you by participating in this study. However, you will be providing valuable input into the intervention development, which could potentially improve antibiotic prescribing practice and thus have direct impact on the future healthcare of patients.

What are the possible disadvantages and risks of taking part?
There are no obvious risks involved in participating in the interview. However, some people may find talking about their experiences difficult or a little upsetting. Please be reassured that the researcher will be sensitive to your feelings and concerns. You would be free to pause, postpone or withdraw from the interview at any time, without having to give a reason for doing so.

What if there is a problem?
If you have a concern about any aspect of this study, please contact the researcher, Gosha Wojcik, who will do her best to answer your questions. Please see her contact details at the end of this sheet.

Will my taking part in the study be kept confidential?
Yes. You will be given a Privacy Notice that provides information about how your personal data will be processed for this study. All the information we collect during the course of the research will be anonymised and kept confidential and there are strict laws which safeguard your privacy at every stage. If you agree to take part in the study, you will be assigned a study number (or pseudonym), which will be used to ensure your anonymity. All written data collected will be kept in a locked filing cabinet to which only the main researcher will have

access. All digital data will be password protected and encrypted. The password will be known only by the main researcher and the research team. Computers used to store and analyse the data will have limited access measures via user names and passwords. The recording will be destroyed after the interview is typed into a transcript and checked for accuracy.

What happens when the study is finished?
We will securely hold the electronic and written data for a period of ten years after the completion of the research project, following which all data that could identify you will be destroyed as per Edinburgh Napier University policy.

Will there be any attempts to contact me after the study is complete?
No. There is no follow-up once the study is complete.

What will happen to the results of the study?
Once the study is complete, the information will be analysed and the study will be written up as part of a PhD thesis. In addition, the study will be reported in academic journals and may also be presented at conferences for healthcare professionals and researchers. You will not be identifiable in any published results. At the end of the study, if you wish to read a general summary of findings, it will be available to you if you contact Gosha Wojcik.

Who is organising the research and why?
This study is being funded by Edinburgh Napier University.

Who has reviewed the study?
The study proposal has been reviewed by the Edinburgh Napier University Ethics Committee and study documentation approved by the NHS Lothian Research and Development (R&D) Office.

What are my rights?
If you would like to discuss the study details with someone outside the research team, or make a complaint, please contact Janyne Afseth, who is a lecturer and an independent advisor at Edinburgh Napier University. Her contact details are: j.afseth@napier.ac.uk or 0131 455 5703.

If you have any further questions about the study, please contact Gosha Wojcik at the address below:

Edinburgh Napier Univerisy
9 Sighthill Crescent
Edinburgh EH11 4BN
Tel: 07908485534
Email: G.Wojcik@napier.ac.uk

Thank you for taking the time to read this Information Sheet and for considering taking part in this study.

Appendix 12: Privacy Notice

Privacy Notice

Name of Research Project: The IMPACT Study.
Description of Project: This study involves the development of a theory-based behaviour change intervention to promote optimal antibiotic use in acute hospitals.

Data Controller	Edinburgh Napier University
Purposes for collection/ processing	With the lack of new antibiotics currently in development, promoting optimal antibiotic use is the only option available to slow the spread of resistance. Therefore, the aim of this study is to develop and test a new intervention to promote appropriate antibiotic use for hospital inpatients. The purpose of data collection is to gather advice and feedback about the content and look of the intervention during its developmental stage. With your permission, the researcher will ask at the start of the interview if she can record the discussion. This is strictly for data analysis purposes. The recording will be transcribed into a word document as soon as possible after the interview and the recording deleted immediately afterwards. The researcher will then analyse this transcription and produce a summary of the main points that have been raised. This summary will form a contribution to the final research report. Direct, anonymised, quotes may be used to support the analysis, but no individuals will be identifiable in the reported results. Published quotations from participants' interviews will be anonymised.
Legal basis	Art 6(1)(e), performance of a task in the public interest/exercise of official duty vested in the Controller by Statutory Instrument No. 557 (S76) of 1993 as amended, e.g. for education and research purposes.
Whose information is being collected	Lay participants and NHS staff (including pharmacists, doctors and nurses).
What type/classes/fields of information are collected	Information will be collected about your: □ Name □ Contact details (email and phone number) □ Sensitive personal data (age, gender, years of practice) □ Educational details □ Ethnic origin During the online interview, you will be asked about your views and opinions on the antibiotic intervention we have designed. You will also be asked to fill in a short questionnaire so we can gather your feedback about the content and look of the intervention.

Who is the information being collected from	Data is being collected directly from you as the participant in the study.
How is the information being collected	If you participate in an online interview with a researcher, this will audio-recorded using an encrypted digital recording device. Telephone interview information will be recorded on a paper based form by the researcher during a telephone interview. This will then be transferred to an electronic record.
Is personal data shared with externally	Yes. The audio-recordings will be transcribed by an external company called 1st Class Secretarial Services. The university has a data-sharing agreement in place with this organisation to ensure that all data is kept secure, you can view their Privacy Statement here https://www.1stclass.uk.com/privacy_statement_01052018.pdf
How secure is the information	For services provided locally by Information Services, information is stored on servers located in secure University datacentres. These datacentres are resilient and feature access controls, environmental monitoring, backup power supplies and redundant hardware. Information on these servers is backed up regularly. The University has various data protection and information security policies and procedures to ensure that appropriate organisational and technical measures are in place to protect the privacy or your personal data. The University makes use of a number of third party, including "cloud", services for information storage and processing. Through procurement and contract management procedures the University ensures that these services have appropriate organisational and technical measures to comply with data protection legislation. The University is Cyber Essentials Plus accredited. Interviews shall be recorded on to the interviewer's own encrypted Dictaphone, transferred onto the researcher's personal space on the University's secure V-drive at the first opportunity. The recordings will be deleted from the Dictaphone after transfer. The University V-Drive is the most secure place to store data. Notes taken during the interviews, and demographic data will be typed up fully into separate PDF documents. Any printed copies of interview for analysis shall already be anonymised so that there are no identifiable markers stored with the interview. These will be stored in a lockable drawer to which only the researcher has access.
Who keeps the information updated	It is the researcher`s responsibility to keep the information updated.
How long is the information kept for	The voice files will be destroyed immediately following transcription. Electronic and written personal data will be stored securely for a period of ten years after the completion of the research project as specified by the funder. Computers used to store and analyse the data will have limited access measures via user names and passwords.

Will the data be used for any automated decision making	No
Is information transferred to a third country? Outside the EEA and not included in the adequate countries list.	No
You can access all the University's privacy notices using the following link: https://staff.napier.ac.uk/services/governance-compliance/governance/DataProtection/Pages/statement.aspx You have a number of rights available to you with regards to what personal data of yours is held by the University and how it is processed – to find out more about your rights, how to make a request and who to contact if you have any further queries about Data Protection please see the information online using the following URL: https://staff.napier.ac.uk/services/governance-compliance/governance/DataProtection/Pages/default.aspx	

Appendix 13: Debrief Sheet

PARTICIPANT'S DEBRIEF

Development of a theory-based behaviour change intervention to promote optimal antibiotic use in acute hospitals: The study is called IMPACT.

Thank you very much for your participation in the study.

Purpose of the work:
The main purpose of the work is to help us develop and test a new intervention to promote appropriate antibiotic use for hospital inpatients. We consider your input valuable to the development of this intervention, and we would like to speak to you and gather advice and feedback about the content and look of the intervention during its developmental stage.

While we believe the study has minimal implications for participants, we acknowledge that involvement in research interviews where individuals are asked to reflect on their experiences can, in some cases, cause distress. As researchers, we do not provide any psychological support service or offer advice and are unable to undertake follow-ups with you after this evaluation. However, we want to provide some information should you decide you need assistance. These are listed below.

SAMH 0141 530 1000 http://www.samh.org.uk/
NHS 24 0845 4242424 or www.nhs24.com
Samaritans 0845 7909090 www.samaritians.org/
Contact your own GP – finding a GP go to www.gphelp.scot.nhs.uk

Confidentiality
The data collected in this study will be held on the 'V' drive within Edinburgh Napier University research server and only accessible by a password protected computer, to which only the researchers will have access. Quotations from the group discussions and individual interviews may be used in publications and pseudonyms will be used in each case. All participants will be given a study number and the collected data will be anonymised.

Researcher contact details
If you would like more information or a copy of the findings then please contact Gosha Wojcik on 07908485534 or email: G.Wojcik@napier.ac.uk. These should be available by December 2021.

You may also want to talk to someone else outside the research team but who knows about the project. You can talk to Janyne Afseth, who is a lecturer and an independent advisor at Edinburgh Napier University. Her contact details are: j.afseth@napier.ac.uk or 0131 455 5703.

Please keep a copy of this form for your reference

Participant`s Debrief. Version 1.0 (24th October 2017)

Appendix 14: Published systematic review and meta-ethnography

Wojcik *et al. Archives of Public Health* (2021) 79:134
https://doi.org/10.1186/s13690-021-00624-1

Archives of Public Health

RESEARCH **Open Access**

Understanding the complexities of antibiotic prescribing behaviour in acute hospitals: a systematic review and meta-ethnography

Gosha Wojcik[1*], Nicola Ring[1], Corrienne McCulloch[2], Diane S. Willis[1], Brian Williams[1] and Kalliopi Kydonaki[1]

Abstract

Background: Antimicrobial resistance poses a serious global public health threat. Hospital misuse of antibiotics has contributed to this problem and evidence-based interventions are urgently needed to change inappropriate prescribing practices. This paper reports the first theoretical stage of a longer-term project to improve antibiotic prescribing in hospitals through design of an effective behaviour-change intervention.

Methods: Qualitative synthesis using meta-ethnography of primary studies reporting doctors' views and experiences of antibiotic prescribing in hospitals for example, their barriers to appropriate prescribing. Twenty electronic databases were systematically searched over a 10-year period and potential studies screened against eligibility criteria. Included studies were quality-appraised. Original participant quotes and author interpretations were extracted and coded thematically into NVivo. All study processes were conducted by two reviewers working independently with findings discussed with the wider team and key stakeholders. Studies were related by findings into clusters and translated reciprocally and refutationally to develop a new line-of-argument synthesis and conceptual model. Findings are reported using eMERGe guidance.

Results: Fifteen papers (13 studies) conducted between 2007 and 2017 reporting the experiences of 336 doctors of varying seniority working in acute hospitals across seven countries, were synthesised. Study findings related in four ways which collectively represented multiple challenges to appropriate antibiotic medical prescribing in hospitals: loss of ownership of prescribing decisions, tension between individual care and public health concerns, evidence-based practice versus bedside medicine, and diverse priorities between different clinical teams. The resulting new line-of-argument and conceptual model reflected how these challenges operated on both micro- and macro-level, highlighting key areas for improving current prescribing practice, such as creating feedback mechanisms, normalising input from other specialties and reducing variation in responsibility for antibiotic decisions.

* Correspondence: G.Wojcik@napier.ac.uk
[1]School of Health and Social Care, Edinburgh Napier University, EH11 4BN Edinburgh, UK
Full list of author information is available at the end of the article

Conclusions: This first meta-ethnography of doctors` experiences of antibiotic prescribing in acute hospital settings has enabled development of a novel conceptual model enhancing understanding of appropriate antibiotic prescribing. That is, hospital antibiotic prescribing is a complex, context-dependent and dynamic process, entailing the balancing of many tensions. To change practice, comprehensive efforts are needed to manage failures in communication and information provision, promote distribution of responsibility for antibiotic decisions, and reduce fear of consequences from not prescribing.

Trial registration: PROSPERO registration: CRD42017073740.

Keywords: Antimicrobial resistance, Antibiotic decision-making, Prescribing behaviour, Doctors, Acute hospitals, Meta-ethnography, Qualitative synthesis

Background

The continuing emergence and spread of antimicrobial resistance (AMR) poses a major threat to public health and patient safety due to associated morbidity, mortality and healthcare expenditure [1]. The AMR crisis has been attributed, to a significant extent, to misuse and overuse of antibiotics [2, 3]. A recent study looking at global antibiotic consumption, expressed in defined daily doses (DDD), found that it increased by 65 % (21.1–34.8 billion DDDs) across 76 countries between 2000 and 2015 [4]. Although the increase was largely driven by low- and middle-income countries (LMICs), even within high-income countries, multidrug-resistant organism rates are rising. It is estimated that in the US and Europe alone, infections caused by antibiotic-resistant bacteria lead to at least 50,000 deaths annually, with hundreds of thousands more dying elsewhere across the world [2]. A simultaneous decline in new drug development by the pharmaceutical industry due to reduced financial inducements and challenging government regulatory mechanisms has further compounded the problem [5].

Rising resistance levels and unavailability of newer agents have led to coordinated efforts to implement new national and international initiatives, resume research efforts and minimise the use of currently available antibiotics to preserve their therapeutic effectiveness. These efforts have been underpinned by the concern that by 2050, AMR-related patient deaths will exceed 10 million annually worldwide, with a projected economic cost of 100 trillion US dollars [6]. Despite coordinated efforts, hospitals worldwide currently face significant problems with inappropriate antimicrobial use, as much as 30–50 % of that usage being unnecessary or inappropriate, leading to worse health outcomes [7, 8]. In the UK, despite some progress in primary care, a sustained reduction in total antibiotic prescribing in secondary care has not been observed. Whilst only 20 % of antimicrobial consumption occurs in hospitals, the intensity of use is far higher than in the community. Evidence shows that hospital usage has increased by 6.3 % over the last five years, despite widespread availability of local and national antibiotic prescribing recommendations [9]. This suggests that prescribing guidelines alone are insufficient to change practice and reduce the problem of AMR.

The need for well-designed antimicrobial stewardship (AMS) interventions has never been more critical. The Medical Research Council has long advocated the importance of identifying theory to understand the likely causal processes of change before undertaking the intervention effectiveness stage [10]. The assessment of the likely barriers and facilitators to inform the selection of intervention components is key to that process. However, systematic reviews of strategies employed to reduce inappropriate antibiotic use in hospitals have shown that behavioural and social influences remain underutilised in designing and evaluating AMS interventions [11]. The existing hospital AMS initiatives are not contextually designed or implemented with end-users of different specialties in mind [12]. As the majority of hospital antibiotic prescribing is currently performed by doctors, an in-depth exploration of the determinants that drive their behaviour within that context is crucial to changing that behaviour and enhancing the chances of planned interventions working in a real-world setting [13].

Although a recent Cochrane review provided recommendations on the effectiveness and safety of interventions to improve antibiotic prescribing to hospital inpatients [8], there remains a gap in the evidence-base on what behaviour change strategies work in hospitals, how to implement them and what refinements are needed to tailor the interventions to local contexts [14]. An exploration of the wide-ranging contextual, organisational and interpersonal determinants in antibiotic decision-making and their influence on different groups of prescribers has not received adequate attention.

The Cochrane Qualitative Implementation and Methods Group has increasingly recognised the importance of including qualitative findings within evidence-based healthcare research [15]. Qualitative research is particularly valuable in providing detailed descriptions of human thinking and behaviour in the contexts in which it occurs and capturing the depth and richness of people`s views and experiences of, for example, delivering or receiving health interventions [16]. To date, some related qualitative syntheses have been conducted, such as in prescribing for respiratory infections in general practice [17] and in hospitals globally, including different groups of prescribers [18]. There is a large body of qualitative studies exploring hospital doctors` antibiotic prescribing experiences, but this has not yet been systematically searched for and integrated within a robust qualitative synthesis. Yet, such research would enable knowledge gained from these hospital doctors' insights to generate new, clinically applicable theory to inform development of a much needed future behaviour change intervention.

Methods

This study aimed to identify and synthesise qualitative research reporting doctors` views and experiences of the barriers and facilitators to appropriate antibiotic prescribing in acute hospitals and develop a conceptual model identifying how different pressures and dilemmas influence prescribing behaviour. Appropriate antibiotic prescribing was defined as the practice of initiation, monitoring, review and discontinuation of antibiotic therapy concordant with best practice such as guidelines.

Study design

There are various methods for synthesising qualitative research [19]. Noblit and Hare's meta-ethnography (ME) is an interpretive method widely used in health research as it systematically analyses multiple primary studies to go `beyond` their participant and author findings to generate new conceptual models or theories through translation of original study findings reciprocally (accounts across studies are comparable) and refutationally (accounts contradict one another) to create a line-of-argument synthesis (where accounts can be drawn together in a new higher-level interpretation) [20, 21].

ME consists of seven overlapping phases: getting started; deciding what studies are relevant; reading studies; determining how studies relate; translating studies into one another; synthesising translations; and expressing the synthesis [21]. Reflecting the need for study transparency, ME methods and findings are reported according to the eMERGe guidance [22] and detailed in Additional file 1.

Phase 1 (getting started): ME was selected as the most suitable approach because of its ability to develop theory and/or conceptual understandings [21]. This approach was in line with this review's intention to identify components for a future antibiotic prescribing intervention. The study protocol was devised and registered with PROSPERO (CRD42017073740). Ethical approval was not required.

Search methods and study selection

To help identify relevant studies (Phase 2), we used the SPIDER tool (Table 1) which facilitates searching of qualitative and mixed-method studies [23]. Our detailed search strategy is provided in Additional file 1. We systematically searched 20 electronic databases, including: EMBASE, MEDLINE, PubMed, ScienceDirect, Web of Science and ZETOC from 2007 to 2017. To maximise return, extensive search terminology and relevant synonyms were used, including medical subject headings (MeSH), supplemented by free-text and broad-based terms.

Identification of qualitative research through electronic databases is challenging [24] so, the online search was supplemented with other methods, including hand-searching of relevant publications, reference screening and citation searching of relevant reviews and included studies. Grey literature sources were searched for, including government reports, audits, conference proceedings and doctoral theses. Potential items for the ME were screened initially by title and abstract and then full text against our inclusion criteria (Table 2) by two reviewers (GW and CM) working independently and then comparing outcomes. Any disagreements were referred to the full team for arbitration. Literature searching outcomes were reported using PRISMA (Fig. 1).

Quality appraisal

Phase 3 (reading included studies): each full-text article was read and re-read. Quality appraisal was conducted by two independent reviewers (GW and CM) based on the Critical Appraisal Skills Programme (CASP) assessment tool, which has been widely used in ME [25, 26]. Quality appraisal is not essential for ME, but it supports close reading of studies and helps assess each study's contribution to the final synthesis [20].

Data reporting original participant quotes (first-order) and author interpretations of participant data (second-order) were extracted separately into NVivo v11 software. ME requires rich data for synthesis. If extraction revealed a lack of data, for example, few participant quotes, original authors were contacted for further data. If no further information was available, studies meeting our inclusion criteria but lacking data of suitable depth for synthesis were excluded, PRISMA updated (Fig. 1), and such papers were retained for later reflection (Phase 6).

Analysis

We adopted Toye et al.`s categorisation approach [27], including identifying concepts from qualitative studies,

Table 1 Search terms identified using the SPIDER tool [23]

Sample (hospital clinicians)	Doctor* OR physician* OR clinician* OR medical staff OR health personnel
Phenomenon of **I**nterest (antibiotic prescribing in acute hospitals)	Antibiotic prescribing OR overprescribing OR misuse OR overuse OR antibiotic stewardship OR resistance OR guideline adherence OR decision-making OR practice behaviour AND hospital* OR acute care OR hospital ward
Design/ **E**valuation/ **R**esearch type (*qualitative)	Qualitative OR focus group* OR interview* OR ethnograph* OR observation*

See Additional file 1 for Hybrid Qualitative Filters

grouping concepts into higher conceptual categories, further re-grouping categories into overarching themes and, developing a line-of-argument that makes sense of the themes. Through constant comparison, studies were first related by findings (Phase 4) to identify ‘concepts’ (key metaphors, phrases and meaningful ideas), the raw data of ME [26], to see how studies compared or not. This was done using the first- and second-order data extracted into NVivo and then organised using Microsoft Excel spreadsheets. As the papers were re-read, additional ideas that arose were noted. Studies were initially grouped by their primary thematic focus into two clusters and then data across the studies were ordered into larger related categories. Continual reference throughout to original studies and conservation of their unique language/terms was critical. The balancing of the developed inter-related larger categories and understanding the way they are influenced by other factors was central to translating the studies into one another, the next stage of ME.

Phase 4 seamlessly led into the analytical process of study translation (Phase 5). Through discussion, similar reported concepts were merged and collapsed into higher conceptual categories pertaining to the same aspects of antibiotic prescribing. First- and second-order constructs (participants` quotes and authors` interpretations) in each study were continuously compared with those in other studies. We used a `hands on` approach, drawing arrows, lines, creating concept maps and matrices. This process was idiomatic and carried out chronologically, starting from the earliest publication. We compared key concepts from paper one with paper two, synthesised them and compared the outcome with paper three, and so on. The interpretations and explanations provided by the original study authors were subsequently compared and translated across papers to achieve a synthesis. Translation of findings was reciprocal where similar concepts (albeit expressed differently) were drawn together and refutational, where contradictory or disconfirming concepts were noted. Where differences were noted, for example, if a study reported different concepts from the others, we returned to full text papers to understand its context, such as whether participants were in a different setting or of different gender. The expanded groupings were then refined and re-arranged for two clusters of studies, first separately and then drawn together until they were considered to explicitly and precisely reflect the synthesised findings. This process enabled us to `go beyond` findings from individual studies, from simple descriptions of the data to developing third-order interpretations [28]. Translation led to the development of overarching themes.

Phase 5 merged into Phase 6 (synthesis of translations), whereby through reflection and discussion we went over and above the developed themes to create a new line-of-argument (LOA), that is our ‘third-order constructs interpretation’, a picture of the findings built on the individual parts of studies [20]. Findings generated during the translation, created spreadsheets, data matrices and our explanations and interpretations provided the foundation for higher analysis. Themes were brought together and matched against original author

Table 2 Study inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
• Primary research studies reporting doctors` views and experiences of antimicrobial prescribing in acute hospital settings, including adult and paediatrics • Used qualitative methods of data collection (e.g., interviews, focus groups) and inductive analysis (e.g., grounded theory, phenomenological analysis) • Mixed-methods studies only if the qualitative data are discreet and findings reported adequately • Studies carried out in countries considered to have a developed healthcare system according to international classification • Published in English language between 2007 and 2017	• Primary research reporting doctors` views and experiences of prescribing other treatments or other aspects of prescribing e.g., costs, effectiveness. • Research on prescribing antibiotics in other settings e.g., primary care or residential settings • Studies conducted in countries not considered to have a developed health care system[a] • Sample including prescribers other than acute hospital doctors e.g., general practitioners or nurses • Studies that did not report primary qualitative data collection and analyses e.g., quantitative research, descriptive case studies, commentaries, editorials, reviews. Mixed-methods studies where qualitative data were not reported separately

See Additional file 1for full definitions

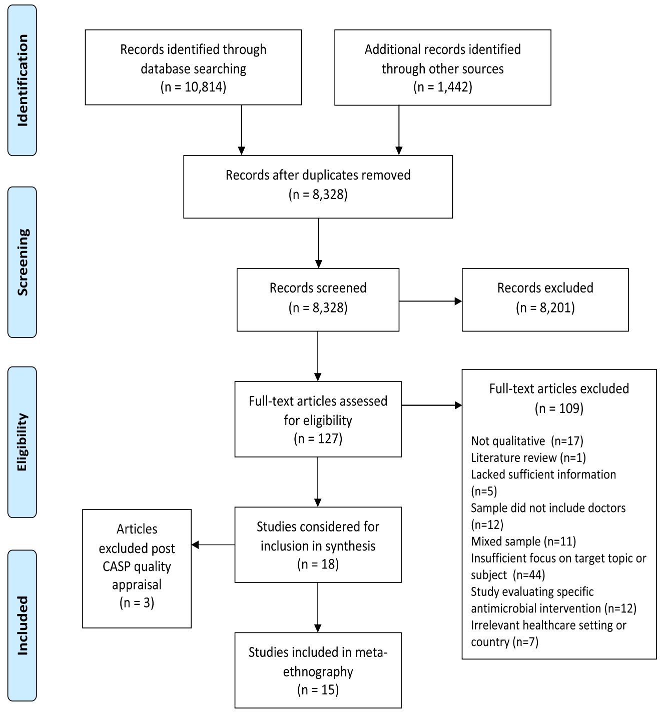

Fig. 1 PRISMA diagram [see Additional file 1 for more details]

interpretations and participant quotes from each study to create a new LOA.

Reflection is critical in ME and this was achieved in three ways [26]: team discussions to check accuracy and emerging findings/perspectives; three group consultations across the study with key stakeholders (professionals involved in hospital antimicrobial stewardship and health service users) and, comparing our LOA with findings in studies excluded following quality appraisal to determine whether their inclusion would have altered our final synthesis. Overall, these processes enabled us to reflect on and refine our LOA and propose a new conceptual model of the multi-dimensional nature of medical antibiotic prescribing which we then expressed in our synthesis findings using narrative and visual representation (Phase 7).

Results

Overall, 12,256 possible references were identified (Fig. 1). Eighteen qualitative papers met our inclusion criteria. Following quality appraisal (Table 3), three papers were excluded due to low quality of their reporting [29–31]. Fifteen papers reporting findings from thirteen studies were finally included in the synthesis [32–46].

The included studies were from seven countries across three continents: Australia [34, 42, 45, 46], USA [36–38] and Europe, including the UK [35, 40, 41, 44], Belgium [32], Sweden [33], Switzerland [43] and Norway [39]. Studies were conducted in 43 acute hospitals, including regional, metropolitan, tertiary and secondary care. All included studies involved research carried out in public hospitals and four papers drew the sample from a mix of hospitals (i.e., public, private and federal) [36–39]. Thirteen papers described the hospitals as teaching [32, 35–37, 39–46]. The studies reported the experience of 336 doctors practising across various disciplines from a range of medical and surgical fields. All except three studies [36, 43, 44] provided gender information that included 274 participants, from which 106 (39 %) were women. Not all authors provided details of their study context (i.e., hospital type) and it was not always possible to determine participants` ethnicity, specialty, length of clinical experience, and exact area of medical expertise. Most studies specified participants` level of experience representing a range of seniority ($n = 14$), whilst one study focused specifically on junior (foundation year) doctors [35]. The age of participants ranged between 20 [35] and 70 years [33].

Sample size varied considerably, from 10 [46] to 64 doctors [45]. Data were collected using individual interviews ($n = 13$) [33–35, 37–46], focus groups ($n = 1$) [32] and a mixed-methods approach comprising an online survey and semi-structured interviews followed by an observational study ($n = 1$) [36]. Overall, the studies had an acceptable methodological quality. However, most studies neglected the value of reflexivity ($n = 12$), with only three studies reporting how the authors` social background, location, role, and assumptions may have affected the research process and findings [39, 44, 46].

Characteristics of the 15 papers, including author, year of publication, country/setting, study focus, population, data collection, analytic approach and key findings, are detailed in Table 4.

Studies related (Phase 4) by their focus into two clusters:

- Cluster A – studies that focused on the adherence to antimicrobial guidelines, including the barriers and enablers to uptake and the suboptimal use [32, 38, 46].
- Cluster B - studies describing the experience of antibiotic prescribing with differing levels of emphasis placed on the influences on the prescribers` behaviour, ranging from the drivers of antibiotics prescribing, clinical decision-making to awareness of AMR [33–37, 39–45].

Across clusters A and B, 142 concepts emerged with the resulting 17 higher conceptual categories (HCCs) or `piles` that shared meaning. The reported concepts within each conceptual category are detailed in Additional file 2. From these concepts and HCC, four overarching themes were identified during study translation (Phase 5): (1) Loss of ownership of prescribing decisions, (2) Tension between individual care and broader public health concerns, (3) Evidence-based practice versus bedside medicine, and (4) Diverse priorities between different clinical teams. Themes 1–3 were derived from reciprocal translation (findings were compatible). Theme 4 arose from refutational analysis when it was noted that some translated findings described alternative dissonant perspectives of the same phenomenon. Themes are presented below with narrative exemplars in Additional file 3.

`Loss of ownership of prescribing decisions`

Many hospital healthcare professionals have a role in antimicrobial stewardship but overall responsibility for antibiotic decisions lies with prescribing clinicians. Many decisions are made by senior clinicians and then enacted by junior doctors. However, during nights and weekends, this arrangement shifts, and junior doctors are often expected to manage complex cases alone and make decisions to prescribe antibiotics on behalf of their senior colleagues, with limited support and feedback available at the time [34–40, 42, 44, 46].

When care delivery happens 'out-of-hours', the allocation of prescribing responsibility becomes ambiguous. Although junior doctors are expected to initiate or escalate antibiotics, they are hesitant to question or change decisions of their senior colleagues consequently reporting feelings of disempowerment [35, 41, 42, 44]. De-escalating or stopping treatments is considered a senior medical decision-maker role as this requires professional confidence and experienced clinical judgement. Making an independent clinical judgement is viewed by less experienced doctors as unrealistic, or `*something of a dark art'* [42], highlighting variation in the perceived responsibility for prescribing decisions.

Patients transitioning between hospital wards means that the provision of care takes place in multiple hospital locations and across various professional groups, adding to the complexity. Doctors` rotations, rapid ward rounds, numbers of staff delivering care and patients being cared for `remotely` from their primary medical team compounds the problem, leading to frustration, anxiety and ultimately distancing from engaging with decision-making [33, 35–37, 39, 40, 43, 44]. Lack of awareness of what ultimately happens to the patient and whether the prescribed antibiotic therapy was the correct choice for the patient denies junior doctors the opportunity to learn from occasions when their prescribing decisions had been over-ruled or changed.

There was also a concern that some information handed over to the next shift (or clinical area) is not always acted on and prescribed antibiotics are not reviewed by the subsequent clinical team taking over a patient's care. Fast-paced clinical environments, error-prone handovers, disjointed information, and cumbersome IT systems present further challenges [32–37, 39, 40, 42–44, 46]. Three studies highlighted that poor documentation of decisions and inconsistencies in monitoring and treatment plans compounded the problem and created a sense of anonymity or `invisibility` of decisions [35, 41, 44]. When reasons for antibiotic prescriptions in clinical patient notes are not documented, clear or easy-to-find, clinicians have to guess whether initial decisions regarding antibiotic choice and rationale was accurate and justified. This incomplete patient

Table 3 CASP Quality Appraisal

Paper	Decision to retain for Phases 4–6	1. Clear research aims		2. Qualitative methodology appropriate		3. Research design		4. Recruitment strategy		5. Data Collection		6. Reflexivity		7. Ethical Issues		8. Data Analysis		9. Findings		10. Research Value	
		R1	R2	R1	R2	R1	R2	R1	R2	R1	R1	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
Almatar et a.l 2014 [29]	✗	Yes	Yes	Yes	Yes	P	Yes	P	Yes	Yes	Yes	No	No	Yes	Yes	U	U	Yes	Yes	P	Yes
Almatar 2015 [30]	✗	This is a thesis and is a copy of the above study [29].																			
Barlow et al. 2008 [31]	✗	P	P	P	Yes	P	P	Yes	Yes	P	Yes	No	No	P	P	No	No	P	Yes	P	P
Cortoos et al. 2008 [32]	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	P	P	P	Yes	Yes	Yes	Yes	Yes	Yes
Bjorkman et al. 2010 [33]	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	P	P	P	P	P	Yes	P	P
Broom et al. 2014 [34]	✓	P	P	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	P	P	P	P	Yes	Yes	Yes	Yes	Yes	Yes
Mattick et al. 2014 [35]	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	P	P	P	Yes	Yes	Yes	Yes	Yes	Yes	Yes
May et al. 2014 [36]	✓	Yes	Yes	Yes	Yes	P	Yes	Yes	Yes	P	P	No	No	P	P	U	U	Yes	Yes	Yes	Yes
Livorsi et al. 2015 [37]	✓	Yes	Yes	Yes	Yes	P	Yes	P	P	Yes	Yes	No	P	P	Yes	Yes	Yes	Yes	Yes	P	Yes
Livorsi et al. 2016 [38]	✓	Yes	Yes	Yes	Yes	Yes	Yes	P	P	P	P	P	P	P	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Skodvin et al. 2015 [39]	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	P	P	Yes	P	Yes	Yes	Yes	P	P
Broom et al. 2016a [40]	✓	Yes	Yes	Yes	Yes	Yes	Yes	P	P	Yes	Yes	P	P	P	P	P	Yes	Yes	Yes	Yes	Yes
Broom et al. 2016b [41]	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	P	P	No	P	P	P	Yes	Yes	Yes	Yes	Yes	Yes
Broom et al. 2016c [42]	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	P	P	Yes	Yes	Yes	Yes	Yes	Yes
Eyer et al. 2016 [43]	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	P	P	No	P	P	P	Yes	Yes	Yes	Yes	Yes	Yes
Rawson et al. 2016 [44]	✓	Yes	Yes	Yes	Yes	P	P	Yes	Yes	P	P	Yes	P	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Broom et al. 2017 [45]	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	P	P	Yes	Yes	Yes	Yes	Yes	Yes
Sedrak et al. 2017 [46]	✓	Yes	Yes	Yes	Yes	P	Yes	Yes	Yes	P	Yes	Yes	P	P	Yes	P	P	Yes	Yes	Yes	Yes

Key: R1 – reviewer 1; R2 – reviewer 2
Individual decisions: *P:* Partially, *U:* Unable to determine

Table 4 Summary of qualitative papers included in the synthesis

Study	Aim(s)	Sample	Data collection & analysis	Key findings
Cortoos et al. 2008 [32]	To determine the opinions and problems concerning the use of a local antibiotic hospital guideline.	1 public tertiary care university teaching hospital	Focus Groups	7 themes reported:
Belgium		22 physicians from internal medicine (7 residents/ 6 staff) and surgery (6 residents/ 3 staff). Ages: 26-60, 5 females/17 males.	Framework Analysis	General attitudes and guideline interpretation; guideline familiarity and awareness; guideline contents and agreement; social influence; multidisciplinary approach, organizational constraints; attitudes about specific interventions.
Bjorkman et al. 2010 [33]	To explore and describe perceptions of antibiotic prescribing among Swedish hospital physicians.	7 acute public hospitals	Semi-structured Interviews	5 main categories of perceptions of hospital antibiotic prescribing and AMR:
Sweden		20 hospital physicians (5 urology physicians, 5 from surgery, 10 from internal medicine). Ages: 31-70, 5 females/15 males.	Phenomenographic Analysis	Prefer "effective" treatment; too uncertain to be restrictive; stuck in the healthcare system; aware and restrictive, but support required; aware, interested and competent.
Broom et al. 2014 [34]	To investigate the experiences of doctors who prescribe antibiotics.	1 acute regional public hospital	Semi-structured Interviews	6 main themes reported:
Australia		30 doctors from: emergency medicine (3), general medicine (4), geriatrics (3), intensive care (2), obstetrics and gynaecology (3), oncology (2), orthopaedics (2), paediatrics (1), renal medicine (2), sexual health (1), surgery (2), urology (1) and infectious diseases (4). House officers (4), registrars (7), advanced trainees (2), consultants/ staff specialists (11), consultants/ senior staff specialists (5). 9 females/21 males.	Thematic Analysis	Everyday sensitivity toward resistance; risk, fear and uncertainty; time, pressure and uncertainty; benevolence and the emotional prerogative; habitus and the internalisation of peer practice norms; hierarchies and the localisation of antibiotic prescribing.
Mattick et al. 2014 [35]	To explore the antimicrobial prescribing experiences of foundation year (FY) doctors.	2 public secondary care teaching hospitals	Narrative Interviews	6 overarching themes reported:
UK (England & Scotland)		33 junior doctors (21 FY1 and 12 FY2) working in medical and surgical wards. Ages: 20-35, 18 females/15 males	Framework Analysis	Personal incident narratives about antimicrobial prescribing; antimicrobial prescribing experiences; systems issues; working relations; educational experiences and needs; process-related data.
May et al. 2014 [36]	To explore current practices and decision-making regarding antimicrobial prescribing among Emergency Department (ED) clinical clinicians.	8 acute hospitals, including: 5 private (2 tertiary care and 3 tertiary academic centres), 2 federal and 1 public	Semi-structured Interviews (mixed-methods study)	5 overarching themes reported:
USA		21 clinicians (attending physicians, residents, and mid-level clinicians with at least 2 years of ED experience). No gender documented.	Thematic Analysis	Resource and environmental factors that affect care; access to and quality of care received outside of the ED consult; patient-provider relationship; clinical inertia; local knowledge generation
Livorsi et al. 2015 [37]	To understand the professional and psychological factors that influence physician antibiotic prescribing habits in the inpatient setting.	2 acute teaching hospitals (1 public tertiary care and 1 federal)	Semi-structured Interviews	4 themes reported:
USA		30 inpatient physicians: 10 physicians-in-training (8 internal medicine, 2 internal medicine/ paediatrics) & 20 supervisory staff (17	Thematic Analysis	Antibiotic over-use is recognised but generally accepted; the potential adverse effects of antibiotics have a limited influence

Table 4 Summary of qualitative papers included in the synthesis *(Continued)*

Study	Aim(s)	Sample	Data collection & analysis	Key findings
		hospital medicine, 3 pulmonary/ critical care). 10 female/20 males		on physicians' decision-making; physicians-in-training are strongly influenced by the antibiotic prescribing behaviour of their supervisors; reluctance to provide critique, feedback or advice.
Livorsi et al. 2016 [38]	To assess physician knowledge and acceptance of antibiotic-prescribing guidelines through the use of case vignettes.	2 acute teaching hospitals (1 public tertiary care and 1 federal)	Semi-structured Interviews	3 major themes reported:
USA		30 inpatient physicians: 10 physicians-in-training (8 internal medicine, 2 internal medicine/ paediatrics) & 20 supervisory staff (17 hospital medicine, 3 pulmonary/ critical care). 10 female/20 males	Thematic Analysis	Lack of awareness of specific guideline recommendations; tension between adhering to guidelines and the desire to individualise patient care; scepticism of certain guideline recommendations.
Skodvin et al. 2015 [39]	To investigate factors influencing antimicrobial prescribing practices among hospital doctors.	12 public and 1 private hospitals (3 teaching and 10 non-teaching)	Semi-structured Interviews	6 major themes reported:
Norway		15 doctors from five major medical fields (internal medicine (4), surgery (4), infectious diseases specialists (2), other medical field: oncology, neurology and intensive care), Interns/residents/consultants 2/5/8. Ages: 25-65, 8 females/7 males.	Thematic Analysis	Colleagues; microbiology; national guideline; training; patient assessment; leadership.
Broom et al. 2016a [40]	To identify why inappropriate prescribing trends continue.	1 public teaching hospital	Semi-structured Interviews	3 major themes reported:
UK		20 doctors: 8 consultant, 12 non-consultants from medical (15) and surgical specialty (5). 9 females /11 males.	Framework Analysis	Consumerism and complaints culture; priorities, team dynamics and the medical hierarchy; mythical properties of intravenous antibiotics.
Broom et al. 2016b [41]	To explore doctors' experiences of antibiotic prescribing, and the role of social and institutional factors in influencing the decision-making process.	1 public teaching hospital	Semi-structured Interviews	3 major themes reported:
UK		20 doctors: 8 consultant, 12 non-consultants from medical (15) and surgical specialty (5). 9 females /11 males.	Framework Analysis	Negotiating multiple masters; junior doctors 'stuck in the middle' between infectious diseases, clinical microbiology and their supervising team; the dynamics of laboratory vs clinical medicine; the transmission of habit: evidence confronts mentoring, anecdote and experiential learning.
Broom et al. 2016c [42]	To explore the potential social dynamics underpinning doctors' antibiotic use and infection management practices.	1 public regional teaching hospital	Semi-structured Interviews	4 main themes reported:
Australia		30 doctors from emergency medicine (3), general medicine (4), geriatrics (3), intensive care (2), obstetrics and gynaecology (3), oncology (2), orthopaedics (2), paediatrics (1), renal medicine (2), sexual health (1), surgery (2), urology (1) and infectious diseases (4). Sample included house officers, registrars, advanced trainees, consultants/staff specialists and consultants/senior staff specialists.	Thematic Analysis	Contesting 'best' practice: risk and ambivalence; 'fear of losing them' and the role of patient vulnerability; intra-professional and workplace context; 'craft groups' and the perpetuation of localised norms.

Table 4 Summary of qualitative papers included in the synthesis *(Continued)*

Study	Aim(s)	Sample	Data collection & analysis	Key findings
		9 females /21 males.		
Eyer et al. 2016 [43]	To determine reasons for using antibiotics to treat asymptomatic bacteruria in the absence of a treatment indication.	1 public tertiary care university teaching hospital	Semi-structured Interviews	5 main themes reported:
Switzerland		21 general medicine physicians: 12 residents/9 senior physicians.	Thematic Analysis	Treatment of laboratory results without considering the clinical picture; physician-centred factors; external factors; lack of attention to detail or analytical thinking, particularly under time constraints; overtreatment due to trivialization of urinary tract infection.
		No gender documented.		
Rawson et al. 2016 [44]	To map out and compare the decision-making processes employed for acute infection management on the hospital wards by non-infection medical specialties and explore any factors that influenced this process.	3 public university teaching hospitals (mix of secondary and tertiary care providers)	Semi-structured Interviews	3 overarching themes reported:
UK		20 physicians (9 consultants, 4 registrars, 2 trainees, 5 junior doctors) from non-infection medical specialties (general internal medicine, such as cardiology, respiratory, and geriatric medicine) and augmented care specialties (haematology and nephrology).	Grounded Theory	Mapping the decision-making process; factors influencing the decision-making process; windows of influence on decision making.
		No gender documented.		
Broom et al. 2017 [45]	To examine how hospital doctors balance competing concerns around antibiotic use and resistance.	2 acute public teaching hospitals (1 regional and 1 metropolitan)	Semi-structured Interviews	2 key themes:
Australia		64 doctors from anaesthetics, emergency, geriatrics, gynaecology, haematology, ICU, infectious diseases, nephrology, oncology, orthopaedics, paediatrics, palliative care, respiratory, sexual health, and surgery.	Framework Analysis	The significance of resistance for the hospital and the role of doctor in perpetuating resistance; overprescribing; easier and without perceived immediate risk.
		27 junior doctors, 37consultants.		
		28 females/36 males.		
Sedrak et al. 2017 [46]	To elucidate potential barriers and enablers to the adherence to antibiotic guidelines by clinicians treating community-acquired pneumonia.	1 public tertiary teaching hospital	Semi-structured Interviews	3 main categories reported:
Australia		10 clinicians from emergency medicine (4), general medicine (4) and infectious disease (2). 5 registrars and 5 consultants.	Thematic Analysis	Knowledge, including familiarity with guidelines; attitudes, including confidence in antibiotic guidelines; behaviour, including documentation and communication, experience and clinical judgement.
		5 females/5 males.		

information impacts on clinicians` ability to take ownership of antibiotic prescribing decisions.

`Tension between individual care and broader public health concerns`

In uncertain clinical situations, doctors must make decisions in the presence of multiple and often conflicting objectives. While the ethical principle of a `*good doctor*` is to make decisions based on what is best for the individual patient [34], at the same time, clinicians have a responsibility to consider population-level consequences of overprescribing. On one hand, antibiotic overprescribing is recognised as a serious global concern but, on the other hand, not treating an infection may lead to serious patient complications, even death [33, 34, 37, 40, 42–45], and loss of professional reputation. The abstract reality of future AMR causes internal conflict for the treating clinician facing the concrete reality of the 'here and now' - the patient`s clinical status and perhaps pressure from family and patients to 'do something'. The short-term individual costs (for patients and professionals) have to be constantly weighed up against longer-terms societal gains.

Although clinicians consider AMR and its potentially severe consequences when choosing treatment, the threat of resistance is generally perceived to be a distant or not immediate issue [33, 34, 37, 42, 45]. With the exception of clinicians working within infectious diseases and microbiology departments [33], most participants appeared to downgrade the importance of the problem and its potentially devastating consequences during their prescribing decision-making process. Long-term effects of resistance at the wider community-level are not prioritised, and some degree of overuse of antibiotics to manage immediate patient risks is considered to be allowed and socially acceptable [33, 34, 37, 40, 45].

The risks of over-prescribing to the individual patient tend to be disregarded [45]. Some clinicians consider antibiotics a *`peripheral thing'*, of *`limited concern`* [34] with the threat of AMR as a theoretical problem, which is morally and professionally important but not necessarily practical [33, 37, 40, 42, 45]. Recognition that individual practice contributes to the emergence of AMR is generally low and some clinicians are *`desensitised`* to the problem [45]. Absence of feedback on juniors` antibiotic prescribing limits the opportunity to identify reasons for the knowledge deficits and improve prescribing practice.

`Evidence-based practice versus bedside medicine`

Internal reasoning, or the way clinicians make sense of their decisions, plays a significant role in antibiotic prescribing. Prescribing behaviour, which may at first appear as `non-rational` or at odds with the evidence, is in fact a realistic and logical choice at the bedside, where positive patient outcomes, maintaining professional reputation and approval from supervisors take a priority [33–37, 41–45]. The health of individual patients lies at the core of medical professionalism and forms part of their professional identity. Being seen by the patient and/or relatives to be *`doing good`* drives clinicians to prescribe antibiotics for their patient regardless of whether it is evidence-based or not [44]. This internalised logic of over-prescribing is driven by the desire to improve patient condition(s) or at least provide a *`beacon of hope`* [43]. This rationale interplays with the expectations of never missing a diagnosis. Prescribing antibiotic treatment is seen a confirmation that *`at least something has been done`* [38].

In busy hospital environments, professional competence is being constantly evaluated. Decisions about whether to prescribe antibiotics are heavily influenced by fear of consequences for prescribers. Missing a potentially treatable infection could result in serious patient harm. Administering antibiotics or prolonging their use creates a perception of an emotional safety net [33, 34, 36–40, 42–46]. Although experience helps to identify and treat the severely ill patients, *`erring on the side of caution`* and prescribing antibiotics *`just in case`* provides reassurance and is therefore the default option irrespective of grade or experience [37].

Junior doctors report experiences of being criticised and seen by colleagues as incompetent when deciding not to treat [35, 37, 40, 42, 45]; in contrast, conservative antibiotic decision-making is rarely recognised as good practice [43]. Senior doctors' preferences, expectations and prescribing habits also influence junior doctors' prescribing decisions. Junior doctors risk facing social disapproval if their decision not to prescribe is at odds with the `social norms` of the hospital [34].

Patient demand, expectations of patients` families and the developing *`consumerism culture`* pose additional pressure [40], resulting in a low threshold for prescribing antibiotics, [33, 34, 36, 37, 39, 41–43, 45, 46]. Fear of patient complaints and of potential lawsuit drives clinicians to adopt defensive medicine approaches and prescribe broad-spectrum antibiotics unnecessarily, irrespective of the healthcare system they work in (public or private). However, external factors, such as patient access to care in the private health system, hinder doctors' ability to foster AMS. For instance, in the US, the emergency departments disproportionately provide care to low-income and uninsured patients [36]. As a result, doctors must not only account for the clinical scenario but also consider the patient's ability to obtain follow-up care.

Prescribing according to guidelines offers some reassurance and protection, provided these are evidence-based, up-to-date, easily available, and accessible and that doctors have time to consult them [32–34, 37–39, 41, 43, 44, 46]. Digressing from antibiotic guidelines is rationalised by the potential discrepancies between guidelines and practice. When the individual case of a patient does not `fit` readily into guidelines, clinical judgement must be applied [32, 35, 38, 41, 46].

`Diverse priorities between different clinical teams`

Multidisciplinary input is essential during hospital inpatient care. However, a multitude of experts are involved in patient care, with different tasks or interventions performed by different professionals, who may have different goals for the patient, which can result in variation of care, including antibiotic use. For instance, diverse priorities are evident in the weighting given to different phases of the antibiotic decision-making process between speciality groups. Despite a common overall approach, emergency department (ED) clinicians and surgical specialities emphasise immediate patient care and infection prevention including initiating antibiotics [32, 36, 40, 45, 46], whilst medical specialities focus on longer-term infection management concerns, including refining/reviewing of initial prescribing decisions and stopping antibiotics [41, 43, 44].

Heightened awareness of sepsis and associated risks and complications culminates in an urgency for surgeons and ED clinicians to commence antibiotics as soon as possible in anyone suspected of having an infection [36, 39]. By contrast, acute care medicine doctors report a common stepwise approach to the decision process surrounding acute infection management, whereby new information is constantly considered in the context of prior knowledge [44] and the use of microbiology test results when selecting antimicrobial therapy is emphasised. Within the same hospital, different clinical teams can have diverging opinions on, and requirements from, guideline content. For example, whilst surgical groups describe a strict interpretation of antibiotic guidelines [32], internal medicine doctors highlight that guidelines are incomplete by promoting a standardised, `one-size fits all` approach to antibiotic prescribing [36, 38, 39, 41, 44, 46].

Most clinicians (both genders, across settings and healthcare sectors) recognise the benefits of collaboration, including the availability of a second opinion in the treatment of infections and the support for the improved use of antibiotic prescribing guidelines. However, junior doctors experience difficulties in negotiating prescribing decisions with multiple authoritative figures from across various clinical teams [34, 35, 41, 44]. Effective collaboration and senior support were perceived by junior doctors as key facilitators in remedying deficiencies in practical knowledge of appropriate antibiotic prescribing [33–35, 38–40, 42–44].

Key professional collaborators identified in antibiotic prescribing were microbiology, infectious disease specialists and pharmacy. Infection diseases specialists were recognised as helping hospital doctors in AMR prevention by promoting and encouraging the use of guidelines and appropriate narrow-spectrum antimicrobials during handover meetings and ward rounds [33, 39]. Clinical microbiology colleagues were reported as acting as an important communication channel in infection management [35, 39, 44]. Medical doctors especially described their services and advice as valuable and convenient to access. Although these experts were generally highly approved across medical and surgical fields, the relationship with them varied significantly depending on individual clinicians` interest in infectious diseases [32, 33, 35, 41, 45].

The presence of ward clinical pharmacists generated conflicting opinions. Most clinicians from medical and surgical groups (mostly males representing different levels of seniority) described pharmacists as helpful in discussing and sharing rationales for antibiotic prescriptions and prompting antibiotic review and de-escalation [37, 40, 44]. However, they were perceived by some participants (mostly male physicians from internal medicine) as interference [32].

Line-of-argument synthesis

From translation of findings across the 15 studies, a new *line-of-argument* emerged. This final stage in the process of meta-ethnographic analysis (Phase 6) enabled us to develop a higher order interpretation, that is, to generate a conceptual model drawn from, `*but more than the sum of*`, the final themes [21]. Through team reflection and by revisiting the original studies, it gradually became apparent that the four overarching themes overlapped and a more complex nuanced interaction between two micro- and macro-level dimensions of hospital antibiotic prescribing emerged. These two dimensions constantly and simultaneously interacted with each other producing multiple tensions for prescribers and formed the basis for our conceptual model (Fig. 2).

The model illustrates the multidimensional nature of hospital antibiotic decision-making and reflects the array of pressures and dilemmas which need to be balanced by clinicians as they decide their prescribing action(s). This multidimensional nature of antibiotic decision-making describes a complex dynamic and for every clinician, there will be a degree of interdependence between different factors influencing prescribing practice, depending on their level of expertise and ability to tolerate risks for their patient and themselves. The illustrated elements, or factors, will form independent components on one level. However, they are not separate or discreet but constitute an integral part of a whole and will therefore exert a degree of direct or indirect influence on prescribing decisions. These elements coexist, interact, and create a constant dynamic. Both macro (wider social structures, including the norms, standards, social and organisational constraints for human behaviour) and micro (individual behaviours) dimensions feature a complex interplay of influence, authority, and the pursuit of treatment goals. The macro-level structures of hospitals provide the social and cultural setting for healthcare professionals to relate to each other, constantly shaping and influencing micro-level dimensions that drives individual behaviours and everyday practice.

This unique and evolving dynamic results in the creation of micro-structures of influence, such as internalised logic of prescribing that underpins antibiotic use and drives social interaction with colleagues and patients. An understanding of these contextual drivers of overuse on both macro- and micro-level is fundamental to the development of sustainable interventions to optimise antibiotic use by hospital doctors.

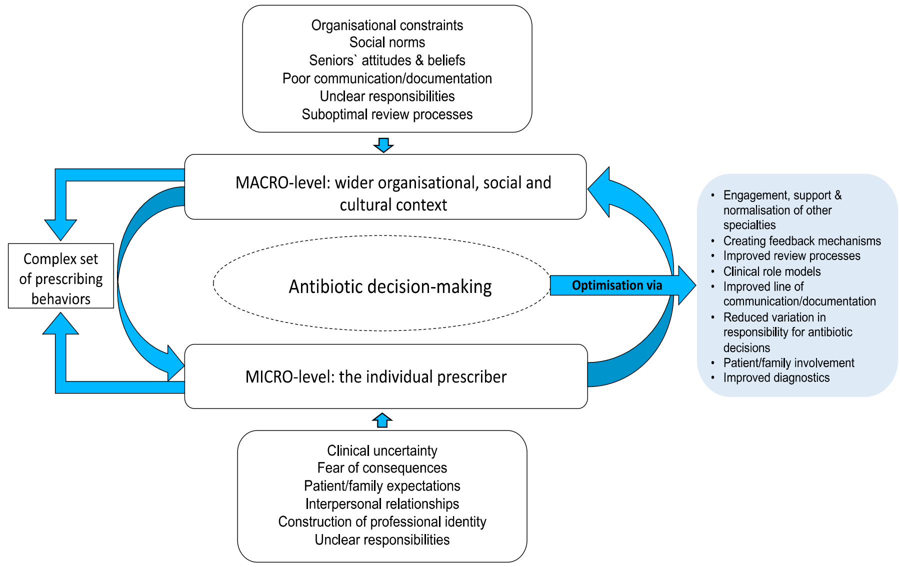

Fig. 2 Conceptual model depicting multidimensional nature of antibiotic prescribing in hospital settings

Discussion

This review is the first to apply an interpretive meta-ethnographic approach and propose a conceptual model to understand the nature of antibiotic prescribing in acute hospitals. The exploration of the challenges to appropriate prescribing in hospitals revealed tensions and uncertainties in antibiotic decision-making by prescribers that occur due to an array of complex organisational and cultural factors. Diversification of priorities between different specialties creates loopholes in the continuity of antibiotic care and treatment. Our review indicates that the transition of patients between wards, busy work environment, high workload, poor documentation and communication and reluctance of junior doctors to question senior colleagues contribute to the partial loss of ownership of antibiotic decisions.

The concept of antibiotic decision ownership does not appear to be highlighted by previous reviews of hospital antibiotic prescribing. It can be argued, however, that when health professionals have a sense of decision ownership, they become personally invested in clinical decisions made for their patients [47]. Although infection management and antibiotic decisions are inherently team-based and interprofessional in nature [48], findings from our ME show that stopping or de-escalating therapy is seen as the responsibility of the consultant or senior specialist. The disparity between expectations of junior clinicians to start but not review and/or stop antibiotics has been previously addressed in a realist review [49], which found that there is a lack of clarity around the specific roles and responsibilities that trainees undertake in relation to antimicrobial prescribing. Communicating an expectation for this group to gain active responsibility for prescribing decisions was suggested as a possible solution to overcome the issue. A recent observational study comparing antibiotic decision-making in acute medical and surgical specialties at a London teaching hospital found that the loss of ownership occurred in the transition of care between the emergency department and inpatient teams specifically [12]. Our ME findings confirm this is the case across different hospital settings and highlights the complexity that arises from each individual`s responsibility for the collective problem of antimicrobial resistance being blurred.

Furthermore, this review has identified inconsistencies in the provision of information between specialties and healthcare professionals. The healthcare system heavily relies on the patient medical records for communication, and safe, and effective care as patients move between wards and their care is handed over between different clinical teams and when staff shifts change. Despite international efforts suggesting that clear documentation of decisions is a key principle in advancing patient safety and improving outcomes [7], the findings show poor documentation of decisions leading to unnecessary continuation of antibiotics as clinicians lack adequate information to make an appropriate decision whether to stop, continue or switch the treatment.

Some studies included in the review appear to indicate that with uncertainty, when an infection is suspected but not proven, the treating clinician will balance immediate clinical risks over long-term population risk. Although commencing antibiotics may be beneficial to the individual, excessive use can increase future AMR and thus be detrimental to the society, a situation known as '*the tragedy of the commons*' [50]. Considering population implications of AMR within bedside antibiotic decisions was viewed by clinicians as difficult. To eliminate concrete clinical concerns, some clinicians will adopt their behaviour accordingly to the culturally accepted norms of the hospital and choose an activity that is perceived as low risk at an individual-level. This fear of consequences heightened by the perception that being conservative in prescribing is not seen as good practice will often lead to prescribing outside of clinical guidelines (either broader spectrum or for longer duration than is clinically indicated), without any clinical benefit to individual patients [18]. Driven by fear of patient deteriorating, an individual`s capacity to adhere to evidence-based practice may be diminished and antibiotic optimisation becomes an absent priority, whilst the risks of over-prescribing to the individual patient tend to be downgraded. This dichotomy between the care recommended in the guidelines and the care provided at the bedside has been reported in earlier works as 'being on the safe side' [51].

The ME further highlights the interprofessional nature of antibiotic prescribing and the associated difficulties in negotiating decisions with multiple authoritative figures, including the immediate clinical team and other specialties. Discord in interpersonal relationships was an influencing factor on prescribing decisions, at times leading to poor continuity of care. Inconsistent advice and misunderstanding of roles and responsibilities pertaining to antibiotic decisions were additional barriers to successful collaboration. Challenging decisions of senior colleagues was perceived as unacceptable. The reluctance of junior doctors to question the prescribing decisions can act as an obstacle to gaining a clear understanding of why prescribing choices differ [49]. In such an environment, deferral to the opinion leaders can become the default mode of practice, suppressing valuable input from all members of the team. Yet, qualitative research suggests that doctors tend to feel drawn towards supportive teams and teachers who engage with or inspire them [52]. In environments where senior clinicians are approachable, trust in working relationships increases, allowing junior doctors to raise questions and thus close the communication gap [53, 54]. Examples of good practice included the presence of a clinical pharmacist, infectious disease and microbiology colleagues on the ward prompting the review of antibiotics and acting as effective communication channels.

A collaborative culture fostering a multidisciplinary approach and normalisation of the role of other specialists within the decision-making process are crucial to aid improvements to antimicrobial stewardship [55]. This review demonstrates that the involvement from other specialties in the decision-making depends on the familiarity and acceptance of those colleagues by the senior clinicians. Some junior doctors in these studies described managing interactions with other healthcare professionals as challenging. The `unspoken` yet widely accepted rules on how to manage multidisciplinary dynamics mean that doctors face difficulties steering through the complex system of interrelationships with colleagues that could potentially provide them with assistance. Yet, turning to other specialties for advice can be a source of support outside the scope of medical hierarchy and the immediate clinical team, as junior clinicians experience less fear of appearing ignorant and attracting criticism [56, 57].

Although literature is still lacking with regards to the contexts under which junior doctors feel more able to challenge decisions effectively, quantitative evidence shows that the provision of feedback on the quality of prescribing and direct interaction with prescribers appear to have the most lasting impact on practice [58, 59]. A recent Cochrane review on interventions to improve antimicrobial prescribing practices for hospital inpatients found that interventions that included feedback were more effective than those that did not [8]. Findings of the ME complement the review by showing that creating effective feedback mechanisms and improving communication on prescribing practice has a potential to elicit behavioural change.

In addition, endorsements for the greater integration of other prescribing groups, including pharmacists and nurse prescribers within antibiotic stewardship efforts have already been highlighted by others [60]. For example, lack of partnership with nurses can limit the success of antibiotic stewardship initiatives [61]. Yet, this ME identified an absence of perceived or reported nursing involvement in antibiotic decision-making. This may reflect perceptions about antibiotic prescribing as a process that requires increased knowledge only exclusive to medical professionals with prescribing powers [62], existing and gaps in undergraduate and postgraduate education about antibiotics and AMR [63]. Yet, it remains essential to maximise the contribution of the existing professionals outside infection disease and microbiology towards appropriate use of antimicrobials [64], especially in view of the new Nursing and Midwifery Council guidance highlighting that newly qualified nurses have to be prepared to undertake prescribing training soon after registration [65].

Lastly, antimicrobial prescribing behaviours may vary significantly across different hospital types and be influenced by the types of patients admitted, prescribing patterns and the resources available. For example, a previous study using data gathered from a nationwide survey highlighted major differences in the available resources and implementation of AMS programmes between public and private hospitals in Australia [66]. Moreover, significant differences in antibiotic use remain across different hospital types. In adjusted models, teaching hospitals were associated with lower use of third- and fourth-generation cephalosporins and anti-pseudomonal agents [67]. Although doctors working in private hospitals acknowledged treating more 'aggressively' with broader-spectrum antibiotics when patient follow-up was uncertain [36], no major sector-specific drivers of doctors` prescribing behaviour emerged in the synthesis. These findings suggest that antibiotic prescribing across different countries and healthcare systems may be influenced by a similar set of cultural factors [37]. However, given that most studies included in this synthesis were conducted in public teaching hospitals, such as in the UK, the developed model can only be claimed to be representative of that context.

Strengths and limitations

Locating suitable qualitative studies can be challenging [68] and small-scale qualitative research can be perceived as biased and lacking transferability [69]. However, the number of included studies in the synthesis ($n = 15$) from seven countries and reflecting a breadth of prescribing perspectives was sufficient for conducting ME [20]. The synthesis was carried out in a rigorous way including a large range of databases and grey literature, with continuous input from the experienced research team, undoubtedly reinforcing the credibility of the findings. All stages of the review were checked for accuracy and were grounded in the data by constantly checking the findings against the original studies.

The novelty of this ME is the generation of a higher translation that helps to understand the complexities of hospital antibiotic prescribing decision-making. Although the conceptual model cannot be claimed to be definitive and represent all healthcare practitioners, it offers a unique lens, through which the experiences of doctors can be considered. Meta-ethnography is an interpretative approach and the development of the conceptual model was informed by the review team`s backgrounds and perspectives. The team had considerable expertise in synthesising qualitative research, including experienced health professionals and social scientists with an interest and experience in developing behaviour-change interventions, but none were medical prescribers. GW had been previously involved in projects exploring hospital antibiotic stewardship, NR and BW have extensive experience in conducting ME and NR is a co-author of the eMERGe meta-ethnography reporting guidance. We conducted our research in close affiliation with an NHS hospital trust with advisory input from clinicians during the project. We acknowledge that a different team may have interpreted the included studies differently.

There is currently no gold standard of appraising qualitative studies and including studies with poorly reported methods could produce ME findings lacking credibility [26]. We conducted critical appraisal using the CASP tool, but a different approach of judging the 'weight of evidence' of each paper may have been justified. To be included in our synthesis, studies needed to meet a certain degree of methodological transparency. This decision was appropriate as there was a large number of methodologically transparent eligible studies that we could review, and which would enable us to rigorously develop new interpretations and an LOA. After creating our LOA we compared our interpretation and findings against the papers excluded following quality appraisal [29, 31]. This strategy ensured that important insights have not been missed, thus eliminating potential bias. One study raised an issue relating to senior doctors` perception that inappropriate antibiotic prescribing outside guideline recommendations originates with junior doctors [29]. Although this perception did not feature in our analysis, including this paper would not have changed the final synthesis. To enhance the quality of the ME, we updated our database searches in December 2020 and found five studies that met our inclusion criteria [12, 70–73]. However, on critically reading them, we believe that including these studies in our ME would have not refuted our findings but resulted in equivalent meaning.

Not all included studies reported details of participants` characteristics, including gender, ethnicity, level of training, length of experience, and some studies analysed data together for samples drawn from across different clinical settings and healthcare systems. Therefore, it was not always possible to fully identify disconfirming cases between papers or carry out a sub-analysis of different drivers of behaviour based on the sample characteristics and study context. Additionally, five included papers were published by the same researchers research team and although the authors explored prescribing practices in two different countries

(Australia and UK), the results may have inadvertently influenced our findings and synthesis [34, 40–42, 45].

The exclusion of studies describing views and experiences of healthcare professionals other than doctors, or where the study population included a mix of healthcare professionals may be contested and a more inclusive approach exploring more diverse perceptions across different clinical groups may have been warranted. However, given that the majority of antibiotics are prescribed by doctors, it was vital to first understand their views and experiences of prescribing practice. The decision was also made to exclude low-income countries to ensure that the theory generated from synthesising primary studies reflects the function of ME and is relevant to the context and setting of the planned antibiotic intervention, that is acute hospitals in well-developed healthcare systems. Including relatively homogenous studies helped strengthen the weight of the conceptual model.

Finally, to increase the credibility of the review and ensure that the breadth and scope of the data were captured in the synthesis, findings were critically reflected on through regular briefing sessions and workshops with key stakeholders (healthcare professionals involved in hospital antimicrobial stewardship and health service users), providing opportunities to develop and refine ideas and interpretations, and analysed using multiple theoretical perspectives. Although decontextualisation of qualitative findings can be debated [74], the quality and rigour of this review means that it is possible to apply the new conceptual model to a variety of clinical contexts and different groups of healthcare professionals.

Future practice and research implications

This ME highlights that there is a need to incorporate the influence of the micro- and macro-level elements in the design and delivery of future behavioural-change interventions to optimise antibiotic use in hospital settings. Addressing this complex interaction may be a contributing factor to finding future solutions to the ever-growing problem of AMR and reducing fear of consequences from non-prescribing or stopping antibiotics. Finding new ways of discussing and questioning prescribing decisions between and within clinical teams may be one strategy to mitigate the negative impact of the loss of ownership of decisions and reduce failures in the provision of adequate information. In clinical practice, the influence of senior colleagues could be harnessed by creating role models who act as custodians of professional agendas and create a supportive and open environment that fosters the culture of learning and feedback. The high-level findings presented in this analysis could be further developed for implementation in practice. The insights into ` doctors`conceptualisation of antibiotic use could also have implications for behavioural interventions in other settings, such as primary care or long-term facilities.

The findings in this study concerning the loss of decision ownership may be worth further empirical examination, with a large sample and across a diverse population. It is suggested that future research about promoting effective hospital antimicrobial stewardship focuses on exploring the idea of invisibility of prescribing decisions. Specifically, it would be of value to investigate the diversity of opinions around the roles and responsibilities junior prescribers should undertake in relation to antimicrobial prescribing and how to help overcome uncertainty and fear of consequences. Finding ways to communicate an expectation for this group may foster transfer of active responsibility down the hierarchy ladder. LastlyMoreover, there remains a gap in research concerning the contexts under which junior doctors feel more able to challenge seniors` decisions effectively. Lastly, identifying and comparing inter-hospital factors associated with inappropriate prescribing across different sectors (private vs. public, teaching vs. non-teaching) will help direct future AMS efforts in the specific settings. These areas warrant further investigation.

Conclusions

This novel ME extends the current evidence-base by providing an understanding of the complexities of hospital antibiotic prescribing. The resulting conceptual framework has the potential to act as the basis for future antibiotic management interventions, exploring clinicians` internal logic of antibiotic prescribing behaviours that goes beyond antimicrobial guidelines and evidence-based practice. Changing ingrained behaviours within a culture or an organisation is undeniably difficult. Yet, improving prescribing practices is essential to minimising the growing public health threat of AMR. It is particularly challenging in acute hospital settings due to the complex relationships between a wide range of stakeholders and multiple teams. Acknowledging this complexity and variability of the hospital contexts and recognising the norms and the ways in which doctors learn to practice will facilitate that change. Healthcare stakeholders can draw on this evidence of *how* and *why* doctors make prescribing decisions to help design and implement more effective antibiotic stewardship interventions in secondary care.

Finally, uncertainty is an unavoidable part of clinical practice and will inevitably persist across all spheres of medicine. Thus, the key dilemma for policymakers and healthcare providers is how to place a higher value on non-prescribing or prescribing narrow-spectrum antibiotics, when available and efficacious, and eliminate a degree of fear while making decisions under uncertain conditions. This ME highlights the need for a more collaborative culture fostering normalisation of the role of other specialists within the decision-making process. The quality of inter-professional relationships between clinicians remains key to achieving this change. Reclaiming the `why` may act as a positive force to shift the individual risk perceptions and have a positive knock-on effect on changing the culture to open collaboration. This shift will require engagement from senior colleagues, managers and opinion leaders to acknowledge the importance of maximising the explanatory knowledge acquisition.

Abbreviations

AMR: Antimicrobial resistance; AMS: Antimicrobial stewardship; CASP: Critical Appraisal Skills Programme; HCC: Higher conceptual category; LOA: Line-of-argument; ME: Meta-ethnography; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SPIDER: Sample, Phenomenon of Interest, Design, Evaluation, Research type; UK: United Kingdom; US: United States

Supplementary Information

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Additional file 1. Details of applied methodology as informed by the eMERGe meta-ethnography reporting guidance.

Additional file 2. Relating studies by reported concepts and developing higher conceptual categories (Phase 4).

Additional file 3. Key emerging themes with exemplar quotes.

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Authors' contributions

All authors made substantive contributions to the qualitative synthesis reported in this paper. GW and CM conducted the searches and the critical appraisal of included studies. GW, NR and KK provided critical input on the design and analysis of the ME and made substantive contributions to manuscript drafts. GW drafted the manuscript and all authors commented on drafts and approved the final manuscript.

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Availability of data and materials

This systematic review is based on an analysis of a number of published papers which are all referenced within this manuscript. Data supporting our findings is included in the form of the supplementary files listed below.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Appendix 15: The eMERGe meta-ethnography reporting guidance (France et al., 2019)

No.	Criteria Headings	Reporting Criteria	Reported on Page No.
Phase 1—Selecting meta-ethnography and getting started			
Introduction			
1	Rationale and context for the meta-ethnography	Describe the gap in research or knowledge to be filled by the meta-ethnography, and the wider context of the meta-ethnography.	68
2	Aim(s) of the meta-ethnography	Describe the meta-ethnography aim(s).	70
3	Focus of the meta-ethnography	Describe the meta-ethnography review question(s) (or objectives).	70
4	Rationale for using meta-ethnography	Explain why meta-ethnography was considered the most appropriate qualitative synthesis methodology.	70
Phase 2—Deciding what is relevant			
Methods			
5	Search strategy	Describe the rationale for the literature search strategy.	73
6	Search processes	Describe how the literature search was carried out and by whom.	76
7	Selecting primary studies	Describe the process of study screening and selection, and who was involved.	80
Findings			
8	Outcome of study selection	Describe the results of study searches and screening.	93
Phase 3—Reading included studies			
Methods			
9	Reading and data extraction approach	Describe the reading and data extraction method and processes.	81
Findings			
10	Presenting characteristics of included studies	Describe characteristics of the included studies.	95
Phase 4—Determining how studies are related			
Methods			
11	Process for determining how studies are related	Describe the methods and processes for determining how the included studies are related: - Which aspects of studies were compared. - How the studies were compared.	87
Findings			
12	Outcome of relating studies	Describe how studies relate to each other.	102
Phase 5—Translating studies into one another			
Methods			
13	Process of translating studies	Describe the methods of translation: - Describe steps taken to preserve the context and meaning of the relationships between concepts within and across studies.	89

		- Describe how the reciprocal and refutational translations were conducted. - Describe how potential alternative interpretations or explanations were considered in the translations.	
Findings			
14	Outcome of translation	Describe the interpretive findings of the translation.	107
Phase 6—Synthesizing translations			
Methods			
15	Synthesis process	Describe the methods used to develop overarching concepts ("synthesised translations"). Describe how potential alternative interpretations or explanations were considered in the synthesis.	91
Findings			
16	Outcome of synthesis process	Describe the new theory, conceptual framework, model, configuration, or interpretation of data developed from the synthesis.	124
Phase 7—Expressing the synthesis			
Discussion			
17	Summary of findings	Summarise the main interpretive findings of the translation and synthesis and compare them to existing literature.	127
18	Strengths, limitations, and reflexivity	Reflect on and describe the strengths and limitations of the synthesis: - Methodological aspects—for example, describe how the synthesis findings were influenced by the nature of the included studies and how the meta-ethnography was conducted. - Reflexivity—for example, the impact of the research team on the synthesis findings.	131
19	Recommendations and conclusions	Describe the implications of the synthesis.	134, 135

Appendix 16: Definitions of the key terms included in the meta-ethnography

KEY TERM	DEFINITION
Antibiotic	Any type of a therapeutic agents produced by an organism or made synthetically that selectively destroy or inhibit the growth of micro-organisms (Brunton et al., 2017). For simplicity, both terms '*antibiotics'* and '*antimicrobials'* were used interchangeably.
Antibiotic prescribing	Practice of antibiotic use, including initiation, monitoring, review and discontinuation (de-escalation) of antibiotic therapy.
Inappropriate *or* sub-optimal antibiotic prescribing	Practice not concordant with local or national guidelines, including: over-prescription (prescribing antibiotics when they are not clinically indicated, e.g. for viral illnesses); omission (when required antibiotics for certain infections are not prescribed); the use of inappropriate dosages (too high or too low); incorrect duration (too short or too long); incorrect selection (mismatch between organisms, for example, prescribing a potent broad-spectrum antibiotic when a lower-risk narrow-spectrum agent, which is equally or more effective for treating the same illness/disease, is available); and unnecessary risk (use of intravenous antibiotics when oral forms would be suitable) (Monnier et al., 2018).
Acute hospitals	Defined using the NHS Care Quality Commission definition and refers to hospitals that provide a wide range of specialist care and treatment for patients, including consultation with specialist clinicians (consultants, nurses, dieticians, physiotherapists and a wide range of other professionals); emergency treatment following accidents; routine, complex and life-saving surgery and specialist diagnostic, therapeutic and palliative procedures (Care Quality Commission, 2015). The types of acute hospitals considered were not restricted, and included both children and adult hospitals, and also private, government, university, teaching and tertiary hospitals.
Developed healthcare system	There are currently no standardised quality criteria against which the healthcare systems performance of countries can be assessed (Papanicolas et al., 2013). Therefore, for the purpose of this review, an approach employed by Charani et al. (2011) was used, which ranked healthcare systems performance using a set of global and the most up to date Organisation for Economic Co-operation and Development (OECD) and the World Health Organization (WHO) indicators and adjusted figures for the year 2016 (OECD, 2018; WHO, 2018). Using these indicators, countries were defined as having a developed healthcare system if their investment on these criteria was within 20% margin of the UK figure:

	• The total expenditure on health as % of GDP was equal to or greater than 7.84% (2016 UK figure 9.8%) • The per capita government spending on health was equal to or greater than $3,331 (2016 UK figure $4,164) • Life expectancy at birth was equal to or greater than 75 years of age • Infant mortality rate was less than 10 per 1000 births As a result, 18 countries were included: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Italy, Japan, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom and United States.

Appendix 17: Hybrid Qualitative Filters

Hybrid Filter for Ovid MEDLINE

1. Qualitative Research/
2. Interview/
3. (theme$ or thematic).mp.
4. qualitative.af.
5. Nursing Methodology Research/
7. ethnological research.mp.
8. ethnograph$.mp.
9. ethnonursing.af.
10. phenomenol$.af.
11. (grounded adj (theor$ or study or studies or research or analys?s)).af.
12. (life stor$).mp.
13. (emic or etic or hermeneutic$ or heuristic$ or semiotic$).af. or (data adj1 saturat$).tw. or participant observ$.tw.
14. (social construct$ or (postmodern$ or post-struc-tural$) or (post structural$ or poststructural$) or postmodern$ or post-modern$ $ or interpret$).mp.
15. (action research or cooperative inquir$ or cooperative inquir$ or co-operative inquir$).mp.
16. (humanistic or existential or experiential or para-digm$).mp.
17. (field adj (study or studies or research)).tw.
18. human science.tw.
19. biographical method.tw.
20. theoretical sampl$.af.
21. ((purpos$ adj4 sampl$) or (focus adj group$)).af.
22. (account or accounts or unstructured or open-ended or open ended or text$ or narrative$).mp.
23. (life world or life-world or conversation analys?s or personal experience$ or theoretical saturation).mp
24. (lived or life adj experience$.mp
25. cluster sampl$.mp.
26. observational method$.af.
27. content analysis.af.
28. (constant adj (comparative or comparison)).af.
29. ((discourse$ or discurs$) adj3 analys?s).tw.
30. narrative analys?s.af.

Hybrid Filter for CINAHL

1. MH Interview+
2. MH audiorecording
3. MH Grounded theory
5. MH Qualitative Studies
6. MH Research, Nursing
8. MH Focus Groups
9. MH Discourse Analysis

10. MH Content Analysis
11. MH Ethnographic Research
12. MH Ethnological Research
13. MH Ethnonursing Research
14. MH Constant Comparative Method
15. MH Qualitative Validity+
16. MH Purposive Sample
17. MH Observational Methods+
18. MH Field Studies
19. MH Theoretical sample
20. MH Phenomenology
21. MH Phenomenological Research
22. MH Life Experiences+
23. MH Cluster Sample+
25. ethnograph*
26. phenomenol*
27. grounded N1 theor*
28. grounded N1 study
29. grounded N1 studies
30. grounded N1 research
31. grounded N1 analys?s
32. life stor*
33. emic or etic or hermeneutic$ or heuristic$ or semiotic$
34. data N1 saturat*
35. participant observ*
36. social construct* or postmodern* or post-structural* or post structural* or poststructural* or postmodern* or post-modern* or interpret*
37. action research or cooperative inquir* or cooperative inquir* or co-operative inquir*
38. humanistic or existential or experiential or paradigm*
39. field N1 stud*
40. field N1 research
41. human science
42. biographical method
43. theoretical sampl*
44. purpos* N4 sampl*
45. focus N1 group*
46. account or accounts or unstructured or open-ended or open ended or text* or narrative*
47. life world or life-world or conversation analys?s or personal experience* or theoretical saturation
48. lived experience*
49. life experience*
50. cluster sampl*
51. theme* or thematic
52. observational method*
53. content analysis
54. discourse* N3 analys?s
55. discurs* N3 analys?s
56. constant N1 comparative
57. constant N1 comparison
58. narrative analys?s

Hybrid Filter for Web of Science

1. TS=(interview*)
2. TS=(theme*)
3. TS=(thematic analysis)
4. TS=(qualitative)
5. TS=(nursing research methodology)
7. TS=(ethnograph*)
8. TS=(ethnonursing)
9. TS=(ethnological research)
10. TS=(phenomenol*)
11. TS=(grounded theor*) OR TS=(grounded stud*) OR TS=(grounded research) OR TS=(grounded analys?s)
12. TS=(life stor*)
13. TS=(emic) OR TS=(etic) OR TS=(hermeneutic) OR TS=(heuristic) OR TS=(semiotic) OR TS=
(data saturat*) OR TS=(participant observ*)
14. TS=(social construct*) OR TS=(postmodern*) OR TS=(post structural*) OR TS=(interpret*)
15. TS=(action research) OR TS=(co-operative inquir*)
16. TS=(humanistic) OR TS=(existential) OR TS=(experiential) OR TS=(paradigm*)
17. TS=(field stud*) OR TS=(field research)
18. TS=(human science)
19. TS=(biographical method*)
20. TS=(theoretical sampl*)
21. TS=(purposive sampl*)
22. TS=(open-ended account*) OR TS=(unstructured account) OR TS=(narrative*) OR TS=(text*)
23. TS=(life world) OR TS=(conversation analys?s) OR TS=(theoretical saturation)
24. TS=(lived experience*) OR TS=(life experience*)
25. TS=(cluster sampl*)
26. TS=observational method*
27. TS=(content analysis)
28. TS=(constant comparative)
29. TS=(discourse analys?s) or TS =(discurs* analys?s)
30. TS=(narrative analys?s)

Appendix 18: Overview of databases

DATABASE	REMIT	SCALE	COVERAGE
Academic Search Complete	Multi-disciplinary including pharmaceutical science, psychology, veterinary science, biology, geography, chemistry, mathematics and many more.	Includes full texts for more than 8.500 journals and 12,500 indexed journals.	1887 - present
AMED (Allied and Complementary Medicine Database)	Complementary medicine and allied health.	Provides almost 600 indexed journals (mostly European), many not indexed in other biomedical databases.	1985 - present
ASSIA (Applied Social Sciences Index and Abstracts)	Nursing, health, social sciences, psychology, economics, politics, and education.	Contains more than 500 journals published in English from 16 countries including the UK and the US.	1987 - present
BASE (Bielefeld Academic Search Engine)	Multi-disciplinary	Includes more than 100 million documents from more than 5,000 sources (specialises in storing journals, institutional repositories and digital collections contained in digital repositories and indexing materials in open sources).	Not stated
CINAHL (Cumulative Index to Nursing and Allied Health Literature)	Nursing, biomedicine, health sciences, alternative medicine, and allied health disciplines.	Includes citations from more than 3,100 indexed journals containing over 3.8 million records; also indexes healthcare books, dissertations, conference proceedings, and more.	1981 – present
CORE (Connecting Repositories)	Multi-disciplinary	Open access repository that aggregates content from repositories registered in OpenDOAR. Contains more than 77 million articles, from over 6,000 international journals.	Not stated

EMBASE	Biomedicine, pharmacology and toxicology, psychology, psychiatry, selected coverage of nursing, dentistry, veterinary medicine, and alternative medicine.	Contains 32 million records including more than 8,500 peer-reviewed international journals (over 2,900 not available in MEDLINE, including many EU titles). Particularly strong focus on drug trials.	1980 - present
ERIC (Education Resources Information Center)	Education	Provides access to indexed and full-text education literature and resources. The largest education database in the world, containing more than 1.6 million records of journal articles, books, research reports, teaching guides, conference papers, dissertations, and theses.	1966 - present
eTHOS (E-theses Online Service)	Multi-disciplinary	UK's national thesis service. Contains around 450,000 records relating to doctoral research theses awarded by more than over 120 UK Higher Education institutions.	1700 - present
Google Scholar	Multi-disciplinary	A free search engine that indexes the full text of scholarly literature, including articles, theses, books, abstracts, court opinions and many others. It doesn't provide access to any full-text articles except free sources but includes links to locate paid papers. Provides citation service and contains more than 160 million documents.	Not stated
MedNar	Medically focused	Free 'deep web search' engine that uses advanced 'federated search technology', which unlike Google Scholar, returns high quality medical information in real time.	Not stated
OAIster	Multi-disciplinary	A bibliographic catalogue built from open access collections worldwide. Contains more than 50 million records from digital resources.	Not stated
OpenGrey	Biomedical, science, social sciences, humanities, economics, and technology.	Provides open access to more than 700,000 bibliographic references of grey literature produced in Europe, including technical and research reports, doctoral theses, conference papers and official publications.	1997 – present

Ovid MEDLINE	Medicine, nursing, dentistry, pharmacy, veterinary medicine, allied health, and pre-clinical sciences.	The largest biomedical database available. International coverage of approximately 5,600 current peer-reviewed biomedical journals published in the US and 70 other countries. Contains more than 23 million citations in almost 40 languages.	1946 – present
ProQuest Dissertations & Theses	Multi-disciplinary	Contains citations for dissertations and theses accepted for higher degrees by universities in the UK and Ireland since 1716, and internationally since 1743. Currently, it includes around 4 million abstracts of graduate works, with 2 million in full text.	1716 - present
PsycINFO	Psychology, behavioural and health sciences.	Relatively small coverage; contains approximately 2,500 indexed journals and more than 4 million records. Includes references and abstracts to journals, dissertations, and books.	1806 – present
PubMed	Medicine and biomedical sciences, nursing, dentistry, and health care systems.	Contains more than 22 million citations for biomedical literature from MEDLINE and life science journals. Provides access to Pre-Medline which is an in-process database for MEDLINE.	1946 - present
ScienceDirect	Life, health and social sciences, humanities, and engineering.	Contains more than 14 million peer-reviewed publications and 3,800 journals, also more than 35,000 books.	1823 - present
Web of Science (Social Sciences Citation Index)	Multi-disciplinary with particular focus on social sciences, arts and humanities.	Previously known as Web of Knowledge, includes more than 2,500 indexed core medical journals. Science Citation Index covers more than 5,300 fully indexed journals, and Social Science Index includes more than 1,700 fully indexed journals covering a wide range of disciplines. In total, WoS includes more than 50,000 scholarly books, 12,000 journals and 160,000 conference proceedings.	1945 - present
ZETOC	Medical and Social Sciences, Economics, Engineering, Humanities and Applied Sciences and more.	Provides access to more than 30,000 journals and contains over 52 million citations and conference papers.	1993 - present

Appendix 19: Example of the search strategy applied in Ovid MEDLINE

Database(s): **Ovid MEDLINE(R)** 1946 to August Week 4 2017

Search Strategy:

#	Searches	Results
1	Anti-Bacterial Agents/	295885
2	Anti-Bacterial Agents/	295885
3	exp antibiotic agent/ or exp antiinfective agent/ or "Anti-Bacterial Agent*".mp. or exp antifungal agent/ or exp antibacterial activity/ or exp bacterial infection/	1176588
4	exp drug resistance/ or exp antibiotic resistance/ or "Drug Resistance, Microbial*".mp.	293939
5	"medical staff".mp. or exp medical staff/ or doctor*.ti,ab. or physician*.ti,ab.	417138
6	health personnel.mp. or exp health care personnel/	154381
7	attitude of health personnel.ti,ab.	28
8	view*.ti,ab.	364525
9	opinion*.ti,ab.	75851
10	perspective*.ti,ab.	210702
11	belief*.ti,ab.	59993
12	(prescription or "prescri$ authority").ti,ab.	56759
13	exp clinical practice/ or exp practice guideline/	23858
14	("decision making" or "clinical decision making").ti,ab.	85072
15	inappropriate prescri$.ti,ab.	1068
16	overprescribing.ti,ab.	214
17	(stewardship or "antibiotic misuse").ti,ab.	2946
18	behavio$r.ti,ab.	431563
19	(hospital* or "acute care").mp.	1266211
20	Qualitative Research/	35821
21	Interview/	27476
22	(theme$ or thematic).mp.	63368
23	qualitative.af.	161664
24	Nursing Methodology Research/	16969
25	ethnological research.mp.	7
26	ethnograph$.mp.	7495
27	ethnonursing.af.	135
28	phenomenol$.af.	17028
29	(grounded adj (theor$ or study or studies or research or analys?s)).af.	8075
30	life stor$.mp.	869
31	(emic or etic or hermeneutic$ or heuristic$ or semiotic$).af. or (data adj1 saturat$).tw. or participant observ$.tw.	15869
32	(social construct$ or (postmodern$ or post-structural$) or (post structural$ or poststructural$) or post modern$ or post-modern$ or interpret$).mp.	415332
33	(action research or cooperative inquir$ or co operative inquir$ or co-operative inquir$).mp.	2987
34	(humanistic or existential or experiential or paradigm$).mp.	110655
35	(field adj (study or studies or research)).tw.	12319
36	human science.tw.	241
37	biographical method.tw.	15
38	theoretical sampl$.af.	460
39	((purpos$ adj4 sampl$) or (focus adj group$)).af.	41682
40	(account or accounts or unstructured or open-ended or open ended or text$ or narrative$).mp.	447029
41	(life world or life-world or conversation analys?s or personal experience$ or theoretical saturation).mp.	12735
42	((lived or life) adj experience$).mp.	7102
43	cluster sampl$.mp.	4837
44	observational method$.af.	532
45	content analysis.af.	15925
46	(constant adj (comparative or comparison)).af.	3108
47	((discourse$ or discurs$) adj3 analys?s).tw.	1508
48	narrative analys?s.af.	764
49	3 or 4	1370640
50	5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18	1668388
51	49 and 50	51555
52	19 and 51	9551
53	20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48	1208983
54	52 and 53	785
55	limit 54 to (english language and yr="2007 - 2017")	412

Appendix 20: Results of electronic and non-electronic searches

a) Electronic searches (*n*=10,814)

Database	No. of hits
Academic Search Complete	21
ASSIA	20
AMED	32
BASE	208
CINAHL	69
CORE	133
EMBASE	235
ERIC	4
eTHOS	32
Google Scholar	7,410
MedNar	360
OAIster	16
OpenGrey	13
Ovid MEDLINE	412
ProQuest Dissertations & Theses	10
PsycINFO	27
PubMed	254
ScienceDirect	429
Web of Science	1,092
ZETOC	37
Total	**10,814**

b) Non-electronic searches (*n*=1,442)

- Reference list searching: 47 additional and potentially relevant papers were identified.
- Citation pearl searching: 502 additional references identified from 40 citation pearls of initially eligible articles (including duplicates).
- Hand searching: 893 additional titles identified (including duplicates).

Appendix 21: Citation pearl growing applied in Google Scholar

Reference	No of citations
Almatar, (2015). *Implementation and evaluation of tailored intervention strategies to influence antibiotic prescribing for community-acquired pneumonia* [Doctoral Thesis, University of Tasmania]. EPrints. http://eprints.utas.edu.au/22746/	0
Almatar, M.A., Peterson, G.M., Thompson, A., & Zaidi, S.T.R. (2014). Factors influencing ceftriaxone use in community-acquired pneumonia: Emergency doctors' perspectives. *Emergency Medicine Australasia: EMA*, *26*(6), 591–595.	3
Barlow, G., Nathwani, D., Myers, E., Sullivan, F., Stevens, N., Duffy, R., & Davey, P. (2008). Identifying barriers to the rapid administration of appropriate antibiotics in community-acquired pneumonia. *Journal of Antimicrobial Chemotherapy*, *61*(2), 442–451.	60
Björkman, I., Berg, J., Röing, M., Erntell, M., & Lundborg, C.S. (2010). Perceptions among Swedish hospital physicians on prescribing of antibiotics and antibiotic resistance. *Quality & Safety in Health Care*, *19*(6), 1-5.	22
Broom, A., Broom, J., & Kirby, E. (2014). Cultures of resistance? A Bourdieusian analysis of doctors' antibiotic prescribing. *Social Science and Medicine*, *110*(1), 81–88.	30
Broom, A., Broom, J., Kirby, E., Plage, S., & Adams, J. (2015) What role do pharmacists play in mediating antibiotic use in hospitals? A qualitative study. *BMJ Open*, *5*(11), 1-6.	5
Broom, A., Broom, J., Kirby, E., & Scambler, G. (2015). The path of least resistance? Jurisdictions, responsibility and professional asymmetries in pharmacists' accounts of antibiotic decisions in hospitals. *Social Science and Medicine*, *146*(1), 95–103.	5
Broom, J., Broom, A., Adams, K., Plage, S. (2016). What prevents the intravenous to oral antibiotic switch? A qualitative study of hospital doctors' accounts of what influences their clinical practice. *Journal of Antimicrobial Chemotherapy*, *71*(8), 2295–2299.	3
Broom, A., Broom, J., Kirby, E., & Scambler, G. (2016). Nurses as Antibiotic Brokers: Institutionalized Praxis in the Hospital. *Qualitative Health Research, 27*(13), 1924-35.	0
Broom, J., Broom, A., Plage, S., Adams, K., & Post, J. (2016). Barriers to uptake of antimicrobial advice in a UK hospital: a qualitative study. *Journal of Hospital Infection*, *93*(4), 418–422.	3
Broom, A., Gibson, A.F., Broom, J., Kirby, E., Yarwood, T., & Post, J.J. (2016). Optimizing antibiotic usage in hospitals: a qualitative study of the perspectives of hospital managers. *Journal of Hospital Infection*, *94*(3), 230–235.	2
Broom, A., Plage, S., Broom, J., Kirby, E., & Adams, J. (2016). A qualitative study of hospital pharmacists and antibiotic governance: negotiating interprofessional responsibilities, expertise, and resource constraints. *BMC Health Services Research*, 16(1), 1-9.	1
Broom, J.K., Broom, A.F., Kirby, E.R., Gibson, A.F., & Post, J.J. (2017). Clinical and	0

social barriers to antimicrobial stewardship in pulmonary medicine: A qualitative study. *American Journal of Infection Control, 45*(8), 911-16.	
Bruins, M.J., Ruijs, G.J., Wolfhagen, M.J., Bloembergen, P., & Aarts, J.E. (2011). Does electronic clinical microbiology results reporting influence medical decision making: a pre- and post-interview study of medical specialists. *BMC Medical Informatics and Decision Making*, *11*(19), 1-7.	9
Cantey, J.B., Vora, N., & Sunkara, M. (2016). Prevalence, Characteristics, and Perception of Nursery Antibiotic Stewardship Coverage in the United States. *Journal of The Pediatric Infectious Diseases Society, 6*(3), 30-35.	0
Charani, E., Castro-Sanchez, E., Sevdalis, N., Kyratsis, Y., Drumright, L., Shah, N., & Holmes, A. (2013). Understanding the determinants of antimicrobial prescribing within hospitals: The role of "prescribing etiquette." *Clinical Infectious Diseases*, *57*(2), 188–96.	108
Charani, E., Tarrant, C., Moorthy, K., Sevdalis, N., Brennan, L., & Holmes, A.H. (2017). Understanding antibiotic decision making in surgery – a qualitative analysis. *Clinical Microbiology and Infection, 23*(10), 752-60.	0
Chen, A.W.J., Khumra, S., Eaton, V., & Kong, D.C.M. (2010). Snapshot of antimicrobial stewardship in Australian hospitals. *Journal of Pharmacy Practice and Research*, *40*(1), 19–25.	7
Cortoos, P.J., De Witte, K., Peetermans, W.E., Simoens, S., & Laekeman, G. (2008). Opposing expectations and suboptimal use of a local antibiotic hospital guideline: A qualitative study. *Journal of Antimicrobial Chemotherapy*, *62*(1), 189-195.	28
Cotta, M.O., Robertson, M.S., Marshall, C., Thursky, K A., Liew, D., Buising, K.L. (2015). Implementing antimicrobial stewardship in the Australian private hospital system: a qualitative study. *Australian Health Review: A Publication of the Australian Hospital Association*, *39*(3), 315–322	3
Diorio, C., Tomlinson, D., Boydell, K.M., Regier, D.A., Ethier, M.C., Alli, A., Sung, L. (2012). Attitudes toward infection prophylaxis in pediatric oncology: a qualitative approach. *PloS One*, *7*(10), 1-5.	5
Eyer, M.M., Lang, M., Aujesky, D., & Marschall, J. (2016). Overtreatment of asymptomatic bacteriuria: a qualitative study. *Journal of Hospital Infection*, *93*(3), 297–303.	0
Farhadieh, F. (2013). *Clinician's resistance to antibiotic control measures: A qualitative study.* [Doctoral Thesis, Swinburn University of Technology]. http://hdl.handle.net/1959.3/379314	0
Giusti, A., Alegiani, S.S., degli Atti, M.L C., Colaceci, S., Raschetti, R., Arace, P., Grp, A.S. (2016). Surgical antibiotic prophylaxis in children: a mixed method study on healthcare professionals' attitudes. *BMC Pediatrics*, *16*(1), 1-8.	0
James, R., Luu, S., Avent, M., Marshall, C., Thursky, K., Buising, K., Buising, K. (2015) A mixed methods study of the barriers and enablers in implementing antimicrobial stewardship programmes in Australian regional and rural hospitals, *Journal of Antimicrobial Chemotherapy*, *70*(9), 2665-2670.	1
Jeffs, L., Thampi, N., Maione, M., Steinberg, M., Morris, A M., Bell, C M. (2015). A Qualitative Analysis of Implementation of Antimicrobial Stewardship at 3 Academic Hospitals: Understanding the Key Influences on Success. *Canadian Journal of Hospital Pharmacy*, *68*(5), 395–400.	0

Livorsi, D., Comer, A., Matthias, M.S., Perencevich, E.N., & Bair, M.J. (2015). Factors Influencing Antibiotic-Prescribing Decisions Among Inpatient Physicians: A Qualitative Investigation. *Infection Control and Hospital Epidemiology*, *36*(9), 1065–1072.	5
Livorsi, D., Comer, A. R., Matthias, M.S., Perencevich, E.N., & Bair, M.J. (2016). Barriers to guideline-concordant antibiotic use among inpatient physicians: A case vignette qualitative study. *Journal of Hospital Medicine*, *11*(3), 174–180.	3
Mattick, K., Kelly, N., & Rees, C. (2014). A window into the lives of junior doctors: narrative interviews exploring antimicrobial prescribing experiences. *Journal of Antimicrobial Chemotherapy*, *69*(8), 2274–83.	26
May, L., Gudger, G., Armstrong, P., Brooks, G., Hinds, P., Bhat, R., Rand, C. (2014). Multisite Exploration of Clinical Decision-Making for Antibiotic Use by Emergency Medicine Providers Using Quantitative and Qualitative Methods. *Infection Control & Hospital Epidemiology*, *35*(9), 1114–25.	15
McLellan, L., Dornan, T., Newton, P., Williams, S. D., Lewis, P., Steinke, D., & Tully, M.P. (2016). Pharmacist-led feedback workshops increase appropriate prescribing of antimicrobials. *The Journal of Antimicrobial Chemotherapy*, *71*(1), 1415–1425.	1
Newham, R., Thomson, A. H., Semple, Y., Dewar, S., Steedman, T., & Bennie, M. (2015). Barriers to the safe and effective use of intravenous gentamicin and vancomycin in Scottish hospitals, and strategies for quality improvement. *European Journal of Hospital Pharmacy-Science and Practice*, *22*(1), 32–37.	2
Pakyz, A.L., Moczygemba, L.R., Vanderwielen, L.M., Edmond, M.B., Stevens, M.P., & Kuzel, A.J. (2014). Facilitators and barriers to implementing antimicrobial stewardship strategies: Results from a qualitative study. *American Journal of Infection Control*, *42*(10), S257–S263.	12
Pasay, D K., Chow, S.J.S., Bresee, L.C., Guirguis, M., & Slobodan, J. (2015). Assessment of current antimicrobial stewardship policies and resources: a focus group project. *Healthcare Infection*, *20*(1), 7–15.	2
Rawson, T.M., Charani, E., Moore, L.S.P., Hernandez, B., Castro-Sanchez, E., Herrero, P., Holmes, A.H. (2016). Mapping the decision pathways of acute infection management in secondary care among UK medical physicians: a qualitative study. *BMC Medicine*, *14*(1), 1-10.	2
Salci, T.P., Batilana, A.P., Pietrobon, R., & Caparroz-Assef, S.M. (2014). Problems related to antifungal prescription: a qualitative study of the views of intensivists. *Journal of Evaluation in Clinical Practice*, *20*(4), 460–466.	0
Schouten, J.A., Hulscher, M.E., Natsch, S., Kullberg, B.J., van der Meer, J.W.M., Grol, R.P. (2007). Barriers to optimal antibiotic use for community-acquired pneumonia at hospitals: a qualitative study. *Quality & Safety in Health Care*, *16*(2), 143–149.	76
Skodvin, B., Aase, K., Charani, E., Holmes, A., Smith, I. (2015). An antimicrobial stewardship program initiative: a qualitative study on prescribing practices among hospital doctors. *Antimicrobial Resistance and Infection Control*, *4*(1), 1-8.	7
Tonna, A.P., Stewart, D.C., West, B., & McCaig, D.J. (2010). Exploring pharmacists' perceptions of the feasibility and value of pharmacist prescribing of antimicrobials in secondary care in Scotland. *The International Journal of Pharmacy Practice*, *18*(1), 312–319.	16

Velasco, E., Ziegelmann, A., Eckmanns, T., & Krause, G. (2012). Eliciting views on antibiotic prescribing and resistance among hospital and outpatient care physicians in Berlin, Germany: results of a qualitative study. *BMJ Open*, *2*(1), 1-10.	13

Appendix 22: Excluded studies (Phase 2)

STUDY		REASON FOR EXCLUSION
1.	**Anthierens**, S., Tonkin-Crine, S., Cals, J.W., Coenen, S., Yardley, L., Brookes-Howell, L., Francis, N.A. (2015). Clinicians' Views and Experiences of Interventions to Enhance the Quality of Antibiotic Prescribing for Acute Respiratory Tract Infections. *Journal of General Internal Medicine*, *30*(4), 408-416.	Irrelevant healthcare setting
2.	**Bailey**, C.A. (2013). *The Evaluation of the Antimicrobial Self-Assessment Toolkit for NHS Trusts* [Doctoral Thesis, The University of Manchester]. EScholar. https://www.escholar.manchester.ac.uk/uk-ac-man-scw:205475	Topic or intervention – study evaluating content validity of a specific antimicrobial intervention
3.	**Bailey**, C., Tully, M., & Cooke, J. (2015). An investigation into the content validity of the Antimicrobial Self-Assessment Toolkit for NHS Trusts (ASAT v15a) using cognitive interviews with antimicrobial pharmacists. *Journal of Clinical Pharmacy and Therapeutics*, *40*(2), 208-212.	Topic or intervention – study evaluating content validity of a specific antimicrobial intervention
4	**Bailey**, C., Tully, M., & Cooke, J. (2015). Perspectives of clinical microbiologists on antimicrobial stewardship programmes within NHS trusts in England. *Antimicrobial Resistance and Infection Control*. *4*(37), 1-9.	Topic or intervention – study evaluating content validity of a specific antimicrobial intervention
5.	**Beard**, R., Karimova, G., & Smith, P. (2013). Linking integrated electronic prescribing and robotic dispensing: identifying benefits at ward level. *European Journal of Hospital Pharmacy: Science and Practice*, *21*(1), 65–68.	Not relevant to the review
6.	**Beuscart-Zéphir**, M.C., Pelayo, S., Anceaux, F., Maxwell, D., & Guerlinger, S. (2007) Cognitive analysis of physicians and nurses cooperation in the medication ordering and administration process. *International Journal of Medical Informatics*, *76*(1), S65–S77.	Topic or intervention – study evaluating content validity of a specific antimicrobial intervention
7.	**Black**, E., Cartwright, A., Bakharaiba, S., Al-Mekaty, E., & Alsahan, D. (2014). A qualitative study of pharmacists' perceptions of, and recommendations for improvement of antibiotic use in Qatar. *International Journal of Clinical Pharmacy*, *36*(4), 787–794.	Population – pharmacists
8.	**Bond**, SE., Crowther, S. P., Adhikari, S., Chubaty, A.J., Yu, P., Borchard, J P., Miyakis, S. (2017). Design and Implementation of a Novel Web-Based E-Learning Tool for Education of Health Professionals on the Antibiotic Vancomycin. *Journal of Medical Internet Research*, *19*(3), e93.	Methodology – survey
9.	**Braaf,** S., Rixon, S., Williams, A., Liew, D., & Manias, E. (2015). Medication communication during handover interactions in specialty practice settings. *Journal of Clinical Nursing*, *24*(19–20), 2859–2870.	Not relevant to the review
10.	**Bratzler**, D.W., Dellinger, E.P., Olsen, K.M., Perl, T.M., Auwaerter, P.G., Bolon, M.K., Weinstein, R.A. (2013). Clinical practice guidelines for antimicrobial prophylaxis in surgery. *American Journal of Health-System Pharmacy*, *70*(3), 195–283	Not relevant to the review
11.	**Brazinha**, I., & Fernandez-Llimos, F. (2014). Barriers to the	Not relevant to the

	implementation of advanced clinical pharmacy services at Portuguese hospitals. *International Journal of Clinical Pharmacy*, *36*(5), 1031–1038.	review
12.	**Broom**, J.K., Broom, A.F., Kirby, E.R., Gibson, A.F., & Post, J.J. (2017). Clinical and social barriers to antimicrobial stewardship in pulmonary medicine: A qualitative study. *American Journal of Infection Control*, *45*(8), 911-916.	Population – sample included nurses; data analysed together
13.	**Broom,** J., Broom, A., Kirby, E., Gibson, A.F., & Post, J.J. (2017). How do hospital respiratory clinicians perceive antimicrobial stewardship (AMS)? A qualitative study highlighting barriers to AMS in respiratory medicine. *Journal of Hospital Infection*, *96*(4), 316–322.	Population – sample included nurses; data analysed together
14.	**Broom**, A., Broom, J., Kirby, E., Plage, S., & Adams, J. (2015) What role do pharmacists play in mediating antibiotic use in hospitals? A qualitative study. *BMJ Open*, 5, e008326.	Population – pharmacists
15.	**Broom**, A., Broom, J., Kirby, E., & Scambler, G. (2015). The path of least resistance? Jurisdictions, responsibility and professional asymmetries in pharmacists' accounts of antibiotic decisions in hospitals. *Social Science and Medicine*, *146*, 95–103.	Population – pharmacists
16.	**Broom**, A., Broom, J., Kirby, E., & Scambler, G. (2016). Nurses as Antibiotic Brokers: Institutionalized Praxis in the Hospital. *Qualitative Health Research*, *27*(13), 1924-35.	Population – nurses
17.	**Broom**, A., Gibson, A.F., Broom, J., Kirby, E., Yarwood, T., & Post, J.J. (2016). Optimizing antibiotic usage in hospitals: a qualitative study of the perspectives of hospital managers. *Journal of Hospital Infection*, *94*(3), 230–235.	Population – hospital managers
18.	**Broom**, A., Plage, S., Broom, J., Kirby, E., & Adams, J. (2016). A qualitative study of hospital pharmacists and antibiotic governance: negotiating interprofessional responsibilities, expertise and resource constraints. *BMC Health Services Research*, *16*, 43.	Population – pharmacists
19.	**Brooks**, L., Shaw, A., Sharp, D., & Hay, A.D. (2008). Towards a better understanding of patients' perspectives of antibiotic resistance and MRSA: A qualitative study. *Family Practice*, *25*(5), 341–348.	Population – patients
20.	**Brown,** N., & Nettleton, S. (2016). 'There is worse to come': the biopolitics of traumatism in antimicrobial resistance (AMR). *The Sociological Review*, *65*(3), 493-508.	Methodology – not a qualitative study
21.	**Bruins**, M.J., Ruijs, G.J., Wolfhagen, M.J., Bloembergen, P., & Aarts, J.E. (2011). Does electronic clinical microbiology results reporting influence medical decision making: a pre- and post-interview study of medical specialists. *BMC Medical Informatics and Decision Making*, *11*(1), 19.	Topic or intervention – study evaluating specific antimicrobial intervention
22.	**Bush-Knapp**, M.E., Brinsley-Rainisch, K.J., Lawton-Ciccarone, R.M., Sinkowitz-Cochran, R.L., Dressler, D.D., Budnitz, T., & Williams, M. V. (2007). Spreading the word, not the infection: Reaching hospitalists about the prevention of antimicrobial resistance. *American Journal of Infection Control*, *35*(10), 656–661.	Not relevant to the review
23.	**Cantey**, J.B., Vora, N., & Sunkara, M. (2016). Prevalence, Characteristics, and Perception of Nursery Antibiotic Stewardship Coverage in the United States. *Journal of The Pediatric Infectious Diseases Society, 6*(3), e30-35.	Not relevant to the review
24.	**Chamberlain-Salaun**, J., Mills, J., Kevat, P.M., Remond, M.G.W., & Maguire, G.P. (2016) Sharing success -	Irrelevant healthcare setting – community

	understanding barriers and enablers to secondary prophylaxis delivery for rheumatic fever and rheumatic heart disease. *BMC Cardiovascular Disorders*, *16*(1), 166.	
25.	**Charani**, E., Castro-Sanchez, E., Sevdalis, N., Kyratsis, Y., Drumright, L., Shah, N., & Holmes, A. (2013). Understanding the determinants of antimicrobial prescribing within hospitals: The role of "prescribing etiquette." *Clinical Infectious Diseases*, *57*(2), 188–196.	Population – sample included nurses, pharmacists and midwives; data analysed together
26.	**Charan**i, E., Kyratsis, Y., Lawson, W., Wickens, H., Brannigan, E.T., Moore, L.S.P., & Holmes, A.H. (2013). An analysis of the development and implementation of a smartphone application for the delivery of antimicrobial prescribing policy: Lessons learnt. *Journal of Antimicrobial Chemotherapy*, *68*(4), 960–967.	Not relevant to the review
27.	**Charani**, E., Tarrant, C., Moorthy, K., Sevdalis, N., Brennan, L., & Holmes, A.H. (2017). Understanding antibiotic decision making in surgery - a qualitative analysis. *Clinical Microbiology and Infection*, *23*(10), 752-60.	Population – sample included nurses and pharmacists; data analysed together
28.	**Chen**, A.W.J., Khumra, S., Eaton, V., & Kong, D.C.M. (2010). Snapshot of antimicrobial stewardship in Australian hospitals. *Journal of Pharmacy Practice and Research*, *40*(1), 19–25.	Population – directors of pharmacy
29.	**Cortoos,** P., Peetermans, W.E., Schreurs, B., De Witte, K., Laekeman, G. (2009) Theory of planned behaviour and its use in antibiotic prescribing in a hospital setting: P755. [Abstract] *Clinical Microbiology & Infection.* 15(4) Supplement 1:S184-S185.	Methodology – only abstract available
30.	**Cortoos**, P.J., Schreurs, B.H.J., Peetermans, W.E., De Witte, K., & Laekeman, G. (2012). Divergent Intentions to Use Antibiotic Guidelines: A Theory of Planned Behavior Survey. *Medical Decision Making*, *32*(1), 145–153.	Methodology – survey
31.	**Cotta**, M.O., Robertson, M.S., Marshall, C., Thursky, K.A., Liew, D., Buising, K.L. (2015). Implementing antimicrobial stewardship in the Australian private hospital system: a qualitative study. *Australian Health Review: A Publication of the Australian Hospital Association*, *39*(3), 315–322.	Population – sample included nurses, pharmacist and hospital managers; data analysed together
32.	**Cuthbertson**, B.H., Campbell, M.K., MacLennan, G., Duncan, E.M., Marshall, A.P., Wells, E.C., Francis, J.J. (2013). Clinical stakeholders' opinions on the use of selective decontamination of the digestive tract in critically ill patients in intensive care units: an international Delphi study. *Critical Care*, *17*(6), R266.	Methodology – Delphi study; unable to extract qualitative data
33.	**Doherty, C. (2009)** A qualitative study of health service reform on nurses' working lives: Learning from the UK National Health Service (NHS). *International Journal of Nursing Studies*, *46*(8), 1134–1142.	Population – nurses
34.	**Dombrowski**, S.U., Prior, M.E., Duncan, E., Cuthbertson, B. H., Bellingan, G., Campbell, M.K., Francis, J.J. (2013). Clinical components and associated behavioural aspects of a complex healthcare intervention: Multi-methods study of selective decontamination of the digestive tract in critical care. *Australian Critical Care*, *26*(4), 173–179.	Topic or intervention
35.	**Diorio**, C., Tomlinson, D., Boydell, K.M., Regier, D.A., Ethier, M.C., Alli, A., Sung, L. (2012). Attitudes toward infection prophylaxis in pediatric oncology: a qualitative approach. *PloS One*, *7*(10), e47815.	Population – sample included clinicians, nurses, pharmacists, parents, and children; data analysed together

36.	**Duane**, S., Domegan, C., Callan, A., Galvin, S., Cormican, M., Bennett, K., Vellinga, A. (2016). Using qualitative insights to change practice: exploring the culture of antibiotic prescribing and consumption for urinary tract infections. *BMJ Open*, *6*(1), 1-8.	Irrelevant healthcare setting – general practice and community
37.	**Dubos**, F., Nicolini, G., Bielicki, J., & Sharland, M. (2015). Qualitative Review of Web-Based Professional Education on Antibiotic Prescribing for Children: 10 Million Hits, But Only 10 Good Web Sites. *Journal of the Pediatric Infectious Diseases Society*, *4*(2), 159–162.	Methodology – review
38.	**Duncan**, E.M., Cuthbertson, B.H., Prior, M.E., Marshall, A.P., Wells, E C., Todd, L.E., Francis, J.J. (2014). The views of health care professionals about selective decontamination of the digestive tract: An international, theoretically informed interview study. *Journal of Critical Care*, *29*(4), 634–640.	Topic or intervention (*see SuDDICU study by Francis et al., 2014)
39.	**Easton**, P.M., Sarma, A., Williams, F.L.R., Marwick, C.A., Phillips, G., & Nathwani, D. (2007). Infection control and management of MRSA: assessing the knowledge of staff in an acute hospital setting. *Journal of Hospital Infection*, *66*(1), 29–33.	Not relevant to the review
40.	**Eghdam**, A., Forsman, J., Falkenhav, M., Lind, M., & Koch, S. (2011). Combining usability testing with eye-tracking technology: Evaluation of a visualization support for antibiotic use in intensive care. *Studies in Health Technology and Informatics*, *169,* 945–949.	Not relevant to the review
41.	**Engel**, M.F., Postma, D.F., Hulscher, M.E., Van Berkhout, F.T., Emmelot-Vonk, M.H., Sankatsing, S., Oosterheert, J.J. (2013). Barriers to an early switch from intravenous to oral antibiotic therapy in hospitalised patients with CAP. *European Respiratory Journal*, *41*(1), 123–130.	Methodology – mixed-methods, data analysed together
42.	**Erugina**, M.V, Grozdova, T.Y., Savinov, V.A., Sazanova, G.Y., Dolgova, E.M., Lotsmanov, Y.F., & Ushakov, Y.V. (2011) Problems and solutions on issues of medical care quality in community-acquired pneumonia in hospitals of Saratov region. *Saratov Journal of Medical Scientific Research, 7*(2), 369–372.	Not relevant to the review
43.	**Farhadieh**, F. (2013). Clinicians' resistance to antibiotic control measures: A qualitative study. [Doctoral Thesis, Swinburn University of Technology]. http://hdl.handle.net/1959.3/379314	Topic or intervention – examines clinician's resistance to using clinical decision support system
44.	**Forsman**, J., Anani, N., Eghdam, A., Falkenhav, M., & Koch, S. (2013). Integrated information visualization to support decision making for use of antibiotics in intensive care: design and usability evaluation. *Informatics for Health & Social Care*, *38*(4), 330.	Not relevant to the review
45.	***Francis**, J.J., Duncan, E.M., Prior, M.E., MacLennan, G.S., Dombrowski, S.U., Bellingan, G., Cuthbertson, B.H. (2014). Selective decontamination of the digestive tract in critically ill patients treated in intensive care units: A mixed-methods feasibility study (the SuDDICU study). *Health Technology Assessment*, *18*(25), 1–169.	Methodology – mixed-methods feasibility study
46.	**Francis**, J.J., Duncan, E.M., Prior, M.E., Maclennan, G., Marshall, A.P., Wells, E.C., Cuthbertson, B.H. (2014) Comparison of four methods for assessing the importance of attitudinal beliefs: An international Delphi study in intensive	Not relevant to the review (*see SuDDICU study above by Francis et al., 2014)

	care settings. *British Journal of Health Psychology*, *19*(2), 274–291.	
47.	**Gaynes**, R.P., Gould, C.V., Edwards, J., Antoine, T.L., Blumberg, H.M., Desilva, K., Jernigan, J.A. (2009). A multicenter study on optimizing piperacillin-tazobactam use: lessons on why interventions fail. *Infection Control and Hospital Epidemiology*, *30*(8), 794–796.	Methodology – not a qualitative study
48.	**Gharbi**, M., Moore, L.S.P., Castro-Sánchez, E., Spanoudaki, E., Grady, C., Holmes, A.H., & Drumright, L.N. (2016). A needs assessment study for optimising prescribing practice in secondary care junior doctors: the antibiotic prescribing education among doctors (APED). *BMC Infectious Diseases*, *16*(456), 1-10.	Methodology – survey
49.	**Giusti**, A., Alegiani, S.S., degli Atti, M.L.C., Colaceci, S., Raschetti, R., Arace, P., Spiazzi, R., Raponi, M. (2016). Surgical antibiotic prophylaxis in children: a mixed method study on healthcare professionals' attitudes. BMC Pediatrics, *16*(1), 203.	Population – sample included nurses; data analysed together
50.	**Hamad**, A.A. (2015). *Evaluating, Understanding and Managing Medication Incidents with High-Risk Antibiotics*. [Doctoral Thesis, King's College]. Ethesis. https://kclpure.kcl.ac.uk/portal/files/45225832/2015_Hamad_Anas_1045375_ethesis.pdf	Not relevant to the review
51.	**Haydon**, T.P., Presneill, J.J., & Robertson, M.S. (2010). Antibiotic prophylaxis for cardiac surgery in Australia. *Medical Journal of Australia*, *192*(3), 141–143.	Methodology – survey
52.	**Henard**, S., Boussat, S., Demoré, B., Clément, S., Lecompte, T., May, T., & Rabaud, C. (2014). Comparison of hospital databases on antibiotic consumption in France, for a single management tool. *Medecine et Maladies Infectieuses*, *44*(7), 308–314.	Not relevant to the review
53.	**Iwami** M, Ahmad R, Castro-Sánchez E, Birgand G, Johnson A, H.A. (2017). Capacity of English NHS hospitals to monitor quality in infection prevention and control using a new European framework: A multi-level qualitative analysis. *BMJ Open*, *7*(1), e012520.	Not relevant to the review
54.	**James**, R., Luu, S., Avent, M., Marshall, C., Thursky, K., Buising, K., Buising, K. (2015) A mixed methods study of the barriers and enablers in implementing antimicrobial stewardship programmes in Australian regional and rural hospitals, *Journal of Antimicrobial Chemotherapy, 70*(9), 2665–2670.	Irrelevant healthcare setting – rehabilitation and non-acute hospitals
55.	**James**, R., Upjohn, L., Cotta, M., Luu, S., Marshall, C., Buising, K., & Thursky, K. (2014). Measuring antimicrobial prescribing quality in Australian hospitals: Development and evaluation of a national antimicrobial prescribing survey tool. *Journal of Antimicrobial Chemotherapy*, *70*(6), 1912–1918.	Topic or intervention – pilot study to assess the usability and generalisability of a newly designed audit tool
56.	**Jeffs**, L., Thampi, N., Maione, M., Steinberg, M., Morris, A. M., Bell, C.M. (2015). A Qualitative Analysis of Implementation of Antimicrobial Stewardship at 3 Academic Hospitals: Understanding the Key Influences on Success. *Canadian Journal of Hospital Pharmacy*, *68*(5), 395–400.	Population – sample included physicians and pharmacists; data analysed together
57.	**Johnston**, K., & Pharm, B. (2014) *A qualitative exploration of physician attitudes toward implementing protocol-based prescribing for empiric use of antimicrobials for common infections in a tertiary intensive care unit* [Doctoral Thesis, The	Not relevant to the review

	University of Queensland]. Espace. http://espace.library.uq.edu.au/view/UQ:335739	
58.	**Jones**, M., Butler, J., Graber, C.J., Glassman, P., Samore, M. H., Pollack, L.A., Goetz, M.B. (2016). Think twice: A cognitive perspective of an antibiotic timeout intervention to improve antibiotic use. *Journal of Biomedical Informatics*, *71*, S22-31.	Topic or intervention – study evaluating the impact of a specific antimicrobial intervention
59.	**Kaba**, A., Baumann, A., Kolotylo, C., & Akhtar-Danesh, N. (2016). A descriptive case study of the changing nature of nurses' work: The impact of managing infectious diseases requiring isolation. *American Journal of Infection Control*, *45*(2), 200–202.	Not relevant to the review
60.	**Kroezen,** M., Mistiaen, P., van Dijk, L., Groenewegen, P.P., & Francke, A.L. (2014) Negotiating jurisdiction in the workplace: A multiple-case study of nurse prescribing in hospital settings. *Social Science & Medicine*, *117*, 107–115.	Not relevant to the review
61.	**Kuehlein**, T., Goetz, K., Laux, G., Gutscher, A., Szecsenyi, J., & Joos, S. (2011). Antibiotics in urinary-tract infections. Sustained change in prescribing habits by practice test and self-reflection: a mixed methods before-after study. *BMJ Quality & Safety*, *20*(6), 522–526.	Irrelevant healthcare setting – primary care
62.	**Lewis**, P.J., Ashcroft, D.M., Dornan, T., Taylor, D., Wass, V., & Tully, M.P. (2014). Exploring the causes of junior doctors' prescribing mistakes: a qualitative study. *British Journal of Clinical Pharmacology*, *78*(2), 310–319.	Not relevant to the review
63.	**Lim**, C.J. (2014) *Antimicrobial use and multidrug-resistant organisms in community-based healthcare settings – optimising infection control and antimicrobial stewardship* [Doctoral Thesis, Monash University]. Arrow. http://arrow.monash.edu.au/hdl/1959.1/977282	Irrelevant healthcare setting – residential care facilities
64.	**Livorsi**, D., Knobloch, M.J., Blue, L.A., Swafford, K., Maze, L., Riggins, K., Safdar, N. (2016). A rapid assessment of barriers and facilitators to safety culture in an intensive care unit. *International Nursing Review*, *63*(3), 372–376.	Not relevant to the review
65.	**Liu**, W., Manias, E., & Gerdtz, M. (2013). Medication communication during ward rounds on medical wards: Power relations and spatial practices. *Health*, *17*(2), 113–34.	Not relevant to the review
66.	**Liu**, W., Manias, E., & Gerdtz, M. (2012). Medication communication between nurses and patients during nursing handovers on medical wards: A critical ethnographic study. *International Journal of Nursing Studies*, *49*(8), 941–952.	Not relevant to the review
67.	**Ljungberg**, C., Lindblad, A.K. & Tully, M. (2009). Secondary care doctors' perception of appropriate prescribing. *Journal of Evaluation in Clinical Practice*, *15*(1), 110–115.	Not relevant to the review
68.	**Marc**, C., Vrignaud, B., Levieux, K., Robine, A., Gras-Le Guen, C., & Launay, E. (2016) Inappropriate prescription of antibiotics in pediatric practice: Analysis of the prescriptions in primary care. *Journal of Child Health Care: For Professionals Working with Children in the Hospital and Community*, *20*(4), 1–7.	Methodology – survey
69.	**Marshall**, A.P., Weisbrodt, L., Rose, L., Duncan, E., Prior, M., Todd, L., Francis, J. (2014). Implementing selective digestive tract decontamination in the intensive care unit: A qualitative analysis of nurse-identified considerations. *Heart and Lung: Journal of Acute and Critical Care*, *43*(1), 13–18.	Topic or intervention (*see SuDDICU study by Francis et al., 2014)
70.	**McCulloch**, A.K. & Kumarasamy, Y. (2012). Investigation of the	Methodology – only

	occurrence and the reason for errors in the prescription and monitoring of gentamicin in Raigmore Hospital. *International Journal of Pharmacy Practice*, *20*, 9-10.	abstract available
71.	**McLellan**, L., Dornan, T., Newton, P., Williams, S.D., Lewis, P., Steinke, D., & Tully, M.P. (2016). Pharmacist-led feedback workshops increase appropriate prescribing of antimicrobials. *The Journal of Antimicrobial Chemotherapy*, *71*, 1415–1425.	Topic or intervention – study evaluating specific antimicrobial intervention
72.	**Münch**, D. (2016). Translating clinicians' needs into requirements for a future Computerised Decision Support System in antibiotic therapy - A user-centred design and requirements engineering approach in a German geriatric hospital setting [Master Dissertation, University of Twente]. http://essay.utwente.nl/70678/1/M%C3%BCnch_MA_BMS.pdf	Methodology – lacked sufficient information
73.	**Murri**, R., de Belvis, A.G., Fantoni, M., Tanzariello, M., Parente, P., Marventano, S., Antonacci, M.G. (2016). Impact of antibiotic stewardship on perioperative antimicrobial prophylaxis. *International Journal for Quality in Health Care*, *28*(4), 502–507.	Methodology – survey
74.	**Newham**, R., Thomson, A.H., Semple, Y., Dewar, S., Steedman, T., & Bennie, M. (2015). Barriers to the safe and effective use of intravenous gentamicin and vancomycin in Scottish hospitals, and strategies for quality improvement. *European Journal of Hospital Pharmacy-Science and Practice*, *22*(1), 32–37.	Methodology – the study was part of service evaluation
75.	**Noble**, C., Brazil, V., Teasdale, T., Forbes, M., & Billett, S. (2017). Developing junior doctors' prescribing practices through collaborative practice: Sustaining and transforming the practice of communities. *Journal of Interprofessional Care*, *31*(2), 263–272.	Not relevant to the review
76.	**Olans** Drummond, R., Nicholas, K., Hanley, D., & DeMaria, A. (2015). Defining a Role for Nursing Education in Staff Nurse Participation in Antimicrobial Stewardship. *Journal of Continuing Education in Nursing*, *46*(7), 318.	Not relevant to the review
77.	**Olson**, C.A., Tooman, T.R., & Alvarado, C.J. (2010). Knowledge systems, health care teams, and clinical practice: A study of successful change. *Advances in Health Sciences Education*, *15*(4), 491–516.	Not relevant to the review
78.	**Ong**, S., Nakase, J., Moran, G.J., Karras, D.J., Kuehnert, M.J., & Talan, D.A. (2007). Antibiotic Use for Emergency Department Patients with Upper Respiratory Infections: Prescribing Practices, Patient Expectations, and Patient Satisfaction. *Annals of Emergency Medicine*, *50*(3), 213–220.	Methodology – mixed-methods study; data analysed together
79.	**Page**, M.A., Bajorek, B.V, & Brien, J.A.E. (2008). Prescribing in teaching hospitals: A qualitative study of social and cultural dynamics. *Journal of Pharmacy Practice and Research*, *38*(4), 286–291.	Not relevant to the review
80.	**Pakyz**, A.L., Moczygemba, L.R., Vanderwielen, L.M., Edmond, M.B., Stevens, M.P., & Kuzel, A.J. (2014). Facilitators and barriers to implementing antimicrobial stewardship strategies: Results from a qualitative study. *American Journal of Infection Control*, *42*(10), S257–S263.	Population – pharmacists and physicians; data analysed together
81.	**Panesar**, P., Jones, A., Aldous, A., Kranzer, K., Halpin, E., Fifer, H., Pollara, G. (2016). Attitudes and behaviours to antimicrobial prescribing following introduction of a smartphone App. *PLoS ONE*, *11*(4), e0154202.	Methodology – survey

82.	**Pasay**, D.K., Chow, S.J.S., Bresee, L.C., Guirguis, M., & Slobodan, J. (2015). Assessment of current antimicrobial stewardship policies and resources: a focus group project. *Healthcare Infection*, *20*(1), 7–15.	Population – pharmacists
83.	**Payne**, K.F., Weeks, L., & Dunning, P. (2014). A mixed methods pilot study to investigate the impact of a hospital-specific iPhone application (iTreat) within a British junior doctor cohort. *Health Informatics Journal*, *20*(1), 59–73.	Topic or intervention – pilot study investigating the impact of smartphone application
84.	**Rattanaumpawan**, P., Morales, K. H., Binkley, S., Synnestvedt, M., Weiner, M.G., Gasink, L.B., Lautenbach, E. (2011). Impact of antimicrobial stewardship programme changes on unnecessary double anaerobic coverage therapy. *Journal of Antimicrobial Chemotherapy*, *66*(11), 2655–58.	Methodology – a case-control study
85.	**Reynolds**, M., Jheeta, S., Benn, J., Sanghera, I., Jacklin, A., Ingle, D., & Franklin, B.D. (2016). Improving feedback on junior doctors' prescribing errors: mixed-methods evaluation of a quality improvement project. *BMJ Quality & Safety*, *26*(3), 240-247.	Not relevant to the review
86.	**Rodriguez,** K.L., Burkitt, K.H., Sevick, M.A., Scott Obrosky, D., Aspinall, S.L., Switzer, G., Fine, M.J. (2009). Assessing processes of care to promote timely initiation of antibiotic therapy for emergency department patients hospitalized for pneumonia. *Joint Commission Journal on Quality and Patient Safety*, *35*(10), 509–518.	Methodology – mixed-methods study; data analysed together
87.	**Safdar,** N., Abbo, L. M., Knobloch, M.J., & Seo, S.K. (2016) Research Methods in Healthcare Epidemiology: Survey and Qualitative Research. *Infection Control and Hospital Epidemiology*, *37*(11), 1–6.	Not relevant to the review
88.	**Saint**, S., Kowalski, C. P., Forman, J., Damschroder, L., Hofer, T.P., Kaufman, S.R., Krein, S.L. (2008). A multicenter qualitative study on preventing hospital-acquired urinary tract infection in US hospitals. *Infection Control & Hospital Epidemiology*, *29*(4), 333–41.	Not relevant to the review
89.	**Salci**, T.P., Batilana, A.P., Pietrobon, R., & Caparroz-Assef, S.M. (2014). Problems related to antifungal prescription: a qualitative study of the views of intensivists. J*ournal of Evaluation in Clinical Practice, 20*(4), 460–466.	Excluded country
90.	**Shah**, N., Castro-Sanchez, E., Charani, E., Drumright, L.N., & Holmes, A.H. (2015). Towards changing healthcare workers' behaviour: A qualitative study exploring non-compliance through appraisals of infection prevention and control practices. *Journal of Hospital Infection*, *90*(2), 126–134.	Not relevant to the review
91.	**Shebl**, N., Franklin, B., Barber, N., Burnett, S., & Parand, A. (2012). Failure Mode and Effects Analysis: views of hospital staff in the UK. *Journal of Health Services Research & Policy*, *17*(1), 37–43.	Not relevant to the review
92.	**Souza-Oliveira**, A.C., Cunha, T.M., Passos, L.B. da S., Lopes, G. C., Gomes, F.A., & Rder, de B. (2016). Ventilator-associated pneumonia: the influence of bacterial resistance, prescription errors, and de-escalation of antimicrobial therapy on mortality rates. *Brazilian Journal of Infectious Diseases*, *20*(5), 437–443.	Methodology – retrospective study
93.	**Stach**, L.M., Hedican, E.B., Herigon, J.C., Jackson, M.A., & Newland, J.G. (2012) Clinicians' attitudes towards an antimicrobial stewardship program at a children's hospital. *Journal of the Pediatric Infectious Diseases Society*, *1*(3), 190–	Methodology – survey

	197.	
94.	**Szymczak**, J.E., Feemster, K.A., Zaoutis, T.E., & Gerber, J.S. (2014). Pediatrician Perceptions of an Outpatient Antimicrobial Stewardship Intervention. *Infection Control and Hospital Epidemiology*, *35*(S3), S69–S78.	Irrelevant healthcare setting – primary care
95.	**Teo**, C.K., Baysari, M.T., & Day, R.O. (2013). Understanding compliance to an antibiotic prescribing policy: Perspectives of policymakers and prescribers. *Journal of Pharmacy Practice and Research*, *43*(1), 32–36.	Population – sample included general practitioners; data analysed together
96	**Tonna**, A.P., Stewart, D.C., West, B., & McCaig, D.J. (2010). Exploring pharmacists' perceptions of the feasibility and value of pharmacist prescribing of antimicrobials in secondary care in Scotland. *The International Journal of Pharmacy Practice*, *18*, 312–319.	Population – pharmacists
97.	**Treiber**, L.A., & Jones, J.H. (2012) Medication Errors, Routines, and Differences Between Perioperative and Non-perioperative Nurses. *AORN Journal*, *96*(3), 285–294.	Not relevant to the review
98.	**Velasco**, E., Ziegelmann, A., Eckmanns, T., & Krause, G. (2012). Eliciting views on antibiotic prescribing and resistance among hospital and outpatient care physicians in Berlin, Germany: results of a qualitative study. *BMJ Open*, *2*(1), e000398.	Population – sample included outpatient care physicians; data analysed together
99.	**Van der Sijs**, H., Aarts, J., van Gelder, T., Berg, M., & Vulto, A. (2008). Turning Off Frequently Overridden Drug Alerts: Limited Opportunities for Doing It Safely. *Journal of the American Medical Informatics Association*, *15*(4), 439–448.	Not relevant to the review
100.	**Van Parys**, J., Stevens, M.P., Moczygemba, L.R., & Pakyz, A.L. (2016). Antimicrobial Stewardship Program Members' Perspectives on Program Goals and National Metrics. *Clinical Therapeutics*, *38*(8), 1914–1919.	Not relevant to the review
101.	**Vlahovic-Palcevski**, V., Francetic, I., Palcevski, G., Novak, S., Abram, M., & Bergman, U. (2007) Antimicrobial use at a university hospital: appropriate or misused? A qualitative study. *International Journal of Clinical Pharmacology and Therapeutics*, *45*(3), 169–74.	Methodology – survey
102.	**Warburton**, J., Hodson, K., & James, D. (2014). Antibiotic intravenous-to-oral switch guidelines: Barriers to adherence and possible solutions. *International Journal of Pharmacy Practice*, *22*(5), 345–353.	Methodology – Delphi study followed by interviews; no direct quotes available
103.	**Weeks**, G.R., Ciabotti, L., Gorman, E., Abbott, L., Marriott, J.L., & George, J. (2014). Can a redesign of emergency pharmacist roles improve medication management? A prospective study in three Australian hospitals. *Research in Social and Administrative Pharmacy*, *10*(4), 679–692.	Not relevant to the review
104.	**Weeks,** G.R. (2015). *Collaborative prescribing roles as part of advanced practice for Australian hospital pharmacists* [Doctoral Thesis, Monash University].	Population – pharmacists
105.	**Weiss**, K., & Simon, A. (2016). Antibiotic Stewardship and Hospital Hygiene in German Paediatric Inpatient Facilities: A Qualitative Survey from the Paed IC Working Group. *Klinische Padiatrie*, *228*(5), 257–262.	Methodology – survey
106.	**Wentzel**, J., van Velsen, L., van Limburg, M., de Jong, N., Karreman, J., Hendrix, R., & van Gemert-Pijnen, J.E. (2014). Participatory eHealth development to support nurses in antimicrobial stewardship. *BMC Medical Informatics and Decision Making*, *14*(1), 45.	Not relevant to the review

107.	**Wiklund**, S., Fagerberg, I., Örtqvist, A., Broliden, K., & Tammelin, A. (2015) Staff experiences of caring for patients with extended-spectrum b-lactamase producing bacteria: A qualitative study. *American Journal of Infection Control*, *43*(12), 1302–09.	Not relevant to the review
108.	**Zaidi**, S.T.R., & Thursky, K.A. (2013). Using formative evaluation to improve uptake of a web-based tool to support antimicrobial stewardship. *Journal of Clinical Pharmacy and Therapeutics*, *38*(6), 490–497.	Not relevant to the review
109.	**Zuberi**, D.M., Ptashnick, M.B., Collet, J.C., Lau, T.T.Y., Mirzanejad, Y., & Thomas, E.E. (2015). Mobilising for safer care: addressing structural barriers to reducing healthcare-associated infections in Vancouver, Canada. *Health Sociology Review*, *24*(2), 137–151.	Not relevant to the review

Appendix 23: CASP Quality Appraisal (Phase 3)

Paper	Decision to retain for Phases 4-6	1. Clear research aims		2. Qualitative methodology appropriate		3. Research design		4. Recruitment strategy		5. Data Collection		6. Reflexivity		7. Ethical Issues		8. Data Analysis		9. Findings		10. Research Value	
		R1*	R2*	R1	R2	R1	R2	R1	R2	R1	R1	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
Almatar et al. 2014	✗	Yes	Yes	Yes	Yes	P	Yes	P	Yes	Yes	Yes	No	No	Yes	Yes	U	U	Yes	Yes	P	Yes
Barlow et al. 2008	✗	P	P	P	Yes	P	P	Yes	Yes	P	Yes	No	No	P	P	No	No	P	Yes	P	P
Almatar 2015	✗	This is a thesis and is a copy of Almatar et al.'s (2014) study																			
Cortoos et al. 2008	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	P	P	P	Yes	Yes	Yes	Yes	Yes	Yes
Björkman et al. 2010	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	P	P	P	P	P	Yes	P	P
Broom et al. 2014	✓	P	P	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	P	P	P	P	Yes	Yes	Yes	Yes	Yes	Yes
Mattick et al. 2014	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	P	P	P	Yes	Yes	Yes	Yes	Yes	Yes	Yes
May et al. 2014	✓	Yes	Yes	Yes	Yes	P	Yes	Yes	Yes	P	P	No	No	P	P	U	U	Yes	Yes	Yes	Yes
Livorsi et al. 2015	✓	Yes	Yes	Yes	Yes	P	Yes	P	P	Yes	Yes	No	P	P	Yes	Yes	Yes	Yes	Yes	P	Yes
Livorsi et al. 2016	✓	Yes	Yes	Yes	Yes	Yes	Yes	P	P	P	P	P	P	P	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Skodvin et al. 2015	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	P	P	Yes	P	Yes	Yes	Yes	P	P

Broom et al. 2016a	✓	Yes	Yes	Yes	Yes	Yes	Yes	P	P	Yes	Yes	P	P	P	P	P	Yes	Yes	Yes	Yes	Yes
Broom et al. 2016b	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	P	P	No	P	P	P	Yes	Yes	Yes	Yes	Yes	Yes
Broom et al. 2016c	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	P	P	Yes	Yes	Yes	Yes	Yes	Yes
Eyer et al. 2016	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	P	P	No	P	P	P	Yes	Yes	Yes	Yes	Yes	Yes
Rawson et al. 2016	✓	Yes	Yes	Yes	Yes	P	P	Yes	Yes	P	P	Yes	P	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Broom et al. 2017	✓	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	P	P	Yes	Yes	Yes	Yes	Yes	Yes
Sedrak et al. 2017	✓	Yes	Yes	Yes	Yes	P	Yes	Yes	Yes	P	Yes	Yes	P	P	Yes	P	P	Yes	Yes	Yes	Yes

Key: *R1 – reviewer 1; **R2** – reviewer 2.

Individual decisions: **P**- Partially, **U**- Unable to determine.

Appendix 24: Example of tabulated data for Cluster B studies (Phase 4)

CONCORDANCE WITH ANTIBIOTIC GUIDELINES		
First-order constructs	**Second-order constructs**	**Additional ideas**
Björkman et al., 2010 *"So, in all treatment with antibiotics this [antibiotic resistance] is, so to speak, kept in one's mind. To be frank, this is not exactly my main area of interest, and then you follow these recommendations and guidelines we get from the department of infectious diseases." [Interview 4]* **Broom et al., 2014** *[Consultant, Renal, Male] "No [antibiotics] it's a peripheral thing. I think to be honest, it's a peripheral thing. You don't go read up, I don't memorise antibiotic guidelines. I don't bother reading up what's new in the last 12 months. Only when patients have allergies do you ever pull out antibiotic guidelines."* *[Consultant, Renal, Male] "Some of the habits I've picked up are guidelines driven but derived in another hospital, and I carry that over here sometimes. Until I get familiar with "Oh, okay, look this is now the new practice, this is now the new recommendation," alright I'll change it now. Do I keep up with antibiotics? Only via osmosis on the ward."* **May et al., 2014** *[Attending, Male, 12yrs] "We see a very broad spectrum of disease, so being able to keep up with all the antibiotic regimens and recommendations from all of the specialties I think is difficult."* *[Attending, 10 yr] "The problem with guidelines in general, is there is unique patient populations. And if they're not addressed in the*	• The patient must be treated and guidelines for restrictive treatment should be followed. • The strategy is to follow guidelines carefully, which include the safe use of antibiotics with narrow spectrum in the treatment of most patients. • Antibiotic prescribing, in sum, is viewed as variable, shifting and adaptable to a given context, regardless of best practice or therapeutic guidelines. • Doctors' practices are governed by external factors at a local level – they are disciplined into habitual practices that do not necessarily correlate with therapeutic guidelines or current best practice. • Junior doctors mention protocols and guidelines frequently, particularly the support they provide for ward- specific prescribing decisions if easily accessible. • Awareness of guidelines is frequently lacking, and junior doctors describe finding guidelines by chance, sometimes after doing something wrong. • Protocol-led prescribing is described by junior doctors in positive terms since it encouraged familiarity with managing commonly occurring cases. • Following protocols is not always straightforward, but off-protocol prescribing is generally described as more difficult and error prone, requiring greater judgement and with greater potential to involve conflicting guidance. • Clinicians reference pocket antibiotic guides or local or national guidelines to make prescribing decisions; however, they have a difficult time keeping abreast with evolving recommendations and frequently turn to the internet to obtain current evidence-based guidance. • Clinicians' attitudes towards the national guideline correspond with	• Distribution • Accessibility • Clarity • Interpretation • Content • Agreement • Familiarity • Awareness • Acceptability • Stringency • Sense of security • Evidence-based • Scepticism • Only an instrument • One size doesn't fit all All studies except three (Broom et al., 2016a, Broom et al., 2016c and Eyer et al., 2016) address the drivers of guideline-concordant care. Emphasis placed on the familiarity, awareness, and acceptability of antibiotic guidelines. Lack of awareness regarding the existence of guidelines, insufficient familiarity with the content, lack of clarity and appropriate training on their use and time constraints to look up the

guidelines, then you kinda just have to default to what you think is best." *[Attending, 5 yrs] "We love guidelines. I mean they make it easy for us and also gives us ammunition when we're talking to the patient. We have specific guidelines that say to do this. We have specific guidelines that say to prescribe this"* *[Attending, 6 yrs]"They're really difficult to read. And if you don't have the knowledge on what you might be covering in the first place they're a bit pointless."* **Livorsi et al., 2015** *[Resident] "When it is 3:00 in the morning, depending on how busy you are, the easiest solution is to throw vancomycin and piperacillin-tazobactam at every patient because you do not have time to read the confusing guidelines that tell you 16 different things you would potentially do."* **Skodvin et al., 2015** *[Intern] "When I was told that the guideline was outdated I panicked. What am I going to do, what am I going to use now? Fortunately, the new ones were then published."* *[Intern, Internal Medicine] "The computer works incredibly slow here. It is very annoying when logging on, that is. You just sit there and twiddle your thumbs for... That's when it would have been great to have an app, just great. Suboptimal IT-systems impairs the availability of the guidelines. Distribution on several platforms would promote the availability."* *[Intern, Internal Medicine] "It's perfectly okay as long as you use it, you're safe. No one can hold anything against you as long as you treat according to the guideline. It really makes you feel safe when on call."* *[Resident] "There is no scheduled training, no. You're expected to*	level of clinical experience. Whereas interns and inexperienced residents are dependent on the guideline, senior doctors are more sceptical toward it, which is in accordance with other studies • The lack of adherence to guidelines among senior doctors may be due to clinical autonomy and experience. In Norway, it may also be explained by a gap in exposure to ASP interventions. • The national guideline is considered a useful tool by interns and inexperienced residents. • More experienced residents use the guideline as a reference for checking dosages and treating uncommon infectious diseases, whereas consultants, including ID-specialists, consider the guideline as less significant and emphasize the need to adjust treatment to individual patients. • They consider the guideline as a tool and not a law and may point out its weaknesses. • Some clinicians express a desire to have a printout, a pocket guide or a smart phone application. • The guideline is used as a tool to promote antimicrobial policy. • Informal leaders (ID- specialists), and to a lesser extent formal leaders (hospital managers), point to the guideline as a national and local standard for antimicrobial treatment. • When knowledge and experience are insufficient, the guideline is perceived as a useful and supportive tool. • The guideline's significance however decreases with increased experience and knowledge. • The national guideline is used as a substitute for formal training. Experienced doctors or managers may refer to it as a useful tool to the less experienced. • Evidence-based practice often operates in conflict with more traditional models of knowledge transfer. • To rationalise non-compliance with current clinical guidelines or ID/CM advice, participants separate clinicians from non-clinicians, and explore reasons why the clinical guidelines do not apply to their patient or that particular clinical situation. • As guideline adherence is not part of the current learning model, guideline changes were reported to be confusing to the participants and hospital clinicians more broadly, and practice change filtered through the hospital inconsistently and without	recommendations seen as a major barrier to guidelines-concordant care, leading to more permissive use of antibiotics. Broom et al. (2014), Skodvin et al. (2015) and Broom et al. (2016a) highlight the scepticism regarding guidelines use. Less experienced clinicians are more dependent on the guidelines for a reference when checking dosages and treating uncommon infections. Senior doctors tend to be more sceptical towards it. Senior doctors recognise their responsibility in ensuring that guidelines are followed, but they rationalise non-compliance by their autonomy and the need to adjust treatment to the individual patient's particular clinical situation. Print outs, pocket guides and smart phone applications are viewed as useful, but doctors (irrespective of the level of experience) have a difficult time keeping up to date with evolving recommendations and find frequent guideline changes, without the reasons behind the changes, confusing.

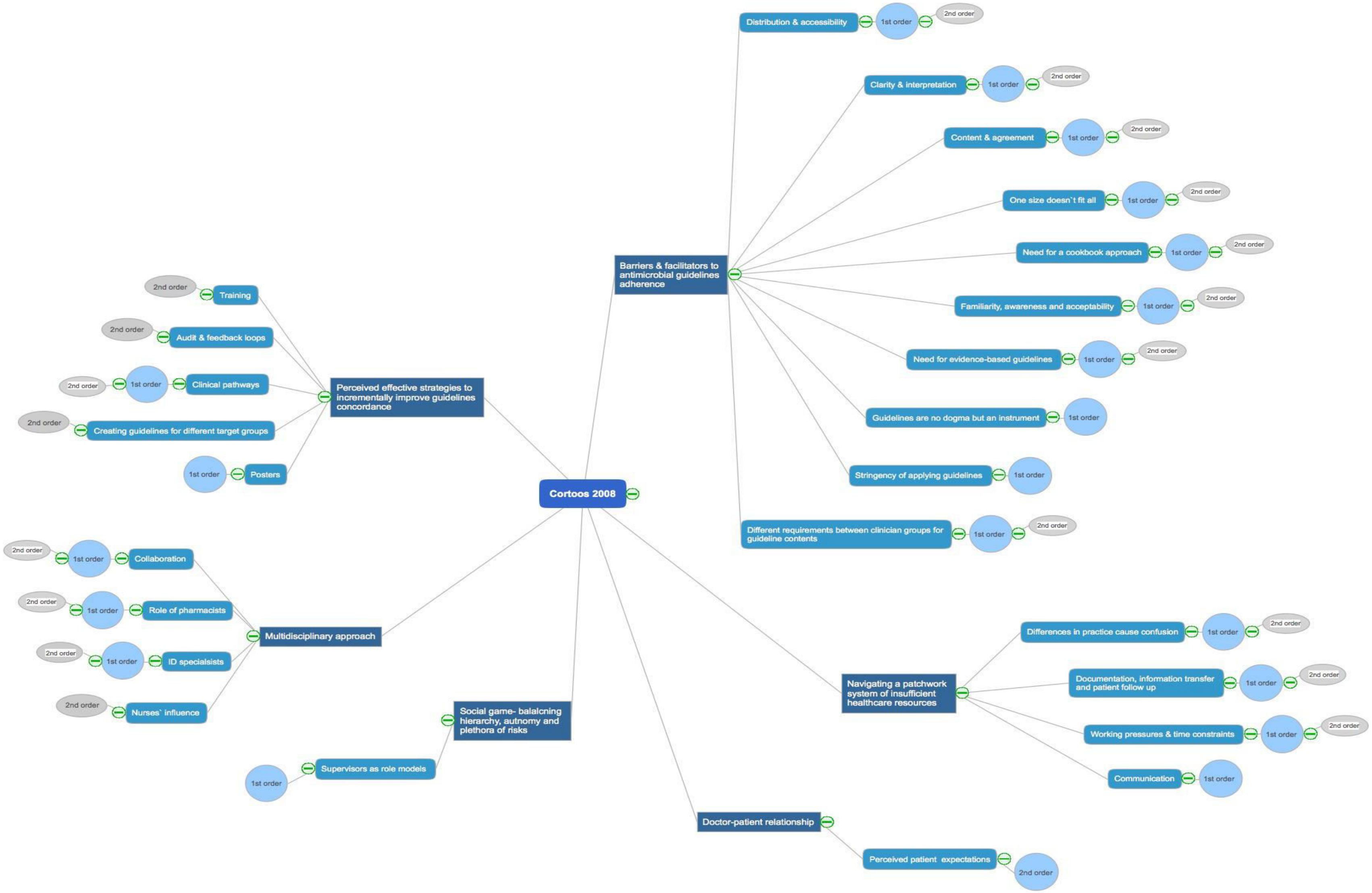
possess that knowledge, which you do not as an intern, because it's too theoretical. To have a guideline, -it is presented to you early on... Just check the guideline, just use it. And you end up reading about it yourself." *[Consultant, ID-specialist] "Well, I try to stick to the guideline, most of the time. If I do not, I normally have good reasons not to. But, I do not always agree with it. And I try to justify it if I do not follow it."* *[Consultant, Internal Medicine] "We have checklists for items they have to check out. And the antibiotic guideline is one among them. That's how we somehow tell them this is to be complied with, and also to be sure that they know how to find it."* **Broom et al., 2016b** *[Male, Non-Consultant, Surgical] "I don't know if they're [consultants] fully up-to-date with microbiology policy. Because it is updated quite a lot, and sometimes it's hard to keep up with what are the latest policies. I can't say for certain, the only thing I can say is [consultants are] just not aware of some of the policies, the most recent policies."* *[Male, Consultant, Medica]) "...the gut reaction is to write up Augmentin. and I'm not sure where it has come from! I really do not know, I'm not aware of any guidelines as to what has prompted us to do that. But I know clinically, this is what this person is suffering from and I know this person benefits from this particular antibiotic even though it is against hospital guidelines."* *[Male, Consultant, Medical] "I know that they [ID/CM] do not always conform to those guidelines and I'm using my clinical judgement and what that patient has had in the past to inform my choice as well."* **Rawson et al., 2016** *[On-rotation, Respiratory/General Medicine] "We use local policy guidelines, so when I am assessing a patient I am thinking – Okay where is the focus? And also, if I know where it is [the focus], what*	understanding regarding the reasons behind the practice change. • Prescribing doctors often do not acquaint themselves regularly with new policies, and if they do, they do not fully understand why and how policies were changed. This background knowledge was located in ID/CM specialists. • Evidence-based practice often operates in conflict with more traditional models of knowledge transfer. • The analysis presented here indicates that antibiotic decision making cannot simply be improved by the delivery of technical advice or dissemination of guidelines. • Lack of awareness regarding the existence of guidelines and insufficient familiarity with their exact content are major barriers to implementing evidence-based best practices. • The less clinical experience physicians have, the more likely they are to be unfamiliar with the exact content of guidelines, which may increase permissive use of antibiotics (Eyer et al., 2016). • Antimicrobial prescribing guidelines and clinical microbiology services play a large role in the decision making process for infection management, despite senior physicians taking responsibility for the patients' overall management and care. • On-rotation and specialist trainee physicians report adherence to guidelines for prescribing as they realise that this is the expectation of their senior colleagues and the hospital. • Consultants report that their job is to ensure that these guidelines are adhered to when this is appropriate, but also retain autonomy to be able to adapt guidelines based on their own experience and feel for the situation. • The decision process is further supported by the provision of detailed local prescribing guidelines, which provide junior trainees with justification for making prescribing decisions and protecting them from judgement by their senior team members, even if those decisions are incorrect.	Passive dissemination does not improve their use.

antibiotics specifically does my hospital use?" *[On-rotation, Acute Medicine 1] "Does that really change your management? With the majority of cases it hasn't. So you strap them on the standard hospital protocol for CAP/infective exacerbation and you tend to just carry it on."* *[On-rotation, Acute Medicine 2] "Well because we're almost held down now by [antibiotic app guidelines] or whatever your Trust uses, so you end up, if you haven't done something by that choice you will go, or normally a pharmacist will go, why haven't you done that?"* *[On-rotation, Respiratory] "Well it's not patient specific [local guidelines] so it's quite generalised and it won't always have all the information about the patient."* *[Specialist Registrar, Geriatrics] "I do find antibiotic guidelines very helpful, and actually in the last couple of trusts I've worked in, they've been so comprehensive that I've not really used any other sources at all."* *[Specialist Registrar, Cardiology] "I think in terms of decision making I have to say I don't keep up to date with the antibiotic formula because I look it up if I need it."* *[Consultant, Respiratory] "Quite often on a post-take ward round say, why are we giving this, has anyone checked the policy, is this in line with policy because I don't think it is?"*		

Appendix 25: How data were organised using Excel spreadsheet (Phase 4)

Cluster B studies	Narrow-spectrum antibiotics considered not effective	Antibiotics are a peripheral thing	Overtreatment due to trivialisation	Mythical properties of IV antibiotics	Anxiety leads to generosity of treatment	Clinical uncertainty	Low threshold for intitiation of antibiotics	Guidelines at odds with the bedsie evidence	AMR awareness not practical at the bedside	Benefits of antibiotics outweight the risks	Therapeutic powerlessness	`Wait and see approach`
Bjorkman 2010 (Sweden)												
1st-order constructs	x				x	x	x					x
2nd-order constructs	x		x		x	x		x	x			x
Broom 2014 (Australia)												
1st-order constructs		x	x		x	x	x	x	x			
2nd-order constructs					x	x			x	x		
Mattick 2014 (UK)												
1st-order constructs												
2nd-order constructs						x						
May 2014 (USA)												
1st-order constructs							x					x
2nd-order constructs		x	x			x	x			x		x
Livorsi 2015 (USA)												
1st-order constructs					x	x	x		x	x	x	
2nd-order constructs		x			x	x	x			x		
Skodvin 2015 (Norway)												
1st-orderconstructs												
2nd-order constructs	x				x	x						x
Broom 2016a (UK)												
1st-order constructs		x		x			x					
2nd-order constructs		x		x				x		x		
Broom 2016b (UK)												
1st-order constructs		x	x				x	x				
2nd- order constructs		x						x				
Broom 2016c (Australia)												
1st-order constructs					x	x	x	x				
2nd-order constructs					x	x	x	x		x		
Eyer 2016 (Switzerland)												
1st-order constructs			x		x	x	x	x		x	x	
2nd-order constructs	x		x	x	x	x	x			x	x	
Rawson 2016 (UK)												
1st-order constructs			x		x	x	x	x		x		
2nd-order constructs	x			x				x				x
Broom 2017 (UK)												
1st-order constructs	x				x		x		x	x		
2nd-order constructs	x				x		x	x	x	x	x	x

Appendix 26: Example of a concept map used during translation of studies (Phase 5)



Appendix 27: Example of vague versus distinct thematic labels (Phase 5)

VAGUE LABELS	DISTINCT LABELS
Working relations (Mattick et al., 2014)	Negotiating multiple masters: junior doctors ‘stuck in the middle’ (Broom et al., 2016b)
Implicit and explicit factors (Rawson et al., 2016)	Mythical properties of intravenous antibiotics: ‘IV anything is better than oral’ (Broom et al., 2016a)
General attitudes (Cortoos et al., 2008)	Antibiotic over-use is recognised but generally accepted (Livorsi et al., 2015)
Colleagues (Skodvin et al., 2015)	‘They’re not a clinician’: the dynamics of laboratory vs clinical medicine (Broom et al., 2016 b)
Attitudes (Sedrak et al., 2017)	Tension between adhering to guidelines and individualising patient care (Livorsi et al., 2016)
External factors (Eyer et al., 2016)	Habitus and the internalisation of peer practice norms (Broom et al., 2014)
Aware, interested, and competent (Björkman et al., 2010)	‘Fear of losing them’ and the role of patient vulnerability (Broom et al., 2016c)
Externalising the problem (Broom et al., 2017)	The potential adverse effects of antibiotics have a limited influence on physicians’ decision making (Livorsi et al., 2016)

Appendix 28: COREQ criteria for reporting qualitative research (Study 1) (Tong et al., 2007)

No Item	Guide questions/description	Reported on Page no.
Domain 1: Research team and reflexivity		
Personal Characteristics		
1. Interviewer/facilitator	Which author/s conducted the interview or focus group?	145
2. Credentials	What were the researcher's credentials? e.g., PhD, MD	17, 185
3. Occupation	What was their occupation at the time of the study?	17, 185
4. Gender	Was the researcher male or female?	17, 185
5. Experience and training	What experience or training did the researcher have?	185
Relationship with participants		
6. Relationship established	Was a relationship established prior to study commencement?	141
7. Participant knowledge of the interviewer	What did the participants know about the researcher? e.g., personal goals, reasons for doing the research	145
8. Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g., Bias, assumptions, reasons and interests in the research topic	185
Domain 2: study design		
Theoretical framework		
9. Methodological orientation and theory	What methodological orientation was stated to underpin the study? e.g., grounded theory, discourse analysis, ethnography, phenomenology, content analysis	148
Participant selection		
10. Sampling	How were participants selected? e.g., purposive, convenience, consecutive, snowball	140
11. Method of approach	How were participants approached? e.g., face-to-face, telephone, mail, email	141
12. Sample size	How many participants were in the study?	143
13. Non-participation	How many people refused to participate or dropped out? Reasons?	142
Setting		
14. Setting of data collection	Where was the data collected? e.g., home, clinic, workplace	144
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	146
16. Description of sample	What are the important characteristics of the sample? e.g., demographic data, date	143
Data collection		
17. Interview guide	Were questions, prompts and guides provided by the authors? Was it pilot tested?	146

18. Repeat interviews	Were repeat interviews carried out? If yes, how many?	N/A
19. Audio/visual recording	Did the research use audio or visual recording to collect the data?	145
20. Field notes	Were field notes made during and/or after the interview or focus group?	146
21. Duration	What was the duration of the interviews or focus group?	145
22. Data saturation	Was data saturation discussed?	148
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction?	183
Domain 3: analysis and findings		
Data analysis		
24. Number of data coders	How many data coders coded the data?	63, 148
25. Description of the coding	Did authors provide a description of the coding tree?	150
26. Derivation of themes	Were themes identified in advance or derived from the data?	148
27. Software	What software, if applicable, was used to manage the data?	149
28. Participant checking	Did participants provide feedback on the findings	183
Reporting		
29. Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g., participant number	153-170
30. Data and findings consistent	Was there consistency between the data presented and the findings?	172
31. Clarity of major themes	Were major themes clearly presented in the findings?	153-170
32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	163

Appendix 29: Recruitment poster (Study 1)

RESEARCH PARTICIPANTS NEEDED

The purpose of this research is to develop a behaviour change intervention to optimise antibiotic use in acute hospitals. The study is called **IMPACT**.

Who can participate?

We are looking for healthcare professionals of any age, specialty or experience involved in everyday decision-making around antibiotic use.

What's involved?

The study involves participating in an online interview, which will last approximately 1 hour. The researcher will ask for your advice and feedback about the design and content of a prototype antibiotic intervention.

FOR MORE INFORMATION OR TO VOLUNTEER FOR THE STUDY, PLEASE CONTACT:

Gosha Wojcik
Email: G.Wojcik@napier.ac.uk
Tel: 07908 48 5534

This study has been reviewed by, and received ethical approval from Edinburgh Napier University Research Committee and the NHS R&D Clinical Governance Board.

This study is being funded by Edinburgh Napier University

Appendix 30: Interview topic guide (Study 1)

NHS
Lothian

Edinburgh Napier
UNIVERSITY

INDICATIVE TOPIC GUIDE FOR FOCUS GROUPS

`Development of a theory-based behaviour change Intervention to Promote optimal antibiotic use in ACute hospiTals: The IMPACT Study`

Welcome - Explain purpose of the group consultation:

- Thank you for agreeing to do this group consultation. My name is Gosha Wojcik and I'll be talking with you today.
- As you know, this study is being funded by the Edinburgh Napier University, which is part of my PhD Thesis.
- The purpose of this group consultation today is to design an intervention to promote appropriate antibiotic use based on the elements derived from high-quality literature and to generate new ideas and explore feasible forms of delivery.
- We'd like to get your input on the content and format and mode of delivery of the intervention.
- The discussion will last no more than 90 minutes.
- Have you had the chance to read the Participant Information Sheet?
- Do you have any questions?

Ground rules:

- Everything you tell us will be kept confidential. To protect your privacy, we won't connect your name with anything that you say.
- At any time during our conversation, please feel free to let me know if you have any questions or if you would rather not answer any specific question. You can also stop the interview at any time for any reason.
- Please help yourself to the refreshments provided.
- Please remember that we want to know your thoughts and opinions and that there are no right or wrong answers.
- Is it okay if I audiotape this interview today?

TOPIC	EXAMPLE QUESTIONS
Theory-generation	• Do you find it easy to prescribe antibiotics? Tell me about this. • What barriers and facilitators to appropriate antibiotic prescribing in a hospital setting can you think of? • Can you visualise how antibiotic prescribing processes would look like in the future, in ideal world? • How do you think we can achieve this ideal form of antibiotic prescribing? • What, in your opinion, facilitates or challenges appropriate prescribing behaviour?

	• How might you promote that behaviour?
Generating the content of the intervention	• What information, key points or guidance should be included in the intervention? • Can you think of different ways we can phrase the main message of the intervention?
Generating the format and mode of delivery of the intervention	• What kind of mode of delivery do you think would work well for this type of an intervention in your area? • What format do you think would be most useful? • What points of communication in a hospital setting are most amenable to intervention? (i.e. ward rounds, handovers) • Who do you think should deliver the intervention? • What challenges might there be on its introduction?
Generating ideas of hypothetical clinical scenarios for the intervention	• In your experience, are there any particular forms of delivering an antibiotic prescribing intervention that healthcare professionals would embrace? • Can you think of any clinical scenarios the intervention would work well in/would not work at all? • How can we tailor the intervention to ensure it does work well in the real world?
Acceptability of the intervention	• Do you think the content and format of the intervention would be acceptable for clinical use? Please explain. • How would you foresee using the intervention? • In your opinion and experience, what is the level of training needed to use the intervention, the time necessary to complete it, the complexity of interpreting it? • Do you think this intervention would be accepted by your colleagues and suitable for hospital use? • What is needed to get different stakeholders to "buy in" to the intervention? Hospital leadership? Health care professionals? Patients?
Applicability and practicality of the intervention in the clinical practice	• Is it possible to use it in routine practice? • How do you feel about the possible implementation of this intervention into clinical practice? • Do you envisage any possible barriers to implementing this intervention? • What are the best ways to disseminate the intervention? • What assistance and resources would be needed to implement it? • What are the best ways to sustain those efforts?

Closing:

- Is there anything else that you would like to add about any of the topics that we've discussed or other areas that we didn't discuss but you think are important?

- Thank you for your time and participation in this group consultation. The information that you provided to us will be very helpful in this project.

Appendix 31: Indexing (Study 1)

Participant	Barriers to appropriate antibiotic prescribing	Enablers to appropriate antibiotic prescribing	Lay participants' voice	Proposed components of the antibiotic intervention
Mary	**1.1** Doctors don't have time to do anything. 8 **1.1** Veering off guidelines and lack of documentation for doing so. 8 **1.1** Disjointed information. 12 **1.2** Consultants' preference for certain antibiotics and juniors afraid of being criticised if they don't prescribe it. 12 **1.3** Posters don't change practice/behaviour as they become part of the environment. 20	**2.1** Daily antibiotic reviews, such as in ICU. 6		**4.2** Would like all the information in one place using electronic system. 2 **4.2** Suggests that electronic prescribing could accumulate a job list for the doctors. 4 **4.2** Reasons that somebody would have to take responsibility for that list as juniors end up doing it. 6 **4.2** Triggers on TRAK would remind prescribers to review antibiotics. 6 **4.2** The antibiotic plan should be written during ward round. 10
Cameron	**1.1** Different prescription written by every prescriber due to lack of time to know and understand the patient. 18 **1.1** Outdated and cumbersome IT systems prevent efficient information transfer. 24 **1.3** Stopping antibiotics is more complex than starting due to fear of patient deterioration. 30 **1.3** Thinks that medical training lacks a comprehensive approach to antibiotic prescribing. 36	**2.1** Thinks that there's no medical hierarchy within ICU decision making. 52 **2.1** Consultant microbiologist who provides daily up to date results for the patients. 56 **2.1** Compliance with evidence-based guidelines. 59 **2.1** Guidelines protect prescribers against complaints. 62 **2.1** Reflects on the advantages of having a Master's module on prescribing, which is a good starting point for ANPs. 98		**4.1** Intervention should target all prescribers irrespective of background or speciality. 42 **4.2** Would like clear documentation of rationales for prescriptions. 44 **4.2** An electronic system might prompt the questions regarding antibiotics and answers out of the consultant. 60 **4.2** Would like a more intuitive system that makes a positive microbiology pop-up on screen. 62
Lydia	**1.1** Thinks that barriers to inappropriate prescribing are technological. 13			**4.2** Would like a system that can force more caution around prescribing. 4 **4.2** Clear documentation of antibiotics

	1.1 The current system takes too long to log on. 15 **1.2** As a non-prescriber, she feels powerless in changing prescribing decisions. 11 **1.3** Practising with fear of 'criminalisation' as dispensing a wrong prescription is a criminal offence. 37			means that prescribers can't shy away from their decisions. 5 **4.2** A system that would help juniors sift through information or suggest next steps for treatments. 23 **4.2** Preference for a didactic system that prescribers couldn't by-pass. 23
Hannah	**1.1** Finds it frustrating that antibiotic prescribed at night are not always followed up in the morning. 8 **1.1** Variable prescribing practice between different clinical areas. 16 **1.1** Lack of clear documentation regarding de-escalation of antibiotics, level or plan of treatment. 24 **1.2** Medical hierarchy can be an obstacle. 32 **1.3** Reflects on being threatened with a lawsuit from a patient because she didn't want to give him antibiotics. 46	**2.1** The 'six Rs': the right antibiotic, dose, route, infection, time and duration. 76 **2.1** More tailored guidelines. 90 **2.1** Robust educational provision for nurse prescribers. 104		**4.2** A diary entry which informs prescribers about action points. 56 **4.2** An electronic system that doesn't issue the prescription until the prescriber ticks from the dropdown box. 62
Anna	**1.1** Different clinical teams involved in patients' care and lack of clarity regarding who the decision maker is. 18 **1.2** Juniors passively complying with the prescribing habits and norms set by their seniors. 28 **1.2** Blasé attitude/lack of priority put on timely antibiotic review. 34	**2.1** Antimicrobial guidelines. 38		**4.1** Everyone should prescribe antibiotics to the same standards. 73 **4.2** Having an alert system would mean that somebody becomes responsible for taking action. 77 **4.2** Would like a Clinical Decision Support (CDS) system that would advise an action based on patient history, symptoms and risk factors. 81
Julia	**1.1** Septic patients need broad-spectrum antibiotics straight away due to clinical uncertainty. 10	**2.1** Guidelines and protocols help in antibiotic decision making. 30		**4.2** A system that can generate a list of antibiotics due for review could help with the transitions between shifts. 11

		2.2 Thinks that prescribing decisions should be a more conscious or holistic action. 26		**4.2** A trigger/prompt could help prescribers to reflect and justify their actions. 74 **4.2** The intervention should have a short message, something easy to say at induction, on the guidelines, on the front page of the app. 78 **4.2** Would like a flow chart for filling prescriptions, like a standard operating procedure. 80
Bruce	**1.2** Thinks that inertia is investable in a large organisation with a shortage of resources. 8		**3.1** Thinks that clinicians should make prescribing decisions based on experience and the patient in front of them. 40 **3.2** Clinicians need to listen to patients. 30 **3.2** All clinicians should be interpreting the patient's experience. 46 **3.3** There is currently a lack of encouragement for the patient to be involved in the decision making. 42 **3.4** Nurses can make a better prescribing decision than a senior consultant due to their knowledge of the patient. 32	**4.2** Suggests that NHS should get rid of the paperwork. 64 **4.2** Thinks that electronic prescribing is a way forward and that IT must have a solution to harvesting and sifting all the information. 66 **4.2** Would like to see user experience inbuilt into the IT systems in the future 70
James	**1.1** Time constraints prevent clinicians from making timely decisions. 2 **1.2 C**ommunication and responsibilities are unclear regarding who is making a decision and when. 14 **1.3** There is now no longer the belief that doctors are infallible, and that's why litigation is becoming an issue. 16	**2.2** A cultural shift in prioritising AMR. 22	**3.1** Describes his experience of being treated for sepsis and how he found the consultant explaining clearly his treatment plan very reassuring. 54 **3.2** Points out that doctors should listen and recognises that every clinician might have a	**4.1** Reduce hassle factor. 52 **4.2** Guidelines at the touch of a button and the system directs prescribing decisions. 54 **4.3** Intervention is more likely to embed if the nursing staff and pharmacy staff are involved 56

			different interpretation. 26 **3.3** Discussing their treatment plan and making sure they are happy with that plan is essential. 64 **3.4** Building trust between patient and healthcare professional is essential. 58 **3.4** Thinks that nurses have better links with patients as they see them regularly. 60	
Alice			**3.2** Thinks that clinicians must take cognisance of what the patient is saying and reflects how it helped her progress and recovery. 24 **3.2** Ability to listen as patients may know where the source of infection is coming from. 42 **3.2** If clinicians don't listen, they won't pick up any new clues that could help them in their decision making. 45 **3.3** Confidence helps clinicians to take into account the patient's view and then balance that on their decision. 33 **3.3** Dialogue with the patient and shared decision making. 37	**4.2** Electronic prescribing would improve documentation as prescribers would have to fill in all the required information. 48
Douglas	**1.1** Poorly documented reasons for antibiotics cause confusion and fear of making a mistake. 10 **1.3** Worries about a governing body rather than public. 12 **1.3** It's easier to do something than	**2.1** Shares an experience from a local hospital of issuing three-day codes for restricted antibiotics, which forces a review. 62 **2.1** Clearly documented antibiotic decisions would		**4.1** The intervention should be based on getting people to review what they're doing. 48 **4.2** If prescribers go off the guideline, they should document the reasons for doing so. 50 **4.2** The system could trigger every

	just sit on your hands and wait. 14 **1.3** The action of prescribing is easier than the action of not prescribing. 18 **1.3** It's more of a judgement call to stop an antibiotic than to start it. 20 **1.3** A single antibiotic is sometimes serving multiple purposes, and this can cause confusion when considering stopping treatment. 42	help clinicians taking over the care of the patient to confidently stop or rationalise the treatment. 22 **2.1** Reflects on his medical training and suggests that improved training on antibiotic prescribing should be embedded into the curriculum. 26 **2.2** It should be acceptable for everyone to question antibiotic decisions. 34 **2.2** Juniors should feel able to say why and for how long. 58		three days and ask if an antibiotic is still necessary. 54 **4.3** Training will be necessary at inductions. 72
Joanna	**1.3** Fear of stopping antibiotics in case patient deteriorates or becomes resistant to that antibiotic. 34	**2.2** Prompting a whole team to review and allow juniors to challenge the decision that has been made already. 18 **2.2** Create a culture whereby people welcome that approach. 66 **2.2** The junior doctors are aware of AMR because it's in the social and the professional media. 68		**4.1** Intervention needs to focus on reviewing antibiotics. 28 **4.2** If clinicians don't take responsibility for their prescribing decisions, the blame can be shifted. 30 **4.2** Would like to see more monitoring and auditing of antibiotics. 102 **4.2** Thinks that emotive images should be avoided. 73 **4.2** Thinks that the 3+3 is non-hierarchical, so can ask it without feeling somebody's being put under pressure. 74 **4.3** Consultants need to buy into the Antibiotic 3 +3 (what, why and how long). 72 **4.3** Culture is very difficult to change, but a simple process like asking the 3+3 questions might encourage it. 74 **4.3** It should be the expectation of all the HCPs to ask that question. 92 **4.3** Training is needed if the

				implementation is to be successful. 94
Warren	**1.1** Information that is in different places causes confusion. 2 **1.2** The consultant who's on the following day comes in and says they don't know what they're talking about, and they change it. 6 **1.2** The hierarchy and the culture make people afraid to do a wrong thing. 12 **1.3** Thinks it's easy to prescribe very broad-spectrum antibiotics when you've got an unwell patient in front of you, without necessarily paying attention to the guidelines. 14 **1.3** Fear of not treating a sick patient, and fear of what will happen to you professionally if you make a mistake. 48			**4.2** Would like to have all the patient information in one place and accessible and follow the patient around, like a passport. 56 **4.2** Thinks most of the patient data does exist. 50 **4.2** The message should be clear, concise and understandable; bullet points rather than explanatory words. 62
Emma	**1.3** De-escalation of antibiotics is a significant judgement call. Wonders who is willing to take this responsibility and take the blame for the decision. 15 **1.3** Clinical uncertainty means that sometimes you just don't know. 121	**1.1** Rapid diagnostics would help clinicians to use a better targeted antibiotic. 46 **1.2** Consultant explaining the rationale for a prescription. 3		**4.2** Would like to see all clinicians writing an indication for antibiotics. 13 **4.3** Training at induction is going to be essential. 94
Paula	**1.1** High workload and patient turnover mean that you have to move patients without you seeing them or halfway through seeing them. 6 **1.1** Reflects on her experience of a patient who had an overly long course of broad-spectrum antibiotics due to lack of continuity and senior supervision over Christmas. 8 **1.2** Doesn't seem surprised that some of the reviewing doesn't happen. 14 **1.2** Thinks that having too many	**2.1** Thorough review and checking all the results even in a busy environment. 2 **2.1** Continuity needs to be encouraged. 46 **2.2** Challenging, questioning and clarifying who said what and why, and how long. 48 **2.2** Juniors should be asking the consultant why and how long. 99 **2.2** Not a long question or a		**4.1** Intervention aim should be to reflect on things and review where prescribers are, and justify the decision they're making in the short and longer-term. 42 **4.2** Allows everyone to go in and see the journey of the antibiotic. 44 **4.2** It has to be a simple message, even if it's just something that says stop and review. 48 **4.2** It could be an electronic prompt, or documentation, or patient's notes, but

	specialists involved is sometimes a way of not taking ownership. 9 **1.3** Has to remind juniors: do not treat the culture, treat the patient. 13 **1.3** Reflects on the Bawa-Garba legal case and feels that fear makes junior doctors throw antibiotics around. 23 **1.3** Thinks that it's easier to be active and try and do something than to take a step back and let nature take its course. 32	lengthy explanation because consultants don't do that. 102 **2.2** Senior support should be accessible. 106 **2.2** Someone approachable that you can contact for advice. 110		it has to be something that is easily recognised and noticed by the people who are using it. 52 **4.2** Thinks that another piece of paper would get lost. 58 **4.2** Reasons that emotive images might upset a busy clinician. 76 **4.2** Thinking what, when, how long, every three days can be quite grounding. 81 **4.3** Approachable senior support is equally essential, the seniors being willing to answer questions. 88
Matt	**1.2** Continuing the trends, continuing the status quo and trying to fit in with seniors' specific preferences. 2 **1.2** Lack of feedback on prescribing is a significant issue. 10 **1.2** Juniors feel intimidated. 16 **1.2** Fear of patients deteriorating and fear of consequences what happens if the patients die. 118 **1.3** Reckons that clinicians are less afraid of the patient dying than being reported to the GMC. Fear of losing their profession is higher than that. 115 **1.3** Thinks that it's far easier to do something than just sit on your hands and wait, so the action of prescribing is easier than the action of not prescribing. 98 **1.3** The action of not prescribing involves two things. Firstly, justification and writing longer notes, and secondly, the inaction of not prescribing may dictate a more	**2.2** Tackle the fear factor. 52 **2.2** Empowering and motivating clinicians not to overprescribe. 90		**4.2** It's got to be based around making people document what their decision is, why they've made it, and build it into the routine of the patient's care. 96 **4.2** Everyone should be able to challenge those decisions. 111 **4.3** An electronic system would require educating people on how to use it. 138

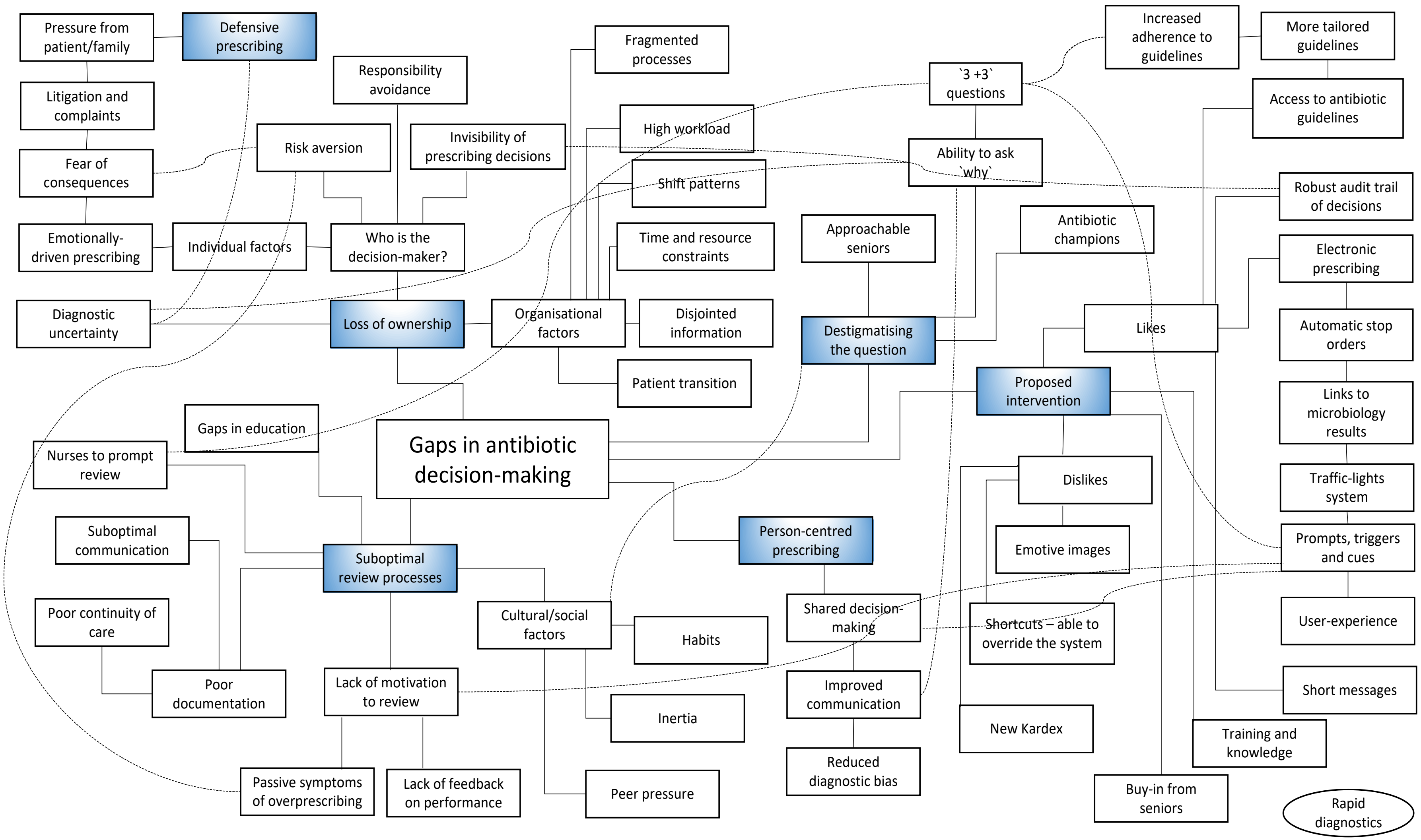
	frequent review. 102 **1.3** Sepsis publications and Sepsis 6 drivers, and sepsis campaigns, and the sepsis three definitions. 108			
Daniel	**1.1** Lack of documentation of what they have reviewed causes confusion. 36 **1.3** Prescribers are caught between two opposites. The best thing for any patient is to give a massive dose of broad-spectrum antibiotics. At the other end of the spectrum, that's the most irresponsible thing. 68 **1.3** Knowledge deficits – some staff groups are familiar with the antibiotics that they use and prescribe, and other staff groups seem disempowered with regard to antibiotics and struggle with the basics. 91	**2.2** Empowerment of medical staff by tapping into their knowledge giving them a structure by which they can realise they can answer their own question. 73		**4.2** Would like an intervention in multi-professional, multi-grade groups because people often end up being taught as a group of FY2s. 50 Skip the Kardex and go straight to the electronic prescribing 52 **4.2** **4.3** Utilise antibiotic guardians in NHS. 58
Olive	**1.1** Lack of review of antibiotics within 24 or 48 hours of prescription. 15 **1.2** Reflects how broad-spectrum use has been perpetrated without rationalising or reviewing. 72	**2.2** Build the 3+3 behaviour into prescribing or as a teaching tool. 48		**4.2** Would like flans recorded and a prompt on the box, or a sticker to review so whoever picks it up, if it's not the person that's done the initial prescription. 76 **4.3** Having facilitators for certain clinical areas that can go in and spend that face-to-face, as that's how most people prefer to learn. 82 **4.3** Training needs to be addressed. 34

Key: Content of interviews divided into themes (code number in bold)

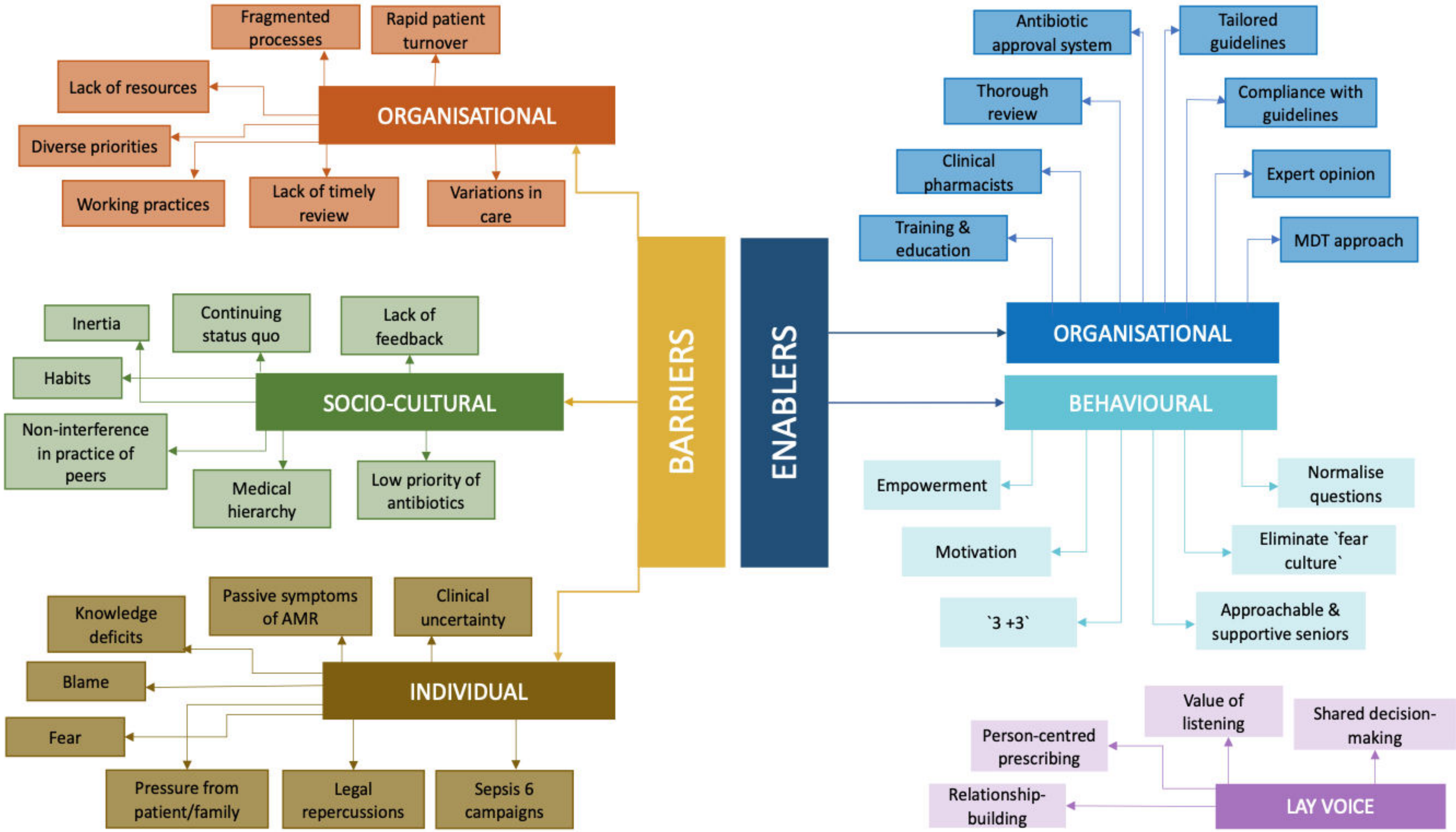
Appendix 32: Charting (Study 1)

<table>
<tr><th>Barrier or Enabler</th><th colspan="2">Behaviour</th><th colspan="2">Applicability to an intervention</th></tr>
<tr><td>Barrier</td><td colspan="2">Gaps in medical and nursing undergraduate education</td><td colspan="2">Embed antimicrobial stewardship into the curriculum. Outwith the scope of the project.</td></tr>
<tr><td>Barrier</td><td colspan="2">Reduce resource constraints</td><td colspan="2">Outwith the scope of the project.</td></tr>
<tr><td>Barrier</td><td colspan="2">Clinical uncertainty</td><td colspan="2">Provide access to rapid diagnostics. Outwith the scope of the project.</td></tr>
<tr><td>Barrier</td><td colspan="2">Reduce time pressures</td><td colspan="2">Employing more efficient systems of working (e.g., electronic prescribing) and streamline clinical workflow.</td></tr>
<tr><td rowspan="8">Barrier</td><td rowspan="8">Sub-optimal antibiotic review process</td><td>Poor documentation of decisions</td><td rowspan="8">TARGET BEHAVIOUR</td><td>Improve the quality of documentation</td></tr>
<tr><td>Disjointed information</td><td>Reduce the hassle factor. All information contained in one place.</td></tr>
<tr><td>Lack of motivation to review</td><td>Increase motivation to review. Provide prompts and triggers.</td></tr>
<tr><td>Low awareness of AMR</td><td>Increase awareness of AMR. Long-term aim. Provide short training sessions during induction.</td></tr>
<tr><td>Loss of decision ownership</td><td>Create a robust audit trail of decisions.</td></tr>
<tr><td>Sub-optimal communication</td><td>Raise awareness of the Antibiotic 3+3 questions.</td></tr>
<tr><td>Risk aversion</td><td>Reduce aversion to taking risks. Provide safeguards.</td></tr>
<tr><td>Unclear responsibilities</td><td>Define specific roles and responsibilities for junior prescribers.</td></tr>
<tr><td>Barrier</td><td colspan="2">Fear of consequences</td><td colspan="2">Increase opportunity to question/challenge decisions of others.</td></tr>
<tr><td>Barrier</td><td colspan="2">Pressure/expectations from patient/family</td><td colspan="2">Increase shared decision making.</td></tr>
<tr><td>Enabler</td><td colspan="2">Senior decision maker</td><td colspan="2">Seniors' engagement, role modelling and support.</td></tr>
<tr><td>Enabler</td><td colspan="2">Feedback mechanisms</td><td colspan="2">Provide timely feedback on performance.</td></tr>
<tr><td>Enabler</td><td colspan="2">Training</td><td colspan="2">Utilise antibiotic champions to provide training.</td></tr>
<tr><td>Enabler</td><td colspan="2">Nurse role</td><td colspan="2">Increase nursing engagement in the review process.</td></tr>
<tr><td>Enabler</td><td colspan="2">Multidisciplinary approach</td><td colspan="2">Normalise input from other specialties in antibiotic decision making.</td></tr>
</table>

Appendix 33: Mapping (connection between themes and sub-themes in Study 1)



Appendix 34: Concept map of barriers and facilitators to appropriate antibiotic prescribing (Study 1 results)



Appendix 35: Definitions of intervention functions and policy categories (Michie et al., 2014)

INTERVENTION FUNCTION	DEFINITION
Education	Increasing knowledge or understanding.
Persuasion	Using communication to induce positive or negative feelings or stimulate action.
Incentivisation	Creating an expectation of reward.
Coercion	Creating an expectation of punishment or cost.
Training	Imparting skills.
Restriction	Using rules to reduce the opportunity to engage in the target behaviour (or to increase the target behaviour by reducing the opportunity to engage in competing behaviours).
Environmental restructuring	Changing the physical or social context.
Modelling	Providing an example for people to aspire to or imitate.
Enablement	Increasing means/reducing barriers to increase capability (beyond education and training) or opportunity (beyond environmental restructuring).

POLICY CATEGORY	DEFINITION
Communication/ marketing	Using print, electronic, telephonic or broadcast media.
Guidelines	Creating documents that recommend or mandate practice. This includes all changes to service provision.
Fiscal measures	Using the tax system to reduce or increase the financial cost.
Regulation	Establishing rules or principles of behaviour or practice.
Legislation	Making or changing laws.
Environmental planning	Designing and/or controlling the physical or social environment.
Service provision	Delivering a service.

Appendix 36: Definitions of TDF domains

Domain	Constructs	Question/s
1. Knowledge (an awareness of the existence of something).	Knowledge (including knowledge of condition/scientific rationale)	Do they know the guideline, what do they think it says or what the evidence is behind it?
	Procedural knowledge	Do they know they should be, and/or why they should be doing X?
	Knowledge of task environment	What is the environment for doing X? Are they aware of the ins and outs of the environment?
2. Skills (an ability or proficiency acquired through practice).	Skills	Do they know how to do X?
	Skills development	Have they had the right training to do X?
	Competence	Do they feel competent in delivering x?
	Ability	How easy or difficult is it to perform x in the given context?
	Interpersonal skills	Do they have the necessary interpersonal skills to work with others to deliver x or undertake X?
	Practice	Are there adequate opportunities to practice X?
	Skill assessment	Are they assessed and given feedback on the quality of their participation or delivery?
3. Social/ Professional Role and Identity (a coherent set of behaviours and displayed personal qualities of an individual in a social or work setting).	Professional identity	What do they think about the credibility of the source of the guideline?
	Professional role	Is the delivery within the role of the professional?
	Social identity	Do they think a guideline should determine their organisation?
	Identity	Do they identify with X?
	Professional boundaries	Is doing x compatible with professional standards?
	Professional confidence	How confident are they about x despite the difficulties?
	Group identity	Do they think the guideline or X is in keeping with what others are doing?
	Leadership	Management or leaders facilitate the delivery of X.
	Organisational commitment	Management or leaders are willing to listen to problems associated with X or guidelines.
4. Beliefs about Capabilities and Self-Confidence (acceptance of the truth, reality, or validity about an ability, talent, or facility that a person can put to constructive use).	Perceived competence	What would help them?
	Self-efficacy	How difficult or easy is it for them to do X?
	Perceived behavioural control	Do they have control over delivering X?
	Beliefs	Do they believe they can effectively deliver X in context?
	Self-esteem	Do they feel good about themselves when delivering X?
	Empowerment	Do they feel empowered by the work in delivering X?
	Professional confidence	Are they confident they can deliver x despite the difficulties with self?
5. Optimism (the	Optimism	Are they optimistic about the outcome?
	Pessimism	Are they pessimistic about the outcome?

confidence that things will happen for the best or that desired goals will be attained).	Unrealistic optimism	Are they always expecting good things to happen, despite the fact that sometimes bad things happen?
	Identity	Do they identify with feelings of optimism?
6. Beliefs about Consequence (acceptance of the truth, reality, or validity about outcomes of behaviour in a given situation).	Beliefs	Do they believe the delivery of X is useful?
	Outcome expectancies	Do they expect a worthwhile outcome?
	Characteristics of outcome expectancies	Is it worthwhile to care?
	Anticipated regret	Do they feel they might regret delivering X?
	Consequences	What are the costs and consequences of doing X?
7. Reinforcement (increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus).	Rewards (proximal / distal, valued / not valued, probable / improbable)	What are and how likely are the rewards associated with doing X?
	Incentives	Does the evidence and other incentives suggest doing x is a good thing?
	Punishment	Are there punishments associated with not doing X?
	Consequences	What are the costs/ consequences of not doing X?
	Reinforcement	How will they feel if they do or don't do X? Are there financial reimbursements or recognitions?
	Contingencies	Do benefits outweigh the costs?
	Sanctions	What sanctions might be imposed and why?
8. Intentions (a conscious decision to perform a behaviour or resolve to act in a certain way).	Stability of intentions	Do they intend to deliver or not deliver X consistently over a period of time?
	Stages of change model	How strong is their intention to deliver X? (Not considering, considering, acting)
9. Goals (mental representations of outcomes or end states that an individual wants to achieve).	Goals (distal/proximal)	Are there goals set in the immediate and distant future for X?
	Goal priority	How important are achieving goals associated with X?
	Goal/target setting	Are there other things that they want to achieve that could interfere with X?
	Goals (autonomous/ controlled)	How much do they feel they need to do X?
	Action planning	Has a plan been put in action to do X?
	Implementation intention	What is the intention of doing x in a given period?
10. Memory, Attention and Decision Processes (the ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives).	Memory	Delivering x is something they seldom or often forget?
	Attention	Will they think to do X?
	Attention control	How much attention will they have to pay to do X?
	Decision making	Will they remember to do and then make the decision to do X? Might they decide not to?
	Cognitive overload/tiredness	How much cognitive power is needed for X? Is it affected by tiredness?
11. Environmental Context and Resources (any circumstance of a person's situation or environment that discourages or encourages the development of skills	Environmental stressors	Are there competing tasks and time constraints?
	Resources/materials	To what extent do availability, physical or resource factors affect the delivery of X?
	Organisational culture /climate	Do overarching policies, procedures, and cultures support or not support X?
	Salient events / critical incidents	Is doing or not doing x associated with or interrupted by critical incidences or events?
	Person x environment interaction	Are there accessibility factors or

and abilities, independence, social competence, and adaptive behaviour).		environmental influences that change the likelihood of X?
	Barriers and facilitators	Are there other barriers and facilitators to X?
12. Social Influences (those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours).	Social pressure	Is there pressure from others to do or not do X?
	Social norms	Most people who are important to them think that doing X is important/not important
	Group conformity	It is important to them that they conform to the group expectations in doing/not doing X?
	Social comparisons	There is comparative pressure amongst them with respect to X.
	Group norms	Most professionals or similar people think that doing X is important/not important.
	Social support	They can count on others when there are problems with X.
	Power	The power balance in the setting/organisation affects the delivery of X.
	Intergroup conflict	Conflicts within a group affect the delivery of X.
	Alienation	Members of a group or unit could face the threat of alienation for doing/not doing X.
	Group identity	Doing/not doing x forms an important part of group identity.
	Modelling	Others model appropriate/inappropriate behaviours with respect to X.
13. Emotion (a complex reaction pattern involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event).	Fear	When working with X, there are feelings of fear.
	Anxiety	When working with X, there are feelings of anxiety.
	Effect	Working with X is likely to create affect.
	Stress	Working with X is likely to be stressful.
	Depression	Working with X contributes to depressed feelings.
	Positive/negative effect	Working with X can be positive, negative, or both.
	Burn-out	Working with X makes them feel burnt-out.
14. Behavioural Regulation (anything aimed at managing or changing objectively observed or measured actions)	Self-monitoring	Are self-monitoring behaviours needed to deliver X?
	Breaking habit	Doing X requires breaking well-formed habits.
	Action planning	Doing X requires making a plan of action.

Source: Refined TDF adapted from Cane et al. (2012) and questions modified from (Huijg et al., 2014)

Appendix 37: BCT Taxonomy (v1): 93 hierarchically clustered techniques (Michie et al., 2013)

Grouping and BCTs	Grouping and BCTs	Grouping and BCTs
1. Goals and planning 1.1. Goal setting (behaviour) 1.2. Problem-solving 1.3. Goal setting (outcome) 1.4. Action planning 1.5. Review behaviour goal(s) 1.6. Discrepancy between current behaviour and goal 1.7. Review outcome goal(s) 1.8. Behavioural contract 1.9. Commitment	**6. Comparison of behaviour** 6.1. Demonstration of the behaviour 6.2. Social comparison 6.3. Information about others' approval	**12. Antecedents** 12.1. Restructuring the physical environment 12.2. Restructuring the social environment 12.3. Avoidance/reducing exposure to cues for the behaviour 12.4. Distraction 12.5. Adding objects to the environment 12.6. Body changes
2. Feedback and monitoring 2.1. Monitoring of behaviour by others without feedback 2.2. Feedback on behaviour 2.3. Self-monitoring of behaviour 2.4. Self-monitoring of outcome(s) of behaviour 2.5. Monitoring of outcome(s) of behaviour without feedback 2.6. Biofeedback 2.7. Feedback on outcome(s) of behaviour	**7. Associations** 7.1. Prompts/cues 7.2. Cue signalling reward 7.3. Reduce prompts/cues 7.4. Remove access to the reward 7.5. Remove aversive stimulus 7.6. Satiation 7.7. Exposure 7.8. Associative learning	**13. Identity** 13.1. Identification of self as role model 13.2. Framing/reframing 13.3. Incompatible beliefs 13.4. Valued self-identify 13.5. Identity associated with changed behaviour
3. Social support 3.1. Social support (unspecified) 3.2. Social support (practical) 3.3. Social support (emotional)	**8. Repetition and substitution** 8.1. Behavioural practice/rehearsal 8.2. Behaviour substitution 8.3. Habit formation 8.4. Habit reversal 8.5. Overcorrection 8.6. Generalisation of target behaviour 8.7. Graded tasks	**14. Scheduled consequences** 14.1. Behaviour cost 14.2. Punishment 14.3. Remove reward 14.4. Reward approximation 14.5. Rewarding completion 14.6. Situation-specific reward 14.7. Reward incompatible behaviour 14.8. Reward alternative behaviour 14.9. Reduce reward frequency 14.10. Remove punishment
4. Shaping knowledge 4.1. Instruction on how to perform the behaviour 4.2. Information about antecedents 4.3. Re-attribution 4.4. Behavioural experiments	**9. Comparison of outcomes** 9.1. Credible source 9.2. Pros and cons 9.3. Comparative imagining of future outcomes	**15. Self-belief** 15.1. Verbal persuasion about capability 15.2. Mental rehearsal of successful performance 15.3. Focus on past success 15.4. Self-talk
5. Natural consequences	**10. Reward and threat** 10.1. Material incentive (behaviour) 10.2. Material reward (behaviour) 10.3. Non-specific reward 10.4. Social reward	**16. Covert learning**

5.1. Information about health consequences 5.2. Salience of consequences 5.3. Information about social and environmental consequences 5.4. Monitoring of emotional consequences 5.5. Anticipated regret 5.7. Information about emotional consequences	10.5. Social incentive 10.6. Non-specific incentive 10.7. Self-incentive 10.8. Incentive (outcome) 10.9. Self-reward 10.10. Reward (outcome) 10.11. Future punishment **11. Regulation** 11.1. Pharmacological support 11.2. Reduce negative emotions 11.3. Conserving mental resources 11.4. Paradoxical instructions	16.1. Imaginary punishment 16.2. Imaginary reward 16.3. Vicarious consequences

Appendix 38: Key findings from the ME and FGs mapped onto COM-B model and the TDF

	CAPABILITY					OPPORTUNITY		MOTIVATION							
	Physical	Psychological				Social	Physical	Reflective						Automatic	
Barriers identified from the ME and FGs	Physical skills	Knowledge	Cognitive and interpersonal skills	Memory, attention and decision processes	Behavioural regulation	Social influences	Environmental context and resources	Beliefs about capabilities	Beliefs about consequences	Social, professional role and identity	Optimism	Intentions	Goals	Reinforcement	Emotion
*Organisational constraints															
**Fragmented processes															
Lack of guideline familiarity/awareness															
Clinical uncertainty															
Guideline's content and applicability															
Knowledge deficits															
Lack of feedback on performance															
Lack of timely review															
Diverse priorities															
Social norms of practice															
Habits															
Inertia															
Blame															

Conflicting opinions															
± Cultural inhibitors															
Fear of consequences															
Fear of legal repercussions															
Risk aversion															
Defensive prescribing															
Pressure from patient/family															
Perceived importance of AMR/antibiotics															
Reputational pressures															
Unclear responsibilities															
Lack of ownership of prescribing decisions															
Low acceptance of other specialities in decision making															
Scarce learning opportunities															
Lack of motivation to review antibiotics															
Sepsis 6 Campaigns															
Facilitators identified from the ME and FGs	Physical skills	Knowledge	Cognitive and interpersonal skills	Memory, attention and decision processes	Behavioural regulation	Social influences	Environmental context and resources	Beliefs about capabilities	Beliefs about consequences	Social, professional role and identity	Optimism	Intentions	Goals	Reinforcement	Emotion
Multidisciplinary approach															
Audit and/or feedback on performance															
Clinical leaders as role models															
Guideline distribution, promotion and easy															

accessibility															
Compliance with guidelines															
Formal training and systematic education															
Recognition of the social norms of practice															
Antibiotics/AMR awareness raising															
Improved line of communication and documentation															
Bedside teaching															
Organisational and process changes															
Engagement and support of other specialities															
Engagement of nurses															
Clinical pharmacists															
Staff meetings/in-person discussions															
Improved diagnostics															
Person-centred prescribing															
Shared decision making with patients															
Guidelines tailored to different target groups															
Induction packs															
ǂ Clinical decision support systems															
Distribution of responsibility for prescribing decisions															
Ownership of decisions															
Watchful waiting and re-assessment															
Benchmarking performance															

Thorough review processes															
Normalise questions															
Eliminate fear culture															
Approachable and supportive seniors															
Engagement and buy-in from seniors															
Robust audit trail of decisions															

Key: *Organisational constraints include time pressures, out-of-hours working, frequent rotations, rapid patient turnover, variations in practice, lack of rapid diagnostics.

**** Fragmented processes** include cumbersome IT system, disjointed information and delayed results.

± **Cultural inhibitors** include lack of rationale sharing for prescribing decisions and unacceptability of contesting colleagues' decisions.

Ɨ **Clinical decision support systems** include alerts, pre-authorisation, or automatic stop orders.

Appendix 39: APEASE criteria (Michie et al., 2014)

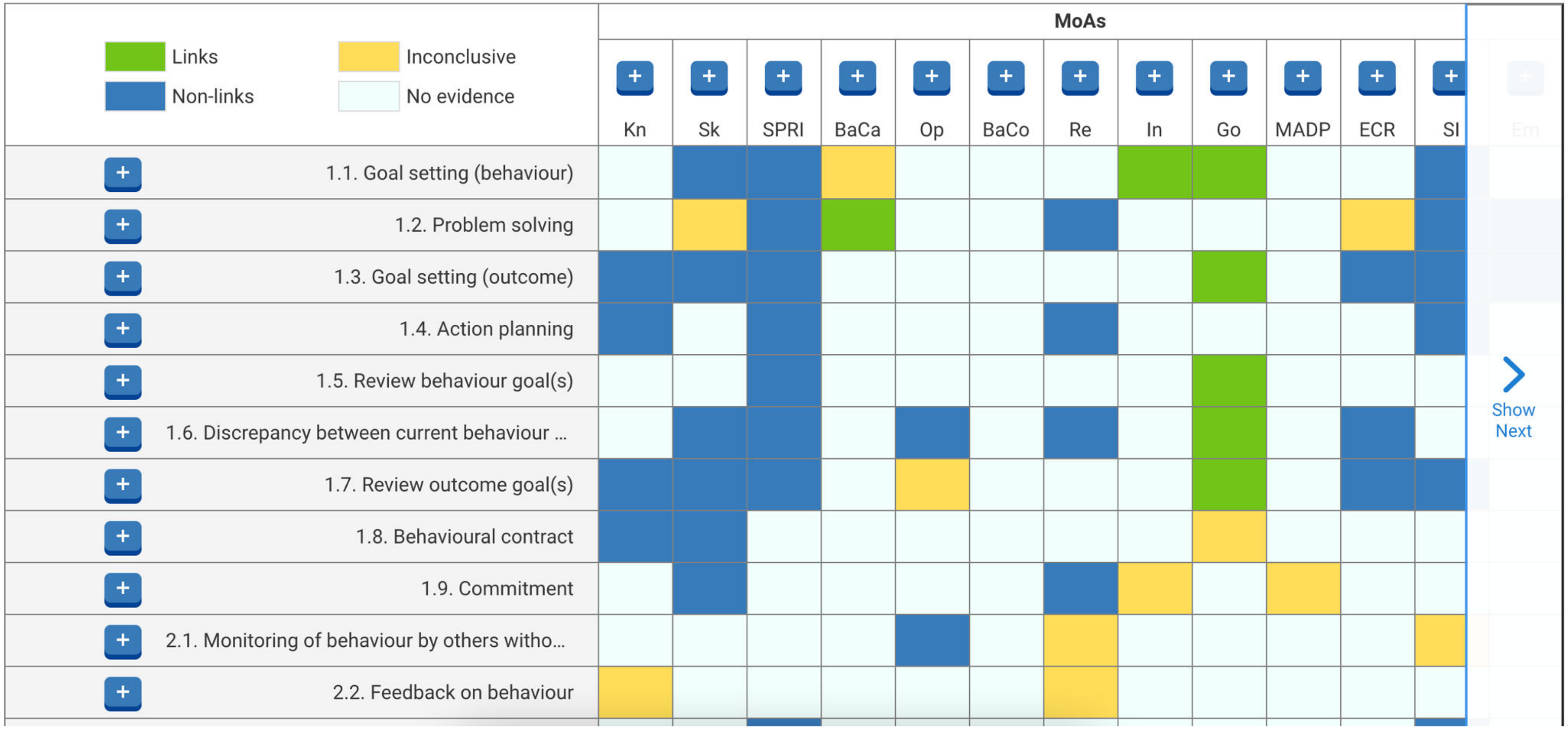
CRITERION	DESCRIPTION
Affordability	Every intervention has an implicit or explicit budget. It does not matter how effective or even cost-effective it may be if it cannot be afforded. An intervention is affordable if, within an acceptable budget, it can be delivered to or accessed by all those for whom it would be relevant or of benefit.
Practicability	An intervention is practicable to the extent that it can be delivered as designed. For example, an intervention may be effective when delivered by selected highly trained staff and extensive resources but this may not be achievable in routine clinical practice.
Effectiveness and cost-effectiveness	Effectiveness refers to the effect size of the intervention in relation to the desired objectives in a real-world context. It is distinct from efficacy which refers to the effect size of the intervention when delivered under optimal conditions in comparative evaluations. Cost-effectiveness refers to the ratio of effect (in a way that has to be defined, and taking account of differences in timescale between intervention delivery and intervention effect) to cost. If two interventions are equally effective, then clearly, the most cost-effective should be chosen. If one is more effective but less cost-effective than another, other issues such as affordability, come to the forefront of the decision making process.
Acceptability	Acceptability refers to the extent to which an intervention is judged to be appropriate by relevant stakeholders, including the general public. Acceptability may differ for different stakeholders. For example, the general public may favour an intervention that restricts marketing of alcohol or tobacco, but politicians considering legislation on this may take a different view. Interventions that appear to limit agency on the part of the target group are often only considered acceptable for more serious problems (Bioethics 2007).
Side-effects/safety	An intervention may be effective and practicable but have unwanted side-effects or unintended consequences. These need to be considered when deciding whether or not to proceed.
Equity	An important consideration is the extent to which an intervention may reduce or increase the disparities in standard of living, wellbeing or health between different sectors of society.

Appendix 40: Expert consensus linking BCTs to TDF domains (Cane et al., 2015)

TDF DOMAIN	BCT
Knowledge	Health consequences Biofeedback Antecedents Feedback on behaviour
Skills	Graded tasks Behavioural rehearsal/practice Habit reversal Body changes Habit formation
Professional Role and Identity	No BCTs are linked to this domain
Beliefs about Capabilities	Verbal persuasion to boost self-efficacy Focus on past success
Optimism	Verbal persuasion to boost self-efficacy
Beliefs about Consequences	Emotional consequences Salience of consequences Covert sensitisation Anticipated regret Social and environmental consequences Comparative imagining of future outcomes Vicarious reinforcement Threat Pros and cons Covert conditioning
Reinforcement	Threat Self-reward Differential reinforcement Incentive Thinning Negative reinforcement Shaping Counter conditioning Discrimination training Material reward Social reward Non-specific reward Response cost Anticipation of future rewards or removal of punishment Punishment

	Extinction Classical conditioning
Intentions	Commitment Behavioural contract
Goals	Goal setting (outcome) Goal setting (behaviour) Review of outcome goal(s) Review behaviour goals Action planning (including implementation intentions)
Memory, Attention and Decision Processes	No BCTs are linked to this domain
Environmental Context and Resources	Restructuring the physical environment Discriminative (learned) cue Prompts/cues Restructuring the social environment Avoidance/changing exposure to cues for the behaviour
Social Influences	Social comparison Social support or encouragement (general) Information about others' approval Social support (emotional) Social support (practical) Vicarious reinforcement Restructuring the social environment Modelling or demonstrating the behaviour Identification of self as role model Social reward
Emotion Behavioural Regulation	Reduce negative emotions Emotional consequences Self-assessment of affective consequences Social support (emotional) Self-monitoring of behaviour

Appendix 41: The Theory and Techniques Tool



Source: Screen shot of the home page of the Theory and Technique Tool (adapted from Johnston et al., 2021). Behaviour change techniques (BCTs) are listed on the left column and mechanisms of action (MoAs) are listed on the top row. Cells are colour coded: green indicates a link, blue a non-link, yellow inconclusive, and white lack of evidence. The online tool is available at: https://theoryandtechniquetool.humanbehaviourchange.org/tool

Appendix 42: Form of Delivery Framework (Dombrowski et al., 2016)

Delivery elements *Delivery features*	**Examples**
Provider (Who delivers, facilitates, or is behind the intervention?) [TIDieR: WHO]*	
Provider Characteristics	Male; female; non-personal (e.g., institute, government, professional body, company).
Professional background	Nurse, GP, psychologist, dietician, lay member
Professional experience	Fifteen years practising nurse, Master's level psychology student, registered dietician for eight years.
Number of providers	Two nurses and one GP; one psychologist; three lay members.
Training in intervention facilitations	Two-hour training session; half-day workshop; online training module.
Training in intervention delivery	Communication skills training; group facilitation training, cognitive behavioural skills training.
Intervention relevant competence	Certified health trainer, certificate in counselling.
Continuity	Same provider; different providers for different topics; mix of same and different providers.
Delivery Format (What are the methods of intervention administration?) [TIDieR: HOW]*	
Mode of delivery	Face-to-face, remote, face-to-face and remote (e.g., Skype), environmental (e.g., prompts).
Delivery method	Individual, group, community, population.
Delivery channel	Personal, self-help, mobile phone application (app), text message (SMS), telephone, email, CD-ROM, videoconferencing, podcast.
Delivery route	Audio, text, picture, experiential.
Materials (What were the physical or virtual materials that the intervention consisted of?) [TIDieR: WHO]*	
Participants' materials	Leaflet, booklet, book, webpage, app, device (e.g., pedometer), certificate, money, voucher.
Providers' materials	Session manual; pop-up reminders, self-monitoring sheets.
Intervention materials	Eligibility forms, questionnaires, sign-in forms.
Setting (Where is the intervention being delivered?) [TIDieR: WHERE]*	
Location	Primary care, hospital, community venue, university, participants' home.
Venue	Consultation room, lecture theatre, research laboratory.
Intensity (What is the intensity with which the intervention is being delivered?) [TIDieR: WHEN & HOW MUCH]*	
Duration of intervention	One hour, one month, 12 months.
Number of contacts	One contact; 26 contacts; 365 contacts.
Length of contacts	One minute, one hour, 90 minutes.
Frequency	Daily, weekly, monthly.

Spacing	Constant, variable, frequent to less frequent.
BCT sequencing	Fixed order, theoretical clusters, variable order.
Contact form	Scheduled, random, proactive, reactive.
Tailoring (Does the intervention delivery differ between participants?) [TIDieR: TAILORING]*	
Intervention variation	One size for all, personalised, titrated or adapted.
Tailoring source	Self-tailored, theory tailored, practitioner tailors.
Standardisation	Automated, semi-automated, personal.
Style (What was the overall style of the intervention?) [TIDieR: NOT INCLUDED]*	
Delivery style	Asset-based, patient-centred, authoritarian.
Communication style	Patient-led, practitioner-led, narrative.
Communication techniques	Listening, questioning, reflecting, pauses.
Visual style	Logo, branding, colour scheme.
Complexity	Reading level, layout, depth of information.
*Mapping of the form of delivery elements to Hoffman et al.'s TIDieR checklist.	

Appendix 43: The RE-AIM Framework (Glasgow et al., 1999)

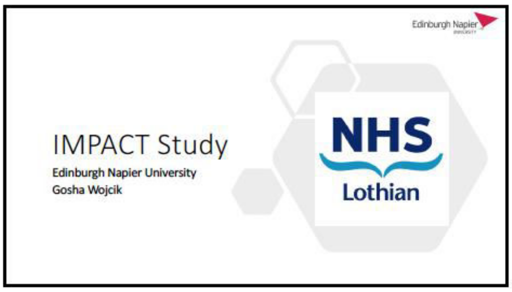
DIMENSION	DESCRIPTION
Reach	The number, proportion and representativeness of individuals willing to participate in a given initiative or programme. • Is the intervention reaching the target population?
Effectiveness	Impact of intervention on important outcomes, including potential negative effects, quality of life and economic outcomes. • Does the intervention accomplish its goals?
Adoption	Absolute number, proportion and representativeness of settings and intervention agents who are willing to initiate a programme. • To what extent are those targeted to deliver the intervention participating?
Implementation	Intervention agent's fidelity to implementation protocol, including consistency of delivery and time and cost of intervention. Clients' use of intervention strategies. • To what extent has the intervention been consistently implemented by staff members?
Maintenance	Extent to which programme/policy becomes institutionalised or part of routine practice. Long term effects of the programme on outcomes after six months or more after most recent intervention. • To what extent has the intervention become part of routine organisational practices and maintains effectiveness?

Appendix 44: COREQ criteria applied to Study 2 (Tong et al., 2007)

No Item	Guide questions/description	Reported on Page no.
Domain 1: Research team and reflexivity		
Personal Characteristics		
1. Interviewer/facilitator	Which author/s conducted the interview or focus group?	145
2. Credentials	What were the researcher's credentials? e.g., PhD, MD	17, 185
3. Occupation	What was their occupation at the time of the study?	17, 185
4. Gender	Was the researcher male or female?	185
5. Experience and training	What experience or training did the researcher have?	185
Relationship with participants		
6. Relationship established	Was a relationship established prior to study commencement?	278
7. Participant knowledge of the interviewer	What did the participants know about the researcher? e.g., personal goals, reasons for doing the research	278
8. Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g., Bias, assumptions, reasons and interests in the research topic	281
Domain 2: study design		
Theoretical framework		
9. Methodological orientation and theory	What methodological orientation was stated to underpin the study? e.g., grounded theory, discourse analysis, ethnography, phenomenology, content analysis	281
Participant selection		
10. Sampling	How were participants selected? e.g., purposive, convenience, consecutive, snowball	277
11. Method of approach	How were participants approached? e.g., face-to-face, telephone, mail, email	278
12. Sample size	How many participants were in the study?	278
13. Non-participation	How many people refused to participate or dropped out? Reasons?	278
Setting		
14. Setting of data collection	Where was the data collected? e.g., home, clinic, workplace	280
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	280
16. Description of sample	What are the important characteristics of the sample? e.g., demographic data, date	279
Data collection		
17. Interview guide	Were questions, prompts and guides provided by the authors? Was it pilot tested?	281
18. Repeat interviews	Were repeat interviews carried out? If yes, how many?	N/A

19. Audio/visual recording	Did the research use audio or visual recording to collect the data?	282
20. Field notes	Were field notes made during and/or after the interview or focus group?	281
21. Duration	What was the duration of the interviews or focus group?	281
22. Data saturation	Was data saturation discussed?	312
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction?	N/A
Domain 3: analysis and findings		
Data analysis		
24. Number of data coders	How many data coders coded the data?	63, 282
25. Description of the coding	Did authors provide a description of the coding tree?	283
26. Derivation of themes	Were themes identified in advance or derived from the data?	282
27. Software	What software, if applicable, was used to manage the data?	282
28. Participant checking	Did participants provide feedback on the findings	N/A
Reporting		
29. Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g., participant number	286-304
30. Data and findings consistent	Was there consistency between the data presented and the findings?	307
31. Clarity of major themes	Were major themes clearly presented in the findings?	286-304
32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	312

Appendix 45: PPT slides shown to participants during semi-structured interviews



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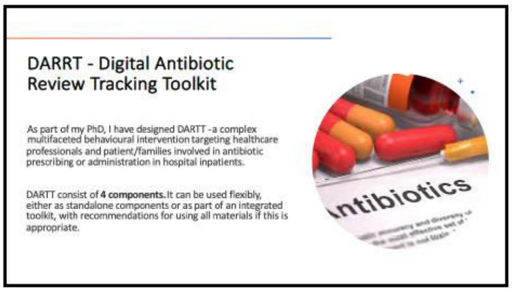

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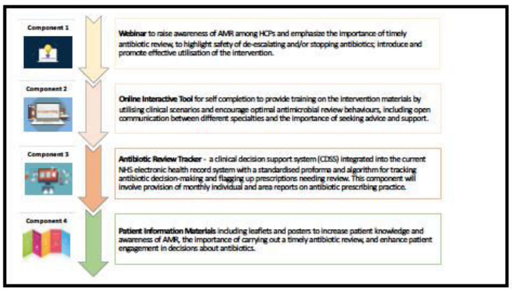

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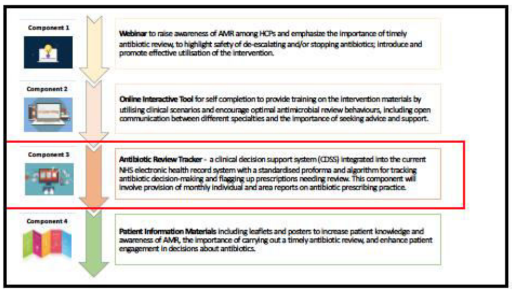

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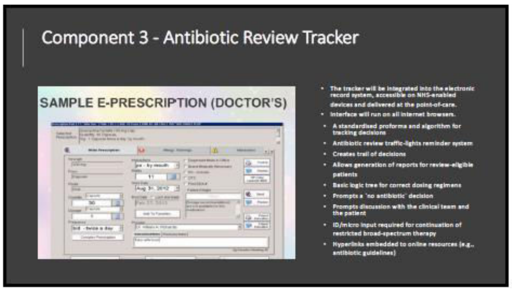

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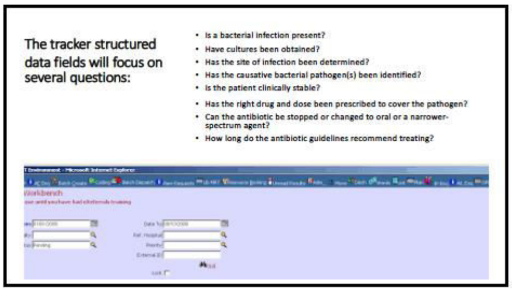

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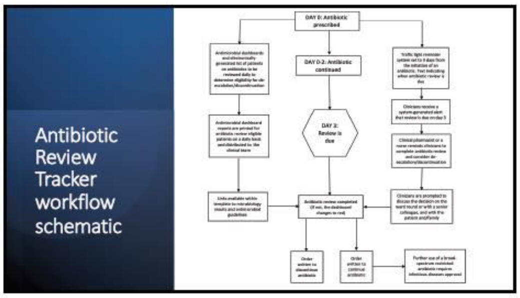
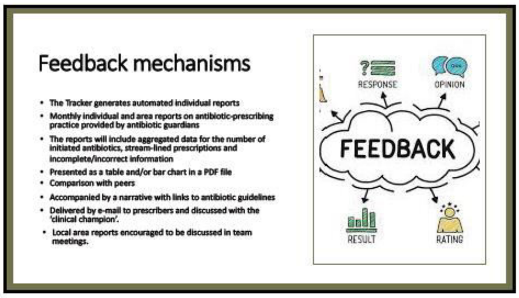

Antibiotic Review Tracker workflow schematic
DAY 0: Antibiotic prescribed
DAY 0-2: Antibiotic continued
DAY 3: Review is due

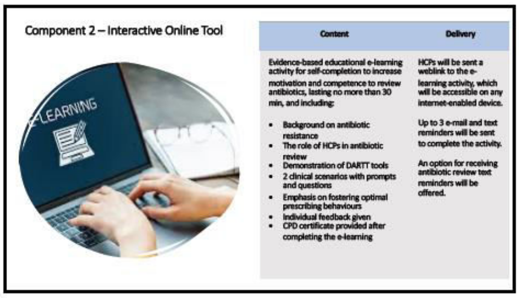
7


Feedback mechanisms
• The Tracker generates automated individual reports
• Monthly individual and area reports on antibiotic-prescribing practice provided by antibiotic guardians
• The reports will include aggregated data for the number of initiated antibiotics, stream-lined prescriptions and incomplete/incorrect information
• Presented as a table and/or bar chart in a PDF file
• Comparison with peers
• Accompanied by a narrative with links to antibiotic guidelines
• Delivered by e-mail to prescribers and discussed with the 'clinical champion'.
• Local area reports encouraged to be discussed in team meetings.
RESPONSE
OPINION
FEEDBACK
RESULT
RATING

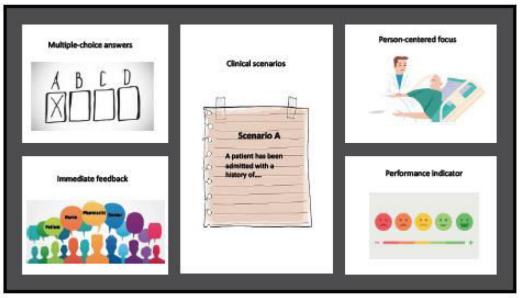
8


Component 1 – Webinar
Webinar delivered through an electronic link embedded in the DARTT supporting documentation
Recorded or clinicians offered a live stream option and encouraged to present the webinar in staff meetings
Professionally delivered by a relevant practicing hospital clinician (e.g. a member of local AMS team, infection control specialist or microbiologist), lasting no more than 1 hr, and summarising:
• Importance of AMR & timely review
• Introduction to DARTT
• Safety of stopping/de-escalating antibiotics
• Local AMR data
• Promote action planning
• No increase in workflow
• Potential benefits of DARTT

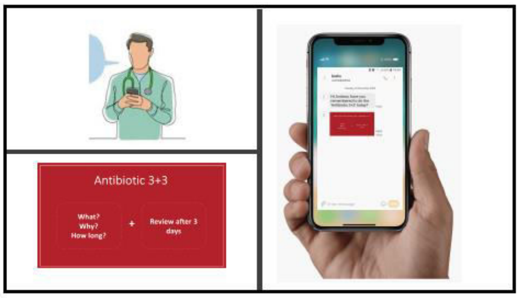
9


Component 2 – Interactive Online Tool
E-LEARNING
Content
Evidence-based educational e-learning activity for self-completion to increase motivation and competence to review antibiotics, lasting no more than 30 min, and including:
• Background on antibiotic resistance
• The role of HCPs in antibiotic review
• Demonstration of DARTT tools
• 2 clinical scenarios with prompts and questions
• Emphasis on fostering optimal prescribing behaviours
• Individual feedback given
• CPD certificate provided after completing the e-learning
Delivery
HCPs will be sent a weblink to the e-learning activity, which will be accessible on any internet-enabled device.
Up to 3 e-mail and text reminders will be sent to complete the activity.
An option for receiving antibiotic review text reminders will be offered.

10


Multiple-choice answers
A B C D
Clinical scenarios
Scenario A
A patient has been admitted with a history of....
Person-centered focus
Immediate feedback
Performance indicator

11


Antibiotic 3+3
What?
Why?
How long?
+
Review after 3 days

12

Component 4 – Patient Information Materials

- Patient information leaflets and posters placed in the hospital waiting rooms provided in a health literate format.
- Professionally designed PIMs, including:
- Patient leaflet to improve patient knowledge and enhance shared decision-making
- Presented in a double-sided A4 format
- Explaining the risks of antibiotics (i.e., AMR and side effects) and the importance of a timely review, stopping or narrowing-down antibiotics
- Poster encouraging patients to ask HCPs about antibiotics – use of `Antibiotic 3+3

13

Patient leaflet

The leaflet will have links to reputable websites and cover the following four areas:

- What are antibiotics and why do we use them?
- What is antibiotic resistance?
- Why is antibiotic review important?
- Can I ask my doctor or nurse about antibiotics?

14

Example of patient poster…

It`s okay to ask…

1. **WHY** have I been prescribed the antibiotics?
2. **WHAT** condition are the antibiotics treating?
3. **HOW LONG** will I receive them for?

+ 3-day review

15

Appendix 46: Interview topic guide (Study 2)

INDICATIVE TOPIC GUIDE FOR INTERVIEWS

`Development of a theory-based behaviour change Intervention to Promote optimal antibiotic use in ACute hospiTals: The IMPACT Study`

Welcome - Explain purpose of the interview:

- Thank you for agreeing to do this interview.
- As you know, this study is being funded by the Edinburgh Napier University, which is part of my PhD Thesis.
- The purpose of this interview today is to explore intervention options and gather your feedback on the proposed content, appearance and mode of delivery.
- I would also like to ask your advice on how the proposed intervention could be strengthened or improved to make it acceptable and suitable in clinical practice.
- The discussion should not take more than 60 minutes.
- Have you had the chance to read the Participant Information Sheet?
- Do you have any questions?

Ground rules:

- Everything you tell me will be kept confidential. To protect your privacy, I won't connect your name with anything that you say.
- At any time during our conversation, please feel free to let me know if you have any questions or if you would rather not answer any specific question. You can also stop the interview at any time for any reason.
- Please remember that there are no right or wrong answers.
- Is it okay if I audiotape this interview today?

PowerPoint presentation:

The interviews will aim to address a number of key areas relevant to the research aims. Using a PowerPoint presentation, each interview will begin with a brief description of the intervention components. Guided by the RE-AIM Framework, the participant will then be asked the following questions plus any question based on specific points raised during the presentation:

TOPIC	EXAMPLE QUESTIONS
REACH	• What group of healthcare professionals do you think the intervention will appeal to and why?
EFFECTIVENESS	• What was your initial impression about the intervention?

	• In your opinion, would your colleagues find the proposed intervention acceptable and practical? • Would it be suitable for clinical use? • Was there anything you didn`t like or that wasn`t and should be there (i.e. strengths and weaknesses)? • Which intervention elements do you see as priorities? • What are the obvious issues that would prevent it from working? • Does the Review Tracker address the communication gap? • Can you think of other similar interventions that have worked in a hospital setting? • One of the intervention components is a feedback mechanism. What kind of feedback on prescribing is acceptable and who do you think should provide it? • In which component of the intervention does the `Antibiotic 3+3` idea fit? • What is the most important outcome you expect to see using this intervention?
ADOPTION	• What settings do you think the intervention would be the most suitable for? (i.e. across acute hospitals, only medical units) • In order to use this intervention, what training or support, if any, do you think that hospital prescribers would need? • What would be the most important elements of training?
IMPLEMENTATION	• How do you think the intervention should be delivered? • Can you think of any adjustments, refinements or modification that would strengthen or improve it to increase its uptake and effectiveness? • Do you think it will work in real practice? • Can you think of possible challenges we will need to overcome to implement this into the real world? • How do you think we should track success and feedback about the intervention?
MAINTENANCE	• How can we ensure the intervention is sustainable overtime? • How do you think we should track success and feedback about the intervention?

Closing:

Is there anything else that you would like to add about any of the topics that we've discussed or other areas that we didn't discuss but you think are important?

Thank you for your time and participation in this interview. The information that you provided to us will be very helpful in this project.

Appendix 47: Indexing (Study 2)

	Acceptability	Usability	Adoption	Implementation	Maintenance	Suggestions for improvement
Mary	**1.1** Thinks DARTT is a great idea. 1 **1.1** Likes the idea of the Tracker being part of daily review. 2 **1.1** Feedback on prescribing would be great because there is very little information available on antibiotic hospital consumption. 12 **1.1** Likes the idea of having aggregated data so everyone can see what other areas order and use. 16 **1.2** Thinks that the Tracker will create a trail of decisions. 28 **1.2** DARTT will make a big difference once we can electronically prescribe. **1.2** The expected outcomes will be different for wards and ITUs. 32 **1.3** DARTT would work best in ICU because a formal round is done there every day, and it could become part of that standard round. 64	**2.1** The Tracker has to be intuitive and tell prescriber what they should be thinking, reminding them to do the right thing. 32 **2.1** The Antibiotic 3+3 will give nurses a script of questions to ask the prescribers and prompt them to review. 34 **2.1** PIMs are available, people tend just to see them and not pick them up, but you do need something for families, especially in critical care. 36 **2.2** The Tracker shouldn't stop HCPs from doing what they intended to do because it then creates a workflow problem. 74 **2.2** Everybody knows TRAK, so	**3.1** Approach Directorates and talk to them about the product to gain advice and support. 38 **3.1** Training is required to make sure that people can practice. 42 **3.2.** Thinks that there are always people who just won't engage regardless of how DARTT will be rolled it out but getting engagement first will help. 66	**4.2** Technology will be a problem because it's really difficult in the NHS and some computers are 20 years old. 18 **4.2** Relying on Wi-Fi in the NHS is a problem as the upload speed is very slow. 20 **4.2** Reflect on the experience of making family videos for patients during COVID and poor internet coverage. 22 **4.2** The interface will require NHS coverage for they may allow better security, but the problem is IT security in the NHS. 24 **4.2** Having Kardex and electronic prescribing would not be practical. 25 **4.2** Doesn't think that pop-up reminders would be easy to install on TRAK. 39 **4.3** Accessibility of computers at the bedspace. 55	**5.1** Talks about maintaining the system similar to TRAK and doing upgrades when necessary. 41 **5.2** The feedback has to show a clinical benefit to using DARTT. 43 **5.2** Thinks that tracking success will be easy as the Tracker will generate data on de-escalation and prescribing according to guidelines. 63	**6.1** Would like to have more nurse involvement in ITUs and thinks that Antibiotic 3+3 will help with that. 17 **6.1** It would be practical to link the Tracker with microbiology reviews so that microbiologists could review antibiotics remotely.19 **6.1** Thinks the Tracker should be made mandatory to be effective. 21 **6.1** Suggests that only microbiology should have privileges to override the system. 29 **6.1** Training could be incorporated into Learn-pro. 31 **6.1** Training shouldn't be a big, huge, elaborate thing. 31 **6.1** Training should focus on allowing HCPs to practice using DARTT. 35 **6.1** Suggests placing Antibiotic 3+3 sticker on the antibiotic

	1.3 It will appeal to ANPs because prescribing is such a new skill for them. They'll appreciate all the cues on the Tracker. 65 **1.3** The tracker is the key component, but the webinar and training are also needed. 76 **1.3** The problem with feedback is getting people to pay attention to the feedback. Individual emails generated by the Tracker would solve this issue. 79 **1.3**. It would be acceptable to put the Antibiotic 3+3 sticker on nursing care plans or in the daily medical reviews, or even on TRAK to make people go to the Tracker. 83 **1.3** Believes that the intervention would be transferable to GP practices. 91	DARTT potentially will just flow as part of the new way of doing it. 77				prescription page, nursing care plans, daily medical reviews, or on TRAK to trigger a review. 37 **6.2** Would like the system to connect to the patient clinical picture, so people are guided through the de-escalation review. 59 **6.2** Suggests creating pop-up messages or outstanding action reminders with recommendations from microbiology. 61 **6.2** Suggests inbuilding a calculator for specific antibiotics, such as Vancomycin and Gentamicin. 69 **6.2** Thinks that there has to be instant access to the MicroGuide. 71 **6.2** Default option needed for antibiotics that aren't bug-related (e.g., Erythromycins for gut motility) that automatically disables the 3-day reminder. 77
Tom	**1.1** The intervention looks great and visually appealing. The imagery is beautiful; it's quite impactful, it's simple, it looks user-friendly, straightforward, the	**2.1** Data on antibiotic use at the unit level helps show local differences and identify disparities	**3.1** If people can find a workaround that they perceive is quicker; they will do it. 42 **3.1** The tracker has	**4.1** Talks about previous experience of implementing intervention and the importance of going round the wards and	**5.1** It's important to change things and improve the system. 52 **5.1** Talks about the importance of	**6.1** Reflects on recent online HEPMA training. Suggests that online video training would be helpful and useful to see the functionality of the

	components are all very sensible, it's got clear clinical value. 5 **1.1** Can normally be quite picky but can't see anything negative. 6 **1.1** Likes the idea of having aggregated data – it would be helpful for ANPs' yearly PDPs, evidence for their re-validation, for their portfolio. 6 **1.2** Thinks that DARTT will help to rationalise antibiotics. 12 **1.3** Timing is good because of the HEPMA system being rolled out. 14 **1.3** Convinced that all the ID consultants and microbiologists will love the intervention. 16 **1.3** Doesn't think posters are effective, describes 'poster blindness'. 18 **1.3** The tracker is the most important but can't be achieved without the webinar or interactive tool. 21 **1.3** PIMs are the least important; it's nice, but more of a bonus add on that could fall out of the others. 24 **1.3** Points out that hospital antibiotic prescribing is very different from GP practice as	and outliers. 53 **2.1** Re online training, thinks that some multiple-choice questions can be useful afterwards to see what has been learned. 61 **2.1** Unsure about the value of interactive online learning as well as a video. 62 **2.1** Live-streamed video is really good in terms of interaction because you can get people on board, but it is difficult in terms of resources. 65 **2.2** If DARTT takes extra time, HCPs need to perceive the real benefits that make it worthwhile. 72	to be straightforward and simple to use and as least clunky as possible. 42 **3.1** Can't think of anybody in particular who would be resistant to it. 45 **3.1** Thinks that there will always be resistance to change, but DARTT is pushing against open doors. 46 **3.1** Engagement from the top-down and people on the floor is required for uptake. 49 **3.1** Enthusiasm and buy-in are required to spread the word about the intervention. 52 **3.1** Thinks training is required, but it can't be burdensome. Undecided whether training should be mandatory or voluntary. 60 **3.1** Thinks that the webinar and interactive stuff will be really helpful when first getting DARTT out to advertise it, raise	hospitals and talking to people about it. 30 **4.1** Start in the places that will use it the most and get people familiar with it, where people are prescribing lots of antibiotics. 84 **4.1** Talks about getting more junior doctors using it in a small area. 86 **4.1** Suggest trialling DARTT in ID and AMU first, where antibiotic prescribing is a big part of clinical practice. 91 **4.1** Suggest rolling DARTT out with new doctors starting. 92 **4.1** Not a fan of local champions but thinks that people listen to positive influencers – important to engage with to ensure successful implementation. 96 **4.1** Successful implementation depends on preparation and getting the high-level people buy-in, also the TRAK people and HEPMA people buy-in to make it work, so it's not clunky. 97 **4.1** Hard graft has to be put in during the initial roll-out. 104 **4.2** Thinks DARTT would	easing out the glitches as quickly as possible and adjusting DARTT based on real-life users' feedback. 52 **5.1** Talks about being open to change. 53 **5.2** The outcomes will be hard to measure or quantify because nobody's measuring it pre-intervention. 141	system. 113 **6.1** Once the intervention is out into a hospital; it could be part of an induction for the new doctors. 116 **6.1** Live webinar is really good in terms of interaction and getting people on board but suggests that live-streamed is not necessary once it's out into a hospital. 137

	there's space for discussion due to illness acuity. 31 **1.3** Thinks that dialogue with patients is important, but patients just want someone to make them feel better. 35 **1.3** Felt uneasy about the text message reminders. 46 **1.3** Feedback is really important, but different HCPs have different feedback requirements. 49 **1.3** Feedback necessary for ANPs because they have to provide evidence of their prescribing and reflection on that as opposed to consultants. 50 **1.3** Wouldn't like comparison with colleagues. 52 **1.3** Suggests that the aggregated data would also work for GPs as it's helpful for them looking at their finances. 56		awareness and get buy-in. 61 **3.1** Junior doctors are great for spreading knowledge about new stuff. 67 **3.1** Junior doctors are positive promoters as they move around and between Health Boards. 67 **3.2** DARTT has to be as user friendly as possible and not add unnecessary or burdensome steps as junior doctors will find workarounds. 81	be able to slot into one of the version updates for HEPMA. 112 **4.2** Moving between paper and electronic would be quite annoying. 119 **4.3** Pharmacy support required with rollout of DARTT. 120 **4.3** Having specific individualised support would be really helpful. 120 **4.3** Thinks that implementation will be easy as everyone knows about antimicrobial stewardship. 129		
James	**1.1** Thinks that DARTT is a great idea, looks very logical, everything is interlinked, is easy to follow and understand, and is an excellent package. 8 **1.1** Can't think of anything missing. 8 **1.1** Likes the ambition to fully integrate this so that it dovetails with everything that's happening with the	**2.1** The leaflet is simple. It prompts the patient to do a bit more. It wouldn't put a patient off but reassure/indicate what the next steps might be. 29 **2.1** Poster is useful and ties in with the leaflet in terms of the overall strategy.	**3.1** People need to see DARTT as a priority to buy into it. 36 **3.1** Need to win over people who would give it a fair go and provide honest feedback. 38 **3.1** Engagement with patients is key because that will	**4.1** Some big data systems take a long time to implement, and phasing things can sometimes buy more time to better reflect on other parts of the project's implications. 52 **4.1** Once the system is officially proven, it could be rolled out on a wider scale. 54	**5.1** The system needs to evolve continually. 130 **5.1** Improving the software based on feedback is important. 132 **5.2** Suggests looking at the impact that PIMs will have and	**6.1** Suggests looking at the WHO reports on AMR and drawing on that for PIMs. 2 **6.1** Recommends introducing DARTT as a professional development opportunity for junior prescribers. 61 **6.1** Suggests introducing DARTT training to junior

	patient. 10 **1.1** Likes that DARTT considers various people at all the various stages likely to be involved in monitoring and administering antibiotics. 10 **1.1** Likes that the interests of the patients have been considered. 11 **1.1** Felt uneasy about people being compared to colleagues as they might be put off, and it will reduce the uptake. 24 **1.1** Reflects that sometimes the best doctors have the most fatalities because they are prepared to take on difficult cases. 26 **1.2** Believes that DARTT will help integrate patient care between different clinical teams and areas and close the communication gap. 32 **1.2** Anticipates that the Tracker will stop any unintended continuation of antibiotics and give HCPs closer focus on how the patient responds to treatment. 34 **1.3** DARTT would work best in general wards as staff have a far broader role, and a far bigger number and range of patients and tasks.	32 **2.1** The poster gives the patient a script of questions to ask. 33 **2.1** Likes the idea of the Tracker generating daily reports and thus creating collective responsibility for antibiotic review. 38 **2.1** Compares DARTT to a one-stop-shop for clinicians to go in and think about the patient's progress. 41 **2.1 S**imple messages such as the Antibiotic 3+3 are the most effective. 53 **2.2** The Tracker will encourage HCPS to speak to somebody who maybe knows a bit more or check if they are doing the right thing. 56 **2.2** DARTT mustn't add additional work but streamline it. 101	help to endorse the value of the whole project. 40 **3.1** DARTT will need support at very senior levels and an endorsement to say that this is worth doing. 40 **3.2** Thinks that there is always some resistance to anything new. 66 **3.2** Reassurance will be required for those HCPs who feel that this is more work. 68	**4.1** To roll out DARTT Scotland-wide, gatekeepers for medicines in every Health Board are needed to take an overall responsibility (e.g., champions, guardians or clinical pharmacists). 54 **4.1** Reflects on previous experience of setting up software and points out the need to get the expertise and the money to set DARTT up. 56 **4.1** Suggests finding a willing partner in the first phase. 56 **4.1** An experienced group of people responsible for implementation is vital. 58 **4.1** Suggest doing a pilot. 112 **4.1** Suggests starting implementation with the webinar and the online interactive tool and then testing the Tracker in one Health Board, maybe in one ward. PIMs can be left till last. 113 **4.1** Talks about the importance of addressing and pre-emptying any difficulties before the implementation. 129 **4.2** The Tracker needs to be compatible with	how effective one particular type of communication is over another. 146 **5.2** The cost-benefits need to be looked at to track the successes of DARTT. 159	doctors during their undergraduate training. 62 **6.1** Training should also be provided when new staff begin.63 **6.1** Suggest inbuilding the Antibiotic 3+3 reminder into the Tracker software. 82

	49 **1.3** The Tracker and the Antibiotic 3+3 prompt are the most important elements of DARTT. 51 **1.3** A review of professional performance has to be dealt with sensitively because of the variation in prescribing. 73 **1.3** The hierarchy of authority within hospitals is quite sensitive, so the feedback has to come from an HCP whose qualifications are senior to that person, someone who has authority, position and is highly respected, a champion or a clinical pharmacist who's sufficiently knowledgeable. 74 **1.3** Points out that the Antibiotic 3+3 can't be overly intrusive and pop-up reminders too frequent. 81 **1.3** Likes the idea of placing a poster in the waiting area. 85 **1.3** Simple, straightforward messages are good for raising awareness. 85 **1.3** Reflects on his own experience of sitting in the waiting room and wanting to take in information. 85 **1.3** Highlights that if people don't get an answer to what they've been alerted to, it can cause more concern if			electronic health records. 137 **4.2** Need to assess the feasibility of the development of the Tracker and what that would mean and what the proforma would look like, how it would all tie together with the CDSS. 143 **4.2** Ease of linking the components is important. 149		

	they're already distressed. 89 **1.3** If expectations are raised, you have to ensure that they are being met. Otherwise, the patient and their relatives will become more unsettled. 90					

Key: Content of interviews divided into themes (code number in bold)

Appendix 48: Charting (Study 2)

DARTT element or feature	Acceptable & feasible?	Suggestions and future considerations
Provider		
DARTT Team	A (+/-), F (+)	Project management team required; need to link to local AMS teams. Leadership and organisation-wide engagement essential. Suggestions to involve/offer project development opportunity to junior doctors and ANPs to champion DARTT.
Delivery Format		
Webinar	A (+), F (+/-)	Resources required for multiple delivery of live webinar – pre-recorded version acceptable and more feasible.
Online Interactive Tool	A (+), F (+/-)	Online and mandatory format acceptable. Long training not feasible in a busy hospital setting. Preference for a short video demonstrating how to use the Tracker and a short practical session. Training embedded into induction packages and ward education acceptable. Suggestions for easy access (e.g., accessible at home).
Antibiotic Review Tracker	A, F (+/-)	Only feasible in areas with electronic prescribing. Need to consider the technical infrastructure available and system compatibility.
Feedback	A, F (+/-)	Regular face-to-face feedback not acceptable and not feasible to be delivered to a large number of staff. Preference for automated emails with aggregated data. Individual feedback only acceptable at annual appraisals or when practice issues identified. Unit and hospital-level feedback and comparison acceptable.
Antibiotic 3+3 reminder	A (+/-), F (+)	Acceptable and feasible as part of the Tracker, NHS banners, posters, stickers, emails. Poster 'blindness' and frequency of reminders may be an issue – need for clinical importance, otherwise the risk of 'reminder fatigue'. Text messages not acceptable. The feasibility of inbuilding it into the TRAK system needs be explored further. Preference for placing the reminder at bedspaces.
Patient Information Materials (PIMs)	A (+), F (+)	Posters and leaflets acceptable and feasible. If the patient/family is prompted to ask about antibiotics, ensure all staff prepared/trained to have those conversations.
Materials		
DARTT manual	A, F (+)	Preference for an online version, suggestions to provide flow charts and inbuild help boxes within the Tracker.
CPD certificate	A, F (+)	Particularly welcomed by junior doctors & ANPs – useful for their portfolio as evidence of learning.
Setting		
Acute hospitals	A,F (+)	Applicable to all hospital areas and potentially transferable to primary care.
Intensity		

One hour long webinar	A, F (-)	Not feasible to have one hour long webinar – needs to be shorter to be incorporated into team meeting (e.g., 20 min).
Monthly discussions	A, F (+)	Monthly team discussions around the Tracker-generated prescribing reports acceptable.
3-day review reminders	A (+), F (+/-)	If a prescription changed within 24 hours, the need to ensure the 3-day review trigger is automatically. recalculated.
Support	A, F (+)	Regular contact with the DARTT team required; need to ensure availability of continuous technical support.
Style		
User-friendly interface	A, F (+)	Essential requirement.
Multiple data fields	A (-), F (+)	Need to minimise the number of data fields; preference for mandatory status.
System workarounds	A (-), F (+)	Workarounds not acceptable.
Multiple design and functionality suggestions	N/A	See section 7.7 for more details.

Appendix 49: Mapping and interpretation (Study 2)