Impact of area deprivation on the cardiac mortality in the UK between 1991 to 2010: Evidence from a population-based longitudinal study

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Abstract

Aim Evidence from longitudinal studies on the influence of area deprivation in cardiac mortality is limited. We aimed to examine the impact of area deprivation on cardiac mortality in a large representative Scottish population. We also examined differences between women and men.

Methods Retrospective analysis was performed by using linked data from Scottish Longitudinal Study from 1991-2010. The main exposure variable was socioeconomic status (SES) using the Carstairs deprivation scores, a composite score of area-level factors. Cox proportional-hazards models were constructed to evaluate the hazard ratios (HRs) and 95% confidence intervals (CIs) for cardiac mortality and all-cause mortality associated with area-based deprivation. Subgroup analyses were stratified by sex.

Results In a representative population of 217,965 UK adults, a total of 58,770 deaths occurred over a median of 10 years of follow-up period. The risk of cardiac mortality and all-cause mortality showed a consistent graded increased across the deprived groups. Compared to the least deprived group, the adjusted HR of cardiac mortality in the most deprived group was 1.27 (1.15-1.39, $p<0.000$). There was strong evidence that women from more deprived areas had significantly higher cardiac death risk than those from the least deprived areas (HR 1.42, 95% CI 1.22-1.65) while this observation was not strong in men with same background.

Conclusion Our study demonstrated area deprivation was the strong predictor of long-term cardiac mortality and all-cause mortality. The inequalities were substantially greater in women from more deprived areas than men from the same background.

Key words

Coronary heart disease, mortality, social determinants, health inequalities, outcome

Introduction

Coronary heart disease (CHD) is the leading cause of death and disease burden in Europe (1). Each year across the continent, CHD is responsible 20% of all deaths. In the UK, CHD is the most common cause of premature death with a total cost to the health service estimated to be £9 billion each year including associated circulatory conditions (2). Although cardiac mortality rates in the UK have declined significantly for the past three decades mainly due to evidenced-based treatment and secondary prevention (2), this reduction has not been observed equally in the lower socioeconomic status (SES) groups. Evidence has shown that people from the most socially deprived backgrounds in the UK still have 3.5-fold greater CHD mortality than those in the least deprived backgrounds (3, 4).

Low SES is one of the strongest contributors to the morbidity and mortality of CHD worldwide (5, 6). The association between SES and CHD risk is well established by using individual-level measurements including education, income, and occupation in high-income countries (5, 7). A systematic review using data from 70 studies showed excess incidence of acute myocardial infarction (AMI) was consistently evident in people with lower level of income (71%), education (34%) and occupational status (35%) compared with those with higher SES (8). Although there has not been a systematic review that examined the impact of areal level deprivation on CHD mortality, prior studies reported the risks of cardiac mortality in people residing in areas of more deprivation were 1.3 to 1.9 times greater than those from less deprived areas (9).

Such disparities in CHD in relation to SES in different measurements can be mediated by multiple level approach encompassing the characteristics of the individual, local healthcare systems, national and international healthcare policies (10-12). Better understanding of risk stratification in relation to socioeconomic circumstances is, therefore, important when relocating resources and improving quality of care. This enables strategies or policies to be adapted at local and national levels to improve cardiovascular outcomes in the most vulnerable population (5). This is particularly relevant in the context of the universal healthcare system like UK with aim to provide the equal care to all people. It has been suggested actions at area-level of SES including physical and social environmental characteristics could have better effects in reducing the disparities of CHD risk (13, 14).

This is particularly important in the context of Scotland as CHD is the leading cause of death with levels higher than England, Wales, or Northern Ireland (2, 15). Despite the importance of this issue, the previous study that examined area deprivation and mortality in Scotland(16) was few decades ago. Recent data has shown cancer to have overtaken CHD as the leading cause of death in men in UK. However, it remains the most common death in women and kills more than twice as many women as breast cancer (2). Taken together, CHD continues to contribute markedly to deaths in deprived groups and to women.

The study reported here set out to ascertain the degree to which inequalities remained in Scotland, and to investigate the impact of area deprivation and sex on the cardiac mortality and all-cause mortality.

Methods

Study design and setting

Retrospective analysis was performed by using linked data from Scottish Longitudinal Study (SLS) from January 1991 to December 2010. SLS is a large-scale linkage study that has a 5.3% representative sample of the Scottish population linked to various datasets including Scottish census from 1991 onwards, vital events (including death registrations), and geography & ecological data. Adults aged 18-74 years old were included in our study. The detail of the derived study population is shown in Figure 1. Permission for use of the data was obtained from SLS research board committee (Project No. 2018_009) no additional informed consent was required as there was no individual patient involvement. This study received ethics approval from Edinburgh Napier University (No. SHS0039).

Outcome variables

The primary outcome was death from coronary heart disease (CHD), which was identified according using the International Classification of Disease (ICD). Specific codes used were 4410-414 for deaths prior to January 1999 (ICD9), and I20 -I 25 for death after January 1999 (ICD10). All-cause mortality was also examined in the study to provide comparison. Cardiac mortality and all-cause mortality to December 2010 was ascertained from Vital Statistics from National Records of Scotland. All analyses were conducted in the SLS Safe Haven guided by the SLS protocol.

Exposure variables

The main exposure variable was the area-level socioeconomic status using the Carstairs deprivation scores. Carstairs score is the indicator of material deprivation available at different geographical levels derived from decennial census data, using levels of unemployment, overcrowding, car ownership, and proportion in social classes IV and V (partly skilled and unskilled) (17). Carstairs was calculated at the level of data zones, ranked from most deprived to least derived on the overall index which provides a detailed and comprehensive picture of relative area deprivation across UK. Carstairs deprivation scores were categorized into quintiles with the lowest category reflecting the least deprived areas and highest quintile reflecting the most deprived areas. The Carstairs deprivation index has been validated and used widely in health-related studies in the United Kingdom. In this study, Carstairs scores were available from 1991. Participants were allocated to deprivation categories using the Carstairs scores into five groups.

Potential confounders:

Potential confounders included marital status, ethnicity, education level, occupation, employment and economic position, having long-term illness or health condition, number of adults in employment in the household, number of dependent children in the household, number of residents with illness in household. All these variables were available from 1991 onwards.

Statistical analysis

Participants were separately divided into 5 groups according to their baseline Carstairs scores by using least deprived group (Quintile 1) as the reference group. Descriptive analyses of baseline characteristics stratified by the deprivation groups were performed using the Pearson $\chi 2$ test for categorical variables (summarized as frequencies/percentages). Continuous variables were compared across area deprivation groups using analysis of variance for normal distribution data presented as mean (95% confidence interval (CI)), or Kruskal–Wallis (summarized as medians and interquartile range) for non-normal distribution.

Survival analysis was performed after exclusion of missing variables from individual SES including education, employment and occupation (Figure1). Survival across deprivation groups was assessed by Kaplan-Meier method and compared by the log-rank test. Cox proportional hazard regression models with survival time (in years) using the age as underlying timescale was used to examine the association between area deprivation and risk of mortality. Cox proportional-hazards models were constructed to evaluate the hazard ratios (HRs) and 95% confidence intervals (CIs) for cardiac mortality and all-cause mortality associated with area-based deprivation. The primary outcome was the cardiac mortality and death from non-cardiac cause was a competing risk event, therefore, cause-specific hazards models was used to assess the hazard risks for both cardiac and non-cardiac death(18). The proportional-hazards assumption was tested with the Schoenfeld residuals. All analyses were adjusted for age (timescale), sex, marital status; ethnicity; education; employment; economic status; long-term illness; and household status including number of adults in employment, number of dependent children and number of residents having long-term illness. Subgroup analyses were stratified by sex. Two-sided P values for all test were calculated with $p<0.05$ considered significant. Data preparation and statistical analyses were conducted using STATA/13(StataCorp, College Station, TX). To test the robustness of our results, sensitivity analyses were performed in using different cutoff point of Carstairs scores.

Results

The basic socio-demographic characteristics were presented stratified by the social deprivation groups in Table 1. In a representative population of 217,965 UK adults, more women from the most deprived group (53%) compared with men (47%). In general, there was a steady decrease in the level of education, occupation, employments status, and increase in long term illness and household burden across the deprived groups. This is particularly evident in the participants from the most deprived group that were significantly less likely to receive the higher degree education (4% vs 29%), were less likely to work in the higher level of occupation (17% vs 60%) and less likely being employed (65% vs 84%). Participants from more deprived groups also had more household burden compared to those from the less deprived group. For example, 36% of people from the most deprived group reported to have more than one resident in the household having long-term condition compared with only 15% in the least deprived group.

Within this cohort, a total of 58,770 deaths occurred over a median of 10 years of follow-up period, of which 5,060 (8.6%) were from cardiac-specific cause and 53,710 (91.4%) were other causes of death. The multivariable-adjusted associations of area deprivation with cardiac and all-cause mortality are shown in Table 2. The unadjusted model showed there was a greater increase in the risk for cardiac-specific cause mortality in the most deprived group (Quintile 5) (HR 1.13, 95% CI 1.03-1.23, $p<0.05$) compared with the least deprived group (Quintile 1). This association remained significant after adjustment for individual sociodemographic status, household characteristics and individual health conditions (Model 3: HR 1.27 1.15-1.39, $p<0.000$). Notably, this pattern was mirrored by similar differences in all-cause mortality. Figure 2 shows the HR with 95%CI between area deprivation and cardiac mortality and all-cause mortality in people from the most deprived group compared to the least deprived group.

The sex-stratified analysis demonstrated the impact of area deprivation on cardiac-mortality was stronger in women (Figure 3). Area deprivation retained sizeable and substantial association with cardiac mortality after adjustments (Table 3). Women from the more deprived groups (Quintile 2-5) had 28-42% higher risk of cardiac death when compared those from least deprived group (Quintile 1). In contrast, there was weak evidence among men both statistically and in magnitude. This has shown the cardiac mortality risk in relation to area deprivation was diminished after adjustments and was only remained statistically significant in the most deprived group (Quintile 5) when compared with the least deprived group (HR 1.15, 1.02-1.31) (Table 3). However, in all-cause mortality the results of sex-stratified analysis were broadly in agreement with the overall analysis and this sex-different pattern was not observed (Figure 3).

Discussion

Using large population-based national longitudinal data, we examined the long-term impact of area deprivation on cardiac mortality and all-cause mortality between 1991 and 2010. Our study demonstrated area deprivation was the strong predictor of long-term cardiac mortality (adjusted HR 1.27, 95% CI 1.15-1.39) and the inequalities were substantially greater in women (adjusted HR 1.42, 95% CI 1.22-1.65) from more deprived areas than men (adjusted HR 1.15, 95% CI 1.02-1.31) from the same background.

Our findings are consistent with the previous national and international studies that social deprivation is associated with poor mid-long term survival. In one of the earliest studies using health survey data from 14,952 participants aged 45 to 64 years in an urban area from

Scotland between 1972 and 1976 (16), the results showed deprivation was associated with both cardiac and all-cause mortality. A recent study of UK biobank from over 300, 000 adults(19) showed deprivation was associated with a higher hazard for all-cause mortality and cardiovascular mortality. International studies also concur with these observations. For example, the Cardiovascular Health Study from US found the risk of cardiac mortality in participants who lived in more deprived areas was 1.3 times greater compared with those from less deprived areas after 8-year follow up(9). However, the majority of previous studies that examined the social deprivation on cardiac outcomes were limited within 10 years. Our study added the additional evidence to the body of knowledge that area deprivation has longer impact on cardiac outcomes over 10 years.

Our study also demonstrated that inequalities in cardiac deaths were particularly marked for women. Although not consistent, the stronger association between cardiac mortality and area deprivation in women has been observed in some studies. For example, in the Atherosclerosis Risk in Communities Studies from US, the results demonstrated livening in the most disadvantaged areas related to a 100% increase in risk of cardiac mortality for women and only 20% for men (20). Our findings were also consistent with the earlier study in Scotland(16) that showed women with more deprived backgrounds have higher risk of dying from cardiovascular disease than man with the same background, indicating the disparities between men and women has not improved over time in Scotland.

There are serval plausible explanations through which area characteristics could be relevant to cardiovascular health (20, 21). One possible explanation could be related to the higher prevalence of cardiovascular risk factors in more deprived areas, which may contribute to the increase risk of cardiac mortality. A range of studies have shown cardiovascular risk factors such as smoking, obesity, diabetes account for over 50% of the association between socioeconomic status and CVD mortality and morbidity (8, 10). A recent systematic review demonstrated the strong association between area deprivation and higher prevalence of cardiovascular risk factors, particularly type 2 diabetes and high body mass index (BMI) (14). These lifestyle risk factors are strongly associated with area deprivation (19, 22) and particularly relevant to the so called "obesogenic environment", which has been related to the areas where people live, work, leisure, transport and availability of healthy food stores (23). These observation was consistent with the Scottish health survey between 1996 and 2010 which has shown a steady upward trend in the prevalence of obesity in adults and people in more socially disadvantaged groups tended to have a higher prevalence of multiple cardiovascular risk factors(24). The increased trend in cardiovascular risk profile could partly explain the disparities in the cardiac mortality across the socially deprived groups in our cohort. The higher risk of CVD mortality in most deprived groups could also be due to more house burden compared to those from the less deprived groups. An Australian study showed CVD risk was associated with worse household economic hardship for patients after an acute cardiac event, contributing to exacerbating socially disadvantaged groups with higher household burden (25).

Our results showed women from deprived areas are at higher risk of cardiac death, which could be due to higher prevalence of cardiovascular risk factors in women from more deprived areas. Women have different risk factor profiles compared with men. For example, obese, one of the strong cardiovascular risk factor is more common in women (30%) than men (27%)(24). Several female related-factors have been shown to increase cardiac risk in women, such as oestrogen deficiency, polycystic ovary syndrome, premature menopause (26, 27).Prior research also has suggested that women with CHD have a poor cardiovascular risk profile, which may contribute to the sex difference in morality after CHD (28). The Scottish Health Survey(24) showed the association between higher prevalence of multiple cardiovascular risk factors were particularly pronounced for women in most deprived quintiles (32%) compared with the least deprived quintiles (17%). The sex-different results have been consistent with a meta-analysis of over 1 million cardiac events that found area deprivation was significantly associated with increased incidence of CHD and such risk was greater in women from deprived area than men (29). Higher cardiac mortality risk in women from deprived group may relate to the suboptimal care for CHD. Receiving guideline-recommended treatment for CHD and secondary prevention is the main contributor to reduce cardiac mortality (30). However, studies showed patients from low SES background were less likely to have guideline recommended treatment and preventive care including percutaneous coronary intervention and attending Cardiac Rehabilitation (CR) (11, 12). A recent study using data from US Atherosclerosis Risk in Communities surveillance showed women with AMI were substantially less likely than men to receive coronary revascularization and lipid-lowering therapies (31). However, the studies that focused on women particularly from socially disadvantaged group in relation to outcome of CHD are extremely limited.

Strengths and Limitations

A major strength of this study lies on the population-based nature of the representative sample that using longitudinal data, which allows for sufficient number of cases in each socioeconomic category analysis and increase the generalisability of findings compared with health surveys. Moreover, the longitudinal nature of our data with linkage to various datasets has allowed better comparisons by important features and survival analysis, and the use of competing risk survival analysis is another strength of this study. We used the competing risk survival analysis to take account of competing events for the non-cardiac death, and adequately estimated the area-level effects on cardiac mortality. Previous studies have not taken account of such considerations, which could lead to overestimate the risk (18).

Our study has several limitations. One of the limitations was the lack of other contributing risk factors to inequality that might have enabled assessment as to the degree to which different causal factors, such as smoking, and use of alcohol, might explain differences. However, a previous study showed these factors only made a limited contribution to the increased risk associated with deprived areas (9) and we had taken individual health condition and other contributing factors such as household characteristics into account and made the adjustments. The other limitation is the generalisability of the study to other ethnic groups maybe limited since most of the Scottish population were white European (99%) in our study. Our studies have controlled the individual SES and household burdens, and individual health status, this could, at least partly explained the higher risk was due to other contributors for example, access to health care, and it could be due to more difficult access to health care facility for assessment and treatment and secondary prevention.

Conclusions

By using large population-based national representative cohort data, our findings confirmed the area deprivation is a significant independent contributor to long-term cardiac mortality, particularly in women. Despite the insights to be gained from considering the deprived women at greater risk from CHD, women have been underrepresented in cardiovascular research from which the guidelines were developed despite the important gap in risk assessment diagnosis, management and prevention of CHD in women. Therefore, our study provides the important evidence for sex-specific approach to risk prediction, clinical management strategies and design of future research. Our findings also have implications both for resource allocation and for intervention strategies to reduce the health inequalities in in people from disadvantaged communities, particularly in women. Future research investigating the other possible contributing factors such as access to health care, particularly the use of secondary prevention programs such as cardiac rehabilitation in the deprived areas are needed.

Authors' contribution

KJ contributed to conception and design, data acquisition, analysis and interpretation, drafted and critically revised the manuscript. LN and IA contributed to conception and design, data acquisition, analysis and interpretation, and critically revised the manuscript. All authors gave final approval and agreed to be accountable for all aspects of work ensuring integrity and accuracy.

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Disclosures

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Declaration of conflicting interests

None.

Abbreviations

AMI: Acute myocardial infarction

BMI: Body mass index

CVD: Cardiovascular disease

CIs: Confidence intervals

CHD: Coronary heart disease

HRs: Hazard ratios HRs

ICD: International Classification of Disease

SLS: Scottish Longitudinal Study

SES: Socioeconomic status

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