The influence of neighbourhood-level socioeconomic deprivation on cardiovascular disease mortality in older age: longitudinal multilevel analyses from a cohort of older British men

S E Ramsay,1 R W Morris,1 P H Whincup,2 S V Subramanian,3 A O Papacosta,1 Lucy T Lennon,1 S G Wannamethee1

ABSTRACT

Background  Evidence from longitudinal studies on the influence of neighbourhood socioeconomic factors in older age on cardiovascular disease (CVD) mortality is limited. We aimed to investigate the prospective association of neighbourhood-level deprivation in later life with CVD mortality, and assess the underlying role of established cardiovascular risk factors.

Methods  A socially representative cohort of 3924 men, aged 60–79 years in 1998–2000, from 24 British towns, was followed up until 2012 for CVD mortality. Quintiles of the national Index of Multiple Deprivation (IMD), a composite score of neighbourhood-level factors (including income, employment, education, housing and living environment) were used. Multilevel logistic regression with discrete-time models (stratifying follow-up time into months) were used.

Results  Over 12 years, 1545 deaths occurred, including 580 from CVD. The risk of CVD mortality showed a graded increase from IMD quintile 1 (least deprived) to 5 (most deprived). Compared to quintile 1, the age-adjusted odds of CVD mortality in quintile 5 were 1.71 (95% CI 1.32 to 2.21), and 1.62 (95% CI 1.23 to 2.13) on further adjustment for individual social class, which was attenuated slightly to 1.44 (95% CI 1.09 to 1.89), but remained statistically significant after adjustment for smoking, body mass index, physical activity and use of alcohol. Further adjustment for blood pressure, high-density lipoprotein cholesterol and prevalent diabetes made little difference.

Conclusions  Neighbourhood-level deprivation was associated with an increased risk of CVD mortality in older people independent of individual-level social class and cardiovascular risk factors. The role of other specific neighbourhood-level factors merits further research.

INTRODUCTION

Cardiovascular disease (CVD) remains the main cause of death in the UK, particularly at older ages.1 Therefore, with the increasing proportion of older people in countries such as those in the UK, CVD poses a significant public health challenge.2 Apart from the overall mortality burden, social inequalities also persist, with higher CVD mortality rates among people from lower compared with higher socioeconomic groups.3 4 Studies have also shown that neighbourhood-level socioeconomic factors are associated with CVD mortality—people living in more deprived or disadvantaged areas are reported to have a greater risk of CVD mortality.3–9 However, most studies on neighbourhood-level socioeconomic factors and CVD mortality have been in middle-aged populations (table 1 for a summary of studies).

There is an increasing interest in understanding the influence of neighbourhood-level socioeconomic factors particularly on the health of older populations10—it has been suggested that socioeconomic factors of neighbourhoods (such as housing, living environment, access to services) are likely to play an important role in older people who are more confined to their area of residence.10 We have previously shown that individual-level socioeconomic position is associated with CVD even in older age.11 However, there is limited evidence from longitudinal studies of older people assessing the influence of neighbourhood socioeconomic factors on CVD mortality.5 7 9 We therefore aimed to investigate the independent relationship between neighbourhood (or area)-level socioeconomic factors and CVD mortality, and all-cause mortality, over a 12 year period in a representative sample of older British men. We also explored the possible role of individual socioeconomic position and established behavioural cardiovascular risk factors (including smoking, obesity, physical activity) in explaining associations between neighbourhood socioeconomic factors and CVD mortality.

METHODS

The British Regional Heart Study (BRHS) is a longitudinal study comprising a socially and geographically representative sample of 7735 men recruited from general practices in 24 British towns. Since the sample frame excluded inner cities and highly mobile towns, the study population comprised almost completely of white European participants. The cohort has been followed up since 1978–1980, when aged 40–59 years. All men provided written informed consent to the investigations, carried out in accordance with the Declaration of Helsinki. Ethical approval was provided by relevant local research ethics committees throughout. Between 1998 and 2000, the men, aged 60–79 years, were invited for a follow-up examination. This reassessment included completion of a questionnaire on lifestyle and medical history, and a physical examination including measurements of anthropometry and blood pressure (BP). Blood samples were...
collected after a minimum 6 h fast, using the Sarstedt Monovette system. Of the surviving participants 4252 men attended the examination, a response rate of 77%, with a slightly higher response rate of 80% in non-manual social classes and 70% in manual groups; 4045 men had biochemical measurements. Details of cardiovascular risk factors in the cohort assessed at this examination at 60–79 years (smoking, physical activity, body mass index (BMI), alcohol intake, BP blood lipids and glucose) have been described. Details of the use of these risk factors in this study are reported in the statistical analyses section below.

**Neighbourhood-level socioeconomic deprivation**

The Indices of Multiple Deprivation (IMD) for England (2004), Scotland (2004) and Wales (2005), were used as measures of neighbourhood-level socioeconomic deprivation. These national scores of deprivation are collected at aggregate level for small geographical units called LSOAs (lower super output area), of which the lower super output area (LSOA) is the smallest with level for small geographical units called.

**Research report**

### Table 1  Studies investigating associations between neighbourhood-level socioeconomic factors and cardiovascular disease mortality

<table>
<thead>
<tr>
<th>Reference</th>
<th>Age of participants, years</th>
<th>Setting</th>
<th>Area or neighbourhood socioeconomic measure used</th>
<th>Relative risks (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith et al 16</td>
<td>45–64</td>
<td>Renfrew and Paisley, Scotland</td>
<td>Carstairs deprivation score (based on male unemployment, overcrowding, car ownership, proportion in social classes IV and V)</td>
<td>HR for most deprived vs least deprived categories 1.26 (1.04 to 1.52) for men 1.33 (1.05 to 1.69) for women</td>
</tr>
<tr>
<td>Waitzman and Smith 17</td>
<td>25–74</td>
<td>USA—National Health and Nutrition Examination Survey</td>
<td>Federally defined poverty areas of residence based on census tracts</td>
<td>RR for poverty-area vs non-poverty area 1.90 (1.24 to 2.90) in 25–54 years 0.83 (0.66 to 1.03) in 55–74 years</td>
</tr>
<tr>
<td>Diez Roux et al 18</td>
<td>≥65</td>
<td>USA—Forsyth Co, North Carolina; Washington Co, Maryland; Sacramento Co, California and Pittsburgh; Pennsylvania</td>
<td>Neighbourhood deprivation score based on census (household income, value of housing units, education and occupation)</td>
<td>HR for most vs least disadvantaged tertiles 1.5 (1.2 to 1.9) in Caucasian participants 1.2 (0.7 to 2.2) in African-American participants</td>
</tr>
<tr>
<td>Borrell et al 19</td>
<td>45–64</td>
<td>USA—Forsyth County, North Carolina; Jackson, Mississippi; the northwestern suburbs of Minneapolis, Minnesota; and Washington County, Maryland</td>
<td>Neighbourhood deprivation score based on census (household income, value of housing units, education and occupation)</td>
<td>HR for most vs least disadvantaged tertiles 1.4 (1.0 to 2.0) in Caucasian participants 1.1 (0.8 to 1.6) in African-American participants</td>
</tr>
<tr>
<td>Steenland et al 20</td>
<td>50–74</td>
<td>USA—Cancer Prevention Study II Nutrition Cohort</td>
<td>Area-level socioeconomic status based on census data including household income, home value, occupation and education</td>
<td>RR for lowest vs highest area-level score group 1.46 (1.22 to 1.74) for men 1.33 (1.00 to 1.77) for women</td>
</tr>
<tr>
<td>Major et al 21</td>
<td>50–71</td>
<td>USA—California, Florida, Louisiana, New Jersey, North Carolina, Pennsylvania, Atlanta (Georgia) and Detroit (Michigan)</td>
<td>Neighbourhood deprivation index based on census data (housing, residential stability, poverty, employment, occupation, racial composition, education)</td>
<td>HR for highest vs lowest deprivation quintile 1.33 (1.19 to 1.49) for men 1.18 (1.01 to 1.38) for women</td>
</tr>
<tr>
<td>Sanchez-Santos et al 22</td>
<td>60–79</td>
<td>24 British towns</td>
<td>Index of multiple deprivation (income, employment, barriers to services, living environment)</td>
<td>HR per SD increase in deprivation score 1.22 (1.09 to 1.37) in women</td>
</tr>
<tr>
<td>Chan et al 2014 23</td>
<td>All ages</td>
<td>USA—458 counties</td>
<td>Community characteristics including US census data</td>
<td>Estimated increase in death per 100 000 from 25th to 75th centile—for education 19.92 (14.12 to 25.80); 16.06 (10.77 to 21.45) for employment in construction</td>
</tr>
</tbody>
</table>

HR, hazard ratio; RR, rate ratio.

**Individual-level socioeconomic position**

The longest-held occupation of participants at study entry (aged 40–59 years) was used to define social class using the Registrar Generals’ Social Class Classification—I (professionals, eg, physicians, engineers), II (managerial, eg, teachers, sales managers), III non-manual (semiskilled non-manual, eg, clerks, shop assistants), III manual (semiskilled manual, eg, bricklayers), IV (partly skilled, eg, postmen) and V (unskilled, eg, porters, general labourers).

**Follow-up**

The cohort has been followed up for mortality through the National Health Service Central Register. CVD deaths included those with International Classification of Diseases, ninth revision (ICD-9) codes of 401–459. Follow-up for this study was for 12 years until 2012. Non-fatal myocardial infarction (MI) and non-fatal stroke were identified from biennial reviews of the general practitioner records of study participants, which include hospital and clinic correspondence, and information on
tiles were level 2 variables, while individual social class and risk
in the data, with individuals nested within LSOAs. IMD quin-
tiles were divided into quintiles from the least to most deprived quintile,
IMD scores for England, Scotland and Wales combined were
adjusted IMD scores for Scotland and Wales. These adjusted
residuals after fitting suitable polynomial functions of time to obtain
a smoothed hazard function.20–22

Multilevel modelling was used to take account of hierarchies in
the data, with individuals nested within LSOAs. IMD quintiles were level 2 variables, while individual social class and risk
factors were level 1 variables. The cohort comprised 1674
LSOs with an average of two men in each LSOA (941 LSOAs
had 1 participant; 297 had 2; 354 had 3–6 and 82 had 7–16
participants). Multilevel discrete-time models were used20–22
for the longitudinal data, whereby the 12 year follow-up was
divided into 1-month discrete intervals. Multilevel logistic
regression analyses were carried out for mortality (all-cause and
CVD) and included discrete-time intervals in the regression
model by fitting suitable polynomial functions of time to obtain
a smoothed hazard function.20–22 ORs (which approximated
HRs within follow-up months) and 95% CIs were obtained
according to quintiles of IMD deprivation, with quintile 1 (least
deprived) as the baseline group. Of the 4045 participants with
biological measures, those of armed forces occupation or
without information on social class (n=114) were excluded
from the analyses; a small number of men living overseas (n=7)
who were not allocated a LSOA were also excluded from the
analyses. Therefore, analyses were carried out on 3924 partici-
ants. Intraclass correlation coefficients (ICC) were calculated to
obtain the variance explained in mortality by the area-level vari-
ables (LSOAs).23 Subsidiary analyses were carried out for CVD

Table 2  Baseline characteristics according to neighbourhood-level deprivation quintiles in a cohort of British men aged 60–79 years

<table>
<thead>
<tr>
<th>Neighbourhood-level deprivation (Index of Multiple Deprivation)</th>
<th>Quintile 1 (least deprived) (n=900)</th>
<th>Quintile 2 (n=918)</th>
<th>Quintile 3 (n=774)</th>
<th>Quintile 4 (n=670)</th>
<th>Quintile 5 (most deprived) (n=662)</th>
<th>p Value for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean, age (SD)</td>
<td>68 (5)</td>
<td>68 (5)</td>
<td>68 (6)</td>
<td>69 (6)</td>
<td>69 (5)</td>
<td>0.006</td>
</tr>
<tr>
<td>Manual occupational social class, n (%)</td>
<td>262 (29)</td>
<td>382 (42)</td>
<td>434 (56)</td>
<td>467 (70)</td>
<td>520 (79)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>≥3 Adverse socioeconomic factors,* n (%)</td>
<td>45 (5)</td>
<td>87 (9)</td>
<td>154 (20)</td>
<td>200 (30)</td>
<td>267 (40)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Current smokers, n (%)</td>
<td>69 (8)</td>
<td>85 (9)</td>
<td>93 (12)</td>
<td>108 (16)</td>
<td>136 (21)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Moderate/heavy drinkers,† n (%)</td>
<td>151 (17)</td>
<td>174 (19)</td>
<td>134 (17)</td>
<td>122 (18)</td>
<td>154 (23)</td>
<td>0.01</td>
</tr>
<tr>
<td>Physically inactive, n (%)</td>
<td>250 (28)</td>
<td>272 (30)</td>
<td>262 (34)</td>
<td>255 (38)</td>
<td>258 (40)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Obese (BMI ≥30 kg/m²), n (%)</td>
<td>111 (12)</td>
<td>148 (16)</td>
<td>125 (16)</td>
<td>136 (20)</td>
<td>134 (20)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mean systolic blood pressure, mm Hg (SD)</td>
<td>149 (24)</td>
<td>149 (25)</td>
<td>149 (24)</td>
<td>150 (24)</td>
<td>149 (24)</td>
<td>0.89</td>
</tr>
<tr>
<td>Prevalent diabetes—n (%)</td>
<td>93 (10)</td>
<td>91 (10)</td>
<td>92 (12)</td>
<td>88 (13)</td>
<td>85 (13)</td>
<td>0.16</td>
</tr>
<tr>
<td>Mean HDL cholesterol, mmol/l (SD)</td>
<td>1.36 (0.34)</td>
<td>1.34 (0.35)</td>
<td>1.31 (0.34)</td>
<td>1.29 (0.32)</td>
<td>1.30 (0.35)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

*Score includes: no car, not house owner, state pension only, no central heating, manual SC, education ≤14 years.
†1–16 drinks of alcohol per week (1 UK unit=10 g).
BMI, body mass index; HDL, high-density lipoprotein.

Statistical analyses
An adjusted IMD score was applied to the cohort, using the
employment and income IMD domains, which are common to
the English, Scottish and Welsh IMDs, and measured with
similar indicators. We obtained component IMD scores for
each country including the income and employment scores
expressed as percentages. For each country, a linear regression
model by fitting suitable polynomial functions of time to obtain
a smoothed hazard function.20–22

Multilevel modelling was used to take account of hierarchies in
the data, with individuals nested within LSOAs. IMD quintiles
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obtain the variance explained in mortality by the area-level vari-
ables (LSOAs).23 Subsidiary analyses were carried out for CVD

Table 3  ORs (95% CI) for cardiovascular disease mortality according to neighbourhood-level deprivation quintiles in a cohort of British men aged 60–79 years followed up for 12 years

<table>
<thead>
<tr>
<th>Number of deaths (%)</th>
<th>Adjusted for age</th>
<th>Further adjusted for individual social class</th>
<th>Further adjusted for smoking, physical activity, alcohol, body mass index</th>
<th>Further adjusted for high-density lipoprotein cholesterol, systolic blood pressure and diabetes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quintile 1 (n=900)</td>
<td>99 (11)</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Quintile 2 (n=918)</td>
<td>118 (13)</td>
<td>1.21 (0.93 to 1.56)</td>
<td>1.17 (0.90 to 1.51)</td>
<td>1.15 (0.89 to 1.50)</td>
</tr>
<tr>
<td>Quintile 3 (n=774)</td>
<td>135 (17)</td>
<td>1.64 (1.28 to 2.11)</td>
<td>1.58 (1.22 to 2.04)</td>
<td>1.50 (1.16 to 1.94)</td>
</tr>
<tr>
<td>Quintile 4 (n=670)</td>
<td>107 (16)</td>
<td>1.57 (1.21 to 2.03)</td>
<td>1.49 (1.14 to 1.96)</td>
<td>1.34 (1.02 to 1.77)</td>
</tr>
<tr>
<td>Quintile 5 (n=662)</td>
<td>121 (18)</td>
<td>1.71 (1.32 to 2.21)</td>
<td>1.62 (1.23 to 2.13)</td>
<td>1.44 (1.09 to 1.89)</td>
</tr>
<tr>
<td>Random effect variance (SE)</td>
<td>0.00</td>
<td>0.0009 (0.06)</td>
<td>0.003 (0.06)</td>
<td>0.003 (0.06)</td>
</tr>
<tr>
<td>Intraclass correlation coefficient (ICC)</td>
<td>0</td>
<td>0.0003</td>
<td>0.00003</td>
<td>0</td>
</tr>
<tr>
<td>P for trend</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>0.006</td>
<td>0.01</td>
</tr>
</tbody>
</table>
RESULTS

Among 3924 men aged 60–79 years, 1545 deaths occurred during the 12 year follow-up period, of which 580 were from CVD. Table 2 shows the distribution of age, individual social class and established cardiovascular risk factors according to IMD quintiles. The proportion of men of manual social class and those with ≥3 adverse socioeconomic indicators increased from quintile 1 (least deprived) to quintile 5 (most deprived).

Proportions of current smokers, physically inactive, moderate/heavy drinkers and obese men were also higher in the more deprived quintiles, while HDL-C levels were lower. Systolic BP, smoking, physical activity, alcohol, BMI and diabetes. The increased risks of CVD mortality in deprived quintiles, while HDL-C levels were lower. Systolic BP, smoking, physical activity, alcohol, BMI, and diabetes. The increased risks of CVD mortality in more deprived quintiles were attenuated slightly after additional adjustment for individual social class. A formal test of interaction between IMD deprivation and social class showed no evidence that the effect of deprivation varied by social class (p for test for interaction=0.66). The increased risk in more deprived quintiles was attenuated slightly after additional adjustment for socio-economic factors (smoking, physical activity and BMI), and remained unchanged on further adjustment for systolic BP, HDL-C and diabetes. The increased risks of CVD mortality in quintiles 3, 4 and 5 remained significant in the final fully adjusted model. Further adjustment for marital status made no material difference to these estimates (data not shown). No difference in risk of CVD incidence (including non-fatal and fatal cases) according to IMD quintiles was observed—adjusted for age and individual social class, compared to quintile 1; OR (95% CI) for CVD incidence were 1.09 (0.88 to 1.34) for quintile 2; 1.25 (1.01 to 1.53) for quintile 3; 1.20 (0.95 to 1.50) for quintile 4 and 1.16 (0.92 to 1.47) for quintile 5.

Results for all-cause mortality according to IMD quintiles of the combined IMD quintiles with results for English IMD quintiles. All analyses were carried out using the combined adjusted IMD quintiles with results for England (n=3374) were carried out to compare results from the main analyses using the combined adjusted IMD quintiles with results for English IMD quintiles. All analyses were carried out using SAS V9.3, MLwiN 2.29 and Stata V13 (using the ‘runmlwin’ command).

Results for all-cause mortality according to IMD quintiles of the combined IMD quintiles with results for England (n=3374) were carried out to compare results from the main analyses using the combined adjusted IMD quintiles with results for English IMD quintiles. All analyses were carried out using SAS V9.3, MLwiN 2.29 and Stata V13 (using the ‘runmlwin’ command).
These increased risks in more deprived quintiles remained statistically significant, with little change in estimates after adjustment for individual social class and risk factors. A test for interaction showed no evidence that the effect of deprivation varied by social class (p for test for interaction=0.77). The random effect variance for LSOA (measure of neighbourhood) was not statistically significant; the corresponding ICCs were also very small, indicating that the neighbourhoods explained little of the variance in mortality. Associations between neighbourhood IMD quintiles and non-CVD mortality were weaker than those with CVD mortality. A greater risk for non-CVD mortality was observed in quintiles 4 and 5—ORs (95% CI) were 1.37 (1.12 to 1.69) and 1.42 (1.15 to 1.75) respectively, compared to quintile 1. However, this association was attenuated after adjustment for individual socioeconomic position and cardiovascular risk factors including smoking, BMI and physical activity. Of the components of neighbourhood deprivation used, employment, health and disability, and income-related deprivation were associated with CVD mortality. Associations between individual social class and CVD, and all-cause mortality and the effect of adjustment for neighbourhood IMD. CVD mortality risk increased from higher (social class I) to lower social class groups. However, this increased risk in manual social classes (social classes III manual, IV and V) was attenuated on adjustment for neighbourhood IMD quintiles (table 6).

Since the IMD measures used were not identical in England, Wales and Scotland, the results of sensitivity analyses restricted to 3374 men from England using the English IMD quintiles are presented in online supplementary table S1. These sensitivity analyses showed results similar to those with all men in the cohort. CVD and all-cause mortality risk according to English IMD quintiles was greater in more deprived quintiles. These risks remained statistically significant after adjustment for individual social class and established cardiovascular risk factors (see online supplementary table S1).

**DISCUSSION**

In this longitudinal study of older British men aged 60–79 years followed up for 12 years, significant differences in CVD mortality and all-cause mortality risk were observed according to neighbourhood-level socioeconomic deprivation. Older men from more deprived neighbourhoods had a higher CVD mortality risk that was independent of individual (occupational) socioeconomic position. This increased risk in those living in more deprived areas was weakened slightly, but remained, after adjustment for individual socioeconomic position and cardiovascular risk factors including smoking, BMI and physical activity. Of the components of neighbourhood deprivation used, employment, health and disability, and income-related deprivation were associated with an increased risk of CVD mortality.

**Strength and weaknesses**

We believe the findings of this paper add considerable evidence to the issue of neighbourhood socioeconomic factors and CVD mortality.
mortality in older populations; to the best of our knowledge, this is the first report using prospective national data to investigate this issue among older British men. We used longitudinal data with multilevel analyses to take account of the hierarchical nature of the data and adequately estimate the area-level effects; previous studies (summarised in table 1) have not all taken account of the multilevel structure of data, which could lead to narrow confidence limits for estimates and inflated significance levels.26 Our results are based on a socially representative cohort of older British men with a high rate of follow-up (nearly 98%). The cohort aged 60–79 years at baseline is a largely stable population; only a very small proportion (<5%) moved from their area of residence during follow-up. We used a combined measure of neighbourhood deprivation (index of multiple deprivation, IMD) for the cohort comprising participants from England, Scotland and Wales, based on a recently proposed method for combining IMD measures for the three countries.19 Sensitivity analyses showed similar results for English IMD (the largest proportion of the cohort). However, since our study comprises only white European men, the generalisability of the study to women and other ethnic groups is limited. A cohort of older British women (comparable to our study) were mostly retired at the point of assessment. The weak influence of other components could be due to poor measurement of crime and education-related deprivation were weakly associated with CVD mortality, while housing and living environment were not associated. Employment-related deprivation is likely to be a strong indicator of neighbourhood-level economic deprivation. It is not, however, likely to have a direct effect on this cohort of older men, who were mostly retired at the point of assessment. The weak influence of other components could be due to poor measurement of housing, living environment and crime. The ‘health and disability’ component (based on years of potential life lost, emergency hospital admissions, illness to disability ratio, adults <60 years with mood/anxiety disorders) was associated with an increased mortality risk, although not as strongly as employment-related deprivation. Inclusion of the health domain in the IMD does not appear to affect socioeconomic inequalities in health.27

We also explored the components of neighbourhood deprivation in an attempt to distinguish specific aspects of neighbourhoods that relate to CVD mortality. Employment and income-related deprivation, in particular, were associated with CVD mortality risk in older people. Crime and education-related deprivation were weakly associated with CVD mortality, while housing and living environment were not associated. Employment-related deprivation is likely to be a strong indicator of neighbourhood-level economic deprivation. It is not, however, likely to have a direct effect on this cohort of older men, who were mostly retired at the point of assessment. The weak influence of other components could be due to poor measurement of housing, living environment and crime. The ‘health and disability’ component (based on years of potential life lost, emergency hospital admissions, illness to disability ratio, adults <60 years with mood/anxiety disorders) was associated with an increased mortality risk, although not as strongly as employment-related deprivation. Inclusion of the health domain in the IMD does not appear to affect socioeconomic inequalities in health.27

In our study, the increased CVD mortality risk associated with more deprived neighbourhoods was stronger than individual socioeconomic position on adjustment. Greater neighbourhood deprivation was associated with a steady increased risk of CVD mortality, which was evident from quintile 3 onwards; this increased risk was independent of individual socioeconomic position. The increased risk in lower (individual-level) socioeconomic groups, however, was attenuated on adjustment for neighbourhood-level deprivation. Previous analyses in our cohort at an earlier age (52–73 years) using the Carstairs

### Table 6

<table>
<thead>
<tr>
<th>Social class</th>
<th>Number of deaths (%)</th>
<th>Adjusted for age</th>
<th>Further adjusted for neighbourhood deprivation quintiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular disease mortality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I (n=381)</td>
<td>39 (10)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>II (n=1078)</td>
<td>165 (15)</td>
<td>1.56 (1.11 to 2.20)</td>
<td>1.48 (1.05 to 2.09)</td>
</tr>
<tr>
<td>III non-manual (n=400)</td>
<td>52 (13)</td>
<td>1.31 (0.88 to 1.96)</td>
<td>1.17 (0.78 to 1.76)</td>
</tr>
<tr>
<td>III manual (n=1600)</td>
<td>246 (15)</td>
<td>1.68 (1.20 to 2.35)</td>
<td>1.42 (1.01 to 2.00)</td>
</tr>
<tr>
<td>IV (n=348)</td>
<td>58 (17)</td>
<td>1.77 (1.19 to 2.64)</td>
<td>1.44 (0.96 to 2.16)</td>
</tr>
<tr>
<td>V (n=117)</td>
<td>20 (17)</td>
<td>1.94 (1.13 to 3.32)</td>
<td>1.53 (0.88 to 2.65)</td>
</tr>
<tr>
<td>Random effect variance (SE)</td>
<td>0.01 (0.06)</td>
<td>0.0009 (0.06)</td>
<td></td>
</tr>
<tr>
<td>ICC</td>
<td>0.00003</td>
<td>0.0003</td>
<td></td>
</tr>
<tr>
<td>P for trend</td>
<td>0.004</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>All-cause mortality</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I (n=381)</td>
<td>126 (33)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>II (n=1078)</td>
<td>409 (38)</td>
<td>1.16 (0.95 to 1.41)</td>
<td>1.12 (0.92 to 1.37)</td>
</tr>
<tr>
<td>III non-manual (n=400)</td>
<td>164 (41)</td>
<td>1.23 (0.98 to 1.55)</td>
<td>1.13 (0.90 to 1.43)</td>
</tr>
<tr>
<td>III manual (n=1600)</td>
<td>640 (40)</td>
<td>1.32 (1.09 to 1.59)</td>
<td>1.15 (0.95 to 1.40)</td>
</tr>
<tr>
<td>IV (n=348)</td>
<td>157 (45)</td>
<td>1.47 (1.17 to 1.85)</td>
<td>1.25 (0.99 to 1.59)</td>
</tr>
<tr>
<td>V (n=117)</td>
<td>49 (42)</td>
<td>1.55 (1.12 to 2.14)</td>
<td>1.26 (0.91 to 1.76)</td>
</tr>
<tr>
<td>Random effect variance (SE)</td>
<td>0.04 (0.03)</td>
<td>0.03 (0.03)</td>
<td></td>
</tr>
<tr>
<td>ICC</td>
<td>0.0005</td>
<td>0.0003</td>
<td></td>
</tr>
<tr>
<td>P for trend</td>
<td>&lt;0.0001</td>
<td>0.08</td>
<td></td>
</tr>
</tbody>
</table>
measure of neighbourhood deprivation showed weaker associations with CVD, which were diminished on adjustment for individual socioeconomic position. The results of the present analyses may reflect a stronger effect of neighbourhood factors in older age. Our results also indicate a stronger association between neighbourhood deprivation and CVD mortality compared to non-CVD mortality—the associations with non-CVD mortality were attenuated on adjustment for behavioural risk factors (smoking, physical activity, BMI).

Implications and conclusions

The findings of this study highlight the impact of neighbourhood socioeconomic factors on CVD mortality in older populations—older people living in more deprived or disadvantaged neighbourhoods are likely to have a greater risk of CVD mortality. It also highlights that the role of neighbourhood factors in older age is independent of individual socioeconomic position. Furthermore, we observed that neighbourhood deprivation was associated with CVD mortality rather than with CVD incidence (which also included non-fatal CVD cases). These findings suggest that the influence of deprivation may particularly affect survival from CVD and its determinants, implicating the availability and quality of treatment rather than the determinants of CVD incidence (smoking, cholesterol, BMI). Given the small differences in prevalence of diabetes across deprivation groups, diabetes does not appear to account for this association between deprivation and CVD mortality.

Individual-level risk factors including smoking, BMI and physical activity, which are known to be influenced by neighbourhood factors, made a limited contribution to the increased risk associated with deprived neighbourhoods. The role of other possible contributing factors, including air pollution, diet, cognition and familial factors or social support, merit further research. Additionally, the contribution of specific aspects of neighbourhood deprivation in older people with better measures of housing, living environment, access to healthcare and stress is needed.

What is already known on this subject

▸ Studies, mostly in middle-aged populations, have shown that neighbourhood-level socioeconomic factors are associated with cardiovascular disease (CVD) mortality.
▸ Evidence from longitudinal studies on the influence of neighbourhood socioeconomic factors in older age on CVD mortality is limited.

What this study adds

▸ In a population-based study of 3924 older British men, CVD mortality risk increased steadily with greater levels of neighbourhood-level deprivation.
▸ This influence of neighbourhood deprivation was independent of individual-level social class and cardiovascular risk factors.
▸ Opportunities remain to reduce inequalities in CVD mortality in older age by addressing neighbourhood-level factors.

Contributors

SER, SGW, PHW and RWM developed the original idea for the paper. SER wrote the first draft. SER, AOP and RWM performed the analyses. SER, RWM, PHW, SVS, SGW, LTL and AOP contributed to the study design and collection of data. All the authors contributed to interpretation of data and the final version of the manuscript, and all are guarantors.

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Competing interests

None declared.

Patient consent

Obtained.

Ethics approval

The British Regional Heart Study has local (from each of the districts in which the study was based) and multicentre ethical committee approvals.

Provenance and peer review

Not commissioned; externally peer reviewed.

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The influence of neighbourhood-level socioeconomic deprivation on cardiovascular disease mortality in older age: longitudinal multilevel analyses from a cohort of older British men

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