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ORIGINAL ARTICLE

Association of socioeconomic status with 30-day survival following out-of-hospital cardiac arrest in Scotland, 2011–2020

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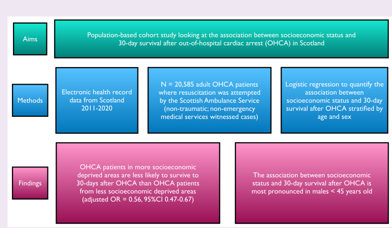
Background and aims The aim of this study was to investigate the crude and adjusted association of socioeconomic status with 30-day survival after out-of-hospital cardiac arrest (OHCA) in Scotland and to assess whether the effect of this association differs by sex or age.

Methods This is a population-based, retrospective cohort study, including non-traumatic, non-Emergency Medical Services witnessed patients with OHCA where resuscitation was attempted by the Scottish Ambulance Service, between 1 April 2011 and 1 March 2020. Socioeconomic status was defined using the Scottish Index of Multiple Deprivation (SIMD). The primary outcome was 30-day survival after OHCA. Crude and adjusted associations of SIMD quintile with 30-day survival after OHCA were estimated using logistic regression. Effect modification by age and sex was assessed by stratification.

Results Crude analysis showed lower odds of 30-day survival in the most deprived quintile relative to least deprived [odds ratio (OR) 0.74, 95% confidence interval (CI) 0.63–0.88]. Adjustment for age, sex, and urban/rural residency decreased the relative odds of survival further (OR 0.56, 95% CI 0.47–0.67). The strongest association was observed in males <45 years old. Across quintiles of increasing deprivation, evidence of decreasing trends in the proportion of those presenting with shockable initial cardiac rhythm, those receiving bystander cardiopulmonary resuscitation, and 30-day survival after OHCA were found.

Conclusions Socioeconomic status is associated with 30-day survival after OHCA in Scotland, favouring people living in the least deprived areas. This was not explained by confounding due to age, sex, or urban/rural residency. The strongest association was observed in males <45 years old.

Graphical Abstract



Keywords Out-of-hospital • Cardiac arrest • Cardiopulmonary resuscitation • Socioeconomic • Survival

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Structured Graphical Abstract

Key Question

- Is socioeconomic status associated with 30-day survival after out-of-hospital cardiac arrest in Scotland and does this association differ by sex and age?

Key Finding

- Socioeconomic status is associated with 30-day survival after out-of-hospital cardiac arrest in Scotland and the association is most pronounced in males under 45 years old.

Take-home Message

- It may be appropriate for cardiopulmonary resuscitation training, and other measures to target the most deprived areas to reduce the socioeconomic disparity in 30-day survival after out-of-hospital cardiac arrest.

Introduction

Out-of-hospital cardiac arrest (OHCA) is the sudden cessation of effective mechanical activity of the heart, evidenced by loss of circulation, occurring outside of the hospital environment.[1] Incidence of OHCA varies between countries, with a systematic review from 2010 reporting an incidence between 28.3 and 54.6 OHCA cases per 100 000 person-years (in Asia and North America, respectively).[2] In Scotland the latest reported incidence (2021–2022) is 49.3 OHCA cases per 100 000 person-years.[3] Differences in incidence associated with socioeconomic status have been consistently observed,[4] including in North America,[5,6] England,[7] Australia,[8] Denmark,[9] and Singapore.[10]

Survival after OHCA requires successful coordination of the 'chain of survival'[11] with key steps including rapid arrest recognition, triggering of the emergency response system, bystander cardiopulmonary resuscitation (bCPR), defibrillation, advanced life support, and post-resuscitation in-hospital care.[12] Survival after OHCA varies between regions but is generally low; the International Liaison Committee on Resuscitation (ILCOR) global registry survey (2020) reports survival to hospital discharge or 30-day survival after OHCA ranging from 3.1% to 20.4%.[13] Gräsner *et al.* report survival to hospital discharge after OHCA in Europe ranging from 0% to 18%.[14] Reported figures from Scotland showed that 30-day survival rates after OHCA have improved from 5.9% in 2011–2012 to 10.2% in 2018–2019.[15] This is towards the lower end of the global range, indicating room for improvement in Scotland. A recently published systematic review showed that evidence for disparities in survival after OHCA is ambiguous. However, the majority of research suggests that people from a socioeconomically deprived background have a lower chance of 30-day survival after OHCA compared with people from a socioeconomically affluent background.[4,16]

Socioeconomic disparities in 30-day survival after OHCA are of particular interest when looking at the Scottish context, as previous research shows socioeconomic disparities in overall health and premature mortality. The Scottish Index of Multiple Deprivation (SIMD) is an area-based measure for socioeconomic status based on important indicators such as income and education.[17] People who live in the ten % most deprived areas in Scotland experience more than twice the number of disability-adjusted life years lost to premature mortality or poor health than people living in the ten % least deprived areas in Scotland.[18] Recent OHCA strategies launched by the Scottish Government in 2015 and 2021 aimed to reduce socioeconomic disparities in OHCA survival.[19,20] Initial analysis for the Scottish Government based on data between 2011 and 2019 shows clear evidence of socioeconomic disparities in incidence and 30-day survival after OHCA in Scotland.[3,21] A recently published systematic review on socioeconomic differences in incidence and survival after OHCA by van Nieuwenhuizen et al. suggested there is a research gap with respect to differences within subgroups of patients, e.g. age and sex differences.[4] Therefore, the aim of this study was to investigate the association between socioeconomic status based on SIMD and 30-day survival after OHCA in Scotland between 2011 and 2020, specifically focusing on age and sex differences.

Methods

Study design and data source

This is a population-based, retrospective cohort study. The cohort consisted of adult, non-traumatic, unique OHCA patients where the Scottish Ambulance Service (SAS) attempted resuscitation between 1 April 2011 and 1 March 2020. Included OHCA cases are defined as 'worked arrests', where Emergency Medical Services (EMS) initiated advanced life support (ALS) resuscitation for at least 20 minutes or return of spontaneous circulation recorded at the hospital. We excluded cases after 1 March 2020 because of the uncertain impact of the COVID-19 pandemic on the EMS response to OHCA. Subsequently, cases were linked with the Scottish Unscheduled Care Data Mart (UCD)[22] and the SAS data warehouse via each patient's Community Health Index (CHI) number.[23]

Exposure and outcome

The patient's area based socioeconomic status was determined using the SIMD, retrieved from the Information Services Division (ISD) Scotland[17] and linked using the patient's home address. The SIMD is a composite area-level measure of overall socioeconomic status calculated for each of almost 7000 'data zones', each containing roughly the same number of people and covering the whole of Scotland. The index is constructed using indicators across seven aspects of socioeconomic status, namely employment, income, education/skills/training ('education' from here on), crime, housing, geographic access to services, and health. The indicators are described in detail elsewhere.[24] For each data zone, scores are calculated for each domain and combined to give an overall SIMD score; the domain contributions are weighted, with income and employment given most emphasis. The data zones are then ranked by overall score from most to least deprived and divided into five quintiles.[24] It is important to note that since SIMD rankings change periodically as census data are updated, we used the version appropriate for the year of the record for each OHCA incident.[24] The UCD contains data on common patient characteristics from the Acute and Inpatient Day Case dataset (SMR01)

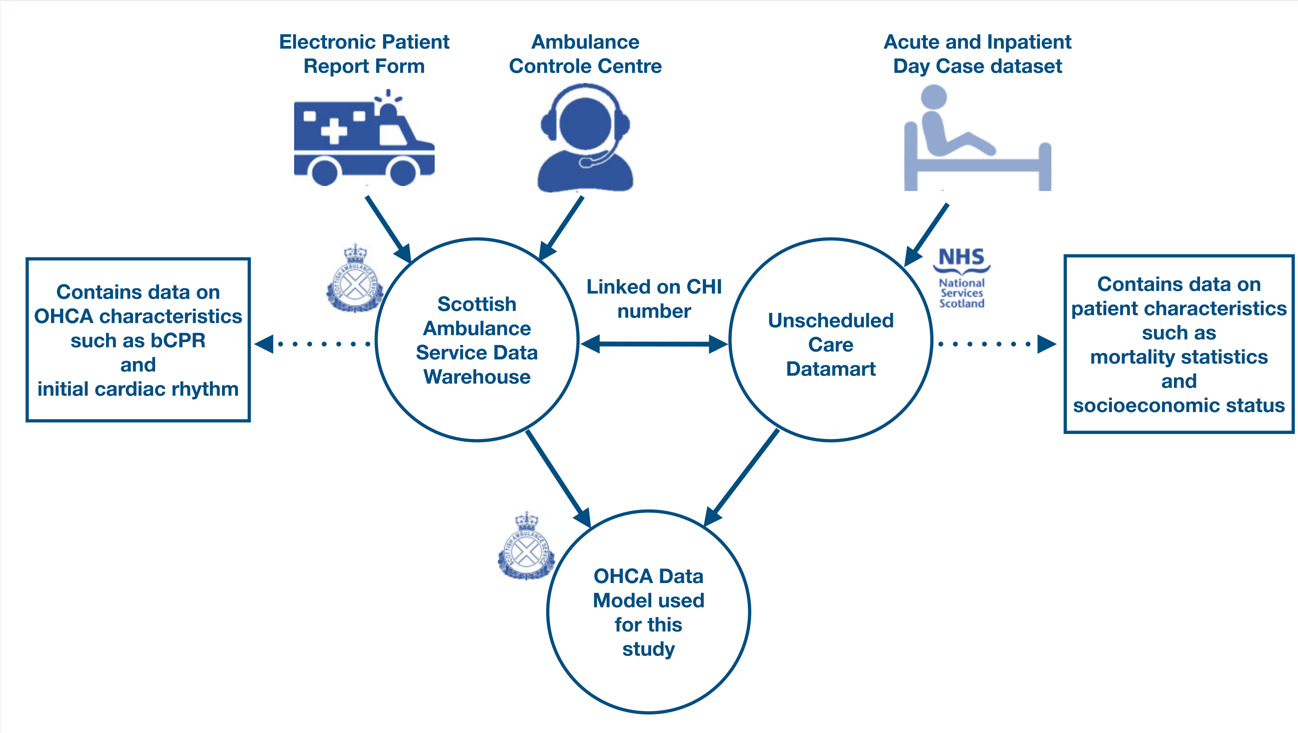

Figure 1 Data linkage process

such as mortality statistics from the National Records Scotland (NRS).[25] The primary outcome used in all analyses was 30-day survival after OHCA. Thirty-day survival was used as a proxy for survival to hospital discharge.

Demographic variables

Data on age and sex were obtained from the UCD. The UCD is a collaboration between Public Health Scotland, NHS 24, and SAS and links several databases to show a patient's journey for records with a valid CHI number.[22] The CHI number uniquely identifies a person on the CHI, which is a population register that is used in Scotland for health care purposes.[23] These data were then linked with other patient characteristics by CHI number.[23] We classified the postcode of the incident location as 'urban' or 'rural' using the Scottish Government Urban Rural Classification, which was retrieved from ISD Scotland.[26] Similar to SIMD, the Scottish Government Urban Rural Classification changes periodically as census data are updated; we used the version appropriate for the year of the record for each OHCA case.

Arrest characteristics

We obtained data on whether bCPR was initiated, cardiac rhythm at initial monitoring, EMS arrival time, and whether or not the arrest was witnessed by EMS crew, from the SAS data warehouse store of SAS patient records. We classified initial cardiac rhythm (ICR) as shockable (ventricular fibrillation/ventricular tachycardia) or non-shockable (pulseless electrical activity/asystole). Arrival time represented the interval from the start of the emergency call to arrival of the first SAS unit; the continuous arrival time was dichotomized at 8 min as this is the target maximum arrival time in Scotland.[27] The maximum arrival time was set at 30 min as longer arrival times are highly unlikely and therefore likely not recorded correctly. Therefore, we set arrival times longer than 30 min as missing ($n = 167$). Arrest characteristics from the SAS Data Warehouse were linked via CHI number to patient characteristics from the UCD (*Figure 1*).

Statistical methods

We reported baseline characteristics of the cohort, with age reported as median [interquartile range (IQR)] and sex, urban/rural location of the incident, 30-day survival, shockable ICR, bCPR, and EMS arrival time reported as numbers with percentages. We assessed the crude and adjusted associations between SIMD quintile and 30-day survival after OHCA using univariable and multivariable logistic regression. SIMD quintile 5 (least deprived) was used as the reference category to facilitate comparison with previous work.[21] We stratified the analyses by age, sex, and urban/rural residency to assess potential effect modification by these factors. Boundaries for age categories for stratification (<45 years; 45 to <65 years; 65 to <80 years; ≥80 years) were chosen based upon previous research to facilitate comparison, as well as allowing sufficient statistical power in each category.[28] Within the age and sex stratified analyses, we made adjustments for age (continuous) and urban/rural location of OHCA. Of note, mediating variables are variables that are part of the causal pathway between the independent and dependent variable and therefore might partially explain any association found.[29] They are different from confounders which are variables that are associated with both the exposure and the outcome but are not an effect of the exposure.[30] In etiological research, adjustments need to be made for confounding variables but not for mediating variables as this could result in effect sizes under- or overestimating the true association.

We also conducted sensitivity analyses to investigate whether using the SIMD determined by the incident location instead of the patient's home address led to different results, as some previous studies have used the SIMD of the incident postcode to look at socioeconomic status.[4] All analyses were performed using R (version 4.0.5).[31]

Table 1 Baseline characteristics

		SIMD				
1 April 2011 to 1 March 2020	**Total n = 20 585**	**Q1* n = 5453**	**Q2 n = 4866**	**Q3 n = 3902**	**Q4 n = 3251**	**Q5 n = 2792**
Incidence in Scotland per 100 000 population	42.5	57.4	51.2	40.6	33.2	28.0
Sex, n (%)						
Male	13 130 (63.8)	3314 (60.8)	3048 (62.6)	2542 (65.1)	2139 (65.8)	1870 (67.0)
Female	7455 (36.2)	2139 (39.2)	1818 (37.4)	1360 (34.9)	1112 (34.2)	922 (33.0)
Age, yr, median (IQR); n (%)						
All ages	70 (22)	65 (25)	69 (23)	71 (22)	72 (21)	74 (20)
<45	2202 (10.7)	836 (15.3)	562 (11.6)	365 (9.4)	240 (7.4)	177 (6.3)
45 to <65	5748 (27.9)	1794 (32.9)	1359 (27.9)	1027 (26.3)	829 (25.5)	635 (22.7)
65 to <80	7508 (36.5)	1823 (33.4)	1765 (36.2)	1485 (38.1)	1236 (38.0)	1074 (38.5)
≥80	5127 (24.9)	1000 (18.4)	1180 (24.3)	1025 (26.2)	946 (29.1)	906 (32.5)
Urban/rural, n (%)						
Urban	14 795 (72.6)	4802 (88.6)	3678 (76.3)	2222 (57.6)	1750 (54.4)	2135 (77.2)
Rural	5589 (27.4)	615 (11.4)	1145 (23.7)	1634 (42.4)	1467 (45.6)	630 (22.8)
Survival to 30 days, n (%)						
No	19 045 (92.5)	5088 (93.3)	4534 (93.2)	3597 (92.2)	3016 (92.8)	2545 (91.2)
Yes	1540 (7.5)	365 (6.7)	332 (6.8)	305 (7.8)	235 (7.2)	247 (8.8)
Initial shockable rhythm, n (%)						
No	15 436 (75.0)	4258 (78.1)	3672 (75.5)	2931 (75.1)	2408 (74.1)	1951 (69.9)
Yes	5149 (25.0)	1195 (21.9)	1194 (24.5)	971 (24.9)	843 (25.9)	841 (30.1)
bCPR, n(%)						
No	9181 (44.6)	2522 (46.3)	2220 (45.6)	1703 (43.6)	1414 (43.5)	1180 (42.3)
Yes	11 404 (55.4)	2931 (53.7)	2646 (54.4)	2199 (56.4)	1837 (56.5)	1612 (57.7)
EMS arrival time* (min), n (%)						
≤8	11 049 (54.1)	3262 (60.3)	2786 (57.6)	1911 (49.7)	1507 (46.9)	1411 (50.8)
>8	9356 (45.9)	2151 (39.7)	2047 (42.4)	1937 (50.3)	1705 (53.1)	1368 (49.2)

bCPR, bystander cardiopulmonary resuscitation; EMS, emergency medical service; IQR, interquartile range; SIMD, Scottish index of multiple deprivation; Q, quintile.
*Q1: most socioeconomically deprived.

Ethical approval

This project was given approval by the SAS Research & Development Committee (reference number: SASRD-2020–011) and submitted to the Health Research Authority's decision tool for ethical input. As this is a non-transferable analysis of routinely collected data, a separate ethical review was not required.

Results

Study population

The study population consisted of 20 585 adult, non-traumatic OHCA cases where EMS resuscitation was attempted, occurring between 1 April 2011 and 1 March 2020 across Scotland. EMS-witnessed arrests were excluded (n = 3932). Only 326 patients had missing data in at least one variable (1.6% of the study population). Incidence of OHCA was twice as high in the most deprived area (Q1: 57.4 per 100 000 population) versus the least deprived area (Q5: 28.0 per 100 000 population).

Table 1 shows baseline characteristics for all OHCA patients stratified by SIMD quintile. Interestingly, the median age is lowest in the most deprived areas (Q1, median age 65 years) and highest in the least deprived areas (Q5, median age 74 years). This difference of almost 10 years indicates people living in the most deprived areas experience OHCA at a significantly younger age than people living in the least deprived areas. Between Q1 (most deprived) and Q5 (least deprived) there was an increase in the proportion of OHCA cases occurring in males (60.8%–67.0%). Proportions of OHCA cases in each SIMD quintile differed substantially across different age groups. There was a much higher proportion of OHCA cases in the youngest age group (<45 years) in Q1 compared with Q5 (Q1: 15.3% versus Q5: 6.3%). However, this reversed in the oldest age group (Q1: 24.9% versus Q5: 32.5%). Therefore, while young people are more likely to experience OHCA in the most deprived areas (Q1) compared with the least deprived areas (Q5), older people are more likely to experience OHCA in the least deprived areas (Q5) compared with the most deprived (Q1).

Association between SIMD and 30-day survival

Figure 2 (*Supplementary Table S1*) shows the unadjusted and adjusted associations of SIMD quintiles with 30-day survival after OHCA. The crude analysis showed that people living in most deprived areas of Scotland (Q1) have approximately 25% lower odds of 30-day survival

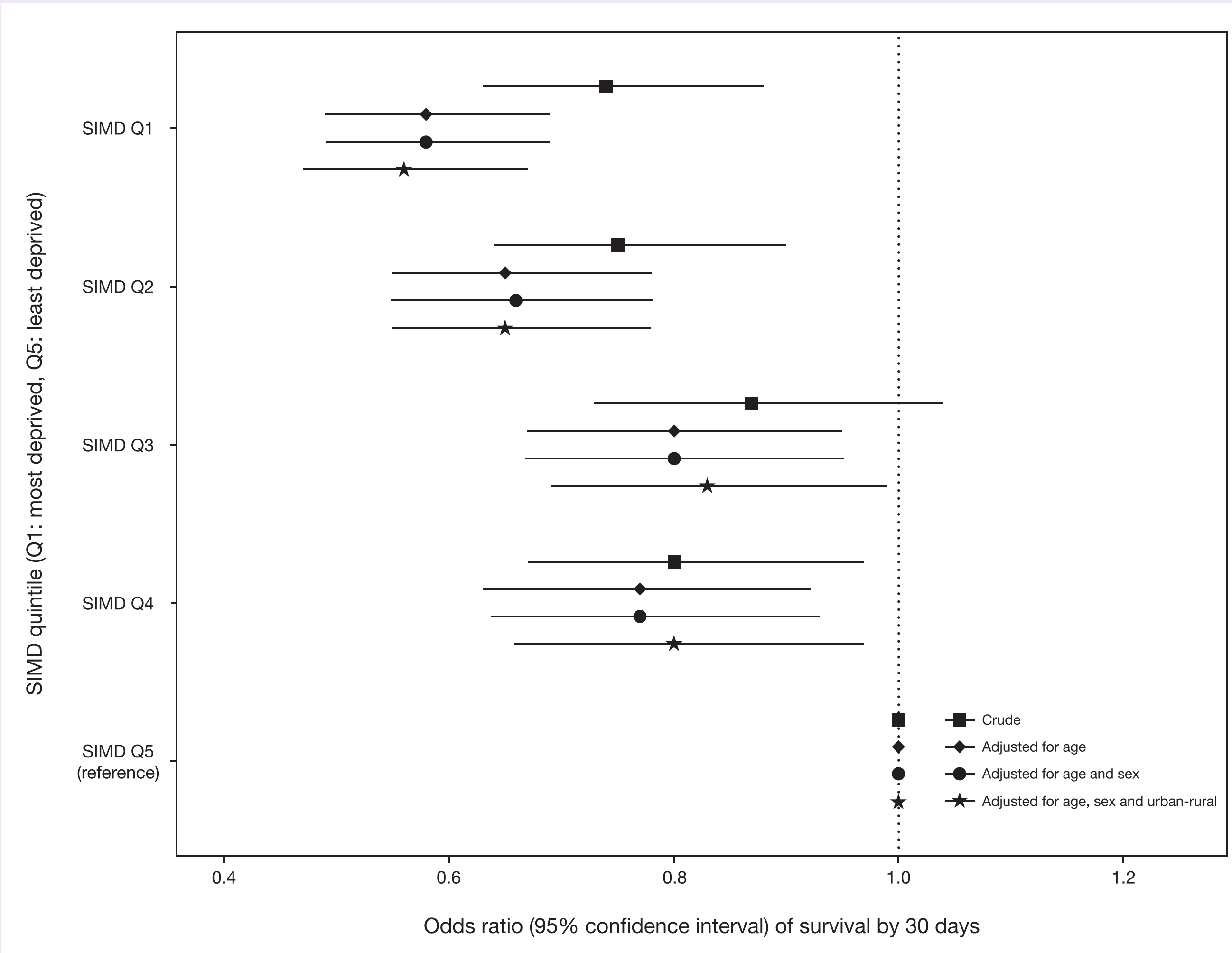

Figure 2 Association of SIMD quintile with survival to 30-days post-OHCA, adjusted for age, sex, and urban/rural location

relative to people living in the least deprived areas in Scotland (Q5). The point estimates of the intermediate quintiles (Q2–Q4) indicated lower odds of 30-day survival after OHCA relative to Q5. After adjustment for the possible confounding variables age, sex, and urban/rural residency, the analysis showed an even stronger association between SIMD and 30-day survival after OHCA. After adjustment, the results indicated approximately 45% lower odds of 30-day survival after OHCA in the most deprived quintile (Q1) compared with the least deprived quintile (Q5) (crude odds ratio [OR] 0.74, 95% confidence interval [CI] 0.63–0.88; adjusted OR 0.56, 95% CI 0.47–0.67). Adjustment for age seemed to account for the stronger association found between SIMD and 30-day survival after OHCA in the adjusted analysis compared with the crude analysis (*Figure 2*). We have conducted analyses to assess whether the strength of the association changed over the course of the study period, changes were relatively minor (see *Supplementary Table S4*).

Effect modification

Using stratified analyses we assessed possible effect modification by age and sex (*Supplementary Tables S2* and *S3* and *Figure 3*). In the group aged < 45 years, people living in Q1 had a 65% lower odds of survival by 30 days relative to Q5 (OR 0.36, 95% CI 0.23–0.56), while the magnitude of this Q1–Q5 association appeared to decrease with increasing age. In the oldest category (≥80 years), there was no clear evidence of lower odds of 30-day survival after OHCA in Q1 relative to Q5. Stratification by age categories (*Supplementary Table S2*) suggested the association between socioeconomic status and 30-day survival after OHCA was the strongest in the youngest age group (<45 years) (OR 0.35, 95% CI 0.21–0.60 for males and OR 0.39, 95% CI 0.19–0.86 for females).

The results of sex stratified analyses showed that males living in most deprived areas in Scotland have half the odds of 30-day survival after OHCA relative to males living in the least deprived areas in Scotland (OR 0.49, 95% CI 0.40–0.60). In females this association appeared not to be present. Therefore, stratification by sex indicated a strong association between socioeconomic status and 30-day survival solely for males.

Stratification by both age and sex (*Figure 3*, *Supplementary Table S3*) showed that the association between SIMD and 30-day survival was most pronounced in males <80 years and females <45 years.

Sensitivity analyses

We conducted a sensitivity analysis looking at SIMD quintiles based on the incident location instead of the patient's home address. Analyses adjusted for age, sex, and urban/rural location of the incident showed

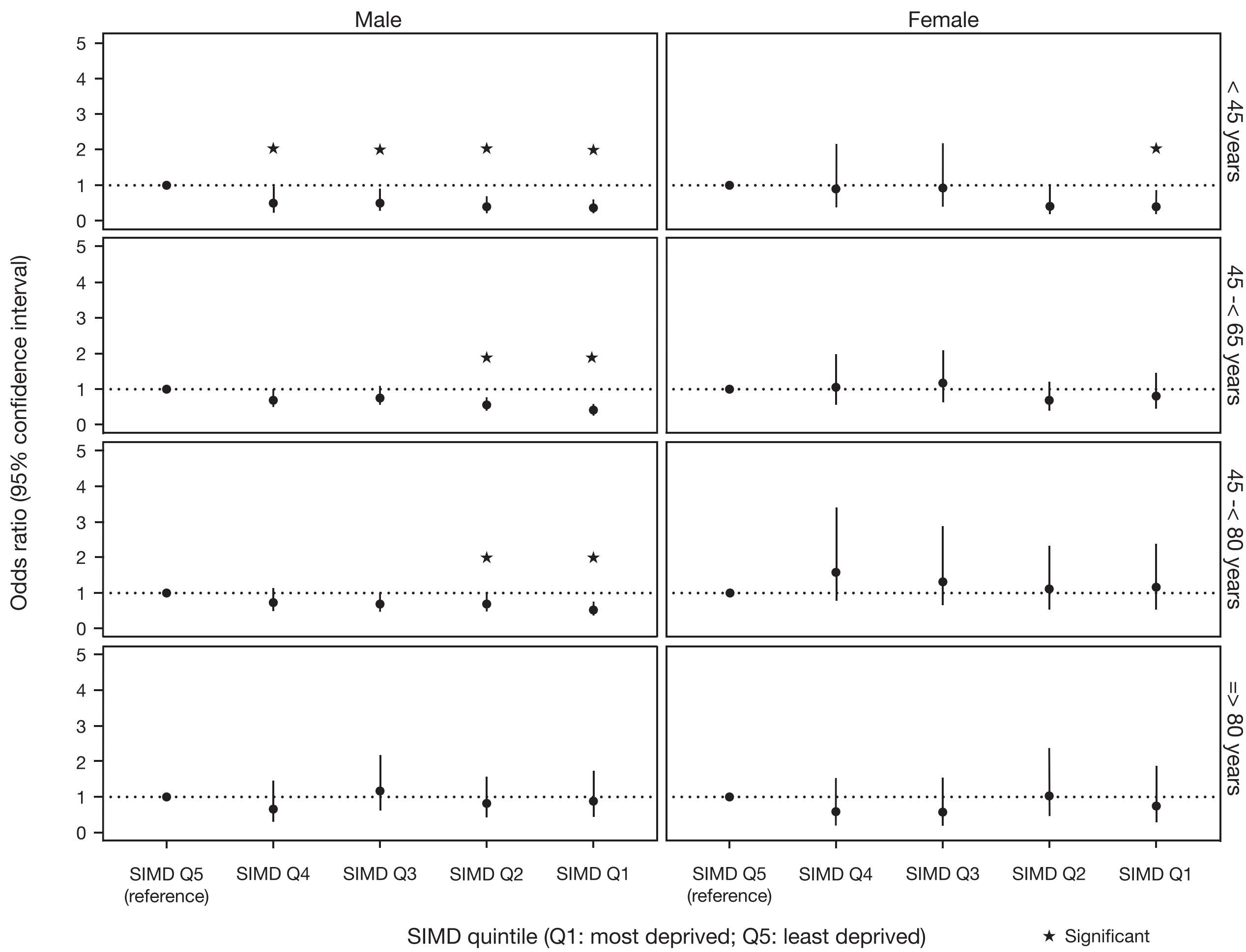

Figure 3 Association of SIMD quintile with survival to 30-days post-OHCA, stratified by age and sex.

that incident SIMD based on the location of the OHCA is associated with 30-day survival after OHCA (OR 0.61, 95% CI 0.51–0.73; Q1 versus Q5). As 71.1% of OHCA incidents included in this analysis took place at home, it is not surprising that the results are comparable.

Table 1 shows that among people living in the most deprived areas, fewer people presented with a shockable ICR (Q1: 21.9% versus Q5: 30.1%) and fewer people received bCPR (Q1: 53.7% versus Q5 57.7%) compared with the least deprived areas.

Discussion

The results of this study showed that people living in the most deprived areas of Scotland were less likely to survive 30 days after OHCA compared with people living in the least deprived areas of Scotland. Stratified analyses showed age and sex differences in the association between SIMD and 30-day survival, with the strongest association in males in the youngest age group (below 45 years) and no association apparent among either males or females older than 80 years. In the most deprived areas, people were less likely to survive 30 days following OHCA (6.7% versus 8.8%), less likely to present with a shockable ICR (21.9% versus 30.1%), and less likely to receive bCPR (53.7% versus 57.7%) compared with the least deprived areas.

Our main finding of an association between socioeconomic status and decreased survival after OHCA is in line with other published studies.[4,16] The large existing heterogeneity in the used measurements for socioeconomic status makes it difficult to make a sensible direct comparison of effect estimates with other studies. Useful comparison may be possible with a study from South Korea, which used the composite Carstairs deprivation index[32] and compared quintiles, reporting age, and sex-adjusted OR of 0.57 (95% CI, 0.45–0.72) for survival to discharge in the most deprived quintile of South Korean districts compared to the least deprived.[33] This indicates a similar magnitude of the effect estimate when comparing to our age and sex-adjusted analyses (OR 0.58, 95% CI 0.49–0.69). There are several similarities between the Carstairs deprivation index and SIMD as they are both based on a combination of factors and area-based measures. However, there are also important differences to note when comparing to different socioeconomic status measures; for example, the South Korean Carstairs deprivation index includes occupation and car-ownership indicators while excluding several aspects that are included in the Scottish SIMD such as income and education.

A systematic review by van Nieuwenhuizen *et al.* looking into the association between socioeconomic status and survival after OHCA also showed a consistent trend of decreased chances of survival after OHCA in low socioeconomic status populations and locations compared with high socioeconomic status populations and locations.[4]

Furthermore, a study conducted by Lee et al. showed that low individual-level socioeconomic status was associated with a higher incidence of OHCA and that disparity by individual-level socioeconomic status appeared to be greater in males than in females and greater in the younger adults compared with older adults.[34]

While the SIMD based on the location of the OHCA might not reflect the socioeconomic status of the patient, it is reflective of the socioeconomic status of the area where the OHCA incident takes place. Multiple previous studies used the postcode of the OHCA incident as a proxy for socioeconomic status of the patient.[4] Furthermore, in the Carstairs study,[33] socioeconomic status was determined based on the postcode of the OHCA incident location rather than the patient's home postcode which was used in this study.[33] In this cohort, 71.1% of OHCA incidents took place at home. Analyses adjusted for age, sex, and urban/rural location of the incident showed that incident SIMD is associated with 30-day survival after OHCA (OR 0.61, 95% CI 0.51–0.73; Q1 versus Q5). This suggests that because most OHCA incidents take place at home, incident SIMD will be the same as patient SIMD for the majority of cases. Therefore, while the results of logistic regression looking at the association between socioeconomic status and survival after OHCA did differ when using incident SIMD instead of the patient SIMD in this cohort, they only differed slightly (OR 0.56, 95% CI 0.47–0.67 using patient SIMD; OR 0.61, 95% CI 0.51–0.73 using incident SIMD).

Our analyses showed that the association between SIMD and 30-day survival was most pronounced in patients $<$45 years old. Previously, Clarke et al. considered age as a possible effect modifier of the association between socioeconomic status and 30-day survival after OHCA, but found no evidence.[35] The study was of moderate size ($n = 1789$). Methodological differences may explain this, namely using a dichotomized age variable (cut point at 67 years), using a cross-product interaction term rather than stratification, and making the assessment within an analysis adjusted for potential mediators. Alternatively, it may indicate that the deprivation measure (value of the patient's residential property) captures a different aspect of deprivation where effect modification by age is not seen.

Survival bias might be an explanation for the age differences found in our study, as patients in more deprived situations who are still alive despite the association of deprivation with premature mortality[18] may be healthier than average and more likely to survive an OHCA. This would attenuate the difference in survival between these patients and those of the same age within less deprived groups, where this 'selection' of more resilient individuals has not occurred. It may also reflect possible differences in OHCA aetiology between age groups, namely non-cardiac causes such as drug overdose may be more common in younger age groups,[36] and may show a stronger association with deprivation.

Possible confounders were taken into account; however, there are also variables which are likely to be part of the causal pathway between socioeconomic status and 30-day survival after OHCA. These intermediate variables or mediators are of interest because they have the potential to contribute to an improved understanding of this complex relationship. Shockable ICR and bCPR are associated with improved survival,[37] making these plausible mediators in the association between SIMD and 30-day survival. *Table 1* shows that among people living in the most deprived areas, fewer people presented with a shockable ICR (Q1: 21.9% versus Q5: 30.1%) and fewer people received bCPR (Q1: 53.7% versus Q5 57.7%) compared with the least deprived areas.

Regarding potential causal pathways, education may give enhanced awareness of health education and ability to communicate with health services,[38] potentially improving symptom recognition, EMS-communication, and likelihood of bCPR initiation.[39] Income may affect access to food and other commodities,[38] with possible impacts on co-morbidity, which may be associated with OHCA survival.[40,41] Individuals who are unemployed may be more likely to experience the OHCA at home and be unwitnessed, delaying arrest recognition and response.

Strengths

The cohort used in this study is a population-based dataset with a very rich data linkage because of the excellent climate for data linkage in Scotland. The cohort consisted of 20 585 adult, non-traumatic OHCA cases; therefore, the power in analyses was high. Data that were missing were likely missing completely at random with only 1.6% of the dataset missing (326 cases excluded from analyses).[42] The whole of Scotland is served by one ambulance service (SAS); therefore, consistency in data reporting was easily achieved. The SIMD score based on the patients' home postcode was used for the main analyses which is a strength because it is more reflective of the actual socioeconomic status of the patient rather than using the SIMD score based on the postcode of the OHCA incident. Reverse causality is unlikely as socioeconomic deprivation was assessed based on patient details collected prior to the OHCA event.

Limitations

The risk of problematic selection bias was low. Exclusion of OHCA without resuscitation attempted may have promoted over-representation of survivors, given that attempted resuscitation is necessary for survival, and patients pronounced dead at the scene and not transported to hospital may be less likely to have sufficient data for linkage.[21] However, this is likely to be at random and not dependent on SIMD. Unfortunately, individual-level data on socioeconomic status, ethnicity, comorbidities, and lifestyle were not available through linkage at this moment.

While there was potential information bias due to misclassification of the individual's level of deprivation by the area-level SIMD (e.g. people who are affluent but live in a deprived area),[43] this should have been non-differential with respect to survival, and therefore any bias would be expected to be in the direction of the null. Furthermore, the probable extent of such misclassification is related to the area size[38]; the small size of SIMD data zones, with a median population of approximately 750 persons,[43] may have limited this. The non-subjective nature of the survival outcome measure, and its sourcing from medical records, limited the risk of inaccurate reporting and information bias.

While the SIMD contains a health domain and therefore the validity of using it to study associations of deprivation with health may be questioned, previous studies have indicated it to be highly correlated with the overall SIMD, and that its exclusion makes little difference to results.[17,44] Additionally, the SIMD's area-level nature also prevents distinguishing effects due to the patient's characteristics from area-level effects of their residential location.[38]

There was some potential for residual confounding via unmeasured variables. Residual confounding by underlying health status was theoretically possible, as poor health may have had some causal effect on deprivation,[45] and may have influenced OHCA survival.[40] However, understanding the direction of the health-deprivation relationship is complex.[45] Age, sex, and rural/urban residency were treated as potential confounders, based on evidence that these variables may be both associated with OHCA survival[21,46,47] and influence aspects of an individual's socioeconomic position, making them potential common causes of exposure and outcome. However, age and urban/rural location may also have roles downstream of deprivation as mediators, given that patients in more deprived areas experience OHCA at younger ages[21] and aspects of socioeconomic position could plausibly affect the decision or ability to live in an urban or rural area. If age or urban/rural location is indeed on the causal pathway, adjusting for them may block any effect mediated through them and attenuate the effect estimate.[48] While this is not observed (*Figure 2*), the 'confounder-adjusted estimate of the association between SIMD and 30-day survival after OHCA' may be better conceptualized as the confounder-adjusted association not mediated through age or urban/rural location.

Clinical implications

Inequalities in rates of shockable ICR might be addressed by increasing bCPR rates, quick connection of automated external defibrillators, and decreasing ambulance arrival times. Inequalities in bCPR rates could be targeted by government initiatives such as Safe A Life for Scotland,[49] by increasing CPR training in schools for example.

The population-based nature of the study makes our findings generalizable throughout Scotland to non-traumatic OHCAs with resuscitation attempted, and to other comparable settings. The magnitude of the estimate for the association between SIMD and 30-day survival after OHCA may not be generalizable to other settings with differing extents of socioeconomic inequality, or differing social patterning of variables mediating the deprivation-survival effect.

Future research could usefully investigate whether certain domains of deprivation, such as income, education, and employment, may be causally driving the association, as the evidence in this area is currently unclear.[4,16] Furthermore, it may be informative to further investigate the youngest age group in which the strongest effect was observed (<45 years) to assess whether any difference is evident between paediatric patients (<18 years) and adults. If suitable aetiology data were available, it would be helpful to also consider whether the association between SIMD and 30-day survival after OHCA varies between cardiac and non-cardiac aetiologies. It could also be useful to investigate potential mediators, including comorbidities, health-related behaviours such as smoking, use of an automated external defibrillator, or in-hospital care factors further. Underlying patient health and smoking may be particularly important to consider, given their strong socioeconomic patterning.[18,50]

Conclusion

This study identified the most deprived areas of Scotland as having particularly low proportions of cases surviving to 30 days post-OHCA, highlighting an inequality that may be contributing to the overall socioeconomic disparity in premature mortality in Scotland.[18] The association was stronger in males and particularly in the age group <45 years. Part of the association might be explained by differences in shockable ICR and bCPR rates.

Supplementary material

Supplementary material is available at *European Heart Journal—Quality of Care and Clinical Outcomes* online.

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Data availability

Due to the nature of the research and due to ethics, supporting data is not readily available.

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