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Review

Socio-economic differences in incidence, bystander cardiopulmonary resuscitation and survival from out-of-hospital cardiac arrest: A systematic review

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Abstract

Background: Individuals with a low socioeconomic status (SES) may have a greater mortality rate from out of hospital cardiac arrest (OHCA) than those with a high SES. We explored whether SES disparities in OHCA mortality manifest in the incidence of OHCA, the chance of receiving bystander cardiopulmonary resuscitation (CPR) or in the chance of surviving an OHCA. We also studied whether sex and age differences exist in such SES disparities.

Methods: The Medline, Embase and Scopus databases were searched from 01-01-1993 until 31-01-2019. Studies utilising any study design or population were included. Studies were included if the exposure was SES of the OHCA victim or the OHCA location and the outcome was either OHCA incidence, CPR provision and/or survival rate after OHCA. Study selection and quality assessment were conducted by two reviewers independently. Descriptive data and measures of association were extracted, both in the total study population and in subgroups stratified by age and/or sex. This review was carried out following the PRISMA guidelines.

Results: Overall 32 studies were included. Twelve studies reported on OHCA incidence, thirteen on bystander CPR provision and fourteen on survival. Some evidence for SES differences was found in each identified stage. In all the studies on incidence, SES was measured over the area of the OHCA victims' residence and was consistently associated with OHCA. In studies on bystander CPR, SES of the area in which the OHCA occurred was associated with bystander CPR, while evidence on individual SES was lacking. In studies on OHCA survival, SES of the victim measured at the individual level and SES of the area in which the OHCA occurred were associated, while SES of the victim, measured at the area of residence was not. Studies reporting age and sex differences in the SES trends were scarce.

Conclusion: SES disparities in OHCA mortality likely manifest in OHCA incidence, bystander CPR provision and survival rate after OHCA. However, there is a distinct lack of data on SES measured at the individual level and on differences within subgroups, e.g. by sex and age.

Keywords: Out-of-hospital, Cardiac arrest, Arrhythmia, Socioeconomic, Incidence, Cardiopulmonary resuscitation, Survival, ESCAPE-NET

Introduction

Out of hospital cardiac arrest (OHCA) is the sudden cessation of effective circulation due to the absence of cardiac pump function, in an out of hospital setting.[1] OHCA has been reported to be responsible for approximately half of all cardiac related deaths and to account for up to 20% of all natural deaths in industrialised countries.[2,3] Marked differences have been shown to exist in OHCA incidence and survival globally.[4] Although great strides have been made in resuscitation in

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some settings,[5] survival rates remain relatively low. Thus, improvements in both prevention and resuscitation strategies are required to decrease this vast public health burden. Such efforts to reduce OHCA incidence are likely to benefit from identifying high-risk populations.

Socioeconomic status (SES) disparities occur in OHCA mortality (e.g. higher level of income is associated with lower mortality),[6–8] but it is unclear from single studies whether SES differences in OHCA mortality manifest mainly in the risk of having an OHCA, in the chance of receiving bystander CPR or in the chance of surviving an OHCA. SES differences in OHCA incidence are conceivable, as established SES gradients in coronary heart disease (CHD) risk factors are likely to translate to OHCA incidence. CHD may lie on the causal path between OHCA and its risk factors or share common risk factors with OHCA.[3,9–15] Likewise, the SES of the area in which an OHCA occurs may be associated with (un)favourable resuscitation characteristics such as provision of bystander cardiopulmonary resuscitation (CPR), e.g. due to a lack of knowledge regarding CPR in lower SES areas.[16] Finally, SES of the individual is likely to be associated with OHCA survival outcome, for instance due to the generally higher comorbidity burden among low SES groups.[17]

It is unclear which subpopulations may be especially vulnerable. Different individual SES indicators (e.g. income, education level, occupational status or composite measures of deprivation) may differ in their ability to identify vulnerable subgroups with regard to OHCA incidence, bystander CPR provision and survival. Importantly, these indicators of SES, when measured at the individual level, may have differing associations with health outcomes than indicators measured at the area level.[18] Additionally, age and sex differences exist in the socioeconomic gradients for cardiovascular risk factors and health outcomes.[19,20] It is likely that such differences are also found in OHCA. Exploring potential age and sex differences in the socioeconomic gradient of OHCA may serve to further identify groups with high risk of OHCA incidence and/or low chances of surviving an OHCA. Due to the multiplicity in exposure and outcome definitions as well as study populations, patterns of SES differences in OHCA cannot be interpreted from single studies. Thus a systematic review was carried out in order to assess the patterns of SES differences in OHCA.

We carried out a systematic review to explore at which stage, in which populations and which locations disparities in OHCA mortality emerge. We assessed the associations between SES at the level of the individual or that of the area in which OHCAs occurred and (1) the incidence of OHCA, (2) bystander CPR and (3) survival rate of OHCA. Moreover, we compared the consistency across individual SES indicators. Lastly, we investigated whether these SES gradients differ by sex or age group.

Methods

The review was written in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) reporting guidelines.

Definitions

SES was defined as a variable describing the relative position in society of an individual or a population, which could include resources and/or skills within the financial, occupational and/or educational domains. SES was defined at the individual level by indicators such as income, highest educational level attained and occupational status. When SES was measured at the individual level, it was referred to in this review by “SESind”. In addition, the SES level of the area of residence of the OHCA victims was considered as a proxy for the SES of the individual, henceforth referred to as “SESres”. Also, in order to capture the environmental factors that may influence the provision of bystander CPR, SES of the area in which the OHCA occurred was considered, which was referred to in this review as “SESloc”. Thus, while SESres and SESloc both measure SES over an area, one characterised the individual based on where the person lives (SESres) and the other the environment where the OHCA took place (SESloc).

OHCA was defined as a sudden cessation of effective circulation due to the absence of cardiac pump function, in an out of hospital setting. Bystander CPR was defined as out-of-hospital CPR provided by bystanders with or without usage of an automated external defibrillator (AED). Survival after OHCA was defined as being alive at the emergency room with return of spontaneous circulation (ROSC), hospitalized with ROSC at any hospital ward (i.e., hospital admission) or being alive at hospital discharge.

Search strategy

We performed a search for studies, worldwide, reporting associations between individual SES or SES of the area in which an OHCA occurs and OHCA incidence, bystander CPR provision and survival after OHCA. A search was performed in the Embase, Medline and Scopus databases from 01-01-1993 databases until 31-01-2019. The lower bound of the year of publication was based on the oldest citation identified[16] in a preliminary search. The search string was developed in collaboration with a medical research librarian (JD), as detailed in Table 1 and Appendix 1. Any study design was permitted as long as it contained original (un)published scientific findings. The search strategy included commonly used indices for SES such as income, education, occupation and unemployment as well as measures of SES such as ‘the Townsend deprivation index’ and common synonyms for all the identified SES indicators.

Study selection

The results of the search were screened by two reviewers (BN & IO) independently, first by title and abstract, followed by full text review, if not already excluded in the abstract screening. Disagreements between the two reviewers about the inclusion of articles, were resolved by consensus or with arbitration by a third reviewer (IV), if consensus was not reached. Inclusion criteria of the citations are described in Table 1.

Quality assessment

Quality assessment was carried out for each study by two reviewers (BN & IO) independently using the National Institutes of Health (NIH) quality assessment tool for cross-sectional studies, or the appropriate NIH tool for quality assessment for other study designs, as found in Appendix 2. Disagreements between the two reviewers about the quality assessment of the included citations were resolved by consensus or with arbitration by a third reviewer (IV). No studies were excluded on the basis of quality assessment results. However, the quality of the included studies was presented to facilitate interpretation of the results.

Table 1 – Inclusion criteria.

I. Criteria related to the search	Publications after 1993, English published articles, original research, full text available
II. Population, or participant and conditions of interest	Studies including a majority adult human general population (not selected on a condition or disease)
III. Interventions or exposures	Socioeconomic status (both individual and area level). One or multiple indicators including: education level, occupation status/level, income, wealth, poverty, social epidemiology, social security, deprivation and inequality as well as synonyms thereof. Composite measures of SES: Townsend deprivation score, Carstairs index, Evaluation of Deprivation and Inequalities in Health Examination Centres, New Zealand Index of Deprivation, Index of Local Conditions, Index of Local Deprivation, Indices of multiple deprivation, Social vulnerability index, Duncan socioeconomic index, Nam-Powers Occupational Status Score, Household prestige scale, Cambridge Social Interaction and Stratification Scale and Statistics Socioeconomic classification
IV. Comparisons or control groups	Comparisons are made between individuals with diverging levels of SES. Control groups are not applicable for this study
V. Outcomes of interest	Incidence[a] of out-of-hospital cardiac arrest (data from emergency medical services attended cases), survival after out-of-hospital cardiac arrest (at hospital admission, hospital discharge, 30 day survival) and bystander CPR provision for OHCA and circumstances (e.g. rates of bystander cardiopulmonary resuscitation, Emergency Medical services (EMS) arrival times, EMS transport times, rates of external automatic defibrillator (AEDs) use, witnessed/unwitnessed arrest rate)
VI. Setting	Any setting
VII. Study designs	Any study design

[a] Any study reporting on mortality from sudden cardiac arrest i.e. the incidence of sudden cardiac death or sudden unexpected death were excluded on the basis of being composed of both the incidence and survival rates of a given population; two aspects we aimed to highlight separately and compare (eTable 2, eTable 3).

Data extraction

The extraction form included identifiers of the citation (including the name of the first author, year of publication and journal), information about the population under study (e.g. city/region, country, ethnic groups, population size and age range), the definitions of exposure and outcome variables used and the results (i.e. risk ratios or odds ratios and confidence intervals). The Supplementary materials, if available, were also checked for relevant results. The extraction table was first piloted in 2 articles[16,21] and checked for inconsistencies between the two reviewers (BN & IO) before proceeding with data extraction from the remaining citations. Information was extracted from published manuscripts. If associations were reported separately across the sexes or in different age groups, this information was also extracted.

Synthesis of results

We gave an overview of the SES gradients by assessing direction, strength and consistency of associations between individual SES indicators and SES of the area in which an OHCA occurred within each outcome measure (OHCA incidence, bystander CPR provision or survival rate after OHCA). We specifically compared consistency across SESind indicators. To be able to understand differences in survival, we also included resuscitation characteristics that may influence the association between SES and survival rate: location of OHCA (residential versus public setting), initial rhythm of the OHCA victim (shockable rhythm versus non-shockable rhythm), whether bystander CPR was performed (yes versus no), witnessed status of the OHCA (yes versus no) and time to defibrillator connection. Moreover, we compared the relative SES differences in incidence and survival across age groups and sex.

Results

Our search strategy yielded 32 results that satisfied the inclusion criteria.[16,21–51] A flowchart of the study selection is presented in Fig. 1. The majority of exclusions at the phase of abstract screening were due to citations reporting results on bystander CPR education efforts, for instance education efforts in primary schools. At the full text screening phase, citations were excluded due to not reporting associations between SES and OHCA incidence, bystander CPR provision or survival after OHCA. Out of the included studies, twelve measured SES differences in OHCA incidence,[25,29–31,35,38–42,47,48] thirteen measured SES differences in bystander CPR provision for OHCA[22,23,26,28,32,34,36,37,40,44,45,48,50] and fourteen measured SES differences in survival rate after an OHCA.[16,21,24,26–28,33,39,43,45,46,49–51] Descriptive characteristics are provided in Table 2.

Stage: OHCA incidence

For analyses of OHCA incidence all the included studies reported associations based on the number of events occurring within one year, apart from one study which reported lifetime cumulative incidences. All twelve of the studies that reported on OHCA incidence reported that low SESres was associated with a higher OHCA incidence than high SESres (Fig. 2,Table 3). As all the studies measured SES with an area proxy, it was not possible to compare associations found with OHCA incidence across different indicators of SES (e.g. education level vs. income).

One citation, with sex-specific information, reported evidence for a modifying effect of sex on the association between SESres and OHCA.[38] Pujades-Rodriguez found women with low SESres to have a higher risk of OHCA incidence than high SESres women, while for men this was not the case. Both the papers that stratified results by age found a stronger trend in those aged 0–64 than in the older group.[41,42] For instance, Reinier (2006) reported a weaker association, although in the same direction, between SESres and OHCA incidence in the group aged over 65 compared to the younger age group.

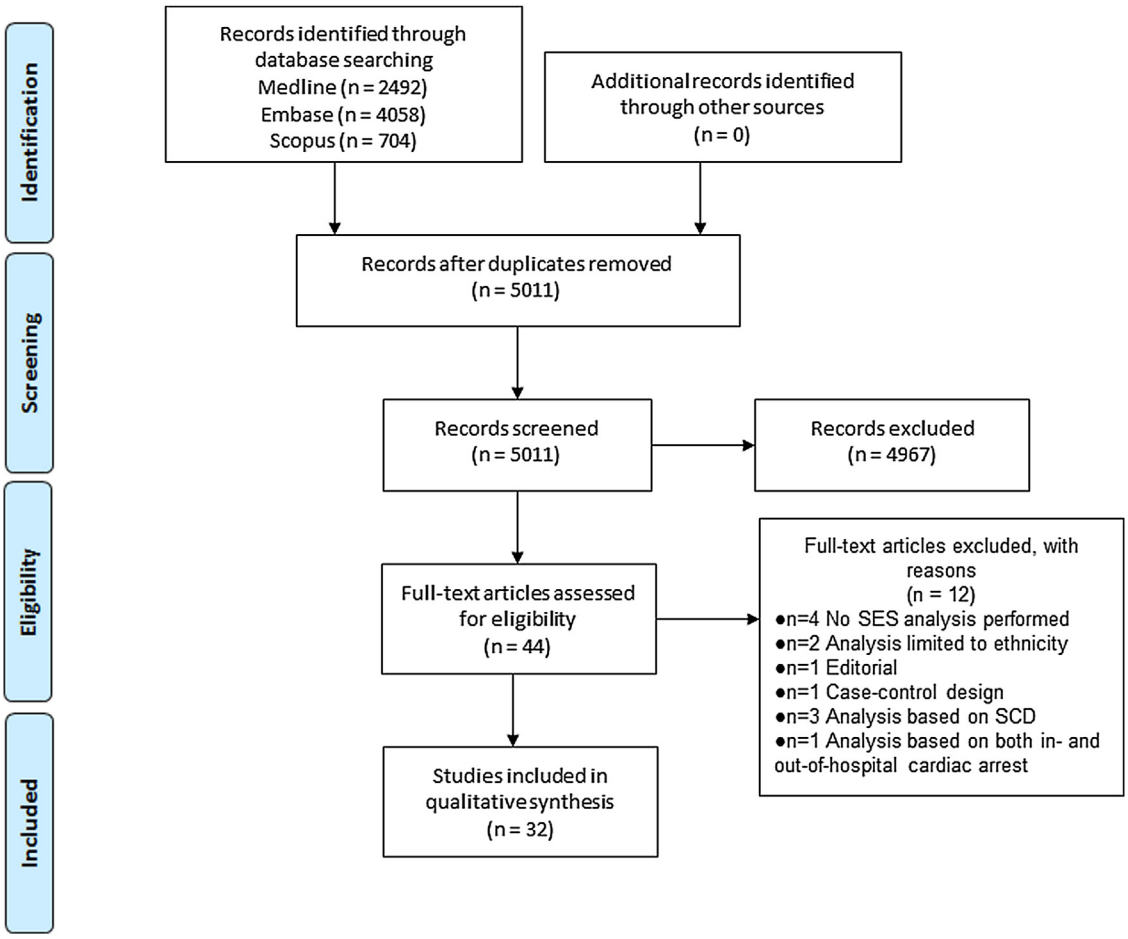

Fig. 1 – Flowchart study inclusion.
Abbreviations: SCD, sudden cardiac death; SES, socioeconomic status. Additional records through 'other sources' refers to reference tracing and expert consultation.

Stage: bystander CPR provision

All thirteen studies that reported on bystander CPR provision, measured SESloc, e.g. by household income, mean property value, education, employment or deprivation (Table 4). Studies on individual SES were lacking. Ten of the twelve studies, reporting on CPR provision, found a low SESloc to be associated with a low rate of bystander CPR (Fig. 2). The single paper to investigate AED connection rates by bystanders, found a significant association between a low SESloc and lower AED connection rates, when adjusted for resuscitation characteristics.[22] None of the studies reported associations separately by age or sex groups.

Stage: survival rate after OHCA

Of the fourteen studies that reported on survival rate, five measured SESind,[16,27,49–51] seven measured SESres,[24,27,28,33,39,46,49] four studies studied SESloc,[21,26,43,45] while two papers reported results on both SESind and SESres (Fig. 2, Table 5). Thirteen studies defined the outcome as survival to hospital discharge and one defined the outcome as 30-day survival.[33] The associations between individual SES and survival were mixed, with a clear difference between individual indicators compared to area level indicators (Fig. 2). All five studies that reported results on SESind found a significantly lower survival in the unemployed,[49] those with low property value[16,27,50] and those with low education[51], but not low occupation level.[51] In contrast, only one of the studies that assessed SESres found a significant difference in OHCA survival rate.[33] For SESloc, all four studies,[21,26,43,45] found a significant trend between higher SES and higher survival. Two of the four studies adjusted for individual level demographic variables, resuscitation characteristics and bystander CPR, factors that may function as mediators in the relationship between SESres and survival rate.[21,49] Four studies[21,24,52,53] reported ROSC on top of survival to hospital discharge (eTable 1). Studies showed consistent results across ROSC and survival to hospital discharge.

There was a lack of evidence on differences in the SES gradient by sex and age. Wells et al.[51] found no significant difference between men and women in the association between individual level education or occupation and OHCA survival. None of the other studies made comparisons by sex or age in the association between individual level SES and OHCA survival, nor between SES of the area in which the OHCA occurred and survival rate.

Table 2 – Descriptives.

Name author	Year of publication	City, country	Study design	Study time	Population size (% female)	Age range	Ethnic composition	SES level	Outcome measure	Adjusted for
Ahn, K.O.	2011	South Korea	Cross- sectional	January 2006–December 2007	34227 (39.5)	NA	Korean	**SESloc**	Survival at hospital discharge, ROSC	*Model 1*: Age, sex; *Model 2 added:* witnessed status, bystander CPR, initial ECG rhythm; *Model 3 added:* EMS response time, call to ED arrival
Andersen, L.W.	2018	USA	Cross- sectional	January 2013–December 2016	25182 (22.3)	NA	White, Black, Hispanic, other	**SESloc**	Bystander AED use	Median age, %white, %living alone, Location, witnessed, initial ECG rhythm, presumed aetiology
Brown, T.P.	2019	England, UK	Cross- sectional	January 2013–December 2015	67219 (39.5)	NA	White: 88.4%, Mixed: 2.8%, Non-white: 8.8%	**SESloc**	Bystander CPR	Not adjusted
Buick, J.E.	2016	Toronto, Canada	Cross- sectional	January 2006–December 2014	9485 (37)	≥20 years	NR	**SESres**	Survival at hospital discharge; ROSC at emergency department arrival	Age, sex, location, neighbourhood instability, neighbourhood dependency, material deprivation, ethnic concentration, crime rate, density family physicians, witnessed, bystander CPR, bystander AED, initial ECG rhythm, EMS response time, ALS skill
Castra, L.	2018	Crown area Paris, France	Spatial analysis	August 2013–August 2015	3414 (39)	NA	NR	**SESres**	OHCA incidence	Age (standardisation)
Chiang, W.C.	2014	Taipei, Taiwan	Cross- sectional	January 2008–December 2009	3573 (37.7)	>17 years	NR	**SESloc**	Bystander CPR, ROSC, survival at hospital discharge	Age, sex, witnessed status, location, recognized by online dispatcher,
Clarke, S.O.	2005	King County, USA	Cross- sectional	January 1999–December 2003	1789 (30.1)	>17 years	NR	**SESind** & **SESres**	Survival at hospital discharge	*Model 1:* age, sex; *Model 4 added:* witnessed status, bystander CPR, initial ECG rhythm, location, EMS response time, EMS witnessed arrest
Fake, A.L.	2013	Wellington, New Zealand	Cross- sectional	July 2007–June 2010	413 (30.8)	>15 years	NR	**SESloc**	Bystander CPR, ROSC and survival at hospital discharge	Witnessed arrest, bystander CPR, initial ECG rhythm, EMS response time
Feero, S.	1995	Portland, USA	Cross- sectional	January–December 1991	322 (NR)	NA	84% White in total of Portland	**SESres**	OHCA incidence	Age, sex
Folke, F.	2010	Central Copenhagen, Denmark	Cross- sectional	January 1994–December 2005	4828 (61.8)	NA	NR	**SESres**	OHCA incidence	Age, household income, population density
Fosbol, E.L.[a]	2014	North Carolina, USA	Cross- sectional	January 2010–December 2011	1466 (36.6)	NA	48% White, 39% Black, 13% Other	**SESres**	OHCA incidence	Age, sex, ethnicity, population density, location, EMS response time
Hallstrom, A.	1993	King County, USA	Cross- sectional	May 1986–August 1988	356 (21)	NA	90% White	**SESind**	Survival at hospital discharge	Age, witnessed status, location, EMS response time, time to defibrillation, chronic comorbidity index

Table 2 *(continued)*

Name author	Year of publication	City, country	Study design	Study time	Population size (% female)	Age range	Ethnic composition	SES level	Outcome measure	Adjusted for
Iwashyna, T.J.	1999	Chicago, USA	Cross- sectional	January 1987–December 1988	4379 (42.9)	NA	44.7% Black	**SESloc**	Bystander CPR	Sex, ethnicity, 10 years older than mean, witnessed status; if neighbourhood had: twice as many arrests per capita, was not all not white, 1000 more people per km^2, 10% more linguistically isolated, 10% more working, 10% more in health related jobs, 10% more with college education, 10% more with age >65, compared to mean of neighbourhoods
Jonsson, M.	2018	Stockholm County, Sweden	Cross- sectional	January 2006–December 2015	7431 (34.6)	NR	NR	**SESres**	30-day survival	Sex, age, population density, witnessed status, bystander CPR, initial ECG rhythm, location, EMS response time, year of cardiac arrest, aetiology
Lee, S.Y.	2016	South Korea	Cross- sectional	January 2012–December 2013	10694 (32.5)	>17 years	NR	**SESloc**	Bystander CPR	Age, sex, metropolitan area, location, dispatcher-provided CPR instruction, past medical history
Masterson, S.	2018	Republic of Ireland	Cross- sectional	January 2012–December 2014	4755 (32.6)	>17 years	NR	**SESres**	OHCA incidence	Age, sex
Mitchell, M.J.	2009	King County, USA	Cross- sectional	January 1999–December 2005	2618 (36.8)	NA	White, black, latino, asian	**SESloc**	Bystander CPR	Age, sex, population density, percentage of healthcare practitioners, households linguistically isolated, household size, proportion of population of several ethnic groups, witnessed, initial ECG rhythm, EMS response time
Moncur, L.	2015	North East England, United Kingdom	Cross- sectional	January 2011–December 2011	3179 (40.5)	NA	NR	**SESloc**	Bystander CPR	Not adjusted
Pujades-Rodriquez, M.	2014	United Kingdom	Time to event analysis	January 1997–March 2010	1301 (37)	>30 years	White 90.5%, south-Asian 2.9% black 3.1% (in total population)	**SESres**	OHCA incidence	Sex, age, ethnicity, diabetes mellitus, smoking status, body mass index, systolic blood pressure, total and HDL cholesterol, medication use
Raun, L.H.	2013	Houston, USA	Spatial analysis	January 2004–December 2011	11389 (NR)	>17 years	White, African American, other	**SESloc**	Bystander CPR	Population size
Reinier, K.	2006	Multinomah County, USA	Cross-sectional	February 2002–January 2004	714 (39)	NA	American	**SESres**	OHCA incidence	Not adjusted
Reinier, K.	2011	Dallas, Pittsburgh, Portland and	Cross-sectional	April 2006–March 2007	9235 (39.9)	NA	American and Canadian	**SESres**	OHCA incidence	Country and study site

(continued on next page)

Table 2 *(continued)*

Name author	Year of publication	City, country	Study design	Study time	Population size (% female)	Age range	Ethnic composition	SES level	Outcome measure	Adjusted for
		Washington, USA; Ottawa. Toronto, and Vancouver, Canada								
Rakun, A.	2018	Singapore	Cross- sectional	April 2010–December 2015	8900 (36.2)	NA	72.5% Chinese, 16.5% Malay, 11.0% Indian	**SESloc**	OHCA incidence, 30-day survival	Age, ethnicity, bystander CPR, location, EMS response time, comorbidities
Rivera, N.T.	2016	South Florida, USA	Cross-sectional	25 month period	125 (41.6)	NA	Classification: White - Black	**SESloc**	Bystander CPR and survival at hospital discharge	NR
Sasson, C.C.	2011	Fulton County, USA	Cross-sectional	October 2005–November 2008	1108 (42.1)	NA	White, black, Hispanic, other, or unknown	**SESloc**	Bystander CPR and survival at hospital discharge	Age (decades), sex, ethnicity, witnessed arrest, location
Sasson, C.C.	2012	29 sites, USA	Cross-sectional	October 2005–December 2009	14225 (37.3)	NA	White, black, Hispanic, other, unknown	**SESloc**	Bystander CPR	Age, sex, witnessed status, location
Sayegh, A.J.	1998	Michigan, USA	Cross-sectional	January 1991–December 1996	1317 (40.8)	>17 years	Black and White	**SESres**	Survival at hospital discharge	Age greater than 80, sex, ethnicity, witnessed status, initial ECG rhythm, ALS response interval less than 9 min
Soo, L.	2001	County of Nottinghamshire, United Kingdom	Cross-sectional	January 1991–December 1993	1634 (24.6)	NA	NR	**SESres**	OHCA incidence	Age
Straney, L.D.	2016	Victoria, Australia	Spatial analysis	January 2011–December 2013	10487 (NR)	NA	NR	**SESres**	OHCA incidence and bystander CPR	Population aged over 65, born overseas, population density, current smokers, high-risk alcohol consumption, obese
Uray, T.	2015	Pittsburgh, USA	Cross-sectional	January 2010–July 2012	415 (NR)	>17 years<65 years	NR	**SESind** & **SESres**	Survival at hospital discharge	Unadjusted
Vaillancourt, C.	2008	Ontario, Canada	Cross-sectional	January 1995–December 1999	3600 (29.2)	NA	NR	**SESind**	Survival at hospital discharge	Age, witnessed status, bystander CPR, EMS response time
Wells, D.V.	2016	King County, USA	Cross-sectional	January 1999–December 2005	1390 (26.5)	>17 years	African-American, Asian-American, White, Other	**SESind**	Survival at hospital discharge	Age, sex, ethnicity, marital status, witnessed status, bystander CPR, location, EMS response time

Abbreviations: ALS, advance life support; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; NA, not applicable; NR, not reported; OHCA, out of hospital cardiac arrest; ROSC, return of spontaneous circulation; SES, socioeconomic status; SESind, socioeconomic status of the individual; SESloc, socioeconomic status of the area in which the OHCA occurred; SESres, socioeconomic status of the area of OHCA victims residence; USA, United States of America.

[a] Aside from the incidence results, this author used a combined outcome measure of low CPR and high OHCA areas compared to areas with the opposing characteristics. This meant that it was impossible for us to separate the SES differences in bCPR and the SES differences in OHCA incidence.

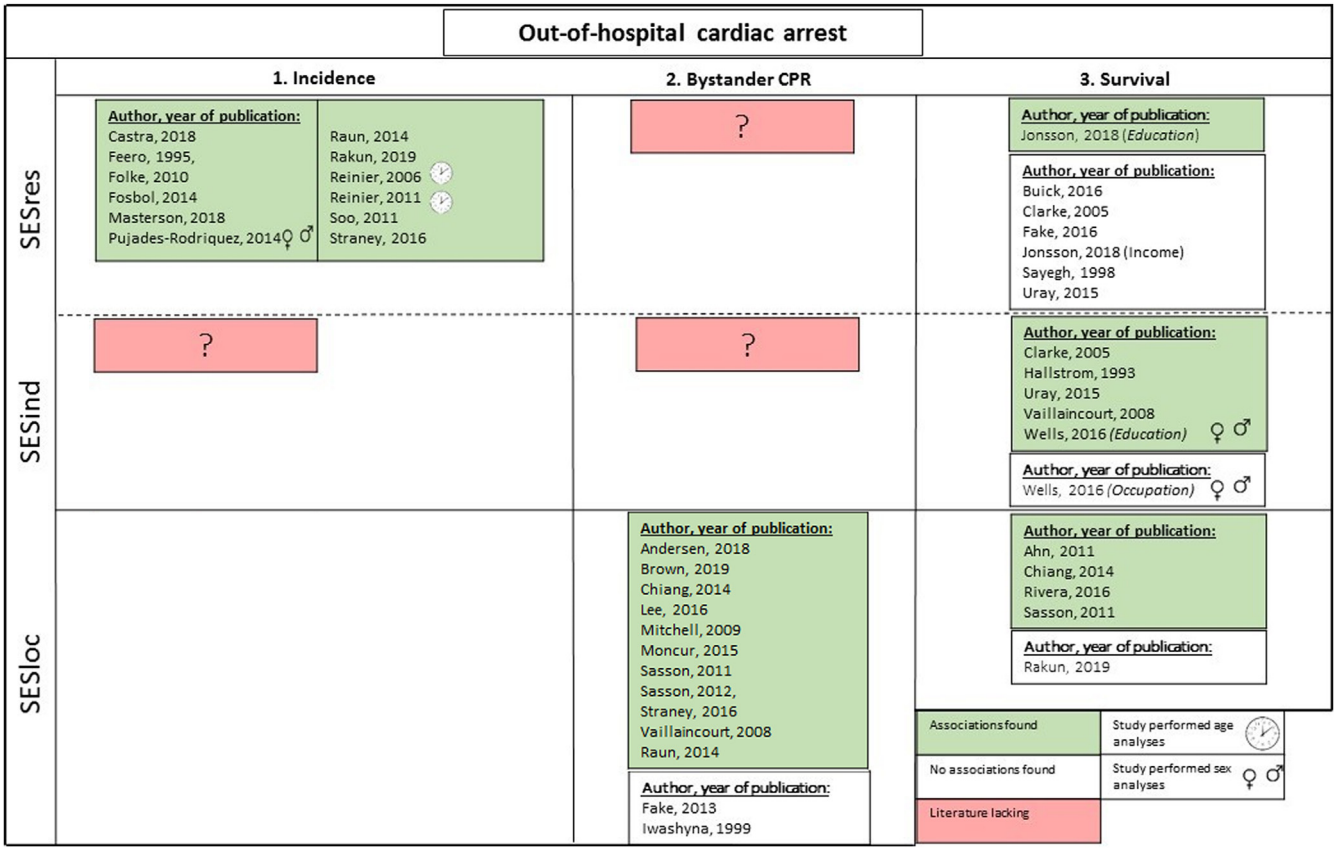

Fig. 2 – Overview of available studies by measured level of SES across stages of OHCA.
Abbreviations: CPR, cardiopulmonary resuscitation; SESind, socioeconomic level of the individual; SESloc, socioeconomic level of the area in which the OHCA occured; SESres, socioeconomic level of the area of OHCA victims residence.
A paper that reported results for different measures of SES (SES of the individual, SES of the area of OHCA victims residence or SES of the area in which the OHCA took place) or with different SES indicators is shown more than once.

Discussion

Key findings

In this systematic review, we investigated where the SES differences in mortality from OHCA are likely to stem from by comparing three major stages at which SES differences may arise (OHCA incidence, bystander CPR provision and survival rate after OHCA). We found a relatively consistent trend of a SES influence across the three stages: an increased risk of OHCA incidence, a decreased chance of receiving bystander CPR and a decreased chance of survival after an OHCA in low SES compared to high SES populations and locations. Although SES gradients were found for different indicators in all three stages, sufficient data to compare the strength of associations across stages or across indicators was lacking (Fig. 2). There was minimal evidence that was suggestive of sex and age differences in the SES gradients although it was similarly too sparse to draw conclusions.

Limitations

This systematic review has several limitations. It may have been the case that we missed relevant citations in our search. We included only full papers in the English language, disregarding data published in other languages. However, we noticed that only one article, in German, would have met the inclusion criteria, which suggests that disregarding of this criterion likely would not have changed the conclusions of our review. Additionally, we did not investigate the potential role of publication bias in minimizing the inclusion of negative results in the published literature.

While not related to the methodology applied, our review also suffers from the low number of studies that appeared to be eligible for this systematic review. In particular, a notable lack of studies measuring individual SES, measured at the individual level (SESind; Fig. 2). This constrains the potential inferences that could be made, as SES measured at the individual level usually highlights greater contrasts in health outcomes[54–56] and comparisons could have been made between effect sizes of different SES indicators, such as education level and income level. This is a key limitation of the literature, as the comparison between SES indicators may have provided insight into which populations are the most vulnerable. It may also have provided an opportunity to compare findings across national contexts. We also found very few studies that reported results by age or sex groups (Fig. 2). Moreover, we found that several studies had a small sample size,[16,28,29,43,49] which may have reduced the accuracy of the point estimates found in these papers. Finally, the heterogeneity of indicators, outcomes, populations and definitions as well as the

Table 3 – Incidence.

Author, year	1. Income	Result	*P* value	2. Education	Result	*P* value	3. Occupation	Result	P value
SESres									
Castra L., 2018				Uneducated persons 15 years or older (%)			Unemployment rate (%)		
	Median income for areas with high CA	16575		Median for areas with high CA	0.194		Median for areas with high CA	0.081	
	Median income for areas with normal CA	25286		Median for areas with normal CA	0.096		Median for areas with normal CA	0.053	
	Median income for areas with low CA	22438		Median for areas with low CA	0.102		Median for areas with low CA	0.056	
	Test for trend		<0.01	Test for trend		<0.01	Test for trend		<0.01
Feero S., 1995	R	−0.79	0.03						
Folke F., 2010	IRR (95%CI); Qa1	1.48 (1.20–1.82)	NR	IRR (95%CI); Qa1	Ref.	NR			
	IRR (95%CI); Qa2	1.03 (0.84–1.27)		IRR (95%CI); Qa2	1.22 (1.03–1.45)				
	IRR (95%CI); Qa3	0.98 (0.81–1.19)		IRR (95%CI); Qa3	1.37 (1.16–1.63)				
	IRR (95%CI); Qa4	Ref.		IRR (95%CI); Qa4	1.94 (1.63–2.31)				
Raun L.H., 2014	<$10,000 per year RR (95%CI)	4.4 (2.2–6.7)	NR	1% increase of proportion of people without high school degree RR (95%CI)	3.2 (1.7–4.8)	NR			
Reinier K., 2006	IRR (95%CI)	1.3 (1.1–1.7)		IRR (95%CI)	1.8 (1.5–2.4)	NR			
Reinier K., 2011	IRR (95%CI)	1.9 (1.8–2.0)	NR						
Straney L.D., 2016				IRR (95%CI)	0.91 (0.88–0.94)	<0.01			

Author, year	4. Combined measure	Result	*P* value	5. Other measure	Result	*P* value
Castra L., 2018				Poverty		
				Median for areas with low CA	9.75	
				Median for areas with normal CA	12.1	
				Median for areas with high CA	25.1	<0.01
Fosbol E.L., 2014				Percent under poverty threshold		
				OR (95%CI)	1.77 (1.16–2.71)	NR
Masterson S., 2018	SAHRU Deprivation index					
	IRR (95%CI)	0.09 (0.06–0.12)	NR			
Pujades-Rodriquez M., 2014	Index of multiple deprivation					
	HR (95%CI); Qi1	1.34 (1.09, 1.66)				
Female	HR (95%CI); Qi2	1.24 (1.02, 1.51)				
	HR (95%CI); Qi3	1.06 (0.87, 1.28)				
	HR (95%CI); Qi4	1.11 (0.92, 1.33)				
	HR (95%CI); Qi5	Ref.				
Male	HR (95%CI); Qi1	0.89 (0.75, 1.06)				
	HR (95%CI); Qi2	0.90 (0.77, 1.05)				
	HR (95%CI); Qi3	0.87 (0.75, 1.01)				

Table 3 (continued)

Author, year	4. Combined measure	Result	*P* value	5. Other measure	Result	*P* value
	HR (95%CI); Qi4	0.88 (0.77, 1.01)				
	HR (95%CI); Qi5	Ref.				
Rakun A., 2018	SEDI					
	OR (95%CI); T1	1.09 (0.90–1.29)				
	OR (95%CI): T2	1.13 (0.96–1.34)				
	OR (95%CI); T3	Ref.				
Soo L., 2001	Townsend index of material deprivation					
	Beta (SE)	0.03 (0.42)	NR			
Straney L.D., 2016	SEIFA					
	IRR (95%CI)	0.85 (0.82–0.90)	<0.01			

Abbreviations: CA, cardiac arrest; CI, confidence interval; T, tertile; IRR, incidence rate ratio; HR, hazard ratio; N, number; NA, not applicable; NR, not reported; OR, odds ratio; Qa, quartile; Qi, quintile; SAHRU, small area health research unit; SE, standard error; SEDI, Singapore socioeconomic disadvantage index; SEIFA, socio-economic indexes for areas; SES, socioeconomic status; SESind, socioeconomic status of the individual; SESloc, socioeconomic status of the area in which the OHCA occurred; SESres, socioeconomic status of the area of OHCA victims residence; Ref, reference category; RR, risk ratio.

[a] Ranking of quantiles or categories: low to high SES.

[b] Household income unless otherwise defined.

[c] Proportion with high school degree unless otherwise defined.

[d] Proportion employed unless otherwise defined.

scarcity of papers prevented the performance of statistical analyses, such as meta-analysis, on the pooled results.

Discussion of key findings

Taken together, the evidence from our review suggests that SES influences may occur within each step in the process leading up to SES differences in OHCA mortality. Below we discuss how our findings fit in with previous knowledge on OHCA and SES differences in health and signal some important gaps for further research.

The observation across studies in this review that the incidence of OHCA varies by individual SES is in line with a multitude of previous studies that have shown SES differences in overall cardiovascular disease morbidity, mortality and risk factors.[14,57] These results also are in line with prior studies that have shown a similar SES gradient in sudden cardiac death (eTable 3). It may be the case that the absolute incidence by SES differs across national contexts. However, we observed consistent patterns within the different contexts we observe consistent patterns of relative differences in OHCA incidence across different SES indicators that reflect the relative position of individuals within societal hierarchies. Individual SES differences in OHCA incidence may be mediated indirectly by SES differences in CHD. As 80% of the OHCAs occur in individuals that have CHD,[3] it is likely that CHD lies on the causal pathway between SES and SCA. CHD and OHCA share several common risk factors.[3] SES differences may occur due to behavioural factors (e.g. smoking, physical inactivity),[12,14,15] biomedical factors (e.g. dyslipidaemia, high blood pressure)[9,10] or psychosocial factors (e.g. depression)[11,13] that are both associated with SES and CVD/CHD. Additionally, a more direct pathway linking SES with OHCA incidence may also exist.[58] Both acute and chronic stressors have been linked to SCA, via dysregulation of the autonomic nervous system. Natural disasters, such as earthquakes, a clear source of acute stress, are often followed by a spike in cardiac arrest incidence.[59] Low SES may also be associated with chronic stress[60,61] and both low SES and chronic stress have been associated with sympathetic nervous system overactivity, as assessed by heart rate variability.[62–64] In turn, such chronic overactivity in the sympathetic nervous system has been associated with increased risk of cardiovascular disease and cardiovascular mortality and thus possibly also with OHCA.[65]

Related to bystander CPR, the majority of studies (10 out of 12) found a consistent association with SESloc. The two papers that did not find a significant difference across SES areas, had a notably small study population[28] (n = 413) or reported older data (1999 as compared to 2008[50] and 2018[22]). The latter paper may have suffered from a lower general knowledge on CPR at the time of data collection; one to two decades ago, there was generally little CPR training offered to the public.[66] Furthermore, the observation that lower bystander CPR provision was associated with low SESloc is consistent with findings of reduced bystander support in medical emergencies in general in deprived areas.[67,68] This may be due to decreased community cohesion in low SES neighbourhoods,[69] decreased security[70] or simply less knowledge about how to perform CPR and alert the EMS.

It may further be the case that a substantial part of the reported associations between SESloc and bystander CPR provision are actually due to individual SES differences. While the chances of bystanders in an area providing CPR may be the product of factors related to a low SES area, factors associated with the individual OHCA victim may also influence the chances of receiving CPR. Individual demographic variables, such as sex and age, have been suggested to

Table 4 – Bystander CPR.

Author, year	1. Income[a]	Result	P value	2. Education[b]	Result	P value	3. Occupation[c]	Result	P value
SESloc									
Andersen L.W., 2018							Unemployed		
	OR (95%CI); Qa1	0.99 (0.78–1.26)	0.92	OR (95%CI); Qa1	0.74 (0.59–00.92)	<0.01	OR (95%CI); Qa1	1.00 (0.83–1.21)	0.99
	OR (95%CI); Qa2	0.99 (0.82–1.19)	0.92	OR (95%CI); Qa2	0.74 (0.62– 0.88)	0.01	OR (95%CI); Qa2	0.90 (0.75–1.08)	0.26
	OR (95%CI); Qa3	0.98 (0.85–1.14)	0.79	OR (95%CI); Qa3	0.85 (0.74–0.99)	0.03	OR (95%CI); Qa3	0.78 (0.66–0.93)	<0.01
	OR (95%CI); Qa4	Ref.		OR (95%CI); Qa4	Ref.		OR (95%CI); Qa4	Ref.	
Brown T.P., 2019				Proportion education qualifications (Yes)			Proportion routine occupation (Yes)		
				In postcode districts with low CPR: Mean (SD)	58.6 (9.3)	<0.01	In postcode districts with low CPR: Mean (SD)	32.2 (9.4)	<0.01
				In postcode districts with high CPR: Mean (SD)	60.6 (8.9)		In postcode districts with high CPR Mean (SD)	29.8 (9.4)	
							Proportion intermediate occupation (Yes)		
							In postcode districts with low CPR: Mean (SD)	22.5 (4.3)	
							In postcode districts with high CPR: Mean (SD)	23.4 (4.6)	
							Proportion higher occupation (Yes)		
							In postcode districts with low CPR: Mean (SD)	31.4 (9.5)	
							In postcode districts with high CPR: Mean (SD)	33.8 (9.8)	
Iwashyna, T.J. 1999	Units = US$ 1000 OR (95%CI)	1.03 (1.01–1.05)	NR						
Lee S.Y., 2016				OR (95%CI); Qa1	0.71 (0.60–0.85)	NR			
				OR (95%CI); Qa2	0.78 (0.66–0.92)				
				OR (95%CI); Qa3	0.84 (0.74–0.95)				
				OR (95%CI); Qa4	Ref.				
Mitchell M.J., 2009	OR (95%CI); Qa1	Ref.		OR (95%CI); Qa1	Ref.		OR (95%CI); Qa1	Ref.	
	OR (95%CI); Qa2	0.82 (0.60–1.11)	0.19	OR (95%CI); Qa2	0.96 (0.71–1.29)	0.78	OR (95%CI); Qa2	1.05 (0.78–1.42)	0.74
	OR (95%CI); Qa3	1.32 (0.99–1.76)	0.06	OR (95%CI); Qa3	1.00 (0.74–1.34)	1.00	OR (95%CI); Qa3	1.24 (0.92–1.66)	0.16
	OR (95%CI); Qa4	1.12 (0.83–1.50)	0.46	OR (95%CI); Qa4	1.10 (0.82–1.48)	0.52	OR (95%CI); Qa4	1.22 (0.91–1.65)	0.19
Sasson C.C., 2011	C1: < $21600 OR (95%CI); C2: $21,601–$30500	Ref.							
		0.94 (0.49–1.81)	≥0.05						

Table 4 *(continued)*

Author, year	1. Income[a]	Result	P value	2. Education[b]	Result	P value	3. Occupation[c]	Result	P value
	OR (95%CI); C3: $30,501–$42000								
	OR (95%CI); C4: $42,001–$62000	1.57 (0.72–3.40)	≥0.05						
	OR (95%CI); C5: >$62001	2.02 (0.83–4.93)	≥0.05						
Raun L.H., 2014	10,000 per year RR (95%CI)	4.4 (2.2–6.7)	NR	RR (95%CI)	3.2 (1.7–4.8)	NR			

Author, year	4. Combined measures	Result	P value	5. Other measures	Result	P value
Brown T.P., 2019	Deprivation					
	In postcode districts with low CPR: Mean (SD)	55.7 (8.6)	<0.01			
	In postcode districts with high CPR Mean (SD)	57.1 (8.8)				
Chiang W.C., 2014				N (%) low mean house value	241 (14.5%)	<0.01
				N (%) high mean house value	376 (19.6%)	
Fake A.L., 2013	New Zealand deprivation index 2006					
	N (%); D1	24 (48.0)				
	N (%); D2	13 (38.2)				
	N (%); D3	18 (56.3)				
	N (%); D4	8 (40.0)				
	N (%); D5	7 (30.4)				
	N (%); D6	46 (43.2)				
	N (%); D7	17 (37.8)				
	N (%); D8	4 (22.2)				
	N (%); D9	14 (48.3)				
	N (%); D10	24 (64.9)				
	Test for trend		0.12			
Moncur L., 2015	Indices of Multiple Deprivation					
	OR (95%CI); Qi1	Ref.	NR			
	OR (95%CI); Qi2	1.3 (0.9–1.7)				
	OR (95%CI); Qi3	1.5 (1.1–2.0)				
	OR (95%CI); Qi4	1.8 (1.3–2.4)				
	OR (95%CI); Qi5	1.8 (1.3–2.4)				
Sasson C.C., 2012	Median household income x ethnic composition					
	C1: <$40,000 and >80% black					
	OR (95%CI);	0.49 (0.41–0.58)	0.90			
	C2: <$40,000 and integrate					
	OR (95%CI);	0.62 (0.56–0.70)	<0.01			
	C3: <$40,000 and >80% white					
	OR (95%CI);	0.65 (0.51–0.82)	<0.01			
	C4: ≥$40,000 and >80% black					
	OR (95%CI); C5: ≥$40,000 and integrated	0.77 (0.68–0.86)	<0.01			

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Table 4 (continued)

Author, year	4. Combined measures	Result	P value	5. Other measures	Result	P value
	OR (95%CI); C6: ≥$40,000 and >80% white	1.03 (0.64–1.65)	<0.01			
	OR (95%CI);	Ref.	0.90			
Straney L.D., 2016	SEIFA score IRR (95%CI)	0.94 (0.86–1.04)	0.24			
Vaillaincourt C., 2008				Property value; unit $100000 OR (95%CI)	1.07 (1.01–1.14)	0.03

Abbreviations: C, category; CI, confidence interval; D, decile; IRR, incidence rate ratio; N, number; NA, not applicable; NR, not reported; OR, odds ratio; Qa, quartile; Qi, quintile; SEIFA, socio-economic indexes for areas; US, United States; USD, United States dollar; SES, socioeconomic status; SESloc, socioeconomic status of the area in which the OHCA occurred; Ref, reference category.

[a] Household income unless otherwise defined.

[b] Proportion with high school degree unless otherwise defined.

[c] Proportion employed unless otherwise defined.

[d] Ranking of quantiles or categories: low to high SES.

[e] Secondary analyses are provided in eTable 4.

influence a bystander to provide CPR or not. However, no studies, as of yet, appear to have investigated the association between individual SES and bystander CPR provision (Fig. 2).

Survival after OHCA was found to be consistently associated with a higher SES when measured at the individual level (SESind). The independence from demographic and resuscitation characteristics indicate that differences are likely, at least in part, to be associated with physical resilience, which may be affected by the level of comorbidities.[72,73] In line with this hypothesis, several studies have shown an increasing Charlson comorbidity index to be associated with a decreased chance of survival, though some studies reported no association.[72–74]

All but one of the studies reporting SESres, observed no association with survival after OHCA. Two of these studies are likely to have suffered from low sample sizes of n = 413[28] and n = 415[49], while over adjusted statistical models may have hampered the detection of an association in two other studies.[24,27] It may, on the other hand, be the case that individual SES measured at the area level (SESres) generates weaker associations with health outcomes due to the heterogeneity of individuals' SES (SESind) within any given area.[56] Other than serving as a proxy for individual SES, SESres may also capture aspects of the environment in which the OHCA victim resides, which may have an influence on the risk of suffering an OHCA. Individuals living in low SES areas may be more frequently exposed to factors linked to the physical and social environment not captured by SES measured at the individual level. Such factors may include the availability of healthy or fast food outlets, parks and recreational spaces, air pollution levels and neighbourhood safety to name a few. These factors have been reported to be associated with CVD.[75]

In contrast to the studies reporting on SESres, we observed an association between OHCA survival and SESloc. Although the reasons are unknown, the differences found in survival rate by SES of the area in which the OHCA has occurred are likely to be, at least in part, due to differences in bystander resuscitation rates. However, the SES differences remained in two studies that adjusted for bystander CPR, suggesting that the disparity in survival rate appears not to be solely dependent on bystander CPR. We speculate that the remaining difference may partly be explained by differences in health-care related factors. Potential reasons for SES differences in these health-care related factors may be a number of system factors, including the distribution of ambulances in the city, neighbourhood structures that influence Emergency Medical Services response time (including road design and traffic patterns), and proximity of high socioeconomic status neighbourhoods to hospital.[76] These factors were not assessed in the studies included in this review. Other factors, not included in this review include potential SES differences in in-hospital care. This choice was made given the focus on an out-of-hospital population. While, SES differences in survival to discharge may be mediated by both pre- as well as in-hospital factors, other reported (pre-hospital) indicators of survival showed consistent results. Thus, it is likely that SES differences reported in survival to discharge was not solely influenced by in-hospital factors.

Sex and age differences

The association between individual SES and OHCA incidence was stronger in women than in men.[19,20] This finding is in line with previous findings on sex differences in social inequalities in cardiovascular disease.[20] While in men, SES gradients in total mortality are steeper, women exhibit a greater SES disparity in cardiovascular disease mortality, morbidity and risk factors (e.g. smoking) than men.[20] Two

Table 5 – Survival.

Author, year	1. Income[a]	Result	P value	2. Education[b]	Result	P value	3. Occupation[c]	Result	P value
SESind									
Uray T., 2015							Unemployment		
							OR (95%CI)	0.39 (0.18–0.84)	0.02
Wells D.V., 2016							C1: Routine and manual		
Female							OR (95%CI)	0.87 (0.43–1.77)	
							C2: Intermediate		
							OR (95%CI)	1.0 (0.48–2.09)	
							C3: Higher managerial and professional		
							OR (95%CI)	0.44 (0.21–0.92)	
							Test for trend	1.02 (0.70–1.47)	
Male							C1: Routine and manual		
							OR (95%CI)	Ref.	
							C2: Intermediate		
							OR (95%CI)	1.02 (0.68–1.54)	
							C3: Higher managerial and professional		
							OR (95%CI)	1.35 (1.0–1.83)	
							Test for trend	1.16 (1.0–1.36)	
SESres									
Jonsson, M. 2018	Qi1	Ref.		Qa1 University degree	Ref.				
	Qi2	1.34 (0.96–1.87)		Qa2 University degree	1.27 (0.92–1.75)				
	Qi3	1.56 (1.14–2.14)		Qa3 University degree	1.65 (1.21–2.24)				
	Qi4	1.49 (1.08–2.05)		Qa4 University degree	1.76 (1.30–2.40)				
	Qi5	1.88 (1.36–2.59)							
Sayegh A.J., 1998	>$33,945–≤$33,945								
	OR (95%CI)	1.51 (0.8-2.8)	NR						
SESloc									
Rivera N.T., 2016	$<30000–$>50,000	NR	0.01						
Sasson C.C., 2011	C1: <$21600								
	OR (95%CI)	Ref.							
	C2: $21,601–$30500								
	OR (95%CI)	2.72 (0.72–10.27)							
	C3: $30,501–$42000								
	OR (95%CI)	2.49 (0.49–12.69)							
	C4: $42,001–$62000								

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Table 5 *(continued)*

Author, year	1. Income[a]	Result	P value	2. Education[b]	Result	P value	3. Occupation[c]	Result	P value
	OR (95%CI)	2.30 (0.48–10.99)							
	C5: >$62001								
	OR (95%CI)	9.11 (1.17–71.00)	<0.05						

Author, year	4. Combined measure	Result	P value	5. Other measure	Result	P value
SESind						
Vaillaincourt C., 2008				Property value per unit $100000		
				OR (95%CI)	0.77 (0.61–0.97)	0.03
Clarke S.O., 2005				Property value		
				C1: 0–$165999		
				OR (95%CI)	Ref.	NR
				C2: $166,000–$212999		
				OR (95%CI);C3: $213,000–$282999	1.03 (0.60, 1.47)	
				OR (95%CI)	1.42 (0.97, 1.87)	
				C4: >$283000		
				OR (95%CI)	1.81 (1.21, 2.42)	
				Test for trend	1.24 (1.08, 1.40)	
Hallstrom A., 1993				Property value		
				OR (95%CI)	1.6 (1.1–2.4)	NR
				C1: ≤50,000%		
				%survival	28.3	
				C1: 50,000–75000		
				% survival	25.8	
				C3: 75000–100000		
				% survival	30.6	
				C4: ≥100000		
				% survival	38.2	
				Test for trend		0.01
SESres						
Buick J.E., 2016	Deprivation					
	OR (95%CI); Qi1	Ref.				
	OR (95%CI); Qi2	1.53 (1.00–2.33)				
	OR (95%CI); Qi3	1.10 (0.68–1.77)				
	OR (95%CI); Qi4	0.98 (0.61–1.59)				
	OR (95%CI); Qi5	1.03 (0.58–1.84)				
Clarke S.O., 2005				Value per unit		
				$0–$45699		
				OR (95%CI); Qa1	Ref.	NR
				$45,700–$58999		
				OR (95%CI); Qa2	1.13 (0.77, 1.50)	
				$59,000–$68499		

Table 5 *(continued)*

Author, year	4. Combined measure	Result	P value	5. Other measure	Result	P value
				OR (95%CI); Qa3 >$68500	1.16 (0.77, 1.54)	
				OR (95%CI); Qa4	1.03 (0.67, 1.39)	
Fake A.L., 2016	New Zealand deprivation index 2006					
	N (%); D1	4 (8.0)				
	N (%); D2	6 (17.6)				
	N (%); D3	4 (12.5)				
	N (%); D4	0				
	N (%); D5	4 (17.4)				
	N (%); D6	3 (8.1)				
	N (%); D7	6 (13.3)				
	N (%); D8	1 (5.6)				
	N (%); D9	3 (10.3)				
	N (%); D10	4 (10.8)				
	Test for trend		0.67			
Uray T., 2015				Poverty > 16%		
				OR (95%CI)	1.01 (0.48–2.10)	0.98
Rakun, 2018	SEDI					
	OR (95%CI)	1.011 (0.978–1.045)				
SESloc						
Ahn K.O., 2011	Carstairs index of deprivation					
	OR (95%CI); Qi1	0.57 (0.45–0.72)				
	OR (95%CI); Qi2	0.61 (0.49–0.77)				
	OR (95%CI); Qi3	0.74 (0.61–0.91)				
	OR (95%CI); Qi4	0.88 (0.72–1.07)				
	OR (95%CI); Qi5	Ref.				
Chiang W.C., 2014				N (%) low mean house value	69 (4.3)	
				N (%) high mean house value	128 (6.8)	

Abbreviations: C, category; CI, confidence interval; D, decile; N, number; NA, not applicable; NR, not reported; OR, odds ratio; Qa, quartile; Qi, quintile; SES, socioeconomic status; SESind, socioeconomic status of the individual; SESloc, socioeconomic status of the area in which the OHCA occurred; SESres, socioeconomic status of the area of OHCA victims residence; Ref, reference category.

[a]Household income unless otherwise defined.

[b]Proportion with high school degree unless otherwise defined.

[c]Proportion employed (level of employment) unless otherwise defined.

[d]Ranking of quantiles or categories: low to high SES.

[e]Secondary analyses are provided in eTable 5.

studies that showed SES differences in sudden cardiac death stratified the results by sex and found contradicting results. One[7] found a significant modifying effect by sex with a stronger gradient in men while the other[6] did not find a significant interaction with sex although the SES gradients appeared stronger in women than in men.

Age differences in the association between individual SES and OHCA incidence were found in two studies.[41,42] Both were limited in only stratifying OHCA cases aged below and above 65 years of age. The higher age group was found to have narrower SES differences in OHCA incidence than the lower age group,[41,42] implying that while absolute differences in incidence may still be larger in high SES versus low SES groups, the relative SES differences are attenuated at a higher age. This finding is in accordance with findings of several studies that have found converging SES differences in health above the age of around 60. This is attributed to a ceiling effect at higher ages due to the morbidity in high SES groups catching up at later ages to their low SES counterparts at lower ages.[77]

Conclusion

We found a consistent trend of an increased risk of OHCA incidence and a decreased chance of receiving bystander CPR and surviving an OHCA in low SES compared to high SES populations and locations. This suggests that SES disparities in OHCA mortality likely manifest at each of these stages relevant to OHCA. Despite the clear SES differences, this review has highlighted several gaps in the literature. One such gap is caused by the lack of detailed information in which specific populations SES disparities in OHCA occur, e.g. differences between men and women and by age groups, and a distinct lack of data on SES measured at the individual level. Furthermore, research into the factors mediating SES disparities in OHCA incidence, bystander CPR and survival rate after OHCA is warranted. This could inform targets such as risk factor prevention in socioeconomically deprived individuals and targeted AED placement in socioeconomically deprived areas.

Conflicts of interest

None.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2019.05.018.

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