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## Socioeconomic Status and Its Impact on the Development of Congenital Heart Disease: A Scoping Review

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### Abstract

**Introduction:** Congenital heart disease (CHD) is the most common congenital anomaly affecting 1% of all live births of which the etiology remains unknown. The incidence is higher in developing countries likely related to low literacy, poverty and higher exposures to hazardous environmental nuisances. The role of socioeconomic status (SES) in CHD development has recently received attention. To gain the breadth of knowledge generated from existing publications, we undertook a scoping review of studies examining the relationship between SES and CHD.

**Methods:** We searched databases using individual or combination of keywords which included non-Medical Subject Heading (non-MeSH) and MeSH terms. We included original observational studies using cohort, case control or ecologic study designs written in English and from 1980-2017.

**Results:** We identified 26 studies, most of which were conducted in developed economies with very few from developing economies. The majority (18/26, 69%) examined individual maternal SES variables and the risk of CHD, whilst fewer (4/26, 15%) examined associations with SES at the area level or neighborhood level and others (4/26, 15%) examined the individual, family and neighborhood SES levels to weigh the relative contribution of each SES level in CHD development. Individual maternal low education and low skilled occupation were associated with CHD in half of the studies and another half of the studies found no associations between these variables and CHD. Evidence regarding the influence of neighborhood SES alone or multiple SES variables has been inconclusive as well.

**Conclusion:** There is a paucity of studies from both developed and even more so from developing countries that have examined the influence of SES in CHD development. More knowledge regarding the contribution of various SES measures (i.e., individual, area level, and combinations) on CHD occurrence is required before relevant and effective interventions can be implemented.

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## Introduction

Seventy years ago, the World Health Organization (WHO) was established specifically to provide reliable and objective information that helps to address public health concerns of all nations also provide evidence that would help in health policy formulations [1]. This initiative was followed by the first publication on the concept of

social determinants of health in 1998 which identified social disadvantage and poverty as the root cause of ill health even after provision of medical care [2]. Subsequent empirical studies found associations between identified social predictors and mortality [3] and neural tube defects [4]. In 2008, a commission established by the WHO published a report on actions that governments need to take to address health inequities globally. The

commission again concluded that health inequities are determined by conditions in which people are born, live, work, access healthcare, education, food, security, shelter and recreational facilities as these factors impact their well-being and full potential in life. It was recognized that decision makers at political and economic levels needed to play an active role in closing the gaps that contribute to the inequities.

Unfortunately, even now, in the 21st century, economic, social, political and health inequalities continue to persist along race and gender lines, and the gap between the rich and poor is growing larger daily [5]. The people who generate the wealth are not the direct beneficiaries and often are exploited, exposed to hazardous occupational conditions with no protection, and work long hours of hard labor with little income to show for their toil [5]. In addition, poor people, due to lack of agency, might be exposed to hazardous environmental pollutants near their places of residences and thus suffer from a “double jeopardy” as shown in some concept papers and empirical studies on environmental justice in some places in the United States [6], including some locations in Canada [7-10].

Congenital heart disease (CHD) is a significant global public health issue affecting 1% of all live births and the most common lethal congenital anomaly in infancy, of which the etiology in most affected children is unknown[11,12]. The impact of CHD is higher in developing countries most likely related to higher population densities, low literacy and poverty levels which speak directly to the social determinants of health espoused in the WHO 2008 report [13,14]. The management of children born with CHD places a huge financial strain on healthcare systems globally and to this effect, most of the studies which have examined socioeconomic status (SES) and CHD have investigated its economic impact due to morbidity and mortality related costs and not as a predictor for CHD development [15-19]. To gain the breadth of knowledge generated from preliminary studies on this topic, we undertook a scoping review of the published literature of studies examining the relationship between SES and CHD.

## Methods

We searched the following databases: Medline, CINAHL, Embase, Scopus, Scifinder, Proquest

dissertations and theses databases. We used individual or combination of keywords which included non-MeSH and MeSH terms: ((heart defect\* or heart disease\* or cardiac defect\* or cardiac disease\*) and (congenital or newborn\* or babies or baby or infant or infants) and (“socioeconomic status “or “social position” or “education” or “income” or “occupat\*” or “maternal socioeconomic status” or “neighborhood socioeconomic status” or “neighbourhood socioeconomic status” or “area socioeconomic status”). We included only original observational studies using cohort, case control or ecologic study designs written in English from 1980-2017. We excluded studies which did not have an abstract or full article in English, systematic reviews, studies examining SES in relation to CHD survival, medical management costs, quality of life, neurodevelopmental outcomes, stress and exercise.

## Results

Figure 1 is a flow diagram illustrating the process of selection of the studies included in the scoping review. The number of studies has increased from three between 1990-1999 to 13 between 2010-2017 (Supplementary Table 1). Amongst developed economies, half of the studies were conducted in the United States and the majority used individual maternal SES variables as shown in Figure 2A and 2B respectively. The next highest proportions were studies from Europe and Asia following a similar pattern as the studies in the United States. There was one study each from the Middle East, Canada, South America and Africa overall (Figure 2A). Canada and South America had no studies that used individual SES variables in relation to CHD development (Figure 2B).

The body of literature searched on the subject identified 26 studies which examined SES in relation to CHD development as listed in Table 1. The majority of the studies (18/26, 69%) examined individual maternal SES variables and the risk of CHD [20-37], whilst fewer (4/26, 15%) examined associations with SES at the area level or neighborhood level [38-41], and still others (4/26, 15%) examined the individual, family and neighborhood SES to weigh the relative contribution of each level of the SES variables in CHD development [42-45].

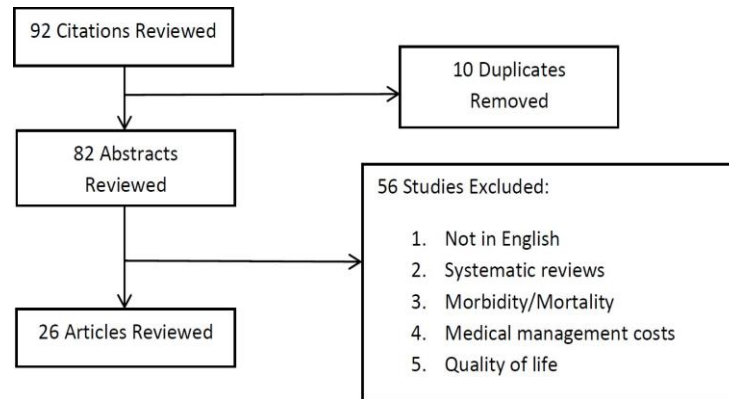
**Table 1.** Studies Examining Socioeconomic Status and Congenital Heart Disease.

Reference Number	Author	Year	Study Location	Study Design	Study Period	SES Measure	Level of SES Assignment	Findings
20	Tikkanen et al.	1992	Finland	CC	1982-1983	Education and occupation	Individual	Level of education not associated with CHD
38	Fixler et al.	1993	USA	Ecologic	1971-1984	Income and education	Census tract	No association with CHD
23	Pradat P	1993	Sweden	CC	1982-1986	Occupation	Individual	No association with CHD
22	Bassili et al.	2000	Egypt	CC	1995-1997	Education and occupation	Individual	Hazardous occupation associated with CHD risk
39	Vrijheid et al.	2000	United Kingdom	CC	1986-1993	Carstairs deprivation index	Census tract	Increased risk of CHD with increased deprivation
42	Carmichael et al.	2003	USA	CC	1987-1989	Education, occupation and neighborhood SES index	Individual, Census tract	Individual low SES and neighborhood SES associated with dTGA,
21	Williams et al.	2004	USA	CC	1968-1980	Education	Individual	Low SES associated with VSD
25	McBride et al.	2005	USA	Cohort	1999-2001	Education	Individual	No association between SES and noncomplex left ventricular outflow tract obstructions
24	Batra et al.	2007	USA	CC	1987-2003	Occupation	Individual	Parental occupation not associated with VSD
44	Yang et al.	2008	USA	CC	1997-2000	Parental education, income, occupation, SES Index	Individual and household index	Low SES at individual and neighborhood level associated with CHD
43	Carmichael et al.	2009	USA	CC	1999-2004	Education, income, occupation	Individual, household index	Low SES not associated with conotruncal heart defects

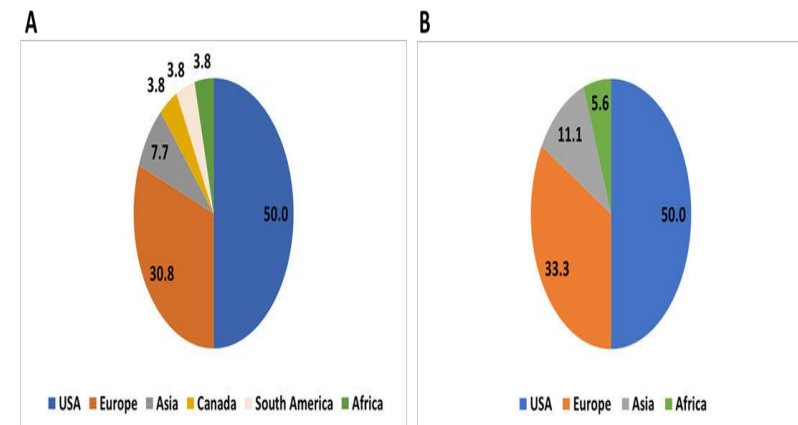
26	Kuciene et al.	2009	Lithuania	CC	1999-2005	Education, occupation	Individual	Low SES associated with risk of CHD
27	Liu et al.	2009	China	CC	2004-2005	Education	Individual	Low SES associated with CHD
28	Long et al.	2010	USA	Cohort	1999-2004	Education	Individual	Low SES associated with TOF
40	Agha et al.	2011	Canada	Cohort	1994-2007	Income, education	Dissemination Area	CHD prevalence higher in low SES regions
29	Agopian et al.	2012	USA	Cohort	1999-2008	Education	Individual	No association with non syndromic AVSD
30	Patel et al.	2012	USA	CC	1997-2005	Education, income	Individual	No association with non syndromic AVSD
33	Vereczkey et al.	2012	Hungary	CC	2009-2010	Occupation	Individual	Low SES associated with increased risk of left sided obstructive defects in unskilled mothers
32	Vereczkey et al.	2012	Hungary	CC	2009-2010	Occupation	Individual	Low SES associated with increased risk of VSD in unskilled mothers and housewives
31	Vereczkey et al.	2013	Hungary	CC	1980-1996	Occupation	Individual	No association of SES with AVCD
34	Egbe et al.	2014	USA	Cohort	1999-2008	Income	Individual	Decreased prevalence of CHD among upper class whites
35	Egbe et al.	2014	USA	Cohort	Jan – Dec 2008	Income	Individual	Lower incidence of CHD in the lowest SES class compared to higher SES class
41	Pawluk	2014	Argentina	CC	1992-2001	Regional SES	Unmet Basic Need Index	Low SES associated with VSD
36	Egbe et al.	2015	USA	Cohort	1998-2008	Income	Individual	Increased prevalence of mild CHD among higher SES Caucasians

45	Li et al.	2015	Sweden	Cohort	2000-2010	Education, income, occupation	Individual, family, neighborhood index	Deprived neighborhoods associated with CHD. Association not independent of individual or family SES
37	Out et al.	2016	China	CC	2004-2013	Education, income, occupation	Individual	Low SES associated with CHD

CC =Case Control



**Figure 1.** PRISMA flow chart illustrating the selection process of the studies.



**Figure 2.** A) Distribution of SES studies (individual and neighborhood) and CHD by region. Half of the studies were conducted in the United States followed by Europe and Asia. B) Distribution of SES studies using individual maternal SES variables. Again, half of the studies were conducted in the United States followed by Europe and Asia.

Amongst the studies that examined individual socioeconomic variables and CHD, the variables that were examined were maternal levels of education, whether they had less than a high school education, completed high school or had a college education, income levels and occupation ranging from unskilled, semi-skilled or professional. Education was the variable most commonly assessed in these studies and the findings were largely inconclusive with some reporting associations between maternal education and CHD [21,26-28] and others finding no associations [25,29,30]. Low skilled occupations and low income similarly were associated with CHD in some studies [22,26,32,33,37] and not in others [20,23,24,30,31]. In the United States, Egbe et al. reported interesting findings on the relationship between income and CHD, where they documented an increased incidence of mild CHD among Caucasian populations in the upper quartiles of SES [34-36] compared to non-Caucasian minority populations. This finding was attributed to enhanced CHD detection with increased access to health care among those of higher SES.

Studies which used SES aggregated at various spatial units constituted 15% out of the 26 studies identified. There were 4 studies, and these represented one study each in the United States, the United Kingdom, Canada and Argentina. Two of the four studies used an index [39,41] and the other two used education and income variables at census tract and dissemination area level spatial aggregation [38,40]. Three studies (United Kingdom, Canada and Argentina) found associations with CHD [39-41], whilst a study from the United States [38] found no associations of SES with CHD.

Beyond the individual or aggregated SES studies alone, there were four studies which examined SES variables at different levels to weigh the relative contribution of the individual, household or neighborhood SES level of which three were conducted in the United States [42-44] and one was conducted in Sweden [45]. Only the study conducted in Sweden found associations between deprived neighborhoods and CHD, which was not independent of individual or family SES [45]. The other three studies found no associations [42-44].

Most of the studies employed a case-control design (17/26, 65%), whereas fewer (8/26, 31%) used a retrospective cohort design and one of the 26 (4%) used an ecologic design.

## Discussion

Investigations examining the role of SES in the development of CHD have been steadily increasing over the past three decades. Most studies performed to date have been conducted in developed economies; whereas, there remains very limited data from developing economies which carry the largest burden of CHD. The latter likely reflects a lack of resources and availability of and access to information that enables the execution of these studies at individual or community level.

Most published work has examined individual maternal SES variables such as education, occupation and income levels and these have been largely conducted in the United States. The most commonly examined variable has been that of maternal education because it is good predictor of health outcomes [46]. For instance, the reduction in child mortality in the past 40 years has been attributed to increased educational attainment of women of childbearing years [47]. Although several studies have supported associations between CHD and the level of education or occupation, a comparable number have not, leaving the value of the associations equivocal. Furthermore, some have suggested the opposite, that those socially advantaged may paradoxically have a higher risk of mild CHD; however, such a finding is more likely explained by increased access to health care services among the more advantaged populations in the United States. As already determined in the WHO report on social determinants of health that there is a direct relationship between health of populations and the places where they live, we found no studies specifically examining the relationship between low SES and maternal residential proximity to hazardous waste sites or industrial facilities in the context of CHD development.

Beyond individual SES, poor material living conditions, including deprived neighborhoods, are increasingly being recognized as important contributors to the overall wellbeing of populations [48]. Neighborhood SES has been examined using various geographic units such as census tract or dissemination area or postal code. Composite scores or indices for the geographic unit have been generated using SES variables such as unemployment, poverty, education levels, occupation, rental occupancy, crowding of people living in the corresponding spatial unit. Although the studies examining neighborhood SES have been

sparse, the findings suggest a potential role for neighborhood SES and CHD development.

Interestingly, SES and its relationship with health is a complex and multifaceted construct requiring interventions at all levels, and, as such, few studies have also examined the interaction of maternal individual SES with composite SES index at household or neighborhood area level to determine if they each contribute independently to CHD development. The relevance of understanding which SES construct represents the most important determinant of adverse health outcomes will enable decision makers to craft policies aimed at individual intervention or large-scale social policy interventions to improve the quality of life.

CHD is understood to be multifactorial in its etiology and the role of environmental chemical pollutants from various sources has gained increasing attention as well. We have recently shown that neighborhoods exposed to very high levels of multiple industrial chemical pollutants had an increased risk of CHD development [49,50]. In addition, other factors such as neighborhood characteristics (e.g. recreational resources, natural spaces, walkability, access to healthy food options) [48] which again relate to elements of SES could modify risk factors for CHD such as obesity and diabetes mellitus [51].

## Conclusion and Recommendations

Overall, although increasing in number, there is a paucity of studies examining the role of SES and CHD development. The majority of the studies have used individual maternal SES with education being the most common measure of SES used. They also employed various methodologies such as cohort, case control or ecologic studies with case control method being most commonly used. The evidence arising from the various studies employing individual, aggregate level or multiple SES measures is still inconclusive at best. Globally, there are limited studies from developing or emerging markets compared to developed economies. Even the current studies conducted from developed economies are insufficient to make conclusive associations with CHD. We recommend that more studies be undertaken from both developed and developing economies to examine the influence of the various levels of SES on CHD development as this information would permit comparisons and inform decisions on relevant

interventions. Studies that examine the interactions of multi-level SES variables to determine the relative weight of their contribution in their effect modifications are also required. Finally, future studies should also interrogate the phenomenon of environmental injustice particularly for vulnerable populations and its contribution to CHD development.

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