Area-level deprivation as a risk factor for stillbirth in upper-middle and high-income countries: a scoping review

Authors:

Jessica V. Keane[1]

Laura A. Robinson[2]

Richard A. Greene[1]

Paul Corcoran[1]

Sara Leitao[1]

Institutional affiliations:

[1]National Perinatal Epidemiology Centre, University College Cork, Ireland

[2]College of Medicine and Health, University College Cork, Ireland

Abstract

Background: Socioeconomic deprivation has been associated with health inequalities and poor perinatal outcomes. Deprivation is described as a multidimensional concept, with composite indicators (e.g. area-based) developed internationally to study population health.

Aim: This scoping review aims to examine published literature on the relationship between area-level deprivation and stillbirth in upper-middle to high-income countries.

Methods: The Joanna Briggs Institute methodology for scoping reviews was utilised. The research question based on the Population (studies that examined stillbirth) Concept (area-level deprivation and its impact on stillbirth) Context (upper-middle- to high-income countries) framework. Six scientific databases were searched. Results were screened and reference lists searched to identify relevant literature. Data extraction on study characteristics and evidence of association provided was completed and a narrative summary reported the main findings.

Results: A total of 29 studies were included, from 9 countries (majority UK-based: n=20) published between 1998-2023. A variety of composite deprivation indices were utilised, the UK's Index of Multiple Deprivation (IMD) was the most common (n=8), followed by the Townsend and Jarman indices (n=6 and n=3, respectively). Income, employment, education and access to services were the most common factors included as measures of deprivation in the indices. Twenty-two of the 29 studies (75.9%) showed positive correlations between stillbirth and areas identified more socioeconomically deprived.

Conclusion: This review suggests that area-level deprivation seems an influencing factor on stillbirth in upper-middle to high-income countries. Focused initiatives to reduce stillbirth among those at higher deprivation related risk may be useful in improving maternal and perinatal outcomes.

Keywords

Socioeconomic deprivation; Stillbirth; Perinatal mortality; Healthcare; Inequality.

Introduction

Socioeconomic deprivation has been long associated with health inequalities, impacting physical and mental health (Mishra and Carleton 2015). For example, those from less advantaged areas have been found to have "substantially higher mortality rates" (Duffy et al. 2022, p99).

Deprivation can be described as a multidimensional concept. It was originally defined by Townsend (1987, p125) as "observable and demonstrable disadvantage relative to the local community or the wider society or nation to which an individual, family or group belongs". Composite indicators such as deprivation indices have been developed to study the impact of deprivation on the health outcomes of populations, using a varying combination of factors to estimate the level of deprivation of a particular area (Carstairs 1995). These deprivation indices have been developed in various countries for use in public health research and by local public health authorities to develop focused initiatives for those areas most in need and to inform policy and resource management, as highlighted by Zelenina et al. (2022). Understanding the risk and how these indices could be utilised is an important consideration for maternity care provision.

For example, the 'Pobal HP Deprivation Index for Small Areas (SA)' by Haase and Pratschke (2017), is a deprivation index currently available in the Republic of Ireland, which uses national Census data to calculate the level of affluence or disadvantage for small geographical areas in the country. This index considers fourteen indicators grouped into the following 3 areas: Demographic Profile, Social Class Composition and Labour Market Situation. Ireland's Central Statistics Office (2019) have used this index to identify that those living in the most deprived areas have the lowest life expectancy. In Ireland's Sláintecare Implementation Strategy & Action Plan 2021- 2023 (Department of Health 2021), enabling "an area-based approach to developing healthy communities, with a particular focus on targeted investment in areas of deprivation" was identified as a pertinent issue in which to allocate budget funds to.

Globally, many countries have developed their own specific area-based deprivation measures, which can provide important information about geographical disparities and the associated health

outcomes (Zelenina et al. 2022). For example, the UK currently uses the 'Indices of Multiple Deprivation (IMD)' for England, Scotland, Wales, and Northern Ireland. This encompasses 7 domains of deprivation: Income, Employment, Education Skills and Training, Health and Disability, Crime, Barriers to Housing and Services and Living Environment (McLennan et al. 2019).

There is strong evidence demonstrating that an individual's level of deprivation is linked to poor perinatal outcomes, such as small for gestational age or intrauterine growth restriction, preterm birth, low birth weight, stillbirth, neonatal death and infant mortality (Vos et al. 2014; Li et al. 2018; Kingdon et al. 2019;). One study by Smith et al. (2009) found that rates of mortality due to very preterm birth was nearly twice that in the most deprived areas compared with the least. The infants born into areas identified as more deprived have continually shown to be at increased risk of perinatal death, with MBRRACE-UK identifying almost a two-fold risk of stillbirth and over 70% excess risk of neonatal death (Draper et al. 2021), leading to widening inequalities. This demonstrates that deprivation can disproportionately affect the health outcomes of certain groups, causing unfair health disparities.

There is an established body of evidence linking single-variable socioeconomic markers of deprivation with perinatal mortality. For example, the use income as a measure of deprivation to assess risk of adverse perinatal outcome (Goza et al. 2004; Pattenden et al. 2011; Matthews et al. 2022). Other studies use socioeconomic markers such as maternal level of education (Fan and Luo 2020), and employment status/occupation (Gissler et al. 2009; Pilkington et al. 2014). However, the aggregate-level indictors provided by geographical deprivation indices allow for the multidimensional nature of deprivation as discussed by Townsend (1987) thus, potentially providing further insight into the multifactorial etiology of stillbirth.

While some studies have examined the association between deprivation and risk of stillbirth (Weightman et al. 2012; Vos et al. 2014), no study has specifically investigated the evidence available between the association of aggregate level indicators and incidence of stillbirth. This review intends to address this gap, providing a clearer understanding of the evidence-based

knowledge on the use of composite area-level deprivation indices and their potential impact on or association with the specific outcome of stillbirth.

Objective

This scoping review aims to examine and provide a descriptive overview of the international literature available on the relationship between area-level deprivation, based on composite measures specifically, and stillbirth in upper-middle to high-income countries. With this focus, this scoping review aims to address a clear gap in the literature in this field, providing a mapping of studies that assess how various socioeconomic factors, when aggregated into composite indices, correlate with stillbirth risk. This study aims to contribute to a clearer understanding of the role of area-level deprivation in stillbirth outcomes, offering valuable insights for future research, policy development, and healthcare interventions aimed at reducing inequalities in perinatal health.

Participants, Ethics and Methods

A scoping review was carried out in order to map the body of evidence on the topic (Munn et al. 2018), including identifying the characteristics of area-level deprivation indices and examining their association with risk of stillbirth. This scoping review was conducted in accordance with the defined methodology provided by Joanna Briggs Institute (JBI) guide for scoping reviews (Peters et al. 2020), including use of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Scoping Review extension (PRISMA-ScR; Tricco et al. 2018)(Supplementary Table I). The review question and inclusion criteria for this piece was developed based on the Population Concept Context (PCC) framework recommended by JBI for scoping reviews (Peters et al. 2020; Supplementary Table I). Supplementary Table II provides further detail on the search terms used in this review. This review did not require ethical approval as it entailed the synthesis of existing published literature.

Eligibility criteria

The population focus for this review included studies that examined stillbirth, the definition of which were according to the definition in the country of the study. Studies that did not report on stillbirth as a singular outcome were not included for review, e.g. where perinatal mortality is reported.

The concept for this review is area-level deprivation and its impact on stillbirth outcomes. Only studies focussing on stillbirth in relation to level of deprivation were reviewed. Studies that used geographical indices of deprivation encompassing composite measures were included. Composite measures included those that factored more than one measure when calculating level of deprivation in an area. Literature that examined single-variable indicators of deprivation were not included for review (Table I).

This review's context is centred on the all upper-middle- to high-income countries, according to the classification of the World Bank Index (2023) at the time of the year of publication of the study.

No further restrictions were included regarding year of publication, language or status of publication to ensure all relevant literature was identified. For selected reviews (i.e. scoping, systematic or meta-analyses), the included studies in that review were screened but the review itself was excluded.

Table I: Inclusion and exclusion criteria as per Population, Concept, Context framework

	Inclusion criteria	**Exclusion criteria**
Population	• Studies that examined stillbirth	• Studies that did not report on stillbirth • Studies that reported stillbirth combined with other outcomes, e.g. combined with neonatal death numbers and presented as perinatal mortality • Studies that included fetal loss that did not meet that country's criteria for stillbirth, e.g. miscarriage
Concept	• Studies that examine effect of area level deprivation on stillbirth outcome • Studies that use deprivation indices that are comprised of composite measures (i.e. more than one factor included in index) • Studies that use deprivation indices for geographical areas	• Studies that examined area level deprivation on other health outcomes only, not stillbirth • Studies that use single-variable measures of deprivation • Studies that use indices that are not focused on a geographical area
Context	• Studies carried out in upper-middle income countries • Studies carried out in high income countries	• Studies carried out in low-income countries • Studies carried out in lower-middle income countries

Data sources and study selection

The following databases were searched to identify all relevant studies on the review topic: Pubmed, EMBASE, CINAHL and Medline via EBSCO host, Web of science and Scopus. Supplementary Table II provides one example of the full electronic search strategy terms. All search results were uploaded onto Rayyan web application to facilitate screening process, whereby one reviewer (JK) title-screened the search results for any clearly ineligible studies.

Due to volume of results in Scopus database, Rayyan was used to refine the search results as described by Elmagarmid et al. (2014) and Ouzzani et al. (2016). Firstly, duplicates retrieved in this database were removed (n=34) and then 500 studies were title screened. The Rayyan rating system was then applied to remaining studies with those rating below 2.5 stars excluded, as deemed a

reliable threshold by Valizadeh et al. (2022). The remaining studies that were rated >2.5 stars (n= 1,632) were manually screened by title by one reviewer.

A total of 4,079 studies were identified as appropriate for the abstract screening stage from all databases. Duplicates were identified in Rayyan; these were reviewed and removed (n= 1,956). Two reviewers then independently completed an abstract screen. Rayyan's computed ratings functionality was utilised for the abstract screening stage after 300 studies were initially screened manually. A total of 165 publications were selected and a full text screening was then undertaken by both reviewers. As a quality control measure, and to ensure consistency and reduction of possible bias, throughout the screening process a random selection of 10% of studies were reviewed by both reviewers. If there was disagreement on the appropriateness of a study for inclusion, these would be discussed by the two reviewers to resolve any conflicting decisions and reach a mutual consensus. Consultation with a third reviewer was sought where necessary.

Once the full text review was completed, 27 studies were identified for inclusion. Reference list searching was undertaken on these 27 studies and a further 2 studies were identified as relevant. In total, 29 studies were identified for inclusion for the purpose of this scoping review (Figure 1).

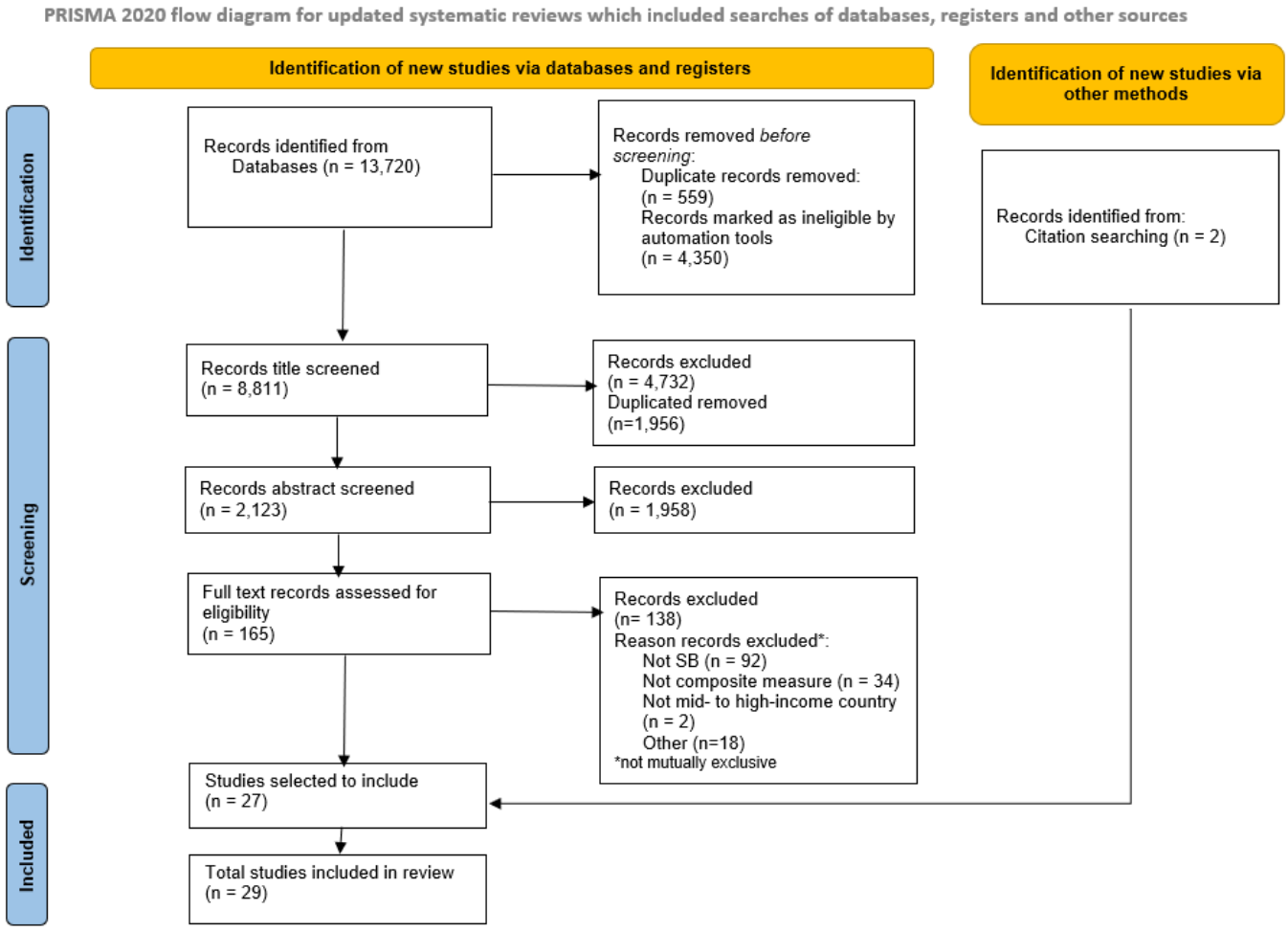

Figure 1: PRISMA Flow diagram of review selection process.

Data extraction and synthesis

Data were extracted from the 29 relevant studies. A data extraction table by Pollock et al. (2021) was adapted for use in this review. The extracted information was organised and synthesised as outlined in Table II and III. The results of this synthesis are presented in a narrative summary within the review, providing a comprehensive overview of the existing literature in relation to the impact of area-level deprivation on the risk of stillbirth.

Results

A total of 29 studies were included for review following the screening process.

Table II outlines the information extracted from each of these studies, in chronological order from earliest to most recently published study.

Table II: Data extraction of study characteristics.

Reference	Year	Country	Population	Stillbirth sample size (n)	Period covered	Index
Sloggett and Joshi	1998	UK	Stillbirth undefined[a]	80,835	1981-1992	Townsend/Carstairs like' index
Joyce et al.	1999	UK	Stillbirth undefined[a]	553	1993-1995	TDS
Joyce et al.	2000	UK	Fetal death after 24 weeks gestation	Nbr stillbirth not reported; stillbirth rates reported from 364 English local authorities	1995	Jarman and TDS
Dummer et al.	2000	UK	Fetal death after 28 weeks gestation until 1992, then from 24 weeks gestation	46,572	1950-1993 Cumbria; 1981-1992 England and Wales	TDS, DoE score and Jarman
Bambang et al.	2000	UK	Stillbirth undefined[a]	1,214	1991-1993	TDS
Neasham et al.	2001	UK	Fetal death after 28 weeks gestation until 1992, then from 24 weeks gestation due to congenital anomaly	10,954 (Stillbirth and NND)	1986-1996	Carstairs
Guildea et al.	2001	UK	Fetal death after 20 weeks gestation	1,146	1993-1998	TDS
Joyce et al.	2004	UK	Fetal death after 24 weeks gestation	3,150	1994-1996	TDS
Craig et al.	2004	New Zealand	Late fetal deaths (LFD) from 28 weeks gestation	4,477	1980-1999	NZDep
Smeeton et al.	2004	UK	Fetal death after 24 weeks gestation	342	1996-1998	Jarman score

Gray et al.	2009	UK	Fetal death after 24 weeks gestation	2,699	1994-2003	Carstairs-Morris score
Francis et al.	2009	UK	Fetal death after 24 weeks gestation	Nbr stillbirth not reported; stillbirth rates reported for each 17 West Midlands primary care trusts.	2006-2008	IMD
Tezcan et al.	2011	UK	Intrauterine death (IUD), gestation unspecified	190	2002-2004	IMD
Timmermans et al.	2011	The Netherlands	Fetal death after 22 weeks gestation	37	2002-2006	Dutch index of deprivation
Wood et al.	2012	UK	Fetal death after 28 weeks gestation	3,259	1992-2008	Carstairs
Seaton et al.	2012	UK	Fetal death after 24 weeks gestation	20,433	2000-2007	IMD
de Graaf et al.	2013	The Netherlands	Fetal death after 22 weeks gestation	5,927	2002-2006	Deprived neighborhoods determined by Dutch government
Smith et al.	2014	UK	Fetal death after 24 weeks gestation, including multiple pregnancies	32,475	1997-2008	IMD
Field et al.	2016	UK	Fetal death after 24 weeks gestation	20,433	1997-2008	IMD
Loiacono	2018	Argentina	Fetal death of an infant weighing 500g or more, if weight unknown, gestation after 22 weeks included	Nbr stillbirth not reported; stillbirth rates reported for each of the 525 geographic areas of Argentina	2007-2014	SESI

Hesselman et al.	2019	Sweden	Fetal death after 22 weeks gestation	524	2013-2017	National Operations Department report
Bonfim et al.	2020	Brazil	Fetal death after 22 weeks gestation	2,210	2006-2010 and 2011-2015	SDI
Bayerlein et al.	2020	Germany	Fetal death of an infant weighing 500g or more	2,473	2009-2016	BIMD
Bailey et al.	2021	UK and Australia	Fetal death after 24 weeks gestation, excluding congenital anomaly	3,725 UK; 2,431 Australia	1993-2015	WIMD and the Index of Relative Socio-Economic Disadvantage for Western Australia
Canuto et al.	2021	Brazil	Fetal death after the 22 weeks gestation, or fetuses weighing 500 g or more, or height from 25 cm identified as avoidable	12,337	2010-2017	ICS
Jardine et al.	2021	UK	Fetal death after 24 weeks gestation	4,505	2015-2017	IMD
Heazell et al.	2021	UK	Fetal death after 28 weeks gestation	287	2014-2016	IMD
Blanco et al.	2023	Chile	Fetal death after 20 weeks gestation	181	2009-2016	MDI
Arechvo et al.	2023	UK	Fetal death after 24 weeks gestation, excluding congenital anomaly	551	2006-2020	IMD

Notes: [a]uses ONS data, stillbirth after 24 weeks gestation. [b]Acronyms used; Bavarian Index of Multiple Deprivation (BIMD), Department of Environment Index (DoE) UK, Index of Multiple Deprivation (IMD), Social Deficiency Index (ICS) Brazil, Multiple Deprivation Index (MDI) Chile, Neonatal Death (NND), New

Zealand Deprivation Index (NZDep), Number (Nbr), Social Deprivation Index (SDI) Brazil, Socioeconomic Status Indicator (SESI) Argentina, Townsend Deprivation Score (TDS), Welsh Index of Multiple Deprivation (WIMD).

Characteristics of the included studies

The years of the included study publication ranged from 1998-2023. However, the study cohorts date back as far as 1981 (Dummer et al. 2000). One publication had a study period of one year (Joyce et al. 2000), two publications had 2 different time periods studied (Dummer et al. 2000; Bonfim et al. 2020) and the remainder of publications covered one study period ranging from 2-22 years (average 8 years).

The included studies related to nine countries, with the majority of study samples originating from the United Kingdom (UK) (n=20). Two studies were carried out in the Netherlands and Brazil, while the other six countries had one study each included in this review (Table II).

When extracting information on study population, the sample size specifically included numbers pertaining to stillbirth, where available. Sample sizes ranged from 37 to 80,835 within the included studies. One study reported stillbirth numbers together with neonatal death (Neasham et al. 2001). Three studies did not report the number of stillbirths examined (i.e. n, population), instead for these, the stillbirth rates for the areas studied were provided (Joyce et al. 2000; Francis et al. 2009; Loiacono 2018).

The stillbirth population was defined as per the country of study with the majority (n=14) identifying this as fetal death from 24 weeks. A further six studies defined stillbirth as fetal death from 22 weeks, one of which used the definition of a birthweight over 500g and only if the weight is unknown, a gestation of 22 weeks is used (Loiacono 2018). One study that defined stillbirth as having a gestation over 22 weeks also included a birthweight over 500g or height from 25cm (Canuto et al. 2021). Three studies focused on “late fetal death” or fetal death from 28 weeks gestation (Craig et al. 2004; Wood et al. 2012; Jardine et al. 2021), with a further two studies by Dummer et al. (2000) and Neasham et al. (2001) originally using the definition of gestational age over 28 weeks up until 1992, then from 24 weeks as the legislation changed in this year in the UK (Still-Birth Act 1992), the study period for these 2 studies were 1950-1993/1981-1992 and 1986-1992, respectively. A further two studies defined stillbirth as fetal death from 20 weeks (Guildea et al. 2001; Blanco et al.

2023), and one study only defined stillbirth as “intrauterine death”, with no gestation or weight specified (Tezcan et al. 2011).

Deprivation indices used in included studies

A wide range of deprivation indices were utilised internationally (n=18). The UK based deprivation indices were the most frequently used, with UK’s Index of Multiple Deprivation (IMD) utilised in a total of 8 studies, followed by the Townsend deprivation score (TDS) (n=6) and Jarman index (n=3). The Carstairs socioeconomic deprivation score was used in 2 of the studies included, with a further two studies using a variation of this index (“Carstairs-Morris scores” by Gray et al. 2009; and a “Townsend/Carstairs like” index by Sloggett and Joshi 1998). The remaining 12 indices were each used once within the included studies. Further detail regarding the measures and domains used for each deprivation index identified in the included studies is provided in Supplementary Table III. The number of measures or components used to constitute each index ranged from 3-18. The most common measures included across the indices used were employment, housing, education, income, crime/safety, access to facilities/service and health. Only two included indices partially considering ethnicity, the Jarman score references “ethnic minorities” (Nolan and Whelan 2007), and the National Operations Department Report Sweden reference “foreign-born individuals” (Hesselman et al. 2019). Some of the included studies in this review (Timmermans et al. 2011; Hesselman et al. 2019; Jardine et al. 2021; Heazell et al 2021) referenced the varying effect that ethnicity had on stillbirth risk, in the context of deprivation, with one study by de Graaf et al. (2013) noting that even when the risk of stillbirth decreased with lower deprivation, this outcome varied across the two ethnic groups examined. Jardine et al. (2021) identified that women of non-White ethnicities were more at risk of stillbirth than White women in the same socioeconomic groups, with adjustments for personal/social factors such as smoking, BMI and deprivation having little effect, demonstrating the clear correlation with ethnicity alone.

Table III provides further detail on the study design, methodology and the evidence of impact of deprivation on stillbirth for each of these studies.

Table III: Design, methods and impact of included studies.

Reference	Year	Study design	Methods	Evidence of association of impact reported	Evidence of impact
Sloggett and Joshi	1998	Prospective census follow up using the Office for National Statistics Longitudinal Study	The risk of stillbirth was calculated, using multiple logistic regression models, adjusted for personal/household circumstances.	Inconclusive	The deprivation gradient is indeterminate for stillbirth.
Joyce et al.	1999	Cross-sectional study	Trends in stillbirth rates tested by chi-squared test for trend. Association stillbirth rate - TDS studied with logistic regression.	Yes	Statistically significant relationship between stillbirth and higher deprivation when TDS used as a continuous variable.
Joyce et al.	2000	Cross-sectional study	Simple linear regression studied association stillbirth rates - deprivation indicators. Pearson's correlation measured strength of relationship.	Inconclusive	Variability in stillbirth explained by deprivation was not statistically significant (less than 10%).
Dummer et al.	2000	Time-trend analysis	Inequality of stillbirth risk between social strata measured by relative index of inequality, estimated with logistic regression.	Yes	The risk of stillbirth in less advantaged areas was significantly higher in the earlier time periods (1950–1975), and subsequently for England.

Bambang et al.	2000	Retrospective cohort study	Crude rates for cause specific deaths calculated for each level of deprivation and relative risk was measured.	Yes	Wigglesworth classification B (Antepartum events) the RR from least to most deprived quintile was 1.81.
Neasham et al.	2001	Population based study	Extended perinatal mortality analysed across deprivation quintiles and time using Nptrend. Poisson regression for relative risk. Analysis repeated for stillbirth alone.	Yes	Reported as extended perinatal mortality rate but analysis for stillbirth separately did not alter results, showing increase in mortality of non-chromosomal anomalies with increased deprivation.
Guildea et al.	2001	Population based ecological study	Poisson regression analysis estimated the magnitude of effect for associations. Relative risk of death between most and least deprived enumeration districts was derived.	Yes	Stillbirth significantly associated with TDS, the magnitude of effect was 4.3% (41% across the whole range).
Joyce et al.	2004	Cross-sectional study	Cross sectional data collected from one region. Multiple regression analysis and Principle Components Analysis studied impact of deprivation on stillbirth. Sensitivity analyses performed to confirm the results.	Inconclusive	Association between stillbirth and TDS does not appear statistically significant.
Craig et al.	2004	Observational study	Trend analysis of crude late fetal death using logistic regression to fit generalised linear models. Multivariable logistic regression calculated odd ratios.	Yes	Modest socioeconomic gradient in LFD when all causes are considered together with an OR of 1.48 for the most deprived decile.

Smeeton et al.	2004	Case-control study	Conditional logistic regression analyses with forward stepwise regression.	Inconclusive	Results were not statistically significant. Deprivation was not an important factor in explaining stillbirth in this health authority.
Gray et al.	2009	Population based retrospective cohort study	Multiple logistic regression modelling was used to derive odds ratios.	Yes	OR 1.56 for stillbirth least to most deprived, aOR 1.32 adjusted for maternal and infant factors. The stillbirth rate increased from 3.8 per 1000 in the least deprived group to 5.9 per 1000 in the most deprived group.
Francis et al.	2009	Epidemiological analysis for Clinical report	Analysis of stillbirth rates for each trust in the West Midlands; comparison across deprivation quintiles. Completed as part of regional report.	Yes	Stillbirth rates in the most deprived quintile are consistently higher, OR 1.5. strong correlation shown between IMD score and stillbirth rate.
Tezcan et al.	2011	Retrospective data analysis	Retrospective data collected and analysed.	Yes	Strong correlation between the IMD and the distribution of IUDs, with IUD more concentrated in areas with high deprivation.
Timmermans et al.	2011	Population based prospective cohort study	Comparisons using Independent Student's t, Mann–Whitney U, andchi-square test. Crude Relative Risk estimated for all outcomes. Multivariable logistic regression analysis applied.	Yes	Substantially higher number of intrauterine fetal deaths in deprived neighbourhoods (20/2,779 versus 17/4,580), RR 1.94.
Wood et al.	2012	Retrospective cohort study	Risk of stillbirth analysed with Logistic regression models. Comparisons made by Kruskal-Wallis test.	Yes	There was a linear association between rates of antepartum stillbirth and socioeconomic deprivation score. OR 1.75, aOR 1.53-1.34

Seaton et al.	2012	Population based study	Poisson regression models estimated relative deprivation gap in rates of stillbirth.	Yes	Rates were twice as high in the most deprived area compared to the least (RR 2.1).
de Graaf et al.	2013	Epidemiological analysis	Multiple logistic regression analysis analysed association between deprived neighbourhoods and fetal mortality.	Yes	The excess risk for perinatal mortality in a deprived neighbourhood is 21%, mainly through foetal mortality.
Smith et al.	2014	Population cohort study	Poisson regression models, including interactions, explored trends over time.	Yes	Births from most deprived decile showed higher rates of stillbirth for singletons and twins.
Field et al.	2016	Population based study	Cause-specific analysis of all stillbirth and live births, poisson regression models estimate relative deprivation gap.	Yes	Rates of stillbirth were twice as high in the most deprived decile as in the least deprived.
Loiacono	2018	Descriptive ecological study	The principle components of geographic areas were analysed and the fetal mortality ratios was calculated. A Poisson regression analysis was performed, the slope index of inequality and the Kunst and Mackenbach relative index of inequality was calculated.	Yes	The fetal mortality ratio is higher in areas identified as having a very unfavourable socioeconomic status.
Hesselman et al.	2019	Population based register study	Associations investigated with logistic regression and risk estimates.	Yes	Living in a deprived neighborhood was associated with stillbirth (deprived OR 1.62, 95% CI 1.17-2.26, severely deprived OR 1.56, 95% CI 1.11-2.19).
Bonfim et al.	2020	Ecological study	Descriptive spatial analysis using distribution of coefficients. Scan statistics used for exploratory spatial analysis.	Yes	There was a presence of clusters of fetal death in areas of greater social deficit.

Bayerlein et al.	2020	Cross-sectional study	Logistic regression calculating ORs (95% CIs) for stillbirth with and without adjustment for potential confounders.	No	Increased deprivation was associated with lower stillbirth rates - overall trend, linear increase per quintile: 0.95 (95% CI 0.92 to 0.98)
Bailey et al.	2021	International retrospective cohort study	Multivariable Poisson regression analysis evaluated interaction between cohort and time period.	Inconclusive	Rates suggest stillbirth is more likely in more deprived areas, but not statistically significant.
Canuto et al.	2021	Ecological study	Factor analysis by main components for the elaboration of the social need index. Spatial analysis applying the local empirical Bayesian estimator and Moran's spatial autocorrelation was verified.	Yes	Avoidable fetal mortality was higher among the strata of greater social need/ increased as social deprivation increased. Rates of 8.0, 8.1, 8.8 and 10.7 from the lowest to highest deprivation.
Jardine et al.	2021	Cohort study	Logistic regression models estimated associations, adjusting for relevant factors. Sensitivity analysis done for stillbirth.	Yes	Risk of stillbirth increased with socioeconomic deprivation, from 0.29% in the least socioeconomically deprived group to 0.47% in the most deprived group.
Heazell et al.	2021	Case-control study	Data collected via questionnaire. Multivariable analysis adjusting for social and behavioural factors.	Yes	Women living in the most deprived quintile had an increased risk of stillbirth compared with the least deprived quintile (adjusted odds ratio [aOR] 3.16; 95% CI 1.47–6.77).
Blanco et al.	2023	Retrospective cohort study	Temporal trend analysis with log binomial regression models, and spatial analysis.	Inconclusive	Numbers of stillbirth were rare and so no correlation was found with neighborhood deprivation.

Arechvo et al.	2023	Prospective observational study	Logistic regression analysis determined whether deprivation provided a significant independent contribution to stillbirth, after adjusting for maternal risk factors.	Yes	Unadjusted analysis shows a correlation between stillbirth and deprivation (OR 1.57).

Notes: [a]Acronyms used; Adjusted odds ratio (aOR), Index of Multiple Deprivation (IMD), Late Fetal Death (LFD), Odds ratio (OR), Rate ratio (RR), Townsend deprivation score (TDS).

Associations between deprivation and stillbirth risk

A positive correlation between the increased risk of stillbirth for areas identified as more deprived was seen in 22 of the 29 studies (75.9%) (Table III). Three of these were conditional on other factors, for example, Dummer et al. (2000) identified higher stillbirth rates in less advantaged areas over both time periods studied for both areas – England and Cumbria, but in the later time period the inequality was no longer statistically significant for the Cumbria area. Also, for two studies (Hesselman et al. 2019; Arechvo et al. 2023) while deprived areas were associated with stillbirth, the risk did not remain after adjusting for maternal and social risk factors. Variation was noted throughout the studies in adjusting for other factors.

The remaining seven studies either showed inconclusive or negative association between increased deprivation and stillbirth risk. For six of these seven studies, although differences may have been noted between the deprivation levels, the results were not deemed to be of statistical significance. One study by Bayerlein et al. (2020) showed decreased stillbirth rate with increasing deprivation, opposing the majority of the evidence.

Table IV presents studies that reported odds ratios (OR) or rate ratios (RR) to outline the potential effect of deprivation on stillbirth. The range of deprivation is also included to provide context for the extent of the disparities between studies where unless otherwise stated, the effect represents the comparison of the most deprived versus the least deprived areas. A total of 18 studies were identified as having used similar methodologies and presentation of results, which is examined further in Table IV. This table was collated to provide a summary and clearer overview of the results in the included studies. However, these should be interpreted with caution as the studies have not been quality assessed. The remaining studies were excluded due to heterogeneity in the analysis methods or presentation of results.

Table IV: Study results on risk of stillbirth in relation to deprivation.

Reference	**Year**	**Range of deprivation**	**Effect for positive association***
			Odd ratios (OR)/ Adjusted Odds Ratios (aOR)
Joyce et al.	1999	Septiles	OR 1.45 (95% CI 1.06 to 1.97)
Craig et al.	2004	Deciles	OR 1.48 (95% CI 1.29 to 1.71)
Gray et al.	2009	Quintiles	aOR 1.32 (95% CI 1.16 to 1.50)
Francis et al.	2009	Quintiles	OR 1.5 (CI 95% 1.4 to 1.7)
Wood et al.	2012	Categories 1-7	aOR 1.34 (95% CI 1.17 to 1.54)
Jardine et al.	2021	Quintiles	aOR 3.16 (95% CI 1.47 to 6.77)
			Rate ratios (RR)/ Adjusted Rate Ratios (aRR)
Dummer et al.	2000	Quintiles for 3 deprivation indices	RR 1.36 (95% CI 1.28 to 1.45)[a]
Timmermans et al.	2011	Deprived neighbourhood yes/no	RR 1.94 (95% CI 1.02 to 3.69)
Seaton et al.	2012	Deciles	RR 2.1 (95% CI 2.0 to 2.2)
de Graaf et al.	2013	Deprived neighbourhood yes/no	RR 1.53 (95% CI 1.40 to 1.67)
Smith et al.	2014	Deciles	RR 2.41 (95% CI 2.25 to 2.58)[b]
Field et al.	2016	Deciles	RR 2.1 (95% CI 2.0 to 2.2)
Loiacono	2018	Quintiles	RR 1.4 (95% CI 1.31 to 1.52)

Reference	**Year**	**Range of deprivation**	**Effect for negative/inconclusive association***
			OR/aOR
Sloggett and Joshi	1998	9 categories	aOR 1.00 (95% CI 0.93 to 1.08)

Hesselman et al.	2019	3 categories, non-exposed/ deprived/ severely deprived	aOR 0.79 (95% CI 0.46 to 1.37)[c]
Bayerlein et al.	2020	Quintiles	aOR 0.86 (95% CI 0.74 to 1.01)
Arechvo et al.	2023	Quintiles	aOR 1.03 (95% CI 0.75 to 1.43)[d]
			RR/aRR
Dummer et al.	2000	Quintiles for 3 deprivation indices	RR 1.10 (95% CI 0.71 to 1.71)[e]
Bailey et al.	2021	Quintiles	aRR 37-38 weeks: 1.26 (0.94, 1.69) and 39-41 weeks: 1.18 (0.93, 1.50)[f] aRR 37-38 weeks: 1.28 (0.14, 1.79) and 39-41 weeks: 1.26 (0.92, 1.71)[g]

Notes:

[a] TDS for England/Wales

[b] Applies to singletons (study presented results for singleton and multiple births)

[c] Applies to severely deprived category. Crude rate showed positive association between deprivation and stillbirth, but risk did not remain after adjustment

[d] Crude rate showed positive association between deprivation and stillbirth, but risk did not remain after adjustment

[e] TDS for Cumbria

[f] Wales, term infants only

[g] Western Australia, term infants only

[*]Note: These figures are derived from the studies where the results were presented in Odds Ratios (OR)/Rate Ratios (RR), so not all studies are represented.

For the purpose of this table, the most recent time period was selected. Adjusted rates were preferred in an attempt to obtain the most representative result by controlling for potential confounding variables.

There were 13 studies that identified a positive association between higher levels of deprivation and stillbirth and a further 6 studies identified a negative or inconclusive association. One study is included across both sections as the different areas studied had varying results (Dummer et al. 2000). Positive association demonstrated a range of odds ratios (OR)/ adjusted odds ratios (aOR) of 1.32 to 3.16 and RR 1.36 to 2.41. Negative or inconclusive correlation demonstrated a range 0.79 to 1.03 OR, and 1.10 to 1.26 RR/aRR.

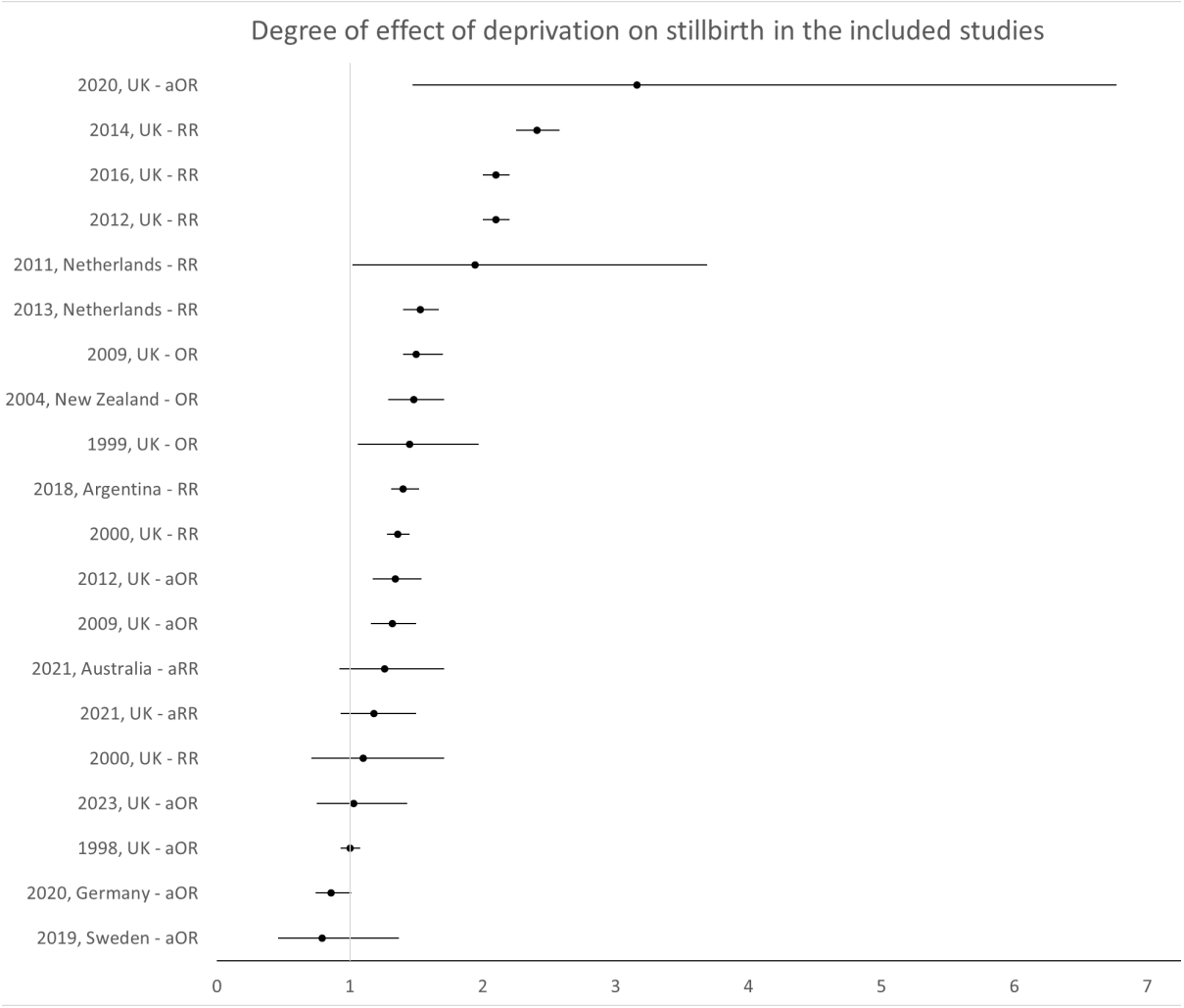

Figure 2: Forest plot demonstrating degree of effect of deprivation on stillbirth in the included studies.[a]

[a]Notes: These figures are derived from the studies where the results were presented in Odds Ratios (OR)/Rate Ratios (RR), so not all studies are represented.

Discussion

This scoping review provides a descriptive overview of the international literature on the relationship between area-level deprivation, based on composite measures, and stillbirth risk in upper-middle to high-income countries. The evidence suggests that an individual's level of deprivation does affect their risk of having a stillbirth, with those living in more deprived areas having an increased risk of stillbirth. Almost 76% of the studies included in this review had findings that indicated a positive correlation. This finding highlights the critical role that socioeconomic factors play in perinatal health outcomes.

Area-level deprivation as a social determinant of health

Area-level deprivation is a multidimensional concept, encompassing a range of factors that extend beyond an individual's control (Townsend 1987; Nolan and Whelan 2007). This is linked closely with the World Health Organisation's Social Determinants of Health (WHO SDH), described as "non-medical factors that influence health outcomes", including the conditions that people are born in and live in. SDH were found to be one of the most important influences on health, possibly even more so than lifestyle choices. This trend is suggested also in this scoping review as the risk of stillbirth remained higher for those living in more deprived areas even after adjusting for specific maternal factors (Gray et al. 2009; Wood et al. 2012; Heazell et al. 2021). The WHO SDH model outlines elements such as income, education, employment, housing and access to services as having an influence on health and equity. This is reflected in the area-level deprivation indices identified by this review, where such aspects were components of the indices. (Supplementary Table III/Figure 1). However, it is worth noting that two studies from within this scoping review did demonstrate a reduction in stillbirth risk after adjusting for individual maternal factors (Hesselman et al. 2019; Arechvo et al. 2023). Thus, further research could be useful in determining a clear measure of the

increase in the risk that maternal factors have on perinatal outcomes specifically, in the context of deprivation.

It is interesting to note that the majority (19 of 29 included papers) were published after 2008, the year in which the WHO released the "Closing the Gap in a Generation" report (WHO 2008). This report has put further emphasis on the SDH and their impact on global health status and inequalities, highlighting that across all countries lower socioeconomic positions have a direct negative impact on health outcomes. The report put out a call for action, advocating for interventions that address health disparities. This has potentially increased awareness on the impact that SDH can have on health outcomes, reflected in the timeline of the publications within this review.

The complexity of measuring deprivation

The wide range of deprivation indices employed in the reviewed studies highlights the level of complexity involved in adequately measuring deprivation. As outlined in the findings, the various deprivation indices applied included numerous deprivation components that ranged from income, employment and education to housing, overcrowding, safety or even access to sanitation. This reflects the intricate nature of deprivation as a concept and the highly complex and multifaceted nature it holds. As highlighted by one included study by Joyce et al. (2000), one index may be more suitable and provide a more accurate measure of deprivation of one area than another, depending on the characteristics of the area being studied. This might explain the wide variety of deprivation indices used throughout the studies in this review, even from studies within the same country, e.g. the UK.

There are some similarities or consistencies on the indices components which are generally accepted as important markers of deprivation, such as income, employment, education, among others (Zelenina et al. 2022). However, it is important to have variation specific to the country or community to ensure further appropriateness and tailoring of the deprivation measure to the culture and environment to where it applies. This was the case for the Chilean Multiple Deprivation

index (MDI) which considers the Mapuche population, an indigenous community of Chile (Blanco et al. 2023). Some indices were noted to have more basic measures surrounding access to facilities, such as the Social Deprivation Index (SDI) of Brazil (Bonfim et al. 2020), which includes factors such as having a main network water supply or a garbage removal service. This underscores the importance of context specific measures to accurately reflect the socioeconomic disparities. Further research could be useful in scrutinizing the components and validity of the available indices internationally, and the appropriateness of their use in measuring health outcomes. A universally accepted systematic approach to the development and validation of deprivation indices that could be used and applied internationally could be of benefit (Zelenina et al. 2022).

The majority of indices included in this review were validated, confirming the accuracy and reliability of their use. This is evident in the indices such as the Index of Multiple Deprivation (used in UK, Welsh and German studies included), the Townsend and Carstairs indices. However not all indices appear to have gone through a validation process and were possibly developed for the purpose of that particular study. This is the case for the "Socioeconomic Status Indicator (SESI) Argentina" (Loiacono 2018) and the "Townsend-Carstairs like" index (Sloggett and Joshi 1998). Although these models reflect many of the measures used in validated indices, utilising census-based information from the country of study, it could be argued that the lack of rigorous validation may lead to a less reliable measure of the outcomes on deprivation. Validating a deprivation index involves verifying whether it adequately reflects the reality of what is being measured (Pampalon et al. 2014). Hence, it is essential that area-level deprivation indices are adequately validated to ensure their accuracy in capturing the multifaceted aspects of deprivation within different communities.

It is also important to consider that one limitation to the use of composite deprivation indices, is the difficulty in identifying which specific factors have the greatest influence within the index. These indices combine multiple factors into a single value. While this allows for a comprehensive view, it might obscure the relative contribution of each individual factor, making it challenging to pinpoint

which component has the most significant impact on health outcomes (Seth and McGillivray, 2018). Further research is required to better understand the relative contribution of each factor.

Despite the large body of evidence available on the association of ethnicity and deprivation (Li et al. 2018; Darlington et al. 2015; Janevic et al. 2010), ethnicity was not seen to be a consistent measure included in the indices, as highlighted in the findings, with only a limited number of studies examining the effect of ethnicity. Those that did, grouped ethnicity with a range of other maternal factors including smoking and BMI, among others (Timmermans et al. 2011; Hesselman et al. 2019; Jardine et al. 2021; Heazell et al 2021) with only one study by de Graaf (2013) examining ethnicity specifically. Each of these studies demonstrated that risk of stillbirth was reduced when adjusted for factors including ethnicity. Further evidence demonstrates ethnicity as an important factor in risk of perinatal mortality, highlighting its relevance for the adequate measure of deprivation and its impact on health outcomes (Opondo et al. 2019; Draper et al. 2021; Matthews et al. 2022). Future studies examining deprivation and the association with health should also explore the effect of ethnicity to gain a more comprehensive understanding of this intricate relationship.

Stillbirth Definitions

While it is suggested in the included studies that a higher level of deprivation is associated with an increased risk of stillbirth, there is variation in how stillbirth is defined throughout the studies. Stillbirth is generally described as fetal death from a specific gestation (20/22/24/28 weeks gestation), with some definitions including birthweight and/or height. The lack of consensus in defining stillbirth is clear in the literature and a strong body of evidence recommends an international review of perinatal mortality definitions (Joseph et al. 2017; Kelly et al 2021). The lack of a standard stillbirth definition affects the ability to effectively analyse the available literature on this topic, hampers the standardised reporting and comparison of stillbirth and neonatal death rates and, ultimately, impacts clinical care (Kelly et al. 2021). National policies on bereavement supports and entitlements are generally founded on these specific definitions, therefore impacting access to maternity leave benefits, parental leave and assistance towards funeral arrangements (Smith et al.

2020). Consequently, families face significant disparities in recognition and entitlements based on the classification of their loss, sometimes leading to a lack of formal recognition of their baby at the state level (Kelly et al. 2021). This profoundly impacts overall wellbeing, the grieving process and possible future pregnancies (Heazell et al. 2016).

Inequalities in Stillbirth Rates

The literature compiled in this review provides a starting point for healthcare practitioners, researchers, and policymakers seeking to develop evidence-based strategies to address inequalities in stillbirth rates. It highlights the need for area-specific interventions that would support and encourage access to care and resources in more deprived areas through tailored initiatives, such as those suggested in the Marmot review (Marmot 2010) which advised the channelling of public expenditure on policies aimed at reducing health inequalities through acting on SDH. It is evident from the literature that interventions must target the wider population of an area to make the required improvements (Jardine et al. 2021). Addressing these disparities requires an intersectional approach involving collaboration between maternity services, public health professionals, and policymakers (Bonfim et al. 2020; Jardine et al. 2021). Supporting universal access to maternity care is also known to be essential to address disparities in stillbirth risk influenced by level of deprivation (Flenady et al. 2011; Gonthier et al. 2017). Prioritising these care initiatives has the potential to reduce stillbirth rates and ensure the well-being of families and their infants.

While deprivation is shown to increase the risk of experiencing stillbirth, this is a complicated and complex relationship with many factors involved and warrants further investigation.

Strengths and Limitations

The scoping review has a strength in its innovation, being one of the few comprehensive reviews analysing the literature on the association between deprivation indices and stillbirth, addressing a timely and relevant topic within the field.

The rigorous methodology provided by the JBI guide for scoping reviews (Peters et al. 2020) was adhered to, allowing for reliability and transparency. The screening process considered many studies

from a wide range of scientific journals and an inclusive variety of search terms, ensuring a comprehensive search of the available published literature on the topic.

However, it was challenging to describe the extent of the effect that deprivation has on stillbirth risk due to the inconsistency in analysis and reporting techniques used within the studies. While a range of effect was noted in the findings of this review, between 0.79 to 3.16, this was based on publications with different study designs and deprivation indices, with varying levels of categories (e.g. quintiles vs. deciles). The use of crude and adjusted rates also varied across the studies. As a scoping review, the aim of this paper is to provide a broad overview of the literature (Pollock et al. 2021). While this allowed for a comprehensive exploration of the topic, the depth of the analysis was somewhat limited. A systematic review of the topic, including quality assessment and meta-analysis, could not be completed on this topic which may have provided a more robust and precise estimation of the degree of effect observed (Higgins et al. 2023).

It is interesting to note the large proportion of studies that were UK-based, 20 of the 29 studies, therefore leading much of the research in this area in relation to deprivation and stillbirth risk. TThe international applicability of the results may be limited due to the predominance of studies from a single country. However, such approach could be an example to be followed in other countries, to expand the body of knowledge in this area, and possibly incorporate into health service analyses and reports.

The scope of this review did not include grey literature searching. While peer-reviewed literature ensures a high standard of evidence, grey literature may have provided further insight on this issue (Pollock et al. 2021).

As noted during the screening process of this review, there is a volume of evidence on other aspects of perinatal and infant mortality on deprivation that, despite of relevance, was beyond the scope of this review and hence, further research in this area would be pertinent.

Implications for practice

While further in-depth research is needed, this review provides a valuable starting point by mapping the current literature on the relationship between deprivation and stillbirth. As Weightman et al. (2012) notes, findings like those presented in the included studies can inform policymakers, research funders, and healthcare providers involved in perinatal care. However, the lack of evidence on effective interventions to mitigate the negative impact of deprivation on perinatal outcomes remains a key challenge.

Some promising approaches have begun to emerge from the literature, such as those identified by Khan et al. (2023) who highlighted possible effective intervention options. These included midwifery models of care, interdisciplinary care and community-centred services (Khan et al. 2023). Similarly, Arblaster et al. (1996), express the importance of a systematic and multidisciplinary approach to the reduction of health inequality. This sentiment is echoed also by Jardine et al. (2021), who emphasise the importance of multi-agency collaboration to reduce inequalities in pregnancy outcomes by addressing the broader social determinants of health, including that of area deprivation. However, Arblaster et al. (1996) also state that interventions must address the needs of target population. Implementing these models for intervention requires careful adaptation to the specific needs and context of each community to ensure relevance and effectiveness. Arblaster et al. (1996) recommend the involvement of peers in the delivery of such intervention. Facilitating access to care and encouragement of the use of services has also been identified in the literature as areas for targeted intervention (Arblaster et al. 1996, Escañuela Sánchez et al. 2022). Gennaro et al. (2016) and Vos et al. (2014) promote the application of individualised maternity care, including tailored antenatal risk assessments paired with specific preconception care, also demonstrating the need for collaboration with local public health initiatives. This community-responsive approach should be considered in addressing any potential disparities in perinatal outcomes associated with deprivation.

Conclusion

The findings of this scoping review suggest that area-level deprivation might influence stillbirth rates in upper-middle to high-income countries. The evidence points to a positive correlation between higher levels of deprivation and an increased risk of stillbirth. These findings highlight the importance of understanding and addressing the multifaceted nature of deprivation and its role as a social determinant of perinatal health.

Countries and regions should consider assessing deprivation when evaluating their stillbirth rates as this could offer valuable information for tailored care programme development to impact deprived areas. The development and implementation of focused initiatives aimed at reducing stillbirth among those at higher deprivation related risk would be beneficial. Using the evidence to guide and inform local policy and resource management will aid in tackling the inequalities in healthcare provision, thus encouraging equal maternity care. These initiatives have the potential to enhance healthcare services, clinical practice, and ultimately improve maternal and perinatal outcomes.

References

1. Arblaster, L., Lambert, M., Entwistle, V., Forster, M., Fullerton, D., Sheldon, T., & Watt, I. (1996). A systematic review of the effectiveness of health service interventions aimed at reducing inequalities in health. Journal of Health Services Research & Policy, 1(2), 93–103
2. Arechvo, A., Nikolaidi, D. A., Gil, M. M., Rolle, V., Syngelaki, A., Akolekar, R., & Nicolaides, K. H. (2023). Incidence of stillbirth: effect of deprivation. Ultrasound in Obstetrics and Gynecology, 61(2), 198–206.
3. Bailey, H. D., Kotecha, S. J., Watkins, W. J., Adane, A. A., Shepherd, C. C. J., & Kotecha, S. (2021). Comparison of stillbirth trends over two decades in Wales, United Kingdom and Western Australia: An international retrospective cohort study. Paediatric and Perinatal Epidemiology, 35(3), 302–314.
4. Bambang, S., Spencer, N. J., Logan, S., & Gill, L. (2000). Cause-specific perinatal death rates, birth weight and deprivation in the West Midlands, 1991-93. Child: Care, Health and Development, 26(1), 73–82.
5. Beyerlein, A., Lack, N., & Maier, W. (2020). Associations of area-level deprivation with adverse obstetric and perinatal outcomes in Bavaria, Germany: Results from a cross-sectional study. PLoS ONE, 15(7).
6. Blanco, E., Ruiz-Rudolph, P., Yohannessen, K., Ayala, S., Quinteros, M. E., Delgado-Saborit, J. M., Blazquez, C. A., Iglesias, V., Zapata, D. A., Bartington, S. E., Harrison, R. M., & Ossa, X. (2023). Temporal and Spatial Trends of Adverse Pregnancy and Birth Outcomes in a Sample of Births from a Public Hospital in Chile. Journal of Urban Health, 100(3), 513–524.
7. Bonfim, C. V. do, Silva, A. P. de S. C., Oliveira, C. M. de, Vilela, M. B. R., & Freire, N. C. F. (2020). Spatial analysis of inequalities in fetal and infant mortality due to avoidable causes. Revista Brasileira de Enfermagem, 73(suppl 4).

8. Canuto, I. M. de B., Macêdo, V. C. de, Frias, P. G. de, Oliveira, C. M. de, Costa, H. V. V. da, Portugal, J. L., & Bonfim, C. V. do. (2021). Spatial patterns of avoidable fetal mortality and social deprivation. Revista Brasileira de Epidemiologia, 24(suppl 1).
9. Carstairs, V. (1995). Deprivation indices: their interpretation and use in relation to health. Journal of Epidemiology and Community Health, 49 Suppl 2(Suppl 2), S3-8.
10. Central Statistics Office. Mortality differentials in Ireland 2016–2017 - CSO - Central Statistics Office; June 28, 2019. https://www.cso.ie/en/releasesandpublications/in/mdi/mortalitydifferentialsinireland2016-2017/. [Accessed 07/04/2023]
11. Craig, E. D., Stewart, A. W., & Mitchell, E. A. (2004). Causes of late fetal death in New Zealand 1980-1999. Australian and New Zealand Journal of Obstetrics and Gynaecology, 44(5), 441–448.
12. Darlington, F., Norman, P., Ballas, D., & Exeter, D. J. (2015). Exploring ethnic inequalities in health: evidence from the Health Survey for England, 1998-2011. Diversity & Equality in Health and Care, 12(2).
13. de Graaf, J. P., Ravelli, A. C. J., de Haan, M. A. M., Steegers, E. A. P., & Bonsel, G. J. (2013). Living in deprived urban districts increases perinatal health inequalities. The Journal of Maternal-Fetal & Neonatal Medicine, 26(5), 473–481.
14. Department of Health (DOH) Ireland. (2021) Sláintecare implementation strategy & action plan 2021 — 2023. Dublin: Department of Health.
15. Draper ES, Gallimore ID, Smith LK, Fenton AC, Kurinczuk JJ, Smith PW, Boby T, Manktelow BN, on behalf of the MBRRACE-UK Collaboration (2021). MBRRACE-UK Perinatal Mortality Surveillance Report, UK Perinatal Deaths for Births from January to December 2019. Leicester: The Infant Mortality and Morbidity Studies, Department of Health Sciences, University of Leicester.

16. Duffy K, Connolly S, Nolan A, Maitre B (2022). Unequal Chances? Inequalities in Mortality in Ireland. Economic, Social and Research Institute. Research series 145. [Accessed 07/04/2023] https://www.esri.ie/pubs/RS145.pdf
17. Dummer, T., Dickinson, H. O., Pearce, M. S., Charlton, M. E., & Parker, L. (2000). Stillbirth risk with social class and deprivation no evidence for increasing inequality. Journal of Clinical Epidemiology, 53(2), 147–155.
18. Elmagarmid A, Fedorowicz Z, Hammady H, Ilyas I, Khabsa M, Ouzzani M. Rayyan (2014) A systematic reviews web app for exploring and filtering searches for eligible studies for Cochrane Reviews. In: Evidence-Informed Publich Health: Opportunities and Challenges. Abstracts of the 22nd Cochrane Colloquium; 2014 21-26 Sep; Hyderabad, India. John Wiley & Sons; 2014.
19. Escañuela Sánchez, T., Linehan, L., O'Donoghue, K., Byrne, M., & Meaney, S. (2022). Facilitators and barriers to seeking and engaging with antenatal care in high-income countries: A meta-synthesis of qualitative research. Health & Social Care in the Community, 30(6).
20. Fan, W., & Luo, L. (2020). Understanding Trends in the Concentration of Infant Mortality Among Disadvantaged White and Black Mothers in the United States, 1983–2013: A Decomposition Analysis. Demography, 57(3), 979–1005.
21. Field, D., Boyle, E., Draper, E., Evans, A., Johnson, S., Khan, K., Manktelow, B., Marlow, N., Petrou, S., Pritchard, C., Seaton, S., & Smith, L. (2016). Towards reducing variations in infant mortality and morbidity: a population-based approach. Programme Grants for Applied Research, 4(1), 1–218.
22. Flenady, V., Middleton, P., Smith, G. C., Duke, W., Erwich, J. J., Khong, T. Y., Neilson, J., Ezzati, M., Koopmans, L., Ellwood, D., Fretts, R., & Frøen, J. F. (2011). Stillbirths 5: Stillbirths: the way forward in high-income countries. The Lancet (British Edition), 377(9778), 1703.

23. Francis, A., Elsheikh, A., & Gardosi, J. (2009). Stillbirths, Infant Deaths and Social Deprivation West Midlands 1997-2007/8.
24. Gennaro, S., Melnyk, B. M., O'Connor, C., Gibeau, A. M., & Nadel, E. (2016). Improving Prenatal Care for Minority Women. MCN: The American Journal of Maternal/Child Nursing, 41(3), 147–153.
25. Gissler, M., Rahkonen, O., Arntzen, A., Cnattingius, S., Andersen, A.-M. N., & Hemminki, E. (2009). Trends in socioeconomic differences in Finnish perinatal health 1991-2006. Journal of Epidemiology & Community Health, 63(6), 420–425.
26. Gonthier, C., Estellat, C., Deneux-Tharaux, C., Blondel, B., Alfaiate, T., Schmitz, T., Oury, J.-F., Mandelbrot, L., Luton, D., Ravaud, P., & Azria, E. (2017). Association between maternal social deprivation and prenatal care utilization: the PreCARE cohort study. BMC Pregnancy and Childbirth, 17(1), 126.
27. Goza, F. W., Stockwell, E. G., & Balistreri, K. S. (2004). The relationship between socioeconomic status and infant mortality in metropolitan Ohio, 1999–2001*. Biodemography and Social Biology, 51(3–4), 83–93.
28. Gray, R., Bonellie, S. R., Chalmers, J., Greer, I., Jarvis, S., Kurinczuk, J. J., & Williams, C. (2009). Contribution of smoking during pregnancy to inequalities in stillbirth and infant death in Scotland 1994-2003: Retrospective population based study using hospital maternity records. BMJ (Online), 339(7726), 906–908.
29. Guildea, Z. E. S., Fone, D. L., Dunstan, F. D., Sibert, J. R., & Cartlidge, P. H. T. (2001). Social deprivation and the causes of stillbirth and infant mortality. Archives of Disease in Childhood, 84(4), 307–310.
30. Haase T and Pratschke J (2017). The 2016 Pobal HP Deprivation Index for Small Areas (SA). http://trutzhaase.eu/deprivation-index/the-2016-pobal-hp-deprivation-index-for-small-areas/ [Accessed 29/09/22]

31. Heazell, A. E. P., Siassakos, D., Blencowe, H., Burden, C., Bhutta, Z. A., Cacciatore, J., Dang, N., Das, J., Flenady, V., Gold, K. J., Mensah, O. K., Millum, J., Nuzum, D., O'Donoghue, K., Redshaw, M., Rizvi, A., Roberts, T., Toyin Saraki, H. E., Storey, C., … Budd, J. (2016). Stillbirths: economic and psychosocial consequences. The Lancet, 387(10018), 604–616
32. Heazell, A. E. P., Budd, J., Smith, L. K., Li, M., Cronin, R., Bradford, B., McCowan, L. M. E., Mitchell, E. A., Stacey, T., Roberts, D., & Thompson, J. M. D. (2021). Associations between social and behavioural factors and the risk of late stillbirth – findings from the Midland and North of England Stillbirth case-control study. BJOG: An International Journal of Obstetrics and Gynaecology, 128(4), 704–713.
33. Hesselman, S., Wikström, A., Skalkidou, A., Sundström-Poromaa, I., & Wikman, A. (2019). Neighborhood deprivation and adverse perinatal outcomes in Sweden: A population-based register study. Acta Obstetricia et Gynecologica Scandinavica, 98(8), 1004–1013.
34. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). Cochrane Handbook for Systematic Reviews of Interventions version 6.4 (updated August 2023). Cochrane, 2023. Available from www.training.cochrane.org/handbook
35. Janevic, T., Stein, C. R., Savitz, D. A., Kaufman, J. S., Mason, S. M., & Herring, A. H. (2010). Neighborhood Deprivation and Adverse Birth Outcomes among Diverse Ethnic Groups. Annals of Epidemiology, 20(6), 445–451.
36. Jardine, J., Walker, K., Gurol-Urganci, I., Webster, K., Muller, P., Hawdon, J., Khalil, A., Harris, T., & van der Meulen, J. (2021). Adverse pregnancy outcomes attributable to socioeconomic and ethnic inequalities in England: a national cohort study. The Lancet, 398(10314), 1905–1912.
37. Jarman, B. (1983). Identification of underprivileged areas. BMJ, 286(6379), 1705–1709.
38. Joseph, K., Basso, M., Davies, C., Lee, L., Ellwood, D., Fell, D., Fowler, D., Kinniburgh, B., Kramer, M., Lim, K., Selke, P., Shaw, D., Sneddon, A., Sprague, A., & Williams, K. (2017). Rationale and recommendations for improving definitions, registration requirements and

procedures related to fetal death and stillbirth. BJOG: An International Journal of Obstetrics & Gynaecology, 124(8), 1153–1157.

39. Joyce, Webb, & Peacock. (1999). Social class and census-based deprivation scores: which is the best predictor of stillbirth rates? Paediatric and Perinatal Epidemiology, 13(3), 269–277.
40. Joyce, R., Webb, R., Peacock, J., & Stirland, H. (2000). Which is the best deprivation predictor of foetal and infant mortality rates? Public Health, 114(1), 21–24.
41. Joyce, R., Webb, R., & Peacock, J. L. (2004). Associations between perinatal interventions and hospital stillbirth rates and neonatal mortality. Archives of Disease in Childhood: Fetal and Neonatal Edition, 89(1).
42. Kelly, K., Meaney, S., Leitao, S., & O'Donoghue, K. (2021). A review of stillbirth definitions: A rationale for change. European Journal of Obstetrics & Gynecology and Reproductive Biology, 256, 235–245.
43. Khan, Z., Vowles, Z., Fernandez Turienzo, C., Barry, Z., Brigante, L., Downe, S., Easter, A., Harding, S., McFadden, A., Montgomery, E., Page, L., Rayment-Jones, H., Renfrew, M., Silverio, S. A., Spiby, H., Villarroel-Williams, N., & Sandall, J. (2023). Targeted health and social care interventions for women and infants who are disproportionately impacted by health inequalities in high-income countries: a systematic review. International Journal for Equity in Health, 22(1), 131.
44. Kingdon C, Roberts D, Turner MA, Storey C, Crossland N, Finlayson KW, Downe S (2019). Inequalities and stillbirth in the UK: a meta-narrative review. BMJ Open. 9(9).
45. Li, Y., Quigley, M. A., Dattani, N., Gray, R., Jayaweera, H., Kurinczuk, J. J., Macfarlane, A., & Hollowell, J. (2018). The contribution of gestational age, area deprivation and mother's country of birth to ethnic variations in infant mortality in England and Wales: A national cohort study using routinely collected data. PLOS ONE, 13(4), e0195146.
46. Loiacono, K. V. (2018). Evolution of fetal mortality in the setting of argentine socioeconomic inequalities. Period 2007-2014. Archivos Argentinos de Pediatria, 116(4), e567–e574.

47. Marmot, M. (2010) Fair society, healthy lives: the Marmot review; strategic review of health inequalities in England post-2010. The Marmot Review.
48. Matthews, R. J., Draper, E. S., Manktelow, B. N., Kurinczuk, J. J., Fenton, A. C., Dunkley-Bent, J., Gallimore, I., & Smith, L. K. (2022). Understanding ethnic inequalities in stillbirth rates: a UK population-based cohort study. BMJ Open, 12(2), e057412.
49. McLennan D, Noble S, Noble M, Plunkett E, Wright G and Gutacker N (2019). Ministry of Housing, Communities and Local Government. The English Indices of Deprivation 2019: Technical report. 2019. [Accessed 07/04/23] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/833951/IoD2019_Technical_Report.pdf
50. Mishra S and Carleton RN (2015). Subjective relative deprivation is associated with poorer physical and mental health. Social Science & Medicine. 147, 144-149.
51. Munn, Z., Peters, M.D.J., Stern, C. et al. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med Res Methodol 18, 143 (2018).
52. Neasham, D., Dolk, H., Vrijheid, M., Jensen, T., & Best, N. (2001). Stillbirth and neonatal mortality due to congenital anomalies: temporal trends and variation by small area deprivation scores in England and Wales, 1986-96: Congenital anomalies, stillbirth and neonatal mortality. Paediatric and Perinatal Epidemiology, 15(4), 364–373.
53. Nolan, B. and Whelan, C.T. (2007). On the multidimensionality of poverty and social exclusion. In Micklewright, J. and Jenkins, S. (Eds.), Poverty and Inequality: New Directions. Oxford: Oxford University Press.
54. Opondo, C., Gray, R., Hollowell, J., Li, Y., Kurinczuk, J. J., & Quigley, M. A. (2019). Joint contribution of socioeconomic circumstances and ethnic group to variations in preterm birth, neonatal mortality and infant mortality in England and Wales: a population-based retrospective cohort study using routine data from 2006 to 2012. BMJ Open, 9(7), e028227.

55. Ouzzani M, Hammady H, Fedorowicz Z et al. (2016) Rayyan—a web and mobile app for systematic reviews. Syst Rev 5, 210
56. Pampalon, R., Hamel, D., Gamache, P., Simpson, A., & Philibert, M. (2014). Validation of a deprivation index for public health: a complex exercise illustrated by the Quebec index. Chronic Diseases and Injuries in Canada, 34(1), 12–22.
57. Pattenden, S., Casson, K., Cook, S., & Dolk, H. (2011). Geographical variation in infant mortality, stillbirth and low birth weight in Northern Ireland, 1992-2002. Journal of Epidemiology & Community Health, 65(12), 1159–1165.
58. Peters MDJ, Godfrey C, McInerney P, Munn Z, Tricco AC, Khalil, H. Chapter 11: Scoping Reviews (2020 version). In: Aromataris E, Munn Z (Editors). JBI Manual for Evidence Synthesis, JBI, 2020. Available from https://synthesismanual.jbi.global.
59. Pilkington, H., Blondel, B., Drewniak, N., & Zeitlin, J. (2014). Where does distance matter? Distance to the closest maternity unit and risk of foetal and neonatal mortality in France. The European Journal of Public Health, 24(6), 905–910.
60. Pollock, D., Davies, E. L., Peters, M. D. J., Tricco, A. C., Alexander, L., McInerney, P., Godfrey, C. M., Khalil, H., & Munn, Z. (2021). Undertaking a scoping review: A practical guide for nursing and midwifery students, clinicians, researchers, and academics. Journal of Advanced Nursing, 77(4), 2102–2113.
61. Seth, S. and McGillivray, M. (2018). Composite indices, alternative weights, and comparison robustness. Social Choice and Welfare, 51(4), 657–679
62. Sloggett, A., & Joshi, H. (1998). Deprivation indicators as predictors of life events 1981-1992 based on the UK ONS longitudinal study. Journal of Epidemiology and Community Health, 52(4), 228–233.
63. Seaton, S. E., Field, D. J., Draper, E. S., Manktelow, B. N., Smith, G. C. S., Springett, A., & Smith, L. K. (2012). Socioeconomic inequalities in the rate of stillbirths by cause: a population-based study. BMJ Open, 2(3), e001100.

64. Smeeton, N. C., Rona, R. J., Dobson, P., Cochrane, R., & Wolfe, C. (2004). Assessing the determinants of stillbirths and early neonatal deaths using routinely collected data in an inner city area. BMC Medicine, 2.

65. Smith, L. K., Draper, E. S., Manktelow, B. N., & Field, D. J. (2009). Socioeconomic inequalities in survival and provision of neonatal care: population based study of very preterm infants. BMJ, 339(dec01 1), b4702–b4702. https://doi.org/10.1136/bmj.b4702

66. Smith, L. K., Manktelow, B. N., Draper, E. S., Boyle, E. M., Johnson, S. J., & Field, D. J. (2014). Trends in the incidence and mortality of multiple births by socioeconomic deprivation and maternal age in England: population-based cohort study. BMJ Open, 4(4), e004514.

67. Smith, L., Blondel, B., & Zeitlin, J. (2020). Producing valid statistics when legislation, culture and medical practices differ for births at or before the threshold of survival: report of a European workshop. BJOG: An International Journal of Obstetrics & Gynaecology, 127(3), 314–318.

68. Still-Birth (Definition) Act 1992. Chapter 34. London: HMSO; 1992.

69. Tezcan, B., Khazaezadeh, N., Ash, A., & Oteng-Ntim, E. (2011). Social disparity and intrauterine death: from politics to policies. Journal of Obstetrics and Gynaecology, 31(6), 507–508.

70. Timmermans, S., Bonsel, G. J., Steegers-Theunissen, R. P. M., MacKenbach, J. P., Steyerberg, E. W., Raat, H., Verbrugh, H. A., Tiemeier, H. W., Hofman, A., Birnie, E., Looman, C. W. N., Jaddoe, V. W. V., & Steegers, E. A. P. (2011). Individual accumulation of heterogeneous risks explains perinatal inequalities within deprived neighbourhoods. European Journal of Epidemiology, 26(2), 165–180.

71. Townsend P. (1987), 'Deprivation', Journal of Social Policy, 16(2), pp. 125-146.

72. Tricco, AC, Lillie, E, Zarin, W, O'Brien, KK, Colquhoun, H, Levac, D, Moher, D, Peters, MD, Horsley, T, Weeks, L, Hempel, S et al. (2018) PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med.169(7):467-473.

73. Valizadeh A, Moassefi M, Nakhostin-Ansari A, Hosseini Asl SH, Saghab Torbati M, Aghajani R, Maleki Ghorbani Z, Faghani S. (2022) Abstract screening using the automated tool Rayyan: results of effectiveness in three diagnostic test accuracy systematic reviews. BMC Med Res Methodol. Jun 2;22(1):160.
74. Vos AA, Posthumus AG, Bonsel GJ, Steegers EA, Denktaş S (2014). Deprived neighborhoods and adverse perinatal outcome: a systematic review and meta-analysis. Acta Obstet Gynecol Scand. 93(8),727-40.
75. Weightman, A. L., Morgan, H. E., Shepherd, M. A., Kitcher, H., Roberts, C., & Dunstan, F. D. (2012). Social inequality and infant health in the UK: systematic review and meta-analyses. BMJ Open, 2(3).
76. Wood, A. M., Pasupathy, D., Pell, J. P., Fleming, M., & Smith, G. C. S. (2012). Trends in socioeconomic inequalities in risk of sudden infant death syndrome, other causes of infant mortality, and stillbirth in Scotland: population based study. BMJ, 344(mar16 2), e1552–e1552.
77. World Bank (2023) The World Bank Data. World Bank Group. [accessed 25/04/2023] https://data.worldbank.org/indicator/SP.POP.TOTL?locations=XT-XD
78. World Health Organisation. Social Determinants of Health. Available at https://www.who.int/health-topics/social-determinants-of-health#tab=tab_1
79. World Health Organization. (2008). Closing the Gap in a Generation: Health Equity through Action on the Social Determinants of Health (Final Report of the Commission on Social Determinants of Health). World Health Organization.
80. Zelenina, A., Shalnova, S., Maksimov, S., & Drapkina, O. (2022). Classification of Deprivation Indices That Applied to Detect Health Inequality: A Scoping Review. International Journal of Environmental Research and Public Health, 19(16).

Supplementary Table I: Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	2-4
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	4
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	N/A
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	4-5
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	5
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Supplementary Table II
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	5-6
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	6-7
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	6-7
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	6-7

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	6 (Figure 1)
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	9-11 (Table I)
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	14-19 (Table II)
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	12-13, 20, 23
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	24-28
Limitations	20	Discuss the limitations of the scoping review process.	28-29
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	30
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	N/A

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850

Supplementary Table II: Full electronic search strategy terms for database Pubmed

Database: Pubmed Date: 07/05/2023		
	Search Terms	**Results**
Concept 1 Problem		
	TI/AB Depriv*	
	TI/AB Poverty	
	TI/AB Inequal*	
1	Search with OR	177,205
Concept 2 Setting		
	TI/AB Area-level	
	TI/AB Area	
	TI/AB Neighbourhood*	
	TI/AB Index*	
	TI/AB Geograph*	
	TI/AB Measure	
	TI/AB Location	
	TI/AB Score*	
	TI/AB Calculation	
	TI/AB Formula*	
	TI/AB Social	
	TI/AB Sociodemographic*	
	TI/AB Socioeconomic*	
2	Search with OR	5,083,059
Concept 3 Population		
	TI/AB Fetal	
	TI/AB Perinatal	
	TI/AB Pregnanc*	
	TI/AB Intrauterine	
	TI/AB Neonat*	
	TI/AB Intrapartum	
	TI/AB Infant	
3	Search with OR	1,170,367
Concept 4 Impact and Outcome		
	MESH Stillbirth	
	MESH Fetal death	
	MESH Perinatal mortality	
	MESH Miscarriage	
	TI/AB Loss	
	TI/AB Death	
	TI/AB Demise	
	TI/AB Mortalit*	
4	Search with OR	2,731,496
5	1 AND 2 AND 3 AND 4	1,902

Supplementary Table III: Deprivation indices included in this review

Deprivation index	Specific measures used
Index of Multiple Deprivation (IMD)	Income, employment, education, health, crime, barriers to housing and services and living environment.
Welsh Index of Multiple Deprivation (WIMD)	Income, employment, health, education, access to services, housing, community safety, physical environment.
Bavarian Index of Multiple Deprivation (BIMD)	Income, employment, education, municipal/district revenue, social capital, environment, security.
Multiple Deprivation Index (MDI) Chile	Crime, education, surrounding green areas, housing, demographics, and Mapuche population.
New Zealand Deprivation Index (NZDep)	In single parent families and aged under 60, on means tested benefit and aged 18-59, below threshold for equivalised household income, without access to a car and aged 18 or over, without qualifications and aged 18-59, unemployed and aged 18-59, separated or divorced and aged 18-59, not in owned home, below threshold for equivalised occupancy, separated or divorced and aged 60 or over.
Dutch index of deprivation	Housing, employment, education, integration and safety.
Social deprivation index (SDI) Brazil	Proportion of permanent private homes that are: a) without water supply connected to the main network, b) with no garbage removal service, c) without a bathroom for the exclusive use of people living there, d) without sewage collection through the main general network for either sewage or pluvial discharge, e) with no nominal monthly income, and f) in which the person responsible for the home was illiterate.
Social Deficiency Index (ICS) Brazil	Proportion of women heads of household, without complete elementary school, and with children under 15 years of age; dependency ratio; distortion rate of secondary education due to total administrative dependency (state, municipal, federal or private); proportion of the population with bathroom and running water; proportion of unemployed persons aged 18 years old or older; and proportion of the extremely poor and mean household income of those vulnerable to poverty.
Socioeconomic status indicator (SESI) Argentina	Percentage of the population who lived in an urban area, had no access to running water or sewer system, had gas connection, met any indicator of unmet basic needs (UBNs), completed only primary education, owned a house, and were employed.
Townsend deprivation score (TDS)	Unemployment, non-car ownership, non-home ownership, and household overcrowding.
Jarman score	Percentage of: elderly living alone, children under 5, unskilled workers, overcrowded households, changed address in last year, ethnic minorities, unemployed, households containing lone parents.

Carstairs socioeconomic deprivation score	Car ownership, male unemployment, overcrowding and low social class.
Carstairs-Morris scores	An extension of the Carstairs score, additional variable of low educational attainment and material deprivation.
'Townsend/Carstairs like' index	The proportion of the labour force unemployed; proportion of households with no car access; proportion of households not owner occupied, and the proportion of employed men and women in Social Class 4 or 5.
Index of Relative Socio-Economic Disadvantage for Western Australia	Income between $1 and $25,999 per year, families with children under 15 years of age who live with jobless parents, occupied private dwellings with no internet connection, people aged 15 years and over whose highest level of education is Year 11 or lower, people (in the labour force) who are unemployed, employed people classified as Labourers, occupied private dwellings paying rent less than $215 per week (excluding $0 per week), one parent families with dependent offspring only, people under the age of 70 who have a long-term health condition or disability and need assistance with core activities, people aged 15 years and over who are separated or divorced, employed people classified as Machinery Operators and Drivers, employed people classified as low skill Community and Personal Service workers, occupied private dwellings with no cars, occupied private dwellings requiring one or more extra bedrooms, people aged 15 years and over who have no educational attainment, and people who do not speak English well.
Deprived neighborhoods determined by Dutch government	40 deprived neighbourhoods identified based on: Physical deprivation, propensity to move, level of education, average disposable income per household, employment rates, physical nuisance based on 4 indicators, social nuisance based on 5 indicators, dwelling dissatisfaction, environment dissatisfactions, rates of notified crime and rates of insecurity.
Department of Environment Index (DoE) UK	Social, economic, housing.
National Operations Department report Sweden	Characterized by low socioeconomic resources with high rates of unemployment, foreign-born individuals, overcrowding, a high grade of segregation, criminality and norm-breaking behaviours.

Supplementary Figure 1: Bar chart of most common measures included in indices