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A systematic review of the association between alcohol-related deaths and area-level socioeconomic deprivation and other geographic characteristics in high-income countries

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Title page

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List of abbreviations

ALRD	alcohol-related liver disease
BAC	blood alcohol concentration
CAPE	Canadian Alcohol Policy Evaluation
CASP	Critical Appraisal Skills Programme
DCI	Distressed Communities Index
ERI	Economic Resilience Index
EU	European Union
HIQA	Health Information and Quality Authority
HRB	Health Research Board
HSE	Health Services Executive
IMD	Index of Multiple Deprivation
IPH	Institute of Public Health
IRSAD	Index of Relative Socioeconomic Advantage and Disadvantage
JBI	Joanna Briggs Institute
NCD	Noncommunicable diseases
NHLBI	National Heart, Lung, and Blood Institute
OECD	Organization for Economic Cooperation and Development
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RTC	road traffic collisions
SDGs	Sustainable Development Goals
SES	Socioeconomic status
UN	United Nations
USA	United States of America
WHO	World Health Organization

1 Abstract

Background

There are substantial inequalities in alcohol-related mortality related to individual-level education, income, and employment status, but less is known about the association between alcohol-related mortality and the geographic characteristics of an area. This systematic review aims to explore whether area-level features, including area-level measures of socioeconomic status, are associated with alcohol-attributable mortality.

Methods

We systematically searched Medline (Ovid), CINAHL, EMBASE, PsycINFO, Web of Science, Emerald Insight, and Epistemonikos databases (2004 – 2024), supplemented with searches of grey literature, for primary quantitative studies conducted in high-income countries. Eligible studies examined associations between alcohol-attributable morality and one or more geographic characteristic. Studies were quality appraised using the Joanna Briggs Institute Critical Appraisal Checklist for Analytical Cross-Sectional Studies, the Critical Appraisal Skills Programme for cohort studies, and the National Heart, Lung and Blood Institute checklist was adapted for assessing ecological studies. The findings were synthesised narratively. PROSPERO ID: CRD42024499928.

Results

The searches identified 73 eligible studies covering mortality from a range of alcohol-attributable conditions, including chronic alcohol-specific conditions (e.g. alcohol-related liver disease) and alcohol-related incidents (e.g. road traffic collisions, suicides). Study quality was found to be good in most cases. Urban-rural location was the most common exposure and alcohol-specific mortality was the most common outcome measured in the included studies. Of the 34 studies examining area-level socioeconomic deprivation, all studies found a positive association between deprived areas and alcohol-attributable mortality. Of the 49 studies that examined urban-rural location, 26 (53.1%)

found a positive association between rural location and alcohol-attributable mortality. Fourteen studies (28.6%) found urban location significant. Rural locations were particularly associated with alcohol-related road traffic collisions and suicides.

Conclusions

Greater area-level deprivation and rurality are associated with higher rates of alcohol-related mortality.

Key words: Alcohol mortality, geography, urban-rural, area-based socioeconomic status, deprivation

2 Background

The United Nations (UN) Sustainable Development Goals (SDGs) require countries to reduce harmful use of alcohol and inequalities in outcomes (1). Alcohol use is the tenth leading cause of death and losses in disability-adjusted life years, and is responsible for 5.3% of all deaths globally (2). Despite an overall decline in per capita alcohol use across high-income countries (from an average of 8.9 litres of in 2011 to 8.6 litres in 2021), alcohol-attributable mortality has increased in many of these countries (3–5). Associated not only with chronic conditions including alcohol dependence, alcohol-related liver disease, cardiovascular disease, and cancer, alcohol use is also associated with traumatic incidents such as suicide, drowning, residential fires, homicide and road traffic collisions (RTC) (6–10). For example, drink driving, which is well-recognised as a risk factor for injuries and death related to RTCs, remains high globally despite extensive road safety campaigns and drink-driving legislation (11). Globally, 1.35 million people die every year due to RTCs (12) and between 5%–35% are alcohol-related (13).

Alcohol use and related health harms are influenced by a range of characteristics at an individual-level, such as sex, age, ethnicity and employment status and these have been examined in detail in three systematic reviews (14–16). These reviews found that, firstly, alcohol use was responsible for

about 27% of the health differences between different socioeconomic groups, and that drinking patterns, especially heavy episodic drinking, were particularly important in explaining these health outcomes (16). Secondly, educational attainment is an important indicator of alcohol-attributable mortality, with lower education levels associated with increased alcohol-attributable mortality (15). Thirdly, lower individual socioeconomic status (SES) was found to be associated with increased alcohol-attributable mortality compared with all-cause mortality (14). This is despite evidence indicating that individuals residing in affluent neighbourhoods with higher SES are more likely to consume alcohol frequently and in greater quantities (17). Importantly, despite higher consumption patterns, their individual-level SES provides a protective effect against alcohol-attributable mortality (18). This phenomenon is referred to as the Alcohol Harm Paradox (AHP) (19–21).

Area-level factors also shape alcohol use and related-health outcomes, including mortality, as defined by the ecosocial theory (22–24). The ecosocial theory is a framework used to understand the complex relationships between social factors and disease distribution and integrates biological, psychosocial, and ecological perspectives to explain how social determinants impact health outcomes throughout a person's life (25). The ecosocial theory explains how our bodies physically incorporate the environment and social conditions we live in and so our health is shaped by our surroundings and experiences over time. The theory highlights how exposures to risks, vulnerabilities, and resistances to disease are shaped by SES and life experiences.

These area-based features include the built environment, and community features such as service availability, and transportation (26–30) and studies have shown that these factors influence alcohol use and its related health impacts (31–34). For example, the association between the higher density of premises selling alcohol within a neighbourhood and increased alcohol use and related-harm has been well documented (35–41). Area-level characteristics are important to consider, particularly in rapidly changing communities.

Several previous reviews have explored the relationship between area-level characteristics and mortality, and some have included alcohol-related deaths as part of their broader analyses. For example, rural areas have been identified as settings with a higher incidence of fatal RTCs and suicides, with alcohol mentioned in some cases as a potential contributing factor (27,42–46).

Systematic reviews examining the literature on "deaths of despair" (i.e. suicide, drug poisoning, and alcohol-related liver disease deaths) similarly report elevated mortality in rural and socioeconomically deprived areas, particularly in communities affected by structural economic changes, such as job losses in manufacturing industries (46,47). A limitation of these reviews is that drug-related deaths and suicides are grouped with alcohol-related deaths under the umbrella term 'deaths of despair' which may mask differences in underlying causes and risks. Related work on how area-level social determinants influence health inequalities (27) further highlights strong links between area-level deprivation and alcohol-related harms, including RTCs and liver disease (48) .

Additionally, several reviews have investigated urban–rural differences in all-cause mortality, that include deaths attributable to alcohol (49,50), as well as the spatial distribution of other drug-related mortality (51). Previous reviews have not brought together the wider literature on area-based characteristics and alcohol-attributable mortality. This study aims therefore to conduct a systematic review of literature on the relationship between area-level characteristics and alcohol-related mortality in high-income countries.

3 Methods

The study protocol for this systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (52) and was preregistered in PROSPERO (registration number CRD42024499928) (53).

3.1 Search strategy

A systematic literature search of seven databases was conducted between 29th December 2024 and 3rd January 2025. The search strategy included terms related to deaths (e.g. death* or mortality* or fatal*), and alcohol (e.g. alcohol*), as well as alcohol-specific conditions (e.g. alcohol* adj hepatit*, adj liver*, adj poisoning, adj pancreatitis or accidents or traffic or road), and geographic features (e.g. socio?economic or SES or disadvantage*or social inequ*or urban or rural or geographi* variation or spatial inequalities or neighbo*rhood or hotspot).

Supplementary Table 1 provides the search terms used for Medline (Ovid), CINAHL, EMBASE, PsycINFO, Web of Science, Emerald Insight, and Epistemonikos. Studies were included if they were published since 2004 (i.e. the last 20 years) to ensure findings have contemporary relevance for informing recommendations for policy and practice. Grey literature searching included searches of Google, Google Scholar, and websites of relevant organisations (See Supplementary Table 2) as well as backwards and forwards citation checking of included studies and of key systematic reviews.

3.1.1 Population

The population for this study is the general population with no restrictions on age and was limited to studies of Organization for Economic Cooperation and Development (OECD) high-income countries, as classified by the World Bank (54). This restriction was applied due to differing alcohol consumption patterns and policies in low- or middle-income countries (13). Studies of specific populations were excluded, such as those that limited the sample to people experiencing homelessness, or those with a specific diagnosis or condition such as epilepsy.

3.1.2 Exposure

We include geographic characteristics measured at both individual-level (i.e. studies where individuals are the unit of analysis and data is collected on geographic characteristics of where they live, such as rurality) and area-level (i.e. studies where areas are the unit of analysis and both exposure and outcome measures are area-based). Eligible characteristics include area-based measures of deprivation including those that define the SES of an area based on domains such as

income, employment, education, skills and training, health and disability, crime, housing, living environment and/or ownership of specific goods or items. Other geographical characteristics of interest include urban and rural differences, green areas or spaces, number and accessibility of services, proportion of migrants within a specific area, density or prevalence of public amenities, or neighbourhood cohesion. We did not include studies examining the association between density of licensed premises and alcohol-related mortality due to the extensive review literature available on this particular topic (35–37,55,56).

3.1.3 Outcome

The outcome is death directly due to alcohol use or related to alcohol use. Deaths were categorised according to their diagnosis. We focused on four groups of alcohol-related deaths as they were broadly presented in the literature. First, alcoholic-specific deaths where the cause of death was directly attributable to alcohol consumption (See Supplementary Table 6) (57,58), second, alcohol-related deaths in which the underlying cause of death was not necessarily directly attributable to alcohol, but alcohol use played a significant role in the development or exacerbation (59–61), third, alcohol-related RTCs, and fourth, alcohol-related suicides.

Study design

Study design was limited to full papers reporting original research findings (not conference abstracts, commentaries, etc.); in English (or were translatable into English using DeepL translation tool). Quantitative study designs were eligible for inclusion and where a study used mixed methods, the quantitative element was included. Although systematic reviews and meta-analyses were not included, their citations (forwards and backwards) were searched for additional studies.

3.2 Screening

The study selection process was guided by PRISMA guidelines to ensure transparency and methodological rigor, see Supplementary Table 7 for the PRISMA checklist. All records were

deduplicated using EPPI-Reviewer and all titles and abstracts were screened in EPPI-Reviewer. Prioritisation tools within EPPI-Reviewer were not used. The original authors of five studies were contacted for further information or data to determine eligibility. One responded and provided raw data (62) and the remaining four did not reply or were not contactable and these studies were therefore excluded due to insufficient information.

3.3 Data extraction

Data was extracted from full text publications by AD. A data extraction form was developed and included characteristics of the studies (study design, time period, location), participants (age group, sex and sample size), measures (geographic characteristics examined, including tool used to measure SES and/or urban-rural location and the type of alcohol-attributable death including ICD-10 codes, or equivalent, if applicable), statistical methods used, and outcomes (main findings). Where cross sectional or longitudinal studies examined changes in associations over time, the most recent findings were considered.

3.4 Quality assessment

To assess risk of bias, a single reviewer (AD) carried out quality appraisal of included studies. The studies used in this review were a mix of ecological studies, prospective cohort studies and cross-sectional studies. We used the National Heart, Lung, and Blood Institute (NHLBI) Quality Assessment Tool to assess the quality of the ecological studies in the absence of a more specific tool to address this type of study design [42]. As ecological studies use aggregated population-based data to describe an outcome in relation to an exposure and cannot prove causality, this study type is vulnerable to ecological fallacy (63). Ecological studies are not usually on the hierarchy of evidence, as their role is to suggest rather than prove causal relationships and therefore, for each ecological study, we calculated an overall quality rating based on four items (3, 4, 5, and 14) from the tool most appropriate for assessing ecological studies (Supplementary Table 3). These items identified the aspects most likely to introduce bias through unrepresentative sampling and confounding. The NHLBI

Quality Assessment Tool has limitations for ecological studies because it is designed for individual-level data and does not account for group-level analysis, ecological fallacy, or context-specific biases inherent in ecological designs. Although we considered the ROBINS I tool, it is designed for interventional longitudinal studies rather than cross-sectional studies, which comprised a large proportion of our research. It is important to note that all ecological studies have inherent biases, particularly regarding confounding, and cannot be classified as low risk of bias. Consequently, all studies would be at high risk of bias based on ROBINS I, preventing discrimination between higher and lower quality studies.

We used the Critical Appraisal Skills Programme (CASP) checklist for longitudinal studies (Supplementary Table 4), and we used the Joanna Briggs Institute Critical Appraisal for Analytical Cross-Sectional Studies for cross-sectional studies (Supplementary Table 5). All studies were included regardless of quality. We did not make qualitative comparisons across study designs, as each design was appraised using tools tailored to its methodological structure, and direct comparisons of quality or risk of bias are not appropriate.

3.5 Synthesis

A descriptive narrative synthesis of the study characteristics is presented followed by a synthesis of the results by outcomes. Data from the included publications have been grouped according to the cause of alcohol-attributable death and further organised by the geographic features of those deaths. A meta-analysis was not conducted due to the variations in study designs and in the population and exposures, making it difficult to combine results for meaningful analysis. We followed the Synthesis Without Meta-analysis (SWiM) guideline, including its Explanation and Elaboration document, to transparently report our narrative synthesis methods and decisions (See Supplementary Table 8).

3.6 Changes to registered protocol

Additional databases were searched in addition to those listed in the registered protocol. The following databases were added after registering the protocol to broaden the search, Web of Science, Emerald Insight, and Epistemonikos.

4 Results

The searches of electronic databases returned 9,294 records. A further 3,247 records were identified through forwards and backwards citation checking and through grey literature searching (Supplementary Table 2). Following de-duplication, 8,683 studies remained, of which 334 were screened on full text and 73 studies met the inclusion criteria (Figure 1).

Due to the nature of this systematic review forming part of a PhD study, not all studies were double screened, rather, a sample of 10% of studies matching the search terms were title and abstract screened by a second reviewer (LM). Of the 88 studies with disagreements (primarily due to clarifying the inclusion and exclusion criteria), all were reconciled via consensus by AD and LM. Full text screening was completed by AD and again, the second reviewer screened 10% of these studies. Agreement was reached on all but one, but this was reconciled subsequently.

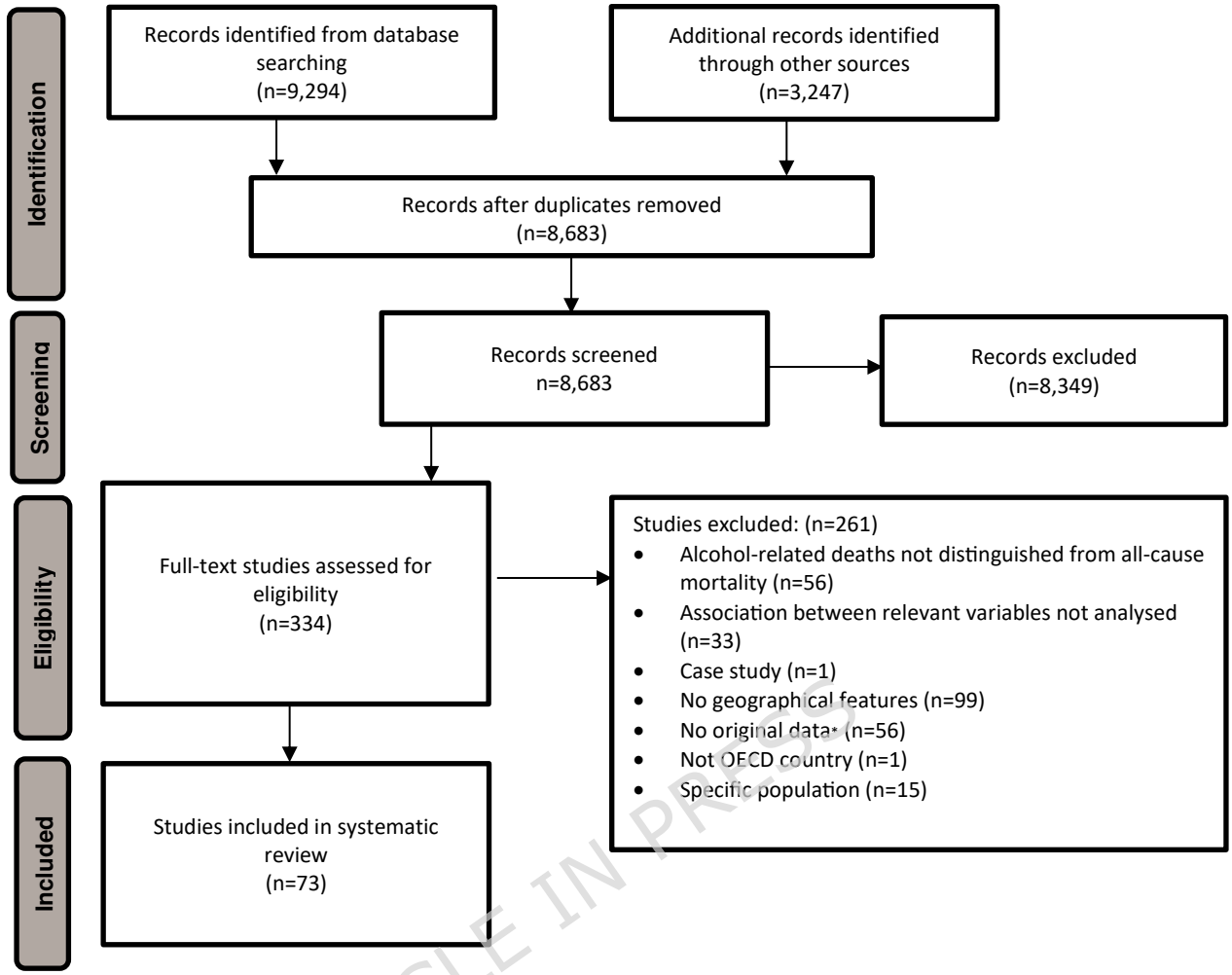

Figure 1 Studies identified through search and studies screened – PRISMA

*More up-to-date data available from same data source

4.1 Quality appraisal results

Overall, the quality of the included studies was good (See Supplementary Table 3, Supplementary Table 4, and Supplementary Table 5). Using the NHLBI quality assessment tool, we considered seven of the ecological studies to be moderate to high quality (64–70). The remaining ecological study scored lower (71) due to not reporting variance and effect estimates.

Using the CASP checklist for cohort studies, the longitudinal studies scored moderate to high (n=23). Two studies received a rating of low quality due to the findings not aligning with other available evidence (62,72). We used the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies.

Nineteen cross-sectional studies were considered high quality, 19 were moderate, and two were low quality (73,74) as confounding variables were not adequately considered.

4.1.1 Study characteristics

Table 1 provides details of the study characteristics of the 73 studies included. The countries with the largest numbers of studies were the United States of America (USA) (n=18, 24.7%) followed by Scotland (n=8, 11.0%) and Australia (n=8, 11.0%). Over one-third of the included papers were published during the final four years of the study period 2021–2024 (n=28, 38.4%).

Alcohol-specific deaths were the outcome in more than half of the included studies (n=42, 57.5%) and RTCs with involvement of alcohol use accounted for 17.8% (n=13). Urban-rural characteristics of alcohol-attributable deaths were examined in 49 studies (67.1%) and various measures of area-based SES were examined in 34 studies (46.6%). With the exception of one study that used the percentages of people who were unemployed within an area only (75), all other studies that examined area-based SES used multi-criteria indices of deprivation, most commonly a combination of educational achievement, employment status, housing tenure and/or car availability. Other geographical characteristics examined in 8 studies included proportion of population with a migrant background within an area, social fragmentation, and coastal or inland locations. A summary of the key characteristics and results of the included studies can be found in Table 2.

Table 1 Study characteristics

	Study characteristics	Number of studies	% of included studies
Design	Area-level	31	42.5
	Individual level[#]	42	57.5
Location∞	USA	18	24.7
	Scotland	8	11.0
	Australia	8	11.0
	Poland	6	8.2
	England	6	8.2
	Canada	5	6.8
	Finland	4	5.5
	Northern Ireland	4	5.5

	Other	14	19.2
Geographical feature*	Urban/Rural	49	67.1
	Area-based SES	34	46.6
	Other geographical feature	8	11.0
Type of alcohol-attributable death	Alcohol-specific	42	57.5
	Alcohol-related road traffic collisions	13	17.8
	Alcohol-related	13	17.8
	Alcohol-related suicide	5	6.8
SES indicator	Index of Multiple Deprivation (IMD)ǂ	13	17.8
	Carstairs deprivation scores	6	8.2
	Gini Index	5	6.8
	Distressed Communities Index (DCI)	2	2.7
	Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD)	2	2.7
	Economic Resilience Index (ERI)	1	1.4
	Other	14	19.2
Year of study	2004–2010	10	13.7
	2011–2015	16	21.9
	2016–2020	19	26.0
	2021–2024	28	38.4

#Area-level studies refers to those where individuals are the unit of analysis and data is collected on geographic characteristics of where they live

*Some studies used more than one geographical feature so the numbers add up to more than the number of studies.

∞ Some studies were conducted in two countries and both countries are listed under 'Location', therefore, the number of locations add up to more than the number of included studies

ǂ Including Scottish, Welsh and Northern Irish versions

4.2 Overview of narrative synthesis findings

Table 3 summarises the findings from the included studies. Of the 34 studies that examined the association between alcohol-attributable mortality and area-level socioeconomic deprivation, all found a positive association between deprived areas and alcohol-attributable mortality, regardless of the study location.

Urban-rural location of alcohol-attributable deaths was considered in 49 studies. More than one-half of studies found that alcohol-attributable deaths were higher in rural areas (27, 55.1%) compared to urban areas. However the findings were not conclusive, as 28.6% of the included studies examining urban-rural location found urban areas were more likely to be associated with alcohol-attributable

mortality (n=28.6%), and 14.3% of studies found no significance between urban-rural location and alcohol-attributable mortality.

Our included studies found rural location was positively associated with alcohol-related RTCs (n=9, 69.2%). Rural location was also positively associated with alcohol-related suicides (76–78) although two studies found no significant difference between urban-rural location and the rate of alcohol-related suicides (79,80).

Twelve studies looked at both urban-rural location and area-level socioeconomic deprivation (18,66,71,72,75,78,81–86). All found a positive association between alcohol-attributable mortality and area-level socioeconomic deprivation. However, the urban-rural findings of these studies varied based on the geographic location in which the study was conducted. For example, European studies that focussed on area-level socioeconomic deprivation as well as urban-rural location more frequently identified deprived urban areas as having a higher risk (71,82,84,86). In contrast, studies from North America and Australia more frequently found that deprived rural areas are associated with greater risk (66,78,81,85).

Table 2 Summary of data extraction for included studies, by country (n=73)

First author (year)	Study design	Study time period	Setting	Alcohol-related 0utcome	Sample size	Age group	Sex	Geographic characteristic	Direction associated with alcohol-related deaths
Scotland									
National Records for Scotland (2024) (75)	Cross-sectional	2023	Scotland	Sp	1277	All	M/F	U/R, SES	Deprived; Urban
Allik (2020) (118)	Longitudinal	2001–2018	Scotland	Sp/R	761	15–44	M	SES	Deprived
Brown (2019) (121)	Longitudinal	1981–2012	Scotland	Sp	G	All	M/F	SES	Deprived
Scottish Health Action on Alcohol Problems (2018) (95)	Cross-sectional	2000–2017	Scotland	Sp	1235	All	M/F	SES	Deprived
Pulford (2018) (106)	Longitudinal	2013	Scotland	Sp	1458	21+	M/F	SES	Deprived
Exeter (2011) (120)	Longitudinal	1980–1982 and 1999–2001	Scotland	Sp	1214	<65	M/F	SES	Deprived
Brown (2010) (88)	Cross-sectional	2000–2002	Scotland	Sp	G	All	M/F	SES	Deprived
Leyland (2007) (117)	Longitudinal	1980–1982, 1991–1992, 2000–2002	Scotland	Sp/R	G	All	M/F	SES	Deprived
England/Wales									
Camacho (2024) (93)	Cross-sectional	2019–2021	England	Sp	G	All	M/F	SES, C	Deprived; Coastal areas
United Kingdom. Office for National Statistics (2024) (49)	Cross-sectional	2022	England	Sp	7912	All	M/F	SES	Deprived
Subhani (2022) (98)	Cross-sectional	2021	England	Sp	799	18+	M/F	SES	Deprived
Alexiou (2021) (113)	Longitudinal	2013–2019	England	Sp	G	All	M/F	SES	Deprived
United Kingdom. Office for National Statistics (2021) (102)	Cross-sectional	2011–2018	England	Sp	4520	All	M/F	C	Coastal regions
United Kingdom. Office for National Statistics (2021) (103)	Cross-sectional	2001–2020	England and Wales	Sp/R	1996	All	M/F	SES	Deprived
Strong (2012) (109)	Longitudinal	1999–2003	England	Sp	607	All	M/F	SES	Deprived
United Kingdom. Office for National Statistics (2024) (49)	Cross-sectional	2022	Wales	Sp	486	All	M/F	SES	Deprived
Erskine (2010) (62)	Ecological	1999–2003	England and Wales	Sp	28839	All	M/F	SES, U/R	Deprived; Urban
Breakwell (2007) (92)	Cross-sectional	1991–2004	England and Wales	Sp	G	All	M/F	SES	Deprived
Poland									
Silczuk (2023) (90)	Cross-sectional	2020–2021	Poland	Sp	9836	All	M/F	U/R	Rural

Karnecki (2023) (71)	Longitudinal	2010–2019	Poland	S	528	All	M/F	U/R	NS urban-rural
Lyubinets (2021) (124)	Cross-sectional ecological	2008, 2018	Poland	Sp	G	16-65	M/F	U/R	Urban
Lasota (2020) (81)	Cross-sectional	2009–2019	Poland	RTC	166	All	M/F	U/R	Rural
Lasota (2019) (87)	Cross-sectional	2009–2013	Poland	RTC	114	18+	M/F	U/R	Rural
Wojtyniak (2005) (53)	Longitudinal	1986–2002	Poland	Sp	G	20+	M/F	U/R	Urban
Finland									
Koskela (2017) (82)	Cross-sectional	2007–2011	Finland	Sp	384	All	M/F	U/R	Rural
Raatiniemi (2016) (104)	Cross-sectional	2007–2011	Finland	Sp/R	515	All	M/F	U/R	NS urban-rural
Lehikoinen (2016) (63)	Longitudinal	1992–2008	Finland	Sp/R	1935	25-74	M/F	SES, U/R	Deprived; NS urban-rural
Blomgren (2004) (18)	Cross-sectional	1991–1996	Finland	Sp/R	9820	25–64	Male	SES, U/R, CC	Deprived; Rural; Low level community cohesion
Northern Ireland									
Northern Ireland Statistics and Research Agency (2024) (64)	Cross-sectional	2018–2022	Northern Ireland	Sp	1677	All	M/F	SES	Deprived
Hughes (2021) (77)	Longitudinal	2011–2017	Northern Ireland	Sp	2120	16–74	M/F	U/R, SES	Deprived; Urban
Northern Ireland Statistics and Research Agency (2019) (97)	Cross-sectional	2018–2022	Northern Ireland	RTC	30	All	M/F	U/R	Rural
Connolly (2011) (73)	Cross-sectional	2001-2006	Northern Ireland	Sp	578	25–74	M/F	SES, U/R	Deprived; Urban
Lithuania									
Miščikienė (2024) (96)	Cross-sectional	2017–2020	Lithuania	Sp/R	8066	All	M/F	U/R	Rural
Grigoriev (2017) (83)	Cross-sectional	2011–2013	Lithuania	Sp	1424	30–64	M	U/R, CC, EM	Higher proportion of ethnic minorities; Low level community cohesion; NS urban-rural
Other European country									
Nagy (2014) (59)	Ecological	2005–2010	Hungary	Sp	G	25–64	M/F	SES	Deprived (males only)
Innamorati (2013) (56)	Ecological	1980–2003	EU countries	Sp/R	G	All	M/F	U/R	Urban
Kovše (2012) (85)	Cross-sectional	2004–2008	Slovenia	Sp	G	All	M/F	SES	Deprived
Rosicova (2011) (91)	Cross-sectional	2001–2003	Slovakia	Sp	G	20-64	M/F	SES	Deprived (males only)
Gjerde (2011) (80)	Cross-sectional	2006–2008	Norway	RTC	196	All	M/F	U/R	Urban

Australia									
Ministry of Health New South Wales (2022) (76)	Cross-sectional	2010–2019	Australia	Sp/R	1452	All	M/F	U/R, SES	Deprived; Rural
Adair (2021) (72)	Longitudinal	2006–2016	Australia	Sp	G	35–74	M/F	SES, U/R	Deprived; Rural
Wundersitz (2017) (84)	Cross-sectional	2008–2010	Australia	RTC	95	16+	M/F	U/R	Rural
Senserrick (2014) (61)	Ecological	2004–2008	Australia	RTC	60	All	M/F	U/R	Rural
Jayasekara (2014) (60)	Ecological	2000–2007	Australia	Sp/R	G	15+	M/F	U/R	Rural
Hurzeler (2011) (69)	Cross-sectional	2010–2015	Australia	S	2734	All	M/F	SES, U/R	Deprived; Rural
Czech (2010) (79)	Cross-sectional	2001–2007	Australia	RTC	264	All	M/F	U/R	Rural
Dietze (2009) (74)	Cross-sectional	2000	Australia	Sp	885	All	M/F	SES, U/R	Deprived; Urban
USA									
Sumetsky (2024) (115)	Longitudinal	2017–2020	USA	Sp/R	11632725	18+	M/F	U/R	Urban
Saunders (2024) (114)	Longitudinal	2012–2022	USA	Sp	51191	All	M/F	U/R	Rural
Zhang (2024) (57)	Ecological	2014–2019	USA	Sp	G	25-64	M/F	SES, U/R	Deprived; Rural
Folk (2024) (101)	Cross-sectional	1999–2020	USA	Sp	373302	All	M/F	B, U/R	Border areas - urban Non-border areas - rural
Rudisill (2023) (89)	Cross-sectional	2009–2019	USA	RTC	80	All	M/F	U/R	NS urban-rural
Warren (2022) (99)	Cross-sectional	2020	USA	Sp	49061	All	M/F	U/R	Rural
Cataldo (2022) (119)	Longitudinal	2010–2014 and 2015–2019	USA	Sp	G	All	M/F	U/R	Urban
Zemore (2022) (86)	Cross-sectional	2008–2017	USA	Sp	G	All	M/F	U/R, B,	Rural; Border areas
Braun (2022) (122)	Longitudinal	2000–2018	USA	Sp	8543	15+	M/F	U/R	Rural
Moon (2020) (105)	Longitudinal	1999–2017	USA	Sp	22231	25+	M/F	U/R	Rural
Ransome (2020) (55)	Ecological	2009–2014	USA	Sp/R	1036	18+	M/F	SES	Deprived
Spencer (2020) (123)	Longitudinal	2000–2018	USA	Sp	495393	25+	M/F	U/R	Rural
Shiels (2020) (66)	Longitudinal	2000–2017	USA	Sp	364733	20-64	M/F	SES, U/R	Deprived; 6 levels of urban-rural continuum, alcohol related deaths were highest in the 3rd and 4th
Yao (2016) (110)	Longitudinal	1996–2006	USA	RTC	G	All	M/F	U/R	Rural
Caetano (2013) (70)	Cross-sectional	2003–2009	USA	S	8798	All	M/F	U/R	NS urban-rural

Kaplan (2013) (67)	Cross-sectional	2003–2009	USA	S	57813	18+	M/F	U/R	Rural
Geedipally (2011) (94)	Cross-sectional	2003–2008	USA	RTC	1305	All	M/F	U/R	Urban
Baeseman (2009) (107)	Longitudinal	1999–2006	USA	RTC	1547	All	M/F	U/R	Rural
Canada									
Hunter (2023) (111)	Longitudinal	2006–2019	Canada	Sp	1380	19-65	M/F	SF	Social fragmentation
Reccord (2021) (68)	Cross-sectional	1997–2016	Canada	S	345	10+	M/F	U/R	Rural
Subedi (2019) (100)	Cross-sectional	2011–2015	Canada	Sp	G	All	M/F	U/R	Rural
Gaudet (2015) (116)	Longitudinal	1998–2011	Canada	RTC	25	All	M/F	U/R	Urban
Auger (2012) (108)	Longitudinal	1991–2001	Canada	Sp	G	25+	M/F	SES	Deprived
South America									
Castillo-Carniglia (2014) (58)	Ecological	2004–2009	Chile	Sp/R	G	15+	M/F	SES	Deprived
Arreola-Rissa (2008) (78)	Cross-sectional	Feb 2003–July 2003	Mexico	RTC	77	All	M/F	U/R	Urban
Asia									
Kinjo (2021) (112)	Longitudinal	1995–2016	Japan	Sp	95455	All	M/F	U/R	NS urban-rural

Outcome: Sp=Alcohol specific mortality; Sp/R= alcohol-specific and alcohol-related mortality; RTC=alcohol-related road traffic collision; S=alcohol-related suicide

Sample size: G=general population rates

Sex: M=male; F=female

Geographic characteristic: SES=area-based socioeconomic status/area of deprivation; U/R=urban/rural; C=Coastal; B=border areas; SF=social fragmentation; CC=community cohesion; EM=Ethnic minorities

Findings: NS=not significant

*Table 3 Summary of associations between geographical characteristic and alcohol-attributable mortality type*ǂ*

	Alcohol-related Road Traffic Collision (n=13)	**Alcohol-related suicide (n=5)**	**Alcohol-specific (n=42)**	**Alcohol-related (n=1)**	**Alcohol-related and alcohol-specific# (n=12)**
Urban/rural	• 4 studies: Urban higher level than rural	• 3 studies: Rural higher than urban	• 8 studies: Urban higher than rural • 11 studies: Rural higher than urban • 2 studies: No significant difference	• 1 study: No significant difference	• 2 studies: Urban higher than rural

	• 7 studies: Rural higher level than urban • 1 study: No significant difference	• 2 studies: No significant difference	• 1 study: Urban in border areas and rural in non-border areas • 1 study: Highest in 3rd and 4th of 6 levels of urban-rural continuum		• 4 studies: Rural higher than urban • 1 study: No significant difference
	Total: 13 studies	**Total: 5 studies**	**Total: 23 studies**	**Total: 1 study**	**Total: 7 studies**
Area-based SES	n/a	• 1 study: Low SES higher than high SES	• 21 studies: Low SES higher than high SES • 4 studies: grey literature	n/a	• 8 studies: Low SES higher than high SES
		Total: 1 study	**Total: 25 studies**		**Total: 8 studies**
Coastal	n/a	n/a	• 2 studies: Coastal areas higher than inland areas	n/a	n/a
			Total: 2		
Social fragmentation	n/a	n/a	• 1 study: Greater social fragmentation∞ higher than lower social fragmentation	n/a	n/a
			Total: 1 study		
Border regions	n/a	n/a	• 2 studies: Border areas higher than inland/non-border areas	n/a	n/a
			Total: 2 studies		
Community cohesion	n/a	n/a	• 1 study: Less community cohesion higher than stronger cohesion	n/a	• 1 study: Less community cohesion higher than stronger cohesion
			Total: 1 study		**Total: 1 study**
Proportion of ethnic minorities	n/a	n/a	• 2 studies: Greater proportion of ethnic minorities higher than areas with fewer ethnic minorities	n/a	n/a
			Total: 2 studies		

*The numbers in the above table represent the statistically significant association between the geographical feature and alcohol-related death, e.g. the findings of 21 studies found a statistically significant positive association between low area-based SES and alcohol-specific mortality (4 studies consisted of grey literature where although the findings were positive, no statistical testing was completed.

ǂ Note that the totals do not always add up as a number of studies include more than one outcome

Alcohol-related and alcohol-specific refer to studies where the outcome was a combination of both and results not differentiated

∞ Higher social fragmentation determined by high proportions of residents living alone, being unpartnered, or having recently moved

4.2.1 Area-based socioeconomic deprivation and alcohol-attributable deaths

4.2.1.1 Alcohol-specific mortality – area-based socioeconomic deprivation

Twenty-five studies (34.2%) included analysis of alcohol-specific deaths and area-level SES, all of which found a positive association between alcohol-specific mortality and deprived areas (58,66,68,71,73,75,82–84,86–101). Such findings were applicable regardless of whether the study was multi-level or ecological, at country level or regional level, and for North American studies as well as European and Australian studies.

Several studies examining alcohol-specific mortality and the association with area-level SES had limitations that may affect the reliability of their findings, including not specifying the participation rate, and providing descriptive analysis only (71,73,74). These studies contribute valuable insights into the topic, however their lower quality means their findings should be interpreted with caution.

Several studies provided additional detail on the association between area-level SES and alcohol-specific mortality. For example, a Hungarian study specifically examined geographic characteristics of alcohol-related liver disease (ALRD) and found higher mortality rates of ARLD in the most deprived areas compared to the least deprived for both males and females (68). However, among females, ARLD mortality was higher in the fourth most-deprived quintile compared to the most-deprived (68). A study examining alcohol-attributable mortality in New York city found alcohol poisoning deaths increased by 10% with a 10% increase in poverty rates of an area (64).

Furthermore, the association between area-level disadvantage and alcohol-specific mortality was stronger among males compared to females (90,95,102). Elsewhere, moving from affluent areas within Scotland to more deprived areas over time was associated with an increase in alcohol-attributable mortality (88).

4.2.1.2 Alcohol-related mortality - area-based socioeconomic deprivation

Eight studies examined alcohol-related mortality and area-level SES. All studies found a positive association between alcohol-related mortality and areas of greater deprivation (18,64,67,72,85,100,103,104). All studies were rated as high quality with the exception of one (72).

4.2.1.3 Alcohol-related and alcohol-specific deaths combined – area-based socioeconomic deprivation

Eight studies examined area-level SES associations among both alcohol-related and alcohol-specific deaths without distinguishing between the two (18,64,67,72,85,100,103,104). All studies noted a positive association between alcohol-related and alcohol-specific deaths combined and areas of greater deprivation. One study was rated as low quality (72). Two studies controlled for individual-level SES and the positive correlation continued to exist between lower area-level SES and alcohol-related and alcohol-specific mortality (18,72).

4.2.1.4 Alcohol-related suicides - area-based socioeconomic deprivation

Typically, area-level socioeconomic deprivation has also been shown to be a risk factor in suicide prevalence regardless of alcohol involvement (105,106). Just one study included in this review examined alcohol-related suicide and its relationship with area-level SES (78). That study found higher rates of alcohol-related suicides in areas of greater disadvantage in Australia which were noted to have lower health services availability (including mental health services) when compared to areas of greater affluence (78).

4.2.1.5 Alcohol-related fatal road traffic collisions- area-based socioeconomic deprivation

There were no studies investigating area-based socioeconomic deprivation and alcohol-related RTCs.

4.3 Urban-rural differences and alcohol-attributable deaths

4.3.1 Alcohol-specific deaths – urban-rural differences

There were mixed findings from the 23 studies that considered the urban-rural differences in levels of alcohol-specific mortality. Eight studies (34.8%) found a positive association between urban areas and alcohol-specific mortality compared to rural areas (62,71,83,84,86,107–109). However two of these studies scored lower in the quality appraisal (62,71).

Almost one-half of the studies (n=11, 47.8%) found rural areas were positively associated with alcohol-specific deaths (66,81,110–118). Two studies found no significant urban-rural differences (119,120). One study found that the third and fourth points on a six-point urban-rural continuum had the highest rate of alcohol-attributable deaths (75). Another study found US states bordering Mexico had higher rates of alcohol-attributable mortality in urban regions compared to rural ones, whereas in non-border areas, the rate was higher in rural regions (121).

A number of studies offered further insights into the association between urban-rural location and alcohol-specific mortality. For example, the higher rate of alcohol-specific mortality in urban areas of Slovakia was found to apply to chronic, but not to acute, alcohol-specific deaths (83). Rates of fatal alcohol poisonings were found to be higher among females who resided in urban areas of Poland compared to those residing in rural areas although a much less pronounced urban-rural gap in males was noted (62), although this study was scored as low quality. Similarly, a study conducted in the United States found significantly higher rates of fatal alcohol poisonings in urban compared to rural areas (122). In contrast, higher rates of fatal alcohol poisonings were found in rural areas of Finland compared to urban areas (114). In the United States, higher rates of chronic alcohol-specific deaths were found in urban areas compared with rural areas (122).

4.3.1.1 Alcohol-related deaths – urban-rural differences

Findings from the eight studies examining urban-rural location of alcohol-related deaths were mixed. Two studies found a higher rate of such deaths in urban areas (65,122), four in rural areas (18,69,85,123) and two studies found no urban-rural difference (72,124) (one low quality rated) (72).

As before, further information on the link between urbanity and rurality of alcohol-related deaths were noted. One study examining 27 European countries comparing those that joined the European Union (EU) before, to those that joined after 2004, found that those countries with a higher urban population rate had increased alcohol-related mortality rates compared with deaths from all causes, and this finding applied to both males and females (65). A study in the United States found that alcohol-related homicides were more prevalent in urban areas (122).

4.3.1.2 Alcohol-related and alcohol-specific deaths combined – urban-rural differences

Seven studies examined urban-rural associations among both alcohol-related and alcohol-specific deaths without distinguishing between the two (18,65,69,72,85,122,123). Four studies noted rates of alcohol-related and alcohol-specific deaths combined were higher in rural areas (18,69,85,123) despite. One study found no urban-rural association with alcohol-related and alcohol-specific deaths combined (72).

4.3.1.3 Alcohol-related suicides – urban-rural differences

Overall, rurality was found to be positively associated with alcohol-related suicides with three of the five studies examining urban-rural location and alcohol-related suicide noting rates of alcohol-related suicides were higher in rural areas compared to urban locations (76–78). However one of those studies found the association between rural location and alcohol-related suicide significant for males only (not females) (76).

A United States-based study found no significant association between urban-rural location and alcohol-related suicides (79), a finding replicated in a Polish study, although the latter did note an increase in rural areas during the study period (2010-2019) (80).

4.3.1.4 Alcohol-related fatal road traffic collisions – urban-rural differences

Thirteen studies examined alcohol-related fatal RTCs (17.8%). Eight studies examined intoxicated driver fatalities (125–132), one of which specifically examined motorcycle rider fatalities (132), one

study examined alcohol-related cyclist fatalities (133), four studies examined mortality among pedestrians who had consumed alcohol prior to the fatal incident (70,134–137) and one study examined both pedestrian and driver alcohol-related RTC fatalities (125). Eight of these studies (64.3%) found alcohol-related RTCs were positively associated with rural location (70,126,128–131,134,135).

Conversely, four studies found alcohol-related RTCs positively associated with urban location (125,127,132,133). One study found no significant association between urban-rural location of alcohol-related RTCs (137).

Rural pedestrians who were victims of RTCs and had consumed alcohol prior to the incident had higher blood alcohol concentration (BAC) readings than their urban counterparts (135).

4.3.2 Other geographic characteristics and alcohol-attributable deaths

Although most of the included studies focused on area-level SES and/or urban-rural location, several other geographic characteristics featured in the included studies. For example, social fragmentation, which is described as a lack of cohesion or interconnectedness within communities and often characterised by high prevalence of rental properties, single occupancy households, and a higher number of migrants in an area, has been associated with poor mental health (138,139). Higher levels of social fragmentation are linked to increased rates of all-cause mortality and 'deaths of despair' (specifically suicides and other drug poisonings). However, it was not associated with alcohol-specific deaths in a Canadian study (140). In Finland, low levels of community cohesion, and low civic participation (indicated by poor voting turnout) was positively associated with alcohol-related mortality (18). Conversely, in Lithuania, *high* civic participation was positively associated with alcohol-related mortality among males (119). Also in Lithuania, areas with a high proportion of manual workers and ethnic minorities, were identified as risk factors associated with alcohol-specific mortality (119). Similarly in Slovakia, areas with a greater proportion of Roma population was associated with a higher rate of alcohol-related mortality (102). Also associated with alcohol-related

mortality were US states *not* bordering Mexico (113). Conversely, mortality rates specifically for alcohol-related liver disease were greater in border states (121). In England, data for 2018 indicated that alcohol-specific mortality rates were greatest in non-coastal cities (141). However, also in England, rates of alcohol-specific deaths were higher in coastal areas when compared to inland regions for the period 2019 – 2021 (99).

5 Discussion

This systematic review aimed to gain a comprehensive understanding of the extent, range and nature of evidence on area-based socioeconomic inequalities and other geographic characteristics, and their association with alcohol-attributable deaths in high-income countries. We found a positive association between area-level socioeconomic deprivation and alcohol-attributable mortality. This applied to both alcohol-specific and alcohol-related deaths including RTCs and suicides. The findings on the association between urban-rural location and alcohol-attributable deaths were less conclusive although broadly, more studies identified rural areas as a risk factor compared with urban areas, aligning with much of the previous research (42–45,105,106,142). However, regional patterns diverge when urban–rural context is considered alongside area-level deprivation, as studies from North America and Australia more often associated alcohol-attributable mortality with deprived rural areas, whereas European studies more commonly identified deprived urban areas as being at higher risk. This heterogeneity suggests that there might be other individual or area-level factors shaping outcomes that warrant further investigation.

Significant rural associations, especially in Australian and North and South American studies, tended to involve road traffic collisions, whereas significant urban associations were more often alcohol-specific deaths and more commonly the focus of European studies. These patterns align with broader mortality gradients, all-cause mortality remains higher in rural areas in the United States and Australia (31,143) while European evidence is less conclusive with no clear urban–rural gradient (144). Differences in settlement patterns, particularly the presence of extensive, sparsely populated

rural regions in the United States and Australia compared with Europe, may partially account for these contrasts.

With respect to suicide, prior research has established higher suicide rates in rural areas irrespective of alcohol involvement. Within the subset of alcohol-related suicides, more studies found that rural location was significantly associated with an increased rate of suicide (76–78,80) but given that two studies found no significant association (79,80), there is uncertainty in the evidence. Alcohol-related suicides may be influenced by similar geographic factors as non-alcohol-related suicides, including limited access to mental health services, social isolation, and poorer economic resources such as transport and employment opportunities (145–148). The greater availability of more lethal suicide methods in rural areas may also contribute (142,149–151). Ensuring adequate health services availability are essential for managing mental health problems caused or exacerbated by alcohol use as well as strengthening social links and community cohesion to reduce loneliness and depression are likely to be important for reducing alcohol-related mortality, including suicide (152).

RTCs, regardless of alcohol involvement, were previously known to be higher in rural areas, and this review found that alcohol-related RTCs were positively associated with rural areas (70,126,128–131,134,135). This applied to studies irrespective of the country the study was conducted. Contributory factors may be that rural roads typically have higher speed limits, road conditions are often less maintained, visibility may be poorer, and emergency response times are longer. Additionally, drivers in rural areas are more likely to travel greater distances from licensed premises, all of which contribute to the increased risks associated with rural locations (153–156).

We also found evidence of additional geographic characteristics associated with alcohol-attributable mortality, including civic participation within an area (18,119), areas with a higher proportion of migrants (87,89,111,119), and areas considered to have low levels of family and community cohesion (18). This review therefore highlights consistent spatial and area-level inequalities, reinforcing the role of built-environment characteristics in shaping health behaviours and alcohol-related harm.

It is interesting to note that five studies examined both individual-level and area-level SES and the positive association remained observed (18,72,82,86,89). Despite one study indicating that the significance of area-based deprivation was primarily due to individual-level aspects of SES (107), the overall evidence suggests that area-based measures remain associated with alcohol-related mortality after adjusting for individual-level SES, indicating that area-level SES may have independent effects on alcohol-related mortality.

The mechanisms underlying geographic inequalities in alcohol-related harms require further investigation, as few studies explored the reasons behind the observed geographic patterns they observed beyond offering hypotheses. The literature notes a number of possible mechanisms to explain why there are higher risks for those living in deprived areas including increased alcohol availability, heightened environmental stressors, poor infrastructure and service provision, and fewer employment opportunities. These mechanisms may differ depending on the urban or rural setting. For example, in deprived urban areas, the increased density of alcohol outlets, greater public disorder, higher crime rates and more concentrated stressors (e.g. crowding, traffic, fewer green spaces) contribute to harmful drinking behaviours and subsequent alcohol-related harms (37,56,157–160). In deprived rural areas, a lack of resources and support (both professional services and social support), transport and access issues to such support, and limited employment opportunities and the consequential financial stress, can lead to increased alcohol use as a coping mechanism, thus increasing vulnerability to alcohol-related harms (161–165). Those living in deprived neighbourhoods, regardless of urban or rural location, are also more likely to engage in binge or heavy episodic drinking, particularly men (166–169). These drinking patterns increase vulnerability to alcohol-attributable mortality as they are associated with higher risk of acute and chronic health harms (170–172). The causes of the higher risk are not fully understood. People living in poverty may experience greater alcohol-related harm not only because of how they drink, but also because challenging living circumstances, such as limited resources, stressful circumstances, and lifelong disadvantage, may contribute to increased vulnerability.

(20,173).

Much of the epidemiological research on alcohol focuses on the causes and effects of alcohol use and related harms, often neglecting the broader context of area-level factors (174–180). This review is the first (to the best of our knowledge) to specifically focus on area-based socioeconomic status and alcohol-attributable mortality. Other reviews on socioeconomic status and alcohol-attributable mortality have also consistently found that lower SES is positively associated with alcohol-attributable mortality but have used individual SES characteristics such as education level, employment status or occupation, and/or income (14,15). This review confirms that area-based SES is also positively associated with alcohol-specific and alcohol-related mortality.

While individual factors are important in shaping alcohol use and associated harms, Boyd *et al* argue that incorporating health inequality theories, such as the ecosocial theory and the social determinants of health, can provide a deeper understanding of the AHP by highlighting the complex interplay between individual behaviours and broader social, economic, and environmental factors (173). Engaging and mobilising communities can foster cohesion, reduce social fragmentation, and address alcohol-related harms (181,182).

Policy interventions should consider the built environment, particularly in disadvantaged areas. Investing in community resources such as green spaces and rural infrastructure, can promote healthier lifestyles. Educating policymakers about spatial factors and geographic features related to alcohol-related mortality is essential for resource allocation in community-level interventions. The role of social support, neighbourhood cohesion, and access to services (particularly health services) are key contextual factors that require consideration. A collective commitment to addressing the factors associated with alcohol-attributable mortality this review has highlighted is imperative for not only reducing alcohol-attributable deaths but benefiting communities as a whole.

5.1.1 Strengths and weaknesses

This review examined only those studies conducted in high-income countries therefore the findings are not generalisable to middle or low-income countries, although of the OECD countries included, there was a good geographical spread. This review did not include studies investigating alcohol-attributable mortality in relation to density of licensed premises as this topic has been examined elsewhere (35–38).

A further limitation is the inconsistent definition of 'urban' and 'rural' across studies. Furthermore, given the wide period examined, it is possible that areas considered rural at the time of the earlier studies may have since become more densely populated, and likewise, SES classification may have changed during this period also. Only one study (88) that examined area-level SES considered whether the individuals had lived in the same area before their death or had relocated in the years prior.

Studies that compared urban and rural locations used differing definitions and were therefore not always comparable, especially depending on the country the study was carried out in. Although this did not affect the individual study quality, it represents a weakness when it comes to summarising the overall findings of the literature because studies are locally specific. This also applied to SES or deprivation where differing interpretations were applied.

The majority of studies were observational, using data gathered about people in an area rather than detailed information about the area's conditions. While this approach can help understand mortality inequalities, it is difficult to determine causal relationships. Having more detailed information, or comparator areas, provides a clearer picture of how area-based features affect alcohol-related mortality inequalities.

There are some key methodological limitations to acknowledge. Given the topic area, there was a large number of studies deemed relevant. Further refinement of the search strategy may have reduced the time required to screen studies. Although this systematic review did not have full double screening, 10% of studies (title and abstract and full text) were screened by a second author. A

further limitation is the use of the NHLBI Quality Appraisal Tool to assess ecological studies for risk of bias. Using this tool made it harder to accurately assess the risk of bias in the included ecological studies, potentially leading to misclassification of study quality due to its emphasis on individual-level criteria that do not align with group-level data and contextual factors typical of ecological designs. A possible alternative for future reviews is the more recently developed quality appraisal tool, ROBINS-E, although is not specifically tailored for ecological studies either and with similar limitations as the NHLBI tool (183). We have not reported effect estimates and confidence intervals from each included study as recommended by PRISMA (159). This is because the included studies are heterogeneous across study designs, outcomes, and exposures. As a result, the effect estimates are not interpretable without substantial additional information that would make the table unduly long. This review identified a small number of studies on geographic characteristics (e.g. social cohesion and coastal regions) that did not have specific associated terms included in the search strategy (18,99,113,119,121,140,141). These studies met our inclusion criteria, but as we did not search for them directly, there may be other studies on these characteristics that we have not identified. Our findings for these characteristics should be taken as indicative in comparison to the more comprehensive review of evidence on urban vs. rural locations and area-based SES.

5.2 Conclusions

This review finds that area-level SES is positively associated with alcohol-attributable mortality in high-income countries. Our findings also strongly indicate that rural areas are positively associated with such deaths, although the evidence is less conclusive and differs depending on the country being examined. The findings underscore the need for targeted interventions to address these inequalities and to consider these geographical factors when developing response systems to address reduce alcohol-attributable mortality.

6 References

1. United Nations. UN Sustainable Development Goals [Internet]. 2015 [cited 2025 Feb 18]. Available from: https://www.un.org/sustainabledevelopment/

2. Brauer M, Roth GA, Aravkin AY, Zheng P, Abate KH, Abate YH, et al. Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. The Lancet. 2024;403(10440):2162–203.

3. OECD data. Alcohol consumption [Internet]. 2024. Available from: OECD (2024), Alcohol consumption (indicator). https://www.oecd.org/en/data/indicators/alcohol-consumption.html (Accessed on 03 December 2024)

4. Esser MB. Deaths from excessive alcohol use—United States, 2016–2021. MMWR Morbidity and Mortality Weekly Report. 2024;73.

5. EuroStat. 3.6 deaths per 100 000 people due to alcohol in 2020 [Internet]. 2023 [cited 2025 Feb 19]. Available from: https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20231010-1

6. Ahlm K. Traffic and drowning incidents with emphasis on the presence of alcohol and drugs [Internet]. [Sweden]: Umeå University, Faculty of Medicine, Department of Community Medicine and Rehabilitation, Forensic Medicine; 2014. Available from: https://www.diva-portal.org/smash/record.jsf?dswid=509&pid=diva2%3A736895

7. Ghassempour N, Kathy Tannous W, Agho KE, Avsar G, Harvey LA. Factors associated with residential fire-related hospitalisations and deaths: A 10-year population-based study. Burns. 2023;49(8):1854–65. Located at: Ovid MEDLINE(R) <2023>. doi:10.1016/j.burns.2023.02.012

8. Amiri S, Behnezhad S. Alcohol use and risk of suicide: a systematic review and Meta-analysis. Journal of addictive diseases. 2020;38(2):200–13.

9. Dean E, Taylor M, Francis H, Appleton D, Jones M. An exploration of alcohol-related fire incidences. Journal of Risk Research. 2018;21(10):1217–32.

10. Rossow I. Alcohol and homicide: a cross-cultural comparison of the relationship in 14 European countries. Addiction [Internet]. 2001 Feb;96(Supplement 1):77–92. Located at: none. Available from: https://www.drugsandalcohol.ie/6907/

11. Sieveneck S, Sutter C. Predictive policing in the context of road traffic safety: A systematic review and theoretical considerations. Transportation research interdisciplinary perspectives. 2021;11:100429.

12. World Health Organization. Global status report on road safety 2018. World Health Organization; 2019.

13. World Health Organization. Global status report on alcohol and health 2018. [Internet]. Geneva: World Health Organization; 2018 Sep. p. 476 p. Report Nos.: 978-92-4-156563–9. Located at: public. Available from: https://www.drugsandalcohol.ie/29701/

14. Probst C, Roerecke M, Behrendt S, Rehm J. Socioeconomic differences in alcohol-attributable mortality compared with all-cause mortality: a systematic review and meta-analysis. International journal of epidemiology. 2014;43(4):1314–27.

15. Probst C, Lange S, Kilian C, Saul C, Rehm J. The dose-response relationship between socioeconomic deprivation and alcohol-attributable mortality risk-a systematic review and meta-analysis. BMC Medicine. 2021 Nov 4;19(1):1–13. Located at: CINAHL. doi:10.1186/s12916-021-02132-z

16. Probst C, Kilian C, Sanchez S, Lange S, Rehm J. The role of alcohol use and drinking patterns in socioeconomic inequalities in mortality: a systematic review. The Lancet Public Health [Internet]. 2020 Jun;5(6):E324. Located at: none. Available from: https://www.drugsandalcohol.ie/32134/

17. Galea SA Jennifer; Tracy, Melissa; Vlahov, David. Neighborhood Income and Income Distribution and the Use of Cigarettes, Alcohol, and Marijuana. American journal of preventive medicine. 2007;32(6):S195-202. doi:10.1016/j.amepre.2007.04.003

18. Blomgren J, Martikainen P, Makela P, Valkonen T. The effects of regional characteristics on alcohol-related mortality-a register-based multilevel analysis of 1.1 million men. Soc Sci Med. 2004;58(12):2523–35. Located at: Ovid MEDLINE(R) <2003 to 2004>

19. Bloomfield K. Understanding the alcohol-harm paradox: what next? The Lancet Public Health. 2020;5(6):e300–1.

20. Boyd J, Sexton O, Angus C, Meier P, Purshouse RC, Holmes J. Causal mechanisms proposed for the alcohol harm paradox-a systematic review. Addiction [Internet]. 2022;117(1):33–56. Located at: none. Available from: https://www.drugsandalcohol.ie/34252/

21. Grittner U, Kuntsche S, Gmel G, Bloomfield K. Alcohol consumption and social inequality at the individual and country levels-results from an international study. EUROPEAN JOURNAL OF PUBLIC HEALTH. 2013 Apr;23(2):332–9. Located at: WOS:000317425100032. doi:10.1093/eurpub/cks044

22. Arcaya MC; TS Reginald D; Kim, Rockli; Schnake Mahl, Alina S; So, Marvin; Subramanian, SV. Research on neighborhood effects on health in the United States: A systematic review of study characteristics. Social science & medicine (1982). 2016;168(NA):16–29. doi:10.1016/j.socscimed.2016.08.047

23. Meijer M. Neighbourhood Context and Mortality: An Overview. In: Neighbourhood Structure and Health Promotion. 2013. p. 11–37. doi:10.1007/978-1-4614-6672-7_2

24. Merz S, Jaehn P, Mena E, Pöge K, Strasser S, Saß AC, et al. Intersectionality and eco-social theory: a review of potentials for public health knowledge and social justice. Critical Public Health. 2023;33(2):125–34.

25. Krieger N. Ecosocial theory, embodied truths, and the people's health. Oxford University Press; 2021.

26. White AM; C I Jen P; Hingson, Ralph W; Powell, Patricia A. Using Death Certificates to Explore Changes in Alcohol-Related Mortality in the United States, 1999 to 2017. Alcoholism, clinical and experimental research. 2020;44(1):178–87. doi:10.1111/acer.14239

27. Karriker-Jaffe KJ, Goode SA, Blakey SM, Humphrey JL, Williams PA, Borja IR, et al. Area-Level Social Determinants of Alcohol-Related Mortality: Knowledge Gaps and Implications for Community Health. Alcohol research : current reviews. 2024;44(1):06. Located at: EPISTEMONIKOS. doi:10.35946/arcr.v44.1.06

28. Rehm J, Rovira P, Llamosas-Falcón L, Shield KD. Dose–response relationships between levels of alcohol use and risks of mortality or disease, for all people, by age, sex, and specific risk factors. Nutrients. 2021;13(8):2652.

29. Schmidt LA, Mäkelä P, Rehm J, Room R. Alcohol: equity and social determinants. Equity, social determinants and public health programmes. 2010;11:30.

30. Roche A, Kostadinov V, Fischer J, Nicholas R. Evidence review: the social determinants of inequities in alcohol consumption and alcohol-related health outcomes. Victoria: VicHealth. 2015.

31. Vierboom YC, Preston SH, Hendi AS. Rising geographic inequality in mortality in the United States. SSM-population health. 2019;9:100478.

32. Dwyer-Lindgren L, Bertozzi-Villa A, Stubbs RW, Morozoff C, Kutz MJ, Huynh C, et al. US county-level trends in mortality rates for major causes of death, 1980-2014. Jama. 2016;316(22):2385–401.

33. Bambra C. Health divides: where you live can kill you. Policy Press; 2016.

34. McGowan VJ, Bambra C. COVID-19 mortality and deprivation: pandemic, syndemic, and endemic health inequalities. The Lancet Public Health. 2022;7(11):e966–75.

35. Gmel G, Holmes J, Studer J. Are alcohol outlet densities strongly associated with alcohol-related outcomes? A critical review of recent evidence. Drug and alcohol review. 2016;35(1):40–54.

36. Sherk A, Stockwell T, Chikritzhs T, Andréasson S, Angus C, Gripenberg J, et al. Alcohol consumption and the physical availability of take-away alcohol: systematic reviews and meta-analyses of the days and hours of sale and outlet density. Journal of studies on alcohol and drugs. 2018;79(1):58–67.

37. Bryden A, Roberts B, McKee M, Petticrew M. A systematic review of the influence on alcohol use of community level availability and marketing of alcohol. Health & place. 2012;18(2):349–57.

38. Livingston M, Chikritzhs T, Room R. Changing the density of alcohol outlets to reduce alcohol-related problems. Drug and alcohol review. 2007;26(5):557–66.

39. Stockwell T, Gruenewald PJ. Controls on the physical availability of alcohol. The essential handbook of treatment and prevention of alcohol problems. 2004;213–33.

40. Bellis MA, Phillips-Howard PA, Hughes K, Hughes S, Cook PA, Morleo M, et al. Teenage drinking, alcohol availability and pricing: a cross-sectional study of risk and protective factors for alcohol-related harms in school children. BMC Public Health. 2009 Oct 9;9(1):380. doi:10.1186/1471-2458-9-380

41. Lightowlers CPS Jose; McLaughlin, Fiona. The role of deprivation and alcohol availability in shaping trends in violent crime. European Journal of Criminology. 2021;20(2):147737082110360–757. doi:10.1177/14773708211036081

42. Razzaghi A, Soori H, Kavousi A, Abadi A, Khosravi A, Alipour A. Risk factors of deaths related to road traffic crashes in World Health Organization regions: A systematic review. 2019.

43. Asgarian FS, Namdari M, Soori H. Worldwide prevalence of alcohol in fatally injured motorcyclists: a meta-analysis. Traffic injury prevention. 2019;20(7):685–9.

44. Fisa R, Musukuma M, Sampa M, Musonda P, Young T. Effects of interventions for preventing road traffic crashes: an overview of systematic reviews. BMC public health. 2022;22(1):513.

45. Smailović E, Pešić D, Antić B, Marković N. A review of factors associated with driving under the influence of alcohol. Transportation research procedia. 2023;69:281–8.

46. Beseran E, Pericas JM, Cash-Gibson L, Ventura-Cots M, Porter KMP, Benach J. Deaths of Despair: A Scoping Review on the Social Determinants of Drug Overdose, Alcohol-Related Liver Disease and Suicide. Int J Environ Res Public Health. 2022;19(19). Located at: Ovid MEDLINE(R) <2022>. doi:10.3390/ijerph191912395

47. Rahimi-Ardabili HF Xiaoqi; Nguyen, Phi Yen; Astell Burt, Thomas. Have Deaths of Despair Risen during the COVID-19 Pandemic? A Systematic Review. International journal of environmental research and public health. 2022;19(19):12835–12835. doi:10.3390/ijerph191912835

48. Bambra C, Gibson M, Sowden A, Wright K, Whitehead M, Petticrew M. Tackling the wider social determinants of health and health inequalities: evidence from systematic reviews. Journal of epidemiology & community health. 2010;64(4):284–91.

49. Friesen EL, Bailey J, Hyett S, Sedighi S, de Snoo ML, Williams K, et al. Hazardous alcohol use and alcohol-related harm in rural and remote communities: a scoping review. The Lancet Public health. 2022;7(2):e177–87. Located at: EPISTEMONIKOS. doi:10.1016/S2468-2667(21)00159-6

50. Carson E, Sharmin S, Maier AB, Meij JJ. Comparing indigenous mortality across urban, rural and very remote areas: a systematic review and meta-analysis. International Health. 2018;10(4):219–27.

51. Cano M, Oh S, Osborn P, Olowolaju SA, Sanchez A, Kim Y, et al. County-level predictors of US drug overdose mortality: A systematic review. Drug & Alcohol Dependence. 2023 Jan;242:N.PAG-N.PAG. Located at: CINAHL. doi:10.1016/j.drugalcdep.2022.109714

52. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. bmj. 2021;372.

53. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Systematic reviews. 2015;4:1–9.

54. Organisation for Economic Co-operation and Development. OECD members and partners [Internet]. 2024 [cited 2025 Jan 5]. Available from: https://www.oecd.org/en/about/members-partners.html

55. Popova S, Giesbrecht N, Bekmuradov D, Patra J. Hours and days of sale and density of alcohol outlets: impacts on alcohol consumption and damage: a systematic review. Alcohol & Alcoholism. 2009;44(5):500–16.

56. Holmes J, Guo Y, Maheswaran R, Nicholls J, Meier PS, Brennan A. The impact of spatial and temporal availability of alcohol on its consumption and related harms: a critical review in the context of UK licensing policies. Drug and alcohol review. 2014;33(5):515–25.

57. Institute of Alcohol Studies. Alcohol-specific and alcohol-related deaths: what does it all mean? [Internet]. London: Institute of Alcohol Studies; 2024 Feb. Report No. Located at: public. Available from: https://www.drugsandalcohol.ie/42871/

58. United Kingdom. Office for National Statistics. Alcohol-specific deaths in the UK: registered in 2022. [Internet]. London: Office for National Statistics; 2024 Apr. Report No. Located at: none. Available from: https://www.drugsandalcohol.ie/40898/

59. Gmel G, Shield KD, Frick H, Kehoe T, Gmel G, Rehm J. Estimating uncertainty of alcohol-attributable fractions for infectious and chronic diseases. BMC Medical Research Methodology. 2011;11:1–12.

60. Institute of Alcohol Studies. How alcohol morbidity and morbidity rates are calculated in the UK [Internet]. Report No. Available from: /https://www.ias.org.uk/uploads/pdf/Health%20Impacts%20docs/How%20alcohol%20mortality%20and%20morbidity%20rates%20are%20calculated%20in%20the%20UK.pdf

61. Jaccard A, Blawat A, Ashton S, Belsman L, Gommon J, Webber L. Alcoholattributable fractions for England: an update [Internet]. 2020.

62. Wojtyniak B, Moskalewicz J, Stokwiszewski J, Rabczenko D. Gender-specific mortality associated with alcohol consumption in Poland in transition. Addiction. 2005;Comment in: Addiction. 2005 Dec;100(12):1800-2 PMID: 16367980 [https://www.ncbi.nlm.nih.gov/pubmed/16367980]100(12):1779–89. Located at: Ovid MEDLINE(R) <2005 to 2007>

63. Piantadosi S, Byar DP, Green SB. The ecological fallacy. American journal of epidemiology. 1988;127(5):893–904.

64. Ransome Y, Subramanian SV, Duncan DT, Vlahov D, Warren J. Multivariate spatiotemporal modeling of drug- and alcohol-poisoning deaths in New York City, 2009-2014. Spat Spatiotemporal Epidemiol. 2020;32(101516571):100306. Located at: Ovid MEDLINE(R) <2020>. doi:10.1016/j.sste.2019.100306

65. Innamorati M, Pompili M, Martinotti G, Serafini G, Amore M, Lester D, et al. Trends in alcohol-related deaths in the EU countries in 1980–2003. International Journal of Social Psychiatry. 2013 Aug;59(5):443–51. Located at: CINAHL. doi:10.1177/0020764012438479

66. Zhang X., Monnat S.M. Geographically specific associations between county-level socioeconomic and household distress and mortality from drug poisoning, suicide, alcohol, and homicide among working-age adults in the United States. SSM Popul Health. 2024;25((Zhang, Monnat) Lerner Center for Public Health Promotion and Population Health, Syracuse University, NY 13244, United States):101595. Located at: Embase Weekly Updates; 2029652175. doi:10.1016/j.ssmph.2023.101595

67. Castillo-Carniglia A, Kaufman JS, Pino P. Small area associations between social context and alcohol-attributable mortality in a middle income country. Drug Alcohol Depend. 2014;137(ebs, 7513587):129–36. Located at: Ovid MEDLINE(R) <2014>. doi:10.1016/j.drugalcdep.2014.01.020

68. Nagy C, Juhasz A, Papp Z, Beale L. Hierarchical spatio-temporal mapping of premature mortality due to alcoholic liver disease in Hungary, 2005-2010. Eur J Public Health. 2014;24(5):827–33. Located at: Ovid MEDLINE(R) <2014>. doi:10.1093/eurpub/ckt169

69. Jayasekara H, Ferris J, Matthews S, Livingston M, Lloyd B. Trends in alcohol-attributable morbidity and mortality for Victoria, Australia from 2000/01 to 2009/10. J Public Health (Oxf). 2014;36(3):399–407. Located at: Ovid MEDLINE(R) <2014>. doi:10.1093/pubmed/fdt063

70. Senserrick T, Boufous S, de Rome L, Ivers R, Stevenson M. Detailed analysis of pedestrian casualty collisions in Victoria, Australia. Traffic inj prev. 2014;15 Suppl 1(101144385):S197-205. Located at: Ovid MEDLINE(R) <2014>. doi:10.1080/15389588.2014.935356

71. Erskine S, Maheswaran R, Pearson T, Gleeson D. Socioeconomic deprivation, urban-rural location and alcohol-related mortality in England and Wales. BMC public health. 2010;10(1):1–8.

72. Lehikoinen M, Arffman M, Manderbacka K, Elovainio M, Keskimaki I. Comparative observational study of mortality amenable by health policy and care between rural and urban Finland: no excess segregation of mortality in the capital despite its increasing residential differentiation. Intern j equity health. 2016;15(101147692):59. Located at: Ovid MEDLINE(R) <2016>. doi:10.1186/s12939-016-0348-2

73. Northern Ireland Statistics and Research Agency. Alcohol-Specific deaths in Northern Ireland, 2022. [Internet]. Belfast: Northern Ireland Statistics and Research Agency; 2024 Feb. p. 18 p. Report No. Located at: public. Available from: https://www.drugsandalcohol.ie/40490/

74. Northern Ireland Statistics and Research Agency. Alcohol related deaths registered in Northern Ireland, 2007-2017. [Internet]. Belfast: Northern Ireland Statistics and Research Agency; 2019 Jan. Report No. Located at: public. Available from: https://www.drugsandalcohol.ie/30162/

75. Shiels MS, Tatalovich Z, Chen Y, Haozous EA, Hartge P, Napoles AM, et al. Trends in Mortality From Drug Poisonings, Suicide, and Alcohol-Induced Deaths in the United States From 2000 to 2017. JAMA netw open. 2020;3(9):e2016217. Located at: Ovid MEDLINE(R) <2020>. doi:10.1001/jamanetworkopen.2020.16217

76. Kaplan MS, McFarland BH, Huguet N, Conner K, Caetano R, Giesbrecht N, et al. Acute alcohol intoxication and suicide: a gender-stratified analysis of the National Violent Death Reporting System. Inj Prev. 2013;19(1):38–43. Located at: Ovid MEDLINE(R) <2013>. doi:10.1136/injuryprev-2012-040317

77. Reccord C, Power N, Hatfield K, Karaivanov Y, Mulay S, Wilson M, et al. Rural-Urban Differences in Suicide Mortality: An Observational Study in Newfoundland and Labrador, Canada: Differences de la Mortalite Par Suicide en Milieu Rural-Urbain: Une Etude Observationnelle a Terre-Neuve et Labrador, Canada. Can J Psychiatry. 2021;66(10):918–28. Located at: Ovid MEDLINE(R) <2021>. doi:10.1177/0706743721990315

78. Hurzeler T, Buckley NA, Noghrehchi F, Malouf P, Page A, Schumann JL, et al. Alcohol-related suicide across Australia: a geospatial analysis. Aust N Z J Public Health. 2021;45(4):394–9. Located at: Ovid MEDLINE(R) <2022>. doi:10.1111/1753-6405.13122

79. Caetano R, Kaplan MS, Huguet N, McFarland BH, Conner K, Giesbrecht N, et al. Acute alcohol intoxication and suicide among United States ethnic/racial groups: findings from the national violent death reporting system. Alcohol Clin Exp Res. 2013;Comment in: Alcohol Clin Exp Res. 2013 May;37(5):717-9 PMID: 23441581 [https://www.ncbi.nlm.nih.gov/pubmed/23441581]37(5):839–46. Located at: Ovid MEDLINE(R) <2013>. doi:10.1111/acer.12038

80. Karnecki K, Gos T, Steiner J, Mankowski D, Kaliszan M. Epidemiology of suicide in the Tri-City metropolitan area in Poland in 2010-2019. Eur Arch Psychiatry Clin Neurosci. 2023;273(4):911–20. Located at: Ovid MEDLINE(R). doi:10.1007/s00406-022-01548-9

81. Adair T, Lopez AD. An egalitarian society? Widening inequalities in premature mortality from non-communicable diseases in Australia, 2006-16. Int J Epidemiol. 2021;Erratum in: Int J Epidemiol. 2021 Aug 30;50(4):1403 PMID: 33738506 [https://www.ncbi.nlm.nih.gov/pubmed/33738506]50(3):783–96. Located at: Ovid MEDLINE(R) <2021>. doi:10.1093/ije/dyaa226

82. Connolly S, O'Reilly D, Rosato M, Cardwell C. Area of residence and alcohol-related mortality risk: a five-year follow-up study. Addiction [Internet]. 2011;106(1):84–92. Located at: none. Available from: https://www.drugsandalcohol.ie/14503/

83. Dietze PM, Jolley DJ, Chikritzhs TN, Clemens S, Catalano P, Stockwell T. Income inequality and alcohol attributable harm in Australia. BMC Public Health. 2009;9(100968562):70. Located at: Ovid MEDLINE(R) <2008 to 2009>. doi:10.1186/1471-2458-9-70

84. National Records for Scotland. Alcohol-specific deaths 2023. [Internet]. Edinburgh: National Records for Scotland; 2024 Sep. p. 14 p. Report No. Located at: public. Available from: https://www.drugsandalcohol.ie/41807/

85. NSW Ministry of Health, Government. Alcohol Use and Related Harms in NSW Surveillance Report 2021 [Internet]. 2022 Mar [cited 2024 Dec 28]. (ISBN 978-1-76023-064-7). Report No. Available from: https://www.health.nsw.gov.au/aod/resources/Publications/alcohol-surveillance-report-2021.pdf

86. Hughes J, IJpelaar J, McAuley R, Lyness D. Alcohol-specific deaths in Northern Ireland: socio-demographic analyses. [Internet]. Belfast: Northern Ireland Statistics and Research Agency; 2021 Mar. p. 26 p. Report No. Located at: public. Available from: https://www.drugsandalcohol.ie/33984/

87. Rosicova K, Geckova AM, Rosic M, Speybroeck N, Groothoff JW, van Dijk JP. Socioeconomic factors, ethnicity and alcohol-related mortality in regions in Slovakia. What might a tree analysis add to our understanding?. Health Place. 2011;17(3):701–9. Located at: Ovid MEDLINE(R) <2010 o 2011>. doi:10.1016/j.healthplace.2011.01.004

88. Pulford A, Gordon R, Graham L, Lewsey J, McCartney G, Robinson M. Do patients who die from an alcohol-related condition 'drift' into areas of greater deprivation? Alcohol-related mortality and health selection theory in Scotland. J Epidemiol Community Health. 2018;72(2):109–12. Located at: Ovid MEDLINE(R) <2018>. doi:10.1136/jech-2017-209790

89. Auger N, Hamel D, Martinez J, Ross NA. Mitigating effect of immigration on the relation between income inequality and mortality: a prospective study of 2 million Canadians. J Epidemiol Community Health. 2012;66(6):e5. Located at: Ovid MEDLINE(R) <2012>. doi:10.1136/jech.2010.127977

90. Breakwell C, Baker A, Griffiths C, Jackson G, Fegan G, Marshall D. Trends and geographical variations in alcohol-related deaths in the United Kingdom, 1991-2004. Health stat q. 2007;(33):6–24. Located at: Ovid MEDLINE(R) <2005 to 2007>

91. Kovse K., Tomsic S., Ponikvar B.M., Nadrag P. Alcohol related harm in Slovenia. Zdravniski Vestn [Internet]. 2012;Posledice tveganega in skodljivega uzivanja alkohola v Sloveniji81(2):119–27. Located at: Embase; 364261779. Available from: http://vestnik.szd.si/index.php/vestnik/article/view/718/668

92. Brown D, Leyland AH. Scottish mortality rates 2000-2002 by deprivation and small area population mobility. Soc Sci Med. 2010;71(11):1951–7. Located at: Ovid MEDLINE(R) <2010 o 2011>. doi:10.1016/j.socscimed.2010.09.015

93. Exeter DJ, Boyle PJ, Norman P. Deprivation (im)mobility and cause-specific premature mortality in Scotland. Soc Sci Med. 2011;72(3):389–97. Located at: Ovid MEDLINE(R) <2010 o 2011>. doi:10.1016/j.socscimed.2010.10.009

94. Brown D, Allik M, Dundas R, Leyland AH. All-cause and cause-specific mortality in Scotland 1981–2011 by age, sex and deprivation: a population-based study. European Journal of Public Health. 2019 Aug;29(4):647–55. Located at: CINAHL. doi:10.1093/eurpub/ckz010

95. Strong M, Pearson T, MacNab YC, Maheswaran R. Mapping gender variation in the spatial pattern of alcohol-related mortality: a Bayesian analysis using data from South Yorkshire, United Kingdom. Spat Spatiotemporal Epidemiol. 2012;3(2):141–9. Located at: Ovid MEDLINE(R) <2012>. doi:10.1016/j.sste.2012.04.007

96. Subhani M, Elleray R, Bethea J, Morling JR, Ryder SD. Alcohol-related liver disease mortality and missed opportunities in secondary care: A United Kingdom retrospective observational study. Drugs and Alcohol Review [Internet]. 2022;41(6):1331–40. Located at: none. Available from: https://www.drugsandalcohol.ie/36376/

97. Adair TL Alan D. Widening inequalities in premature mortality in Australia, 2006-16. Australian Population Studies. 2020;4(1):37–56. doi:10.37970/aps.v4i1.62

98. Scottish Health Action on Alcohol Problems. Dying for a drink. Circumstances of, and contributory factors to, alcohol deaths in Scotland: results of a rapid literature review and qualitative research study. [Internet]. Edinburgh: SHAAP; 2018 Oct. p. 68 p. Report No. Located at: public. Available from: https://www.drugsandalcohol.ie/29860/

99. Camacho C., Webb R.T., Bower P., Munford L. Risk factors for deaths of despair in England: An ecological study of local authority mortality data. Soc Sci Med. 2024;342((Camacho, Bower, Munford) Division of Population Health, Health Services Research and Primary Care, University of Manchester, Oxford Road, Manchester, M13 9PL, UK; National Institute for Health and Care Research (NIHR), Applied Research Collaboration Greater Manchester (ARC-GM), UK):116560. Located at: Embase Weekly Updates; 643235695. doi:10.1016/j.socscimed.2024.116560

100. Leyland AH, Dundas R, McLoone P, Boddy FA. Cause-specific inequalities in mortality in Scotland: two decades of change. A population-based study. BMC Public Health. 2007;7(100968562):172. Located at: Ovid MEDLINE(R) <2005 to 2007>

101. Alexiou AM Kate; Fahy, Katie; Taylor Robinson, David; Barr, Benjamin. Assessing the impact of funding cuts to local housing services on drug and alcohol related mortality: a longitudinal study using area-level data in England. European Journal of Housing Policy. 2021;NA(NA):1–19.

102. Rosicova KG Andrea Madarasova; van Dijk, Jitse P; Rosic, Martin; Zezula, Ivan; Groothoff, Johan W. Socioeconomic indicators and ethnicity as determinants of regional mortality rates in Slovakia. International journal of public health. 2009;54(4):274–82. doi:10.1007/s00038-009-7108-7

103. Allik M, Brown D, Dundas R, Leyland AH. Deaths of despair: cause-specific mortality and socioeconomic inequalities in cause-specific mortality among young men in Scotland. Intern j equity health. 2020;19(1):215. Located at: Ovid MEDLINE(R) <2020>. doi:10.1186/s12939-020-01329-7

104. United Kingdom. Office for National Statistics. Alcohol-specific deaths in the UK: registered in 2020. [Internet]. London: Office for National Statistics; 2021 Dec. Report No. Located at: none. Available from: https://www.drugsandalcohol.ie/35294/

105. Raschke N, Mohsenpour A, Aschentrup L, Fischer F, Wrona KJ. Socioeconomic factors associated with suicidal behaviors in South Korea: systematic review on the current state of evidence. BMC Public Health. 2022;22(1):129.

106. Qian JZ Stephanie; Larsen, Mark; Torok, Michelle. The application of spatial analysis to understanding the association between area-level socio-economic factors and suicide: a systematic review. Social psychiatry and psychiatric epidemiology. 2023;58(6):843–59. doi:10.1007/s00127-023-02441-z

107. Connolly S, O'Reilly D, Rosato M, Cardwell C. Area of residence and alcohol-related mortality risk: a five-year follow-up study. Addiction [Internet]. 2011;106(1):84–92. Located at: none. Available from: https://www.drugsandalcohol.ie/14503/

108. Lyubinets O, Kachmarska M, Sygit KM, Cipora E, Grshybowskyj J. Mortality and Alcohol as Its Cause-Comparative Characteristics of the Two Neighboring Countries: Ukraine and Poland. INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH. 2021 Oct;18(20). Located at: WOS:000714612800001. doi:10.3390/ijerph182010810

109. Cataldo J. Drugs or despair? Unraveling the rise in deaths of despair in Illinois. Journal of Public Mental Health. 2022 Jul;21(3):226–38. Located at: CINAHL. doi:10.1108/JPMH-01-2022-0004

110. Silczuk A, Gujska JH, Wojtyniak B, Camlet K, Stepien M, Stokwiszewski J, et al. The COVID-19 Crisis and the Incidence of Alcohol-Related Deaths in Poland. Med Sci Monit. 2023;29(dxw, 9609063):e940904. Located at: Ovid MEDLINE(R). doi:10.12659/MSM.940904

111. Braun NJ, Gloppen KM, Roesler J. Trends in Deaths Fully Attributable to Alcohol in Minnesota, 2000-2018. Public Health Rep. 2022;137(6):1091–9. Located at: Ovid MEDLINE(R) <2022>. doi:10.1177/00333549211044019

112. Spencer MR, Curtin SC, Hedegaard H. Rates of Alcohol-induced Deaths Among Adults Aged 25 and Over in Urban and Rural Areas: United States, 2000-2018. NCHS data brief. 2020;(383):1–8. Located at: Ovid MEDLINE(R) <2020>

113. Zemore SE, Li L, Bensley K, Karriker-Jaffe KJ, Cherpitel C. Alcohol- and Drug-Related Mortality Among Adults Within and Outside the U.S.-Mexico Border Region. J Stud Alcohol. 2022;Erratum in: J Stud Alcohol Drugs. 2022 May;83(3):454-455 PMID: 35590188 [https://www.ncbi.nlm.nih.gov/pubmed/35590188]83(2):175–84. Located at: Ovid MEDLINE(R) <2022>

114. Koskela L, Raatiniemi L, Bakke HK, Ala-Kokko T, Liisanantti J. Fatal poisonings in Northern Finland: causes, incidence, and rural-urban differences. Scand J Trauma Resusc Emerg Med. 2017;25(1):90. Located at: Ovid MEDLINE(R) <2017>. doi:10.1186/s13049-017-0431-8

115. Subedi R, Greenberg TL, Roshanafshar S. Does geography matter in mortality? An analysis of potentially avoidable mortality by remoteness index in Canada. Health reports. 2019;30(5):3–15.

116. Saunders H, Rudowitz R. A Look at the Latest Alcohol Death Data and Change Over the Last Decade [Internet]. 2024 [cited 2024 Dec 28]. Available from: https://www.kff.org/mental-health/issue-brief/a-look-at-the-latest-alcohol-death-data-and-change-over-the-last-decade/#:~:text=Alcohol%20deaths%20increased%20steadily%20over,from%2027%2C762%20deaths%20in%202012.

117. Warren M, Reavis B. Pain in the Nation: 2022 The Epidemics of Alcohol, Drug, and Suicide Deaths 2022 SPECIAL FEATURE: Two Decades of the Drug Overdose Crisis. Trust for America's Health TFAH.org [Internet]. 2022 [cited 2024 Dec 28]. Report No. Available from: https://wellbeingtrust.org/wp-content/uploads/2022/05/TFAH-2022-PainInTheNation-FINAL.pdf

118. Moon AM, Yang JY, Barritt AS 4th, Bataller R, Peery AF. Rising Mortality From Alcohol-Associated Liver Disease in the United States in the 21st Century. Am J Gastroenterol. 2020;115(1):79–87. Located at: Ovid MEDLINE(R) <2020>. doi:10.14309/ajg.0000000000000442

119. Grigoriev P, Jasilionis D, Stumbrys D, Stankuniene V, Shkolnikov VM. Individual- and area-level characteristics associated with alcohol-related mortality among adult Lithuanian males: A multilevel analysis based on census-linked data. PLoS ONE. 2017;12(7):e0181622. Located at: Ovid MEDLINE(R) <2017>. doi:10.1371/journal.pone.0181622

120. Kinjo AP Bolormaa; Okada, Tomomi; Kuwabara, Yuki; Fujii, Maya; Higuchi, Susumu; Osaki, Yoneatsu. Trends and differences in alcohol-related mortality rates by gender and by prefectures in Japan between 1995 and 2016. Drug and alcohol dependence. 2021;221(NA):108586–108586. doi:10.1016/j.drugalcdep.2021.108586

121. Folk A, Mouhaffel R, Grewal H, Noh S, Le Cam E, Liu F, et al. United States-Mexico Border Disparities in Alcoholic Liver Disease Mortality: A Cross-Sectional Analysis 1999-2020. Journal of Clinical Gastroenterology. 2024;10–1097.

122. Sumetsky N, Brooks MM, Buchanich J, Molina B, Mair C. Changes in six categories of alcohol-attributable mortality from before to during the early phases of the COVID-19 pandemic. Journal of studies on alcohol and drugs. 2024;jsad-23.

123. Miščikienė L, Štelemėkas M, Petkevičienė J, Rehm J, Lange S, Trišauskė J. The prevalence of alcohol-related deaths in autopsies performed in Lithuania between 2017 and 2020: a cross-sectional study. European journal of public health. 2024;ckae059.

124. Raatiniemi L, Steinvik T, Liisanantti J, Ohtonen P, Martikainen M, Alahuhta S, et al. Fatal injuries in rural and urban areas in northern Finland: a 5-year retrospective study. Acta Anaesthesiol Scand. 2016;60(5):668–76. Located at: Ovid MEDLINE(R) <2016>. doi:10.1111/aas.12682

125. Arreola-Rissa C., Santos-Guzman J., Esquivel-Guzman A., Mock C.N. Traffic related deaths in Nuevo Leon, Mexico: Causes and associated factors. Salud Publica Mex [Internet].

2008;50(SUPPL. 1):S48–54. Located at: Embase; 351534994. Available from: http://bvs.insp.mx/rsp/_files/File/2008/suplemento%201%20/6-Nvo.%20Le%F3n.pdf

126. Czech S, Shakeshaft AP, Byrnes JM, Doran CM. Comparing the cost of alcohol-related traffic crashes in rural and urban environments. Accid Anal Prev. 2010;42(4):1195–8. Located at: Ovid MEDLINE(R) <2010 o 2011>. doi:10.1016/j.aap.2010.01.010

127. Gjerde H, Christophersen AS, Normann PT, Morland J. Toxicological investigations of drivers killed in road traffic accidents in Norway during 2006-2008. Forensic Sci Int. 2011;212(1–3):102–9. Located at: Ovid MEDLINE(R) <2010 o 2011>. doi:10.1016/j.forsciint.2011.05.021

128. Wundersitz L, Raftery S. Understanding the context of alcohol impaired driving for fatal crash-involved drivers: A descriptive case analysis. Traffic inj prev. 2017;18(8):781–7. Located at: Ovid MEDLINE(R) <2017>. doi:10.1080/15389588.2017.1322696

129. Baeseman ZJ. Alcohol-related motor vehicle accident fatality: Wisconsin rural-urban trends and observations. WMJ. 2009;108(7):359–64. Located at: Ovid MEDLINE(R) <2008 to 2009>

130. Northern Ireland Statistics and Research Agency. Fatal and serious (KSI) road traffic collisions caused by drink driving, Northern Ireland 2013-2017. [Internet]. Belfast: Department for Infrastructure; 2019 Aug. Report No. Located at: public. Available from: https://www.drugsandalcohol.ie/30917/

131. Yao J, Johnson MB, Tippetts S. Enforcement uniquely predicts reductions in alcohol-impaired crash fatalities. Addiction. 2016;Comment in: Addiction. 2016 Mar;111(3):454-5 PMID: 26860245 [https://www.ncbi.nlm.nih.gov/pubmed/26860245]111(3):448–53. Located at: Ovid MEDLINE(R) <2016>. doi:10.1111/add.13198

132. Geedipally SR, Turner PA, Patil S. Analysis of Motorcycle Crashes in Texas with Multinomial Logit Model. TRANSPORTATION RESEARCH RECORD. 2011;(2265):62–9. Located at: WOS:000302274200008. doi:10.3141/2265-07

133. Gaudet L, Romanow NTR, Nettel-Aguirre A, Voaklander D, Hagel BE, Rowe BH. The epidemiology of fatal cyclist crashes over a 14-year period in Alberta, Canada. BMC Public Health. 2015;15(100968562):1142. Located at: Ovid MEDLINE(R) <2015>. doi:10.1186/s12889-015-2476-9

134. Lasota D, Goniewicz M, Kosson D, Ochal A, Krajewski P, Tarka S, et al. The effect of ethyl alcohol on the severity of injuries in fatal pedestrian victims of traffic crashes. PLoS ONE. 2019;14(9):e0221749. Located at: Ovid MEDLINE(R) <2019>. doi:10.1371/journal.pone.0221749

135. Lasota D, Al-Wathinani A, Krajewski P, Goniewicz K, Pawlowski W. Alcohol and Road Accidents Involving Pedestrians as Unprotected Road Users. Int J Environ Res Public Health. 2020;17(23). Located at: Ovid MEDLINE(R) <2020>. doi:10.3390/ijerph17238995

136. Pawlowski W, Lasota D, Goniewicz M, Rzonca P, Goniewicz K, Krajewski P. The Effect of Ethyl Alcohol upon Pedestrian Trauma Sustained in Traffic Crashes. Int J Environ Res Public Health. 2019;16(8). Located at: Ovid MEDLINE(R) <2019>. doi:10.3390/ijerph16081471

137. Rudisill TM, Barbee LO, Hendricks B. Characteristics of Fatal, Pedestrian-Involved, Motor Vehicle Crashes in West Virginia: A Cross-Sectional and Spatial Analysis. Int J Environ Res Public Health. 2023;20(7). Located at: Ovid MEDLINE(R). doi:10.3390/ijerph20075251

138. Minh Pham T, Kondor I, Hanel R, Thurner S. The effect of social balance on social fragmentation. Journal of the Royal Society Interface. 2020;17(172):20200752.

139. Grigoroglou C, Munford L, Webb RT, Kapur N, Ashcroft DM, Kontopantelis E. Prevalence of mental illness in primary care and its association with deprivation and social fragmentation at the small-area level in England. Psychological Medicine. 2020;50(2):293–302.

140. Hunter SF Gregory; Benny, Claire; Smith, Brendan T; Pabayo, Roman. The association between social fragmentation and deaths attributable to alcohol, drug use, and suicide: Longitudinal evidence from a population-based sample of Canadian adults. Preventive medicine. 2023;175(NA):107688–107688. doi:10.1016/j.ypmed.2023.107688

141. Office for National Statistics. Deaths due to suicide, drug-poisoning, or alcohol-specific causes in English coastal areas, deaths that occurred between 2011 and 2018 [Internet]. 2021 [cited 2025 Feb 8]. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/adhocs/13243deathsduetosuicidedrugpoisoningoralcoholspecificcausesinenglishcoastalareasdeathsthatoccurredbetween2011and2018

142. Casant J, Helbich M. Inequalities of suicide mortality across urban and rural areas: A literature review. International Journal of Environmental Research and Public Health. 2022;19(5):2669.

143. Atalay K, Edwards R, Georgiakakis F. Mortality Inequality: New Evidence from Australia. Life Course Centre Working Paper. 2022;(2022–20).

144. Ayuso-Álvarez A, Ortiz C, López-Cuadrado T, Rodríguez-Blázquez C, Fernández-Navarro P, González-Palacios J, et al. Rural-urban gradients and all-cause, cardiovascular and cancer mortality in Spain using individual data. SSM-Population Health. 2022;19:101232.

145. Beautrais AL. Farm suicides in New Zealand, 2007-2015: A review of coroners' records. Aust N Z J Psychiatry. 2018;52(1):73–86. Located at: Ovid MEDLINE(R) <2018>. doi:10.1177/0004867417704058

146. Barry RR Jürgen; de Oliveira, Claire; Gozdyra, Peter; Kurdyak, Paul. Rurality and Risk of Suicide Attempts and Death by Suicide among People Living in Four English-speaking High-income Countries: A Systematic Review and Meta-analysis: Canadian journal of psychiatry Revue canadienne de psychiatrie. 2020;65(7):441–7. doi:10.1177/0706743720902655

147. Arif AAA Oluwaseun; Laditka, Sarah B; Laditka, James N. Suicide Rates and Risks Across U.S. Industries: A 29-Year Population-Based Survey. Archives of suicide research : official journal of the International Academy for Suicide Research. 2024;NA(NA):1–26. doi:10.1080/13811118.2023.2300324

148. Alston M. Rural male suicide in Australia. Social science & medicine (1982). 2010;74(4):515–22. doi:10.1016/j.socscimed.2010.04.036

149. Pesonen TM, Hintikka J, Karkola KO, Saarinen PI, Antikainen M, Lehtonen J. Male suicide mortality in eastern Finland-urban-rural changes during a 10-year period between 1988 and 1997. Scandinavian Journal of Public Health. 2001;29(3):189–93.

150. McCarthy JF; B Frederic C; Ignacio, Rosalinda V; Ilgen, Mark A; Austin, Karen L; Valenstein, Marcia. Suicide Among Patients in the Veterans Affairs Health System: Rural–Urban Differences

in Rates, Risks, and Methods. American journal of public health. 2012;102(S1):111–7. doi:10.2105/ajph.2011.300463

151. Taylor R, Page A, Morrell S, Harrison J, Carter G. Social and psychiatric influences on urban–rural differentials in Australian suicide. Suicide and Life-Threatening Behavior. 2005;35(3):277–90.

152. Monnat SM. Factors Associated With County-Level Differences in U.S. Drug-Related Mortality Rates. American journal of preventive medicine. 2018;54(5):611–9. doi:10.1016/j.amepre.2018.01.040

153. Breen JM, Naess PA, Hansen TB, Gaarder C, Stray-Pedersen A. Serious motor vehicle collisions involving young drivers on Norwegian roads 2013-2016: Speeding and driver-related errors are the main challenge. Traffic inj prev. 2020;21(6):382–8. Located at: Ovid MEDLINE(R) <2020>. doi:10.1080/15389588.2020.1770237

154. Xie K, Ozbay K, Yang H. Secondary collisions and injury severity: A joint analysis using structural equation models. Traffic inj prev. 2018;19(2):189–94. Located at: Ovid MEDLINE(R) <2018>. doi:10.1080/15389588.2017.1369530

155. Prati GP Víctor Marín; De Angelis, Marco; Fraboni, Federico; Pietrantoni, Luca. Factors contributing to bicycle–motorised vehicle collisions: a systematic literature review. Transport Reviews. 2017;38(2):184–208. doi:10.1080/01441647.2017.1314391

156. Perkins MC Sam; Mitra, Biswadev; Gabbe, Belinda J; Brown, Julie; Oxley, Jennifer Anne; Cameron, Peter; Beck, Ben. Identify the key characteristics of pedestrian collisions through in-depth interviews: a pilot study. International journal of injury control and safety promotion. 2021;28(2):135–40. doi:10.1080/17457300.2021.1876736

157. Azar D, White V, Coomber K, Faulkner A, Livingston M, Chikritzhs T, et al. The association between alcohol outlet density and alcohol use among urban and regional Australian adolescents. Addiction. 2016;111(1):65–72.

158. Bellis MAH Karen; Nicholls, James; Sheron, Nick; Gilmore, Ian; Jones, Lisa. The alcohol harm paradox: using a national survey to explore how alcohol may disproportionately impact health in deprived individuals. BMC public health. 2016;16(1):111–111. doi:10.1186/s12889-016-2766-x

159. Shortt NK, Tisch C, Pearce J, Mitchell R, Richardson EA, Hill S, et al. A cross-sectional analysis of the relationship between tobacco and alcohol outlet density and neighbourhood deprivation. BMC public health. 2015;15:1–9.

160. Katikireddi S.V., Whitley E., Lewsey J., Gray L., Leyland A.H. Socioeconomic status as an effect modifier of alcohol consumption and harm: analysis of linked cohort data. Lancet Public Health. 2017;2(6):e267–76. Located at: Embase; 616133032. doi:10.1016/S2468-2667%2817%2930078-6

161. Keyes KM; H Mark L; Hasin, Deborah S. Stressful life experiences, alcohol consumption, and alcohol use disorders: the epidemiologic evidence for four main types of stressors. Psychopharmacology. 2011;218(1):1–17. doi:10.1007/s00213-011-2236-1

162. Thern E, Ramstedt M, Svensson J. Long-term effects of youth unemployment on alcohol-related morbidity. ADDICTION. 2020 Mar;115(3):418–25. Located at: WOS:000500509800001. doi:10.1111/add.14838

163. Thern E, Ramstedt M, Svensson J. The associations between unemployment at a young age and binge drinking and alcohol-related problems. European journal of public health. 2020;30(2):368–73.

164. De Goeij MC, Suhrcke M, Toffolutti V, van de Mheen D, Schoenmakers TM, Kunst AE. How economic crises affect alcohol consumption and alcohol-related health problems: a realist systematic review. Social science & medicine. 2015;131:131–46.

165. Wolfe DM, Hutton B, Corace K, Chaiyakunapruk N, Ngorsuraches S, Nochaiwong S, et al. Service-level barriers to and facilitators of accessibility to treatment for problematic alcohol use: a scoping review. Frontiers in public health. 2023;11:1296239.

166. Ng Fat L, Scholes S, Jivraj S. The relationship between drinking pattern, social capital, and area-deprivation: findings from the health survey for England. Journal of studies on alcohol and drugs. 2017;78(1):20–9.

167. Fone DLF Daniel; White, James; Lyons, Ronan A; Dunstan, Frank David John. Socioeconomic patterning of excess alcohol consumption and binge drinking: a cross-sectional study of multilevel associations with neighbourhood deprivation. BMJ open. 2013;3(4):e002337-NA. doi:10.1136/bmjopen-2012-002337

168. Matheson FI, White HL, Moineddin R, Dunn JR, Glazier RH. Drinking in context: the influence of gender and neighbourhood deprivation on alcohol consumption. J epidemiol community health. 2012;66(6):e4–e4.

169. Castillo JM, Jivraj S, Fat LN. The regional geography of alcohol consumption in England: comparing drinking frequency and binge drinking. Health & place. 2017;43:33–40.

170. Aberg F, Helenius-Hietala J, Puukka P, Jula A. Binge drinking and the risk of liver events: A population-based cohort study. Liver Int. 2017;Comment in: Liver Int. 2017 Sep;37(9):1281-1283 PMID: 28845617 [https://www.ncbi.nlm.nih.gov/pubmed/28845617]37(9):1373–81. Located at: Ovid MEDLINE(R) <2017>. doi:10.1111/liv.13408

171. Bobak M, Room R, Pikhart H, Kubinova R, Malyutina S, Pajak A, et al. Contribution of drinking patterns to differences in rates of alcohol related problems between three urban populations. JOURNAL OF EPIDEMIOLOGY AND COMMUNITY HEALTH. 2004 Mar 1;58(3):238–42. Located at: WOS:000188970300012. doi:10.1136/jech.2003.011825

172. Degerud E, Ariansen I, Ystrom E, Graff-Iversen S, Hoiseth G, Morland J, et al. Life course socioeconomic position, alcohol drinking patterns in midlife, and cardiovascular mortality: Analysis of Norwegian population-based health surveys. PLoS Med. 2018;Comment in: PLoS Med. 2018 Jan 2;15(1):e1002477 PMID: 29293504 [https://www.ncbi.nlm.nih.gov/pubmed/29293504]15(1):e1002476. Located at: Ovid MEDLINE(R) <2018>. doi:10.1371/journal.pmed.1002476

173. Boyd JB Clare; Purshouse, Robin C; Holmes, John. Beyond Behaviour: How Health Inequality Theory Can Enhance Our Understanding of the 'Alcohol-Harm Paradox'. International journal of environmental research and public health. 2021;18(11):6025-NA. doi:10.3390/ijerph18116025

174. GBD 2020 Alcohol Collaborators. Population-level risks of alcohol consumption by amount, geography, age, sex, and year: a systematic analysis for the Global Burden of Disease Study 2020. The Lancet [Internet]. 2022 Jul;400(10347). Located at: none. Available from: https://www.drugsandalcohol.ie/36626/

175. Griswold MF Nancy; Hawley, Caitlin; et al. Alcohol use and burden for 195 countries and territories, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet (London, England). 2018;392(10152):1015–35. doi:10.1016/s0140-6736(18)31310-2

176. O'Dwyer C, Mongan D, Doyle A, Galvin B. Alcohol consumption, alcohol-related harm and alcohol policy in Ireland. [Internet]. HRB Overview Series 11. Dublin: Health Research Board; 2021 Apr. p. 173 p. Report Nos.: 1649–7198. Located at: public. Available from: https://www.drugsandalcohol.ie/33909/

177. Rossow I, Norström T. The use of epidemiology in alcohol research. Addiction. 2013;108(1):20–5.

178. Rehm J, Zatonksi W, Taylor B, Anderson P. Epidemiology and alcohol policy in Europe. Addiction. 2011;106 Suppl 1(bm3, 9304118):11–9. Located at: Ovid MEDLINE(R) <2010 o 2011>. doi:10.1111/j.1360-0443.2010.03326.x

179. Hart A, Moore D. Alcohol and alcohol effects: Constituting causality in alcohol epidemiology. Contemporary Drug Problems. 2014;41(3):393–416.

180. Parry CD, Patra J, Rehm J. Alcohol consumption and non-communicable diseases: epidemiology and policy implications. Addiction. 2011;106(10):1718–24.

181. World Health Organization. WHO launches SAFER alcohol control initiative to prevent and reduce alcohol-related death and disability. [Internet]. 2018 Sep 28. Located at: none. Available from: https://www.drugsandalcohol.ie/29751/

182. WHO Regional Office for Europe. Making the European region safer: developments in alcohol control policies, 2010–2019 [Internet]. Copenhagen: WHO Regional Office for Europe; 2021. Report No. Available from: https://www.drugsandalcohol.ie/34060/

183. Higgins JP, Morgan RL, Rooney AA, Taylor KW, Thayer KA, Silva RA, et al. A tool to assess risk of bias in non-randomized follow-up studies of exposure effects (ROBINS-E). Environment international. 2024;186:108602.

184. Campbell M, McKenzie JE, Sowden A, Katikireddi SV, Brennan SE, Ellis S, et al. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. bmj. 2020;368.

Appendix

Supplementary Table 1 Search strategy for systematic review

1. Medline

SES/Geographic terms
(socio?economic or SES or SEP or asset? score or socioeconomic position).ti,ab. or exp *social class/ or Disadvantage*.mp. or Health Services Accessibility.mp. or exp "Social Determinants of Health"/ or determinant* of health.mp. or social disparit*.mp. or Poverty Areas.mp. or social inequ*or urban.mp. or rural.mp. or place-based.mp. or Geographi* variation.mp. or exp Geographic Information Systems/ or exp Spatial Analysis/ or spatial inequalities.mp. or exp Residence Characteristics/ or activity-space.mp. or (rural or urban or social discrimination or marginali*ation or social segregation).ti,ab. or neighbo*rhood.mp. or hotspot.mp. or geostatistics.mp. or geomathematics.mp. or Urban Population.mp. or Urbanicity.mp. or rurality.mp. or spatiotemporal.mp. or sociodemographic*.mp. or Poverty.mp. or Environmental Exposure.mp. or environmental features.mp or metropolitan.mp. or exp Healthcare Disparities/ or health inequ*.ab,ti. Or exp Collective Efficacy/ or (geograph* adj3 (Location or region*)).mp. or (depriv* adj3 (measure or score*or calculation or index or area)).mp.
Alcohol use and related conditions terms
(alcohol or (Alcohol* adj3 drink*) or (alcohol* adj3 driv*) or (alcohol* adj hepatit*) or (alcohol* adj liver) or (alcohol* adj gastritis) or (alcohol* adj poisoning) or (alcohol* adj3 suicide) or (alcohol* adj3 fire) or (alcohol* adj pancreatitis) or (alcohol* adj polyneuropathy) or (alcohol* adj cardiomyopathy) or (alcohol* adj myopathy) or (alcohol* adj fibrosis) or (alcohol* adj sclerosis) or (alcohol* adj cirrhosis) or (alcohol* adj nervous system) or deaths of despair or (alcohol* adj3 (accidents or traffic or road))).mp.
Death terms
(death* or dying or mortalit* or fatal*).mp.
High-income countries
australasia/ or exp australia/ or austria/ or baltic states/ or belgium/ or exp canada/ or chile/ or colombia/ or costa rica/ or czech republic/ or exp denmark/ or estonia/ or europe/ or finland/ or exp france/ or exp germany/ or greece/ or hungary/ or iceland/ or ireland/ or israel/ or exp italy/ or exp japan/ or korea/ or latvia/ or lithuania/ or luxembourg/ or mexico/ or netherlands/ or new zealand/ or north america/ or exp norway/ or poland/ or portugal/ or exp "republic of korea"/ or "scandinavian and nordic countries"/ or slovakia/ or slovenia/ or spain/ or sweden/ or switzerland/ or turkey/ or exp united kingdom/ or exp united states/ or European Union/ or "Organisation for Economic Co-Operation and Development"/

2. Web of Science

SES/Geographic terms
("socioeconomic" OR "socio$economic" OR "SES" OR "SEP" OR "asset score" OR "socio$economic position") OR "social class" OR "Disadvantage*" OR "Health Services Accessibility" OR "Social Determinants of Health" OR "determinant* of health" OR "social disparit*" OR "Poverty Areas" OR "social inequ*" OR "urban" OR "rural" OR "place-based" OR "Geographic variation" OR "Geographic Information Systems" OR "Spatial Analysis" OR "spatial inequalities" OR "Residence Characteristics" OR "activity-space" OR "social discrimination" OR "marginali$ation" OR "social segregation" OR "neighbo*rhood" OR "hotspot" OR "geostatistics" OR "geomathematics" OR "Urban Population" OR "Urbanicity" OR "rurality" OR "spatiotemporal" OR "sociodemographic*" OR "Poverty" OR "Environmental Exposure" OR "environmental features" OR "metropolitan" OR "Healthcare Disparities" OR "health inequ*" OR "Collective Efficacy" OR ("geograph*" NEAR/3 ("Location" OR "region*")) OR ("depriv*" NEAR/3 ("measure" OR "score*" OR "calculation" OR "index" OR "area"))
Alcohol use and related conditions terms
(alcohol OR (Alcohol* NEAR/3 drink*)) OR (alcohol* NEAR/3 driv*) OR (alcohol* NEAR hepatit*) OR (alcohol* NEAR liver) OR (alcohol* NEAR gastritis) OR (alcohol* NEAR poisoning) OR (alcohol* NEAR/3 suicide) OR (alcohol* NEAR/3 fire) OR (alcohol* NEAR pancreatitis) OR (alcohol* NEAR polyneuropathy) OR (alcohol* NEAR cardiomyopathy) OR (alcohol* NEAR myopathy) OR (alcohol* NEAR fibrosis) OR (alcohol* NEAR sclerosis) OR (alcohol* NEAR cirrhosis) OR (alcohol* NEAR nervous system) OR (alcohol* NEAR/3 (accidents OR traffic OR road))
Death terms
(mortality OR death* OR dying OR cause of death OR fatal OR deaths of despair)

High-income countries
australasia/ or exp australia/ or austria/ or baltic states/ or belgium/ or exp canada/ or chile/ or colombia/ or costa rica/ or czech republic/ or exp denmark/ or estonia/ or europe/ or finland/ or exp france/ or exp germany/ or greece/ or hungary/ or iceland/ or ireland/ or israel/ or exp italy/ or exp japan/ or korea/ or latvia/ or lithuania/ or luxembourg/ or mexico/ or netherlands/ or new zealand/ or north america/ or exp norway/ or poland/ or portugal/ or exp "republic of korea"/ or "scandinavian and nordic countries"/ or slovakia/ or slovenia/ or spain/ or sweden/ or switzerland/ or turkey/ or exp united kingdom/ or exp united states/ or European Union/ or "Organisation for Economic Co-Operation and Development"/
3. CINAHL
SES/Geographic terms
(socioeconomic or SES or SEP or "asset score" or "socioeconomic position") OR social class OR Disadvantage* OR "Health Services Accessibility" OR "Social Determinants of Health" OR "determinant of health" OR "social disparit*" OR "Poverty Areas" OR "social inequ*" OR urban OR rural OR "place-based" OR "Geographic variation" OR "Geographic Information Systems" OR "Spatial Analysis" OR "spatial inequalities" OR "Residence Characteristics" OR "activity-space" OR ("rural" or "urban" or "social discrimination" or marginalization or "social segregation") OR neighborhood OR hotspot OR geostatistics OR geomathematics OR "Urban Population" OR Urbanicity OR rurality OR "spatiotemporal" OR sociodemographic* OR Poverty OR "Environmental Exposure" OR "environmental features" OR metropolitan OR "Healthcare Disparities" OR "health inequ*" OR "Collective Efficacy" OR (geograph* N3 (Location or region*)) OR (depriv* N3 (measure or score* or calculation or index or area))
Alcohol use and related conditions terms
((alcohol OR (Alcohol* N3 Drink*) OR (alcohol* N3 driv*) OR (alcohol* N3 hepatit*) OR (alcohol* N3 liver) OR (alcohol* N3 gastritis) OR (alcohol* N3 poisoning) OR (alcohol* N3 suicide) OR (alcohol* N3 fire) OR (alcohol* N3 pancreatitis) OR (alcohol* N3 polyneuropathy) OR (alcohol* N3 cardiomyopathy) OR (alcohol* N3 myopathy) OR (alcohol* N3 fibrosis) OR (alcohol* N3 sclerosis) OR (alcohol* N3 cirrhosis) OR (alcohol* N3 nervous system) OR deaths of despair OR (alcohol* N3 (accidents OR traffic OR road)))
Death terms
(death* OR dying OR mortalit* OR fatal*))
High-income countries
australasia/ or exp australia/ or austria/ or baltic states/ or belgium/ or exp canada/ or chile/ or colombia/ or costa rica/ or czech republic/ or exp denmark/ or estonia/ or europe/ or finland/ or exp france/ or exp germany/ or greece/ or hungary/ or iceland/ or ireland/ or israel/ or exp italy/ or exp japan/ or korea/ or latvia/ or lithuania/ or luxembourg/ or mexico/ or netherlands/ or new zealand/ or north america/ or exp norway/ or poland/ or portugal/ or exp "republic of korea"/ or "scandinavian and nordic countries"/ or slovakia/ or slovenia/ or spain/ or sweden/ or switzerland/ or turkey/ or exp united kingdom/ or exp united states/ or European Union/ or "Organisation for Economic Co-Operation and Development"/
4. PsychInfo
SES/Geographic terms
(socio?economic or SES or SEP or asset? score or socioeconomic position).ti,ab. or exp *social class/ or Disadvantage*.mp. or Health Services Accessibility.mp. or social determinants of health.mp. or determinant* of health.mp. or social disparit*.mp. or Poverty Areas.mp. or social inequ*or urban.mp. or rural.mp. or place-based.mp. or Geographi* variation.mp. or exp Geographic Information Systems/ or exp Spatial Analysis/ or spatial inequalities.mp. or exp Residence Characteristics/ or activity-space.mp. or (rural or urban or social discrimination or marginali*ation or social segregation).ti,ab. or neighbo*rhood.mp. or hotspot.mp. or geostatistics.mp. or geomathematics.mp. or Urban Population.mp. or Urbanicity.mp. or rurality.mp. or spatiotemporal.mp. or sociodemographic*.mp. or Poverty.mp. or Environmental Exposure.mp. or environmental features.mp or metropolitan.mp. or exp Healthcare Disparities/ or health inequ*.ab,ti. Or exp Collective Efficacy/ or (geograph* adj3 (Location or region*)).mp. or (depriv* adj3 (measure or score*or calculation or index or area)).mp.
Alcohol use and related conditions terms
(alcohol or (Alcohol* adj3 drink*) or (alcohol* adj3 driv*) or (alcohol* adj hepatit*) or (alcohol* adj liver) or (alcohol* adj gastritis) or (alcohol* adj poisoning) or (alcohol* adj3 suicide) or (alcohol* adj3 fire) or (alcohol* adj pancreatitis) or (alcohol* adj polyneuropathy) or (alcohol* adj cardiomyopathy) or (alcohol* adj myopathy) or (alcohol* adj fibrosis) or (alcohol* adj sclerosis) or (alcohol* adj cirrhosis) or (alcohol* adj nervous system) or deaths of despair or (alcohol* adj3 (accidents or traffic or road))).mp.
Death terms

(death* or dying or mortalit* or fatal*).mp.
5. EMBASE
SES/Geography
("socioeconomic" or "SES" or "SEP" or "asset score" or "socioeconomic position" or "social class exp" or "Disadvantage*" or "Health Services Accessibility" or "Social Determinants of Health exp" or "determinant* of health" or "social disparit*" or "Poverty Areas" or "social inequ*" or "urban" or "rural" or "place-based" or "Geographic variation" or "Geographic Information Systems exp" or "Spatial Analysis exp" or "spatial inequalities" or "Residence Characteristics exp" or "activity-space" or "rural" or "urban" or "social discrimination" or "marginali*ation" or "social segregation" or "neighbo*rhood" or "hotspot" or "geostatistics" or "geomathematics" or "Urban Population" or "Urbanicity" or "rurality" or "spatiotemporal" or "sociodemographic*" or "Poverty" or "Environmental Exposure" or "environmental features" or "metropolitan" or "Healthcare Disparities exp" or "health inequ*" or "Collective Efficacy exp" or ("geograph*" adj3 ("Location" or "region*")) or ("depriv*" adj3 ("measure" or "score*" or "calculation" or "index" or "area"))).ti,ab.
Alcohol use and related conditions
("alcohol" or ("Alcohol*" adj3 "drink*") or ("alcohol*" adj3 "driv*") or ("alcohol*" adj "hepatit*") or ("alcohol*" adj "liver") or ("alcohol*" adj "gastritis") or ("alcohol*" adj "poisoning") or ("alcohol*" adj3 "suicide") or ("alcohol*" adj3 "fire") or ("alcohol*" adj "pancreatitis") or ("alcohol*" adj "polyneuropathy") or ("alcohol*" adj "cardiomyopathy") or ("alcohol*" adj "myopathy") or ("alcohol*" adj "fibrosis") or ("alcohol*" adj "sclerosis") or ("alcohol*" adj "cirrhosis") or ("alcohol*" adj "nervous system") or "deaths of despair" or ("alcohol*" adj3 ("accidents" or "traffic" or "road"))).ti,ab.
Death
("death*" or "dying" or "mortalit*" or "fatal*").ti,ab.
OECD
australasia/ or exp australia/ or austria/ or baltic states/ or belgium/ or exp canada/ or chile/ or colombia/ or costa rica/ or czech republic/ or exp denmark/ or estonia/ or europe/ or finland/ or exp france/ or exp germany/ or greece/ or hungary/ or iceland/ or ireland/ or israel/ or exp italy/ or exp japan/ or korea/ or latvia/ or lithuania/ or luxembourg/ or mexico/ or netherlands/ or new zealand/ or north america/ or exp norway/ or poland/ or portugal/ or exp "republic of korea"/ or "scandinavian and nordic countries"/ or slovakia/ or slovenia/ or spain/ or sweden/ or switzerland/ or turkey/ or exp united kingdom/ or exp united states/ or European Union/ or "Organisation for Economic Co-Operation and Development"/
6. Epistemonikos
(title:("socioeconomic" OR "geograph*" OR "urban" OR "rural") OR abstract:("socioeconomic" OR "geograph*" OR "urban" OR "rural")) AND (title:("alcohol") OR abstract:("alcohol")) AND (title:(death) OR abstract:(death)) 1) (title:("socioeconomic" or "geograph*" or "urban" or "rural") OR abstract:("socioeconomic" or "geograph*" or "urban" or "rural")) 2) AND (title:("alcohol") OR abstract:("alcohol")) 3) AND (title:(death) OR abstract:(death))
7. Emerald Insight
"socioeconomic" or "SES" or "SEP" or "asset score" or "socioeconomic position" or "social class" or "Disadvantage*" or "Health Services Accessibility" or "Social Determinants of Health" or "determinant of health" or "social disparit" or "Poverty Areas" or "social inequ" or "urban" or "rural" or "place-based" or "Geographic variation" or "Geographic Information Systems" or "Spatial Analysis" or "spatial inequalities" or "Residence Characteristics" or "activity-space" or "rural" or "urban" or "social discrimination" or "marginalisation" or "social segregation" or "neighbourhood" or "hotspot" or "geostatistics" or "geomathematics" or "Urban Population" or "Urbanicity" or "rurality" or "spatiotemporal" or "sociodemographic*" or "Poverty" or "Environmental Exposure" or "environmental features" or "metropolitan" or "Healthcare Disparities" or "health inequality" or "Collective Efficacy" or "geographic" or "deprivation" ("alcohol" or ("Alcohol*" adj3 "drink*") or ("alcohol*" adj3 "driv*") or ("alcohol*" adj "hepatit*") or ("alcohol*" adj "liver") or ("alcohol*" adj "gastritis") or ("alcohol*" adj "poisoning") or ("alcohol*" adj3 "suicide") or ("alcohol*" adj3 "fire") or ("alcohol*" adj "pancreatitis") or ("alcohol*" adj "polyneuropathy") or ("alcohol*" adj "cardiomyopathy") or ("alcohol*" adj "myopathy") or ("alcohol*" adj "fibrosis") or ("alcohol*" adj "sclerosis") or ("alcohol*" adj "cirrhosis") or ("alcohol*" adj "nervous system") or "deaths of despair" or ("alcohol*" adj3 ("accidents" or "traffic" or "road"))).ti,ab. ("death*" or "dying" or "mortalit*" or "fatal*").ti,ab.

Supplementary Table 2 Grey literature search

Location	Date	Organisation	Website	Search strings	Results returned	Total screened at Title and Abstract	Total screened at full text	Total included
Ireland	22/09/24	Health Information and Quality Authority (HIQA)	https://www.hiqa.ie/	alcohol	15	15	0	0
		Health Research Board (HRB)	https://www.hrb.ie/	alcohol	173	173	3	0
		Healthy Ireland	https://www.gov.ie/en/campaigns/healthy-ireland/	Alcohol	1	1	0	0
		Health Services Executive (HSE)	https://www.hse.ie/	'alcohol-related death'	1296	1296	0	0
		Institute of Public Health (IPH)	https://www.publichealth.ie/	alcohol	49	49	1	0
		Health Research Board's National Drugs Library	https://www.drugsandalcohol.ie/	'Alcohol' and 'death'	331	331	75	4
		Institute of Public Administration	https://www.ipa.ie/	Alcohol	1	1	0	0
UK		Northern Ireland Statistics and Research Agency	https://www.nisra.gov.uk/publications/	Alcohol-Specific Deaths	16	16	1	1
		Department for Infrastructure	https://www.infrastructure-ni.gov.uk/publications	Alcohol	30	30	1	1
	29/01/25	Office for National Statistics	https://www.ons.gov.uk/	Alcohol	430	430	3	3
	29/01/25	Health Evidence – National Collaborating Centre for Methods and Tools	https://www.healthevidence.org/search.aspx	'Alcohol' and 'death'	38	38	0	0
	29/01/25	NHS Digital	https://digital.nhs.uk/	Alcohol, death	17	1	1	0
	30/01/25	Institute of Alcohol Studies	https://www.ias.org.uk/		17	17	0	0
Canada	12/09/24	University of Victoria Canadian Institute for Substance Use Research	https://www.uvic.ca/research/centres/cisur/projects/cape/index.php		18	18	0	0

Location	Date	Organisation	Website	Search strings	Results returned	Total screened at Title and Abstract	Total screened at full text	Total included
		Canadian Alcohol Policy Evaluation (CAPE) and Community of Practice						
Global		World Health Organization (WHO)	https://www.who.int/	Alcohol, death, geography	236		0	0
		Google Scholar		alcohol death geography/ socioeconomic status	100	First 10 pages	37	0
		Google		alcohol + death + geography	100	First 10 pages	13	4
	23/09/24	Movendi	https://movendi.ngo/	Alcohol	264	20	0	0
	30/01/25	Kettil Bruun Society	https://www.kettilbruun.org/	'Death'	40	40	0	0
	29/01/25	WHO Noncommunicable diseases (NCD) dashboard	https://www.who.int/europe/tools-and-toolkits/noncommunicable-diseases-(ncd)-dashboard	Alcohol	1	1	1	0

Supplementary Table 3 Quality assessment ratings for ecological studies using the National Heart Lung and Blood Institute (NHLBI) Study Quality Assessment Tool for observational cohort and cross-sectional studies

	Erskine et al (2010) (71)	**Ransome et al (2020) (64)**	**Innamorat et al (2013) (65)**	**Zhang et al (2024)(66)**	**Castillo-Carniglia et al (2014) (67)**	**Nagy et al (2013) (68)**	**Jayasekara et al (2014) (69)**	**Senserrick et al (2014) (70)**
1. Was the research question or objective in this paper clearly stated?	✓	✓	✓	✓	✓	✓	✓	✓
2. Was the study population clearly specified and defined?	✓	✓	✓	✓	✓	✓	✓	✓
3. Was the participation rate of eligible persons at least 50%?	**NR**	**n/a**	**n/a**	**n/a**	**✓**	**n/a**	**n/a**	**n/a**
4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? And were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	**✓**	**✓**	**✓**	**✓**	**✓**	**✓**	**✓**	**✓**
5. Was a sample size justification, power description, or variance and effect estimates provided?	**NR**	**n/a**	**NR**	**✓**	**✓**	**✓**	**✓**	**NR**
6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?	✓	n/a	✓	✓	✓	✓	✓	✓
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	✓	✓	✓	✓	✓	✓	✓	✓
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?	✓	✓	✓	✓	✓	✓	✓	✓
9. Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓	✓	✓	✓	✓	✓	✓	✓
10. Was the exposure(s) assessed more than once over time?	NR	n/a	✓	×	×	✓	✓	✓
11. Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?	✓	✓	✓	✓	✓	✓	✓	✓

12. Were the outcome assessors blinded to the exposure status of participants?	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
13. Was loss to follow-up after baseline 20% or less?	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?	✓	✓	✓	✓	✓	✓	✓	✓
Quality rating*	**2 - Low**	**4 -High**	**3- Moderate**	**4 -High**	**4 -High**	**4 -High**	**4 -High**	**3- Moderate**

NR=not reported; n/a=not applicable

*Quality rating is based on the four highlighted in bold items (3, 4, 5, and 14) and were scored as Yes=1.0; No=0; Partly=0.5; Not applicable (census data): 1.0 out of a total of 4, where a score of 2 or lower=low quality rating, 3=moderate, and 4=high quality.

Supplementary Table 4 Quality assessment ratings for longitudinal studies using the Critical Appraisal Skills Programme (CASP) checklist for cohort studies*

Study author(s) (Year of publication)	**1** Did the study address a clearly focused issue?	**2** Was the cohort recruited in an acceptable way?	**3** Was the exposure accurately measured to minimise bias?	**4** Was the outcome accurately measured to minimise bias?	**5.(a)** Have the authors identified all important confounding factors?	**5.(b)** Have they taken account of the confounding factors in the design and/or analysis?	**6.(a)** Was the follow up of subjects complete enough?	**6.(b)** Was the follow up of subjects long enough?	**7** What are the results of this study?	**8** How precise are the results?	**9** Do you believe the results?	**10** Can the results be applied to the local population?	**11** Do the results of this study fit with other available evidence?	**12** What are the implications of this study for practice?
Gaudet et al (2015) (133)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	×	n/a
Adair et al (2020) (97)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Allik et al (2020) (103)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Cataldo (2022) (109)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	×	n/a
Exeter et al (2011) (93)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Brown et al (2019) (94)	✓	✓	✓	✓	✓	×	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Braun et al (2022) (111)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a

Study author(s) (Year of publication)	1 Did the study address a clearly focused issue?	2 Was the cohort recruited in an acceptable way?	3 Was the exposure accurately measured to minimise bias?	4 Was the outcome accurately measured to minimise bias?	5.(a) Have the authors identified all important confounding factors?	5.(b) Have they taken account of the confounding factors in the design and/or analysis?	6.(a) Was the follow up of subjects complete enough?	6.(b) Was the follow up of subjects long enough?	7 What are the results of this study?	8 How precise are the results?	9 Do you believe the results?	10 Can the results be applied to the local population?	11 Do the results of this study fit with other available evidence?	12 What are the implications of this study for practice?
Spencer et al (2020) (112)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Shiels et al (2020 (66)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	×	n/a
Karnecki et al (2023) (80)	✓	✓	✓	✓	✓	×	n/a	n/a	n/a	✓	✓	n/a	×	n/a
Leyland et al (2007) (100)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Moon et al (2020) (118)	✓	✓	✓	✓	✓	×	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Lehikoinen et al (2016) (72)	✓	✓	✓	×	×	×	n/a	n/a	n/a	×	✓	n/a	×	n/a
Pulford et al (2018) (88)	✓	✓	✓	✓	✓	✓	✓	n/a	n/a	✓	✓	n/a	✓	n/a
Baeseman (2009) (129)	✓	✓	✓	✓	×	×	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Auger et al (2012) (89)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Strong et al (2012) (95)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Yao et al (2016) (131)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Hunter et al (2023) (140)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Kinjo et al (2021)(120)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	×	n/a
Alexiou et al (2021) (101)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Saunders and Rudowitz (2024) (116)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a
Wojtyniak et al (2005) (62)	✓	✓	×	✓	×	×	n/a	n/a	n/a	×	✓	n/a	×	n/a

Study author(s) (Year of publication)	1 Did the study address a clearly focused issue?	2 Was the cohort recruited in an acceptable way?	3 Was the exposure accurately measured to minimise bias?	4 Was the outcome accurately measured to minimise bias?	5.(a) Have the authors identified all important confounding factors?	5.(b) Have they taken account of the confounding factors in the design and/or analysis?	6.(a) Was the follow up of subjects complete enough?	6.(b) Was the follow up of subjects long enough?	7 What are the results of this study?	8 How precise are the results?	9 Do you believe the results?	10 Can the results be applied to the local population?	11 Do the results of this study fit with other available evidence?	12 What are the implications of this study for practice?
Sumetsky et al (2024) (122)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	×	n/a
Hughes (2021) (86)	✓	✓	✓	✓	✓	✓	n/a	n/a	n/a	✓	✓	n/a	✓	n/a

n/a=not applicable

* A tick mark ✓ represents that the study met the criteria of the item on the assessment tool. Quality ratings were scored a total of 12, where a score of 4 or lower=low quality rating, 5–8= moderate, and 9–12=high quality.

Supplementary Table 5 Quality assessment ratings for cross-sectional studies using the Joanna Briggs Institute Critical Appraisal Checklist for Analytical Cross-Sectional Studies

Study author (Year of publication)	1. Were the criteria for inclusion in the sample clearly defined?	2. Were the study subjects and the setting described in detail?	3. Was the exposure measured in a valid and reliable way?	4. Were objective, standard criteria used for measurement of the condition?	5. Were confounding factors identified?	6. Were strategies to deal with confounding factors stated?	7. Were the outcomes measured in a valid and reliable way?	8. Was appropriate statistical analysis used?
Blomgren et al (2004) (18)	✓	✓	✓	✓	✓	✓	✓	✓
Arreola-Rissa et al (2008) (125)	✓	✓	✓	✓	✓	×	✓	✓
Czech et al (2010) (126)	✓	✓	✓	✓	✓	✓	✓	✓
Gjerde et al (2011) (127)	✓	✓	✓	✓	✓	✓	✓	✓
Lasota et al (2020) (135)	✓	✓	✓	✓	✓	✓	✓	✓
Koskela et al (2017) (114)	✓	✓	✓	✓	✓	✓	✓	✓
Grigoriev et al (2017) (119)	✓	✓	✓	✓	✓	✓	✓	✓
Wundersitz (2017) (128)	✓	✓	✓	✓	✓	×	✓	✓

Study author (Year of publication)	1. Were the criteria for inclusion in the sample clearly defined?	2. Were the study subjects and the setting described in detail?	3. Was the exposure measured in a valid and reliable way?	4. Were objective, standard criteria used for measurement of the condition?	5. Were confounding factors identified?	6. Were strategies to deal with confounding factors stated?	7. Were the outcomes measured in a valid and reliable way?	8. Was appropriate statistical analysis used?
Connolly et al (2011) (82)	✓	✓	✓	✓	✓	✓	✓	✓
Kaplan et al (2013) (76)	✓	✓	✓	✓	✓	✓	✓	✓
Kovše et al (2012) (91)	✓	✓	✓	✓	×	×	✓	×
Reccord et al (2021) (77)	✓	✓	✓	✓	✓	✓	✓	✓
Brown and Leyland (2010) (92)	✓	✓	✓	✓	×	n/a	✓	×
Rudisill et al (2023) (137)	✓	✓	✓	✓	✓	✓	✓	✓
Silczuk et al (2023) (110)	✓	✓	×	✓	×	×	✓	×
Rosicova et al (2011) (87)	✓	✓	✓	✓	✓	✓	✓	✓
Breakwell et al (2007) (90)	✓	✓	✓	✓	×	×	✓	✓
Caetano et al (2013) (79)	✓	✓	✓	✓	✓	✓	✓	✓
Camacho et al (2024)(99)	✓	✓	✓	✓	✓	✓	✓	✓
Lyubinets et al (2021) (108)	✓	✓	✓	✓	×	×	✓	✓
Zemore et al (2022) (113)	✓	✓	✓	✓	×	×	✓	✓
Geedipally et al (2011) (132)	✓	×	✓	✓	✓	✓	✓	✓
Hurzeler et al (2021) (78)	✓	×	✓	✓	✓	×	✓	✓
Dietze et al (2009) (83)	×	✓	✓	✓	✓	✓	✓	✓
Scottish Health Action on Alcohol Problems (2018) (98)	✓	✓	✓	✓	×	×	✓	✓
Northern Ireland Statistics and Research Agency (2024) (73)	✓	✓	×	×	×	×	×	×
Miščikienė et al (2024) (123)	✓	✓	✓	✓	✓	✓	✓	✓

Study author (Year of publication)	1. Were the criteria for inclusion in the sample clearly defined?	2. Were the study subjects and the setting described in detail?	3. Was the exposure measured in a valid and reliable way?	4. Were objective, standard criteria used for measurement of the condition?	5. Were confounding factors identified?	6. Were strategies to deal with confounding factors stated?	7. Were the outcomes measured in a valid and reliable way?	8. Was appropriate statistical analysis used?
United Kingdom. Office for National Statistics (England) (2024) (58)	✓	✓	✓	✓	×	×	✓	✓
United Kingdom. Office for National Statistics (Wales) (2024) (58)	✓	✓	✓	✓	×	×	✓	✓
Northern Ireland Statistics and Research Agency (2019) (130)	×	✓	✓	✓	×	n/a	✓	✓
National Records for Scotland (2024) (130)	✓	✓	✓	✓	×	×	✓	✓
Subhani et al (2022) (96)	✓	✓	✓	✓	✓	✓	✓	✓
Warren and Reavis (2022) (117)	✓	✓	✓	✓	×	n/a	✓	✓
Subedi et al (2019) (115)	✓	✓	✓	✓	✓	✓	✓	✓
Ministry of Health New South Wales (2022) (85)	✓	✓	✓	✓	✓	×	✓	✓
Folk et al (2024) (121)	✓	✓	✓	✓	✓	✓	✓	✓
United Kingdom. Office for National Statistics (2021) (141)	✓	✓	✓	✓	×	×	✓	✓
United Kingdom. Office for National Statistics (2021) (104)	✓	✓	✓	✓	×	×	✓	✓
Raatiniemi et al (2016) (124)	✓	✓	✓	✓	✓	✓	✓	✓
Lasota et al (2019) (134)	✓	✓	✓	✓	✓	✓	✓	✓

n/a=not applicable

* A tick mark ✓ represents that the study met the criteria of the item on the assessment tool. Quality ratings were scored a total of 8, where a score of 2 or lower=low quality rating, 3–5= moderate, and 6–8=high quality.

Supplementary Table 6 Diagnoses 100% attributable to alcohol use with ICD-10 codes

Diagnosis	ICD-10 code
Alcohol-induced pseudo-Cushing's syndrome	E24.4
Mental and behavioural disorders due to use of alcohol	F10
Acute intoxication	F10.0
Harmful use	F10.1
Dependence syndrome	F10.2
Withdrawal state	F10.3
Withdrawal state with delirium	F10.4
Psychotic disorder	F10.5
Amnesic syndrome	F10.6
Residual and late-onset psychotic disorder	F10.7
Other mental and behavioural disorders	F10.8
Unspecified mental and behavioural disorder	F10.9
Degeneration of nervous system due to alcohol	G31.2
Alcoholic polyneuropathy	G62.1
Alcoholic myopathy	G72.1
Alcoholic cardiomyopathy	I42.6
Alcoholic gastritis	K29.2
Alcoholic liver disease	K70
Alcoholic fatty liver	K70.0
Alcoholic hepatitis	K70.1
Alcoholic fibrosis and sclerosis of liver	K70.2
Alcoholic cirrhosis of liver	K70.3
Alcoholic hepatic failure	K70.4
Alcoholic liver disease, unspecified	K70.9
Alcohol-induced pancreatitis	K85.2
Alcohol-induced chronic pancreatitis	K86.0
Finding of alcohol in blood	R78.0
Toxic effect of alcohol	T51
Toxic effect of ethanol	T51.0
Toxic effect of methanol	T51.1
Toxic effect of other alcohols	T51.8
Toxic effect of alcohol, unspecified	T51.9
Accidental poisoning by and exposure to alcohol	X45
Intentional self-poisoning by and exposure to alcohol	X65
Poisoning by and exposure to alcohol, undetermined intent	Y15
Evidence of alcohol involvement determined by blood alcohol level	Y90

Supplementary Table 7 PRISMA checklist (52)

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	6
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	6
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	7
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	6
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	8
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	8
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	8
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	8
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	9
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	n/a
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	8

Section and Topic	Item #	Checklist item	Location where item is reported
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	8
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	8
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	8
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	n/a
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	n/a
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	n/a
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	9
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	11
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	n/a
Study characteristics	17	Cite each included study and present its characteristics.	48, S7
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	41 – 46
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	n/a
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	12
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	n/a
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	n/a
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	n/a
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	n/a

Section and Topic	Item #	Checklist item	Location where item is reported
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	n/a
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	18 – 21
	23b	Discuss any limitations of the evidence included in the review.	22
	23c	Discuss any limitations of the review processes used.	22
	23d	Discuss implications of the results for practice, policy, and future research.	23
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	3
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	6
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	10
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	16
Competing interests	26	Declare any competing interests of review authors.	n/a
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	n/a

Supplementary Table 8 Synthesis Without Meta-analysis (SWiM) explanation and elaboration (184)

SWiM reporting item	Item description	Page in manuscript where item is reported	Other*
Methods			
1 Grouping studies for synthesis	1a) Studies were grouped according to the cause of alcohol-attributable death and further organised by the geographic features of those deaths.	10	
	1b)	n/a	
2 Describe the standardised metric and transformation methods used	We assessed the magnitude of intervention effects and the direction of effect, indicating whether the interventions were positively or negatively associated with the outcome. The direction of the effect was classified based on the results of each included study, i.e. if a study indicated that rural areas had a higher rate of alcohol-related mortality, it was categorised as a positive effect. This allows an insight into the harms or benefits associated with each geographical characteristic.	13 – 14	
3 Describe the synthesis methods	Studies were summarised qualitatively, extracting key outcomes and effect estimates and presenting them narratively and in tabular format. Studies where the outcome was similar were grouped allowing comparisons to be made.	14 – 18	
4 Criteria used to prioritise results for summary and synthesis	The objective of the synthesis was to answer the research question effectively; are geographical characteristics associated with alcohol-related mortality? To prioritise the results, studies that were most relevant to the research question were prioritised as they suggested greater reliability, followed by the quality of the studies, such as those with large sample sizes, and/or rigorous	14	

	analysis, suggesting greater generalisability of findings. Findings that were consistent across studies, such as low SES association with alcohol related mortality, were also prioritised.	
5 Investigation of heterogeneity in reported effects	Although meta-analysis was not possible, the studies included in this systematic review were descriptively analysed, including both a detailed quality assessment of the studies, summarising the key characteristics of the studies such as design, demographics, population, interventions (where applicable), and outcomes. Through comparison of the study characteristics, potential sources of heterogeneity were identified.	14
6 Certainty of evidence	Each study included was critically appraised for risk of bias using the NHLBI quality assessment tool, for ecological, the CASP checklist for cohort studies, and the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies.	11, 42 – 47
7 Data presentation methods	A table to show the direction and significance of the findings to support the synthesis is available in the systematic review	49 – 51, 56
Results		
8 Reporting results	There was a consistent positive association between lower area-based socioeconomic status and alcohol-related mortality. Rural locations were more common for alcohol-related road traffic collisions and suicides.	13 – 14
Discussion		
9 Limitations of the synthesis	The included studies varied in their methodologies, including longitudinal studies and observational studies, potentially resulting in uncertainty in the generalisability. Definitions of alcohol-related mortality and in definitions of geographical characteristics differed in the studies, typically depending on the country the study was conducted in. This limits the ability to	19 – 23

definitively conclude the role of the geographical characteristics that may influence alcohol-related mortality.

Confounding factors were not always considered in the included studies which highlights a limitation in the observation of significant associations. Geographic features vary by location of study and other confounding factors may have played a more significant role, such as legislation within the jurisdiction, alcohol use patterns, and healthcare access issues.

Although the systematic review was limited to studies conducted since 2004, the time differences and economical changes may have influenced the accuracy of the data.

Declarations

- Ethics approval and consent to participate - Not applicable
- Consent for publication - Not applicable
- Availability of data and materials - Not applicable
- Clinical trial number - not applicable
- Competing interests - The authors declare that they have no competing interests
- Funding – PhD fees for AD are funded through their employer, the Health Research Board (HRB), Dublin, Ireland
- Authors' contributions - AD conceived the idea. AS and JH supervised this work. LM cross checked the inclusion of articles. AS and JH contributed to the interpretation of the results. AD wrote the manuscript with support from AS and JH. All authors discussed the results and read and approved the final manuscript. All authors approved the submitted version.
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