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[Socio-economic and behavioural risk factors for adverse winter health and social outcomes in economically developed countries: a systematic review of quantitative observational studies.](#)

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ABSTRACT

Background: Mortality and morbidity rates are often highest during the winter period, particularly in countries with milder climates. A growing body of research has identified potential socio-economic, housing and behavioural mediators of adverse winter health and social outcomes, but an inclusive systematic review of this literature has yet to be performed.

Methods: A systematic review, with narrative synthesis, of observational research published in English between 2001 and 2011, which quantified associations between socio-economic, housing or behavioural factors and adverse winter health or social outcomes.

Results: Thirty-three studies met the inclusion criteria. Average study quality was not high. Most studies failed to control for all relevant confounding factors, or to conduct research over a long enough period to ascertain causality. Low income (e.g. OR 1.13 for excess winter mortality in lowest, compared to highest income groups; 95% CI 1.08 to 1.19); housing conditions (e.g. OR 1.016 for all-cause mortality associated with lack of central heating; 95% CI 1.009 to 1.022); fuel poverty (e.g. OR 1.7 for excess winter respiratory hospital admissions; 95% CI 1.1 to 2.7) and active smoking (e.g. OR 2.44 for chronic productive cough; 95% CI 2.14 to 2.79) were most consistently associated with adverse winter health or social outcomes.

Conclusion: This review identified socio-economic, housing and behavioural factors associated with a range of adverse health or social outcomes during winter months. Only tentative conclusions can be drawn due to the limitations of existing research. More robust studies are needed to address the methodological issues identified and uncover causal associations. Review of qualitative and intervention studies will help to inform policies to reduce the impacts of adverse winter health outcomes.

Higher rates of mortality and morbidity are apparent during the winter compared to other seasons, in many countries.¹⁻² Excess Winter Mortality (EWM) refers to the number of deaths occurring during the winter season (December-March, Northern Hemisphere; June-September, Southern Hemisphere) minus the average number of non-winter deaths.^{1,3} A positive, non-linear association has been found between mean winter temperatures and EWM rates across different countries.⁴ This suggests that populations of warmer climates adapt less successfully to cold weather conditions.⁴ Over the past two decades, there has been an increase in research investigating modifiable mediators of this adaptation process, with particular emphasis on socio-economic and housing factors. A systematic review of quantitative observational research, published in 2008, found inconsistent associations between these variables and EWM and morbidities,⁵ but did not include literature on behavioural factors, which may also contribute to adverse winter health outcomes.

Political interest in modifiable determinants of winter health outcomes has increased over the last decade, particularly in the UK. After experiencing two excessively cold winters in 2009/10 and 2010/11, the UK Government and devolved administrations produced winter contingency plans to ameliorate some of the preventable health and social impacts of cold weather.⁶⁻⁹

Information campaigns are also used in various countries to encourage behaviours which have been associated with improved winter health outcomes,¹⁰ including influenza vaccination uptake,¹¹ the use of adequate clothing protection in cold weather, minimizing outdoor excursions, keeping physically active whilst outdoors, consumption of an adequate diet, the installation and use of central heating and accessing financial support to subsidise increased winter fuel costs and make households more thermally efficient.^{6,12}

Fuel poverty is currently most widely defined as a situation in which a household needs to spend more than 10% of its income (after tax) on fuel, to maintain a satisfactory heating regime (21°C for the main living area, 18°C for other occupied rooms).¹³ Fuel poverty is caused by a combination of factors, mainly low income, thermally inefficient housing and high energy prices,¹⁴ and has been associated with EWM, morbidities and adverse social outcomes.¹⁵⁻¹⁶ In 2001, the UK Government became the first to develop a 'Fuel Poverty Strategy', which aimed to eradicate fuel poverty in vulnerable households by 2010 and in all other households by 2016.¹⁷ Several independent reviews of the strategy were commissioned after its initial target was missed.¹⁸ These reviews concluded that the current definition of fuel poverty is inadequate¹⁹ and stronger policies and policy implementation are required to meet future targets.²⁰ Using data indicating fuel poverty is widespread throughout the Northern Hemisphere,²¹⁻²² the European Union (EU) and most of its member states have developed their own policies to address the issue.²³ In the Southern Hemisphere, most research and policy interest in fuel poverty has been in New Zealand.²³ Strategies to alleviate fuel poverty have primarily concerned improving household thermal efficiency standards²¹ and protecting consumers within energy markets.²⁴

Socio-economic, housing and behavioural factors are all potentially amenable to public health interventions. This review, therefore, aimed to identify key modifiable factors associated with adverse winter health and social outcomes, to enable effective development and targeting of interventions by public health professionals and policy makers.

METHODS

Systematic methods were used to locate, evaluate and synthesise quantitative, observational research to identify socio-economic, housing and behavioural risk factors of contemporary relevance that are associated with adverse winter health or social outcomes.

Search strategy

A range of medical (Medline, PubMed, PsychInfo and Scopus), social science (Applied Social Sciences Index and Abstracts, Sociological Abstracts, Social Services Abstracts and Social Science Citation Index) and general (Web of Science) electronic research databases were searched. Searches were developed in individual databases using appropriate subject headings and keywords and were restricted to human studies published in English between 2001 and 2011, where this facility was available. An online source of grey literature collated by a major third sector organisation (National Energy Action, UK)²⁵ was also searched for relevant content.

Expert advisors from a range of third sector, local authority, NHS and academic organisations provided additional references.

After deletion of duplicate articles, 2745 references remained from all searches (see Figure 1). Titles and abstracts (where available) were screened against the inclusion criteria.

Inclusion and exclusion criteria

Included studies had to be published in English between 2001, the year of publication of the UK Fuel Poverty Strategy, and 2011. Studies had to use primary observational or systematic reviewing methods and present quantitative data on associations between socio-economic, housing or behavioural variables and adverse winter health or social outcomes in any human

population groups from economically developed countries, defined as such if included in the 'high' or 'very high' categories of the 2011 United Nations Human Development Index.²⁶

Measures of socio-economic status included Townsend (1988)²⁷ and Carstairs and Morris (1991)²⁸ deprivation indices, as well as a range of other indicators of socio-economic status or deprivation at individual or ecological levels. Measures of housing conditions included internal temperatures, location (rural-urban status), occupancy level and tenure. Measures of fuel poverty were considered as a separate risk factor category. Initial scoping of the literature and findings from previous studies identified behavioural factors, including active and passive smoking, insufficient diet, physical inactivity, inadequate clothing protection and outdoor excursions. Outcomes included any mortalities, morbidities or wider social impacts that could be plausibly linked to cold weather.

Data extraction

Articles considered relevant to the review question were obtained in full and screened independently by two reviewers (LT, SDHM), using the inclusion and exclusion criteria.

Exclusion reasons were recorded at this stage. Inter-rater agreement was high (81%).

Disagreements over whether or not to include particular articles were resolved by discussion between reviewers. A third reviewer (SM) adjudicated unresolved decisions by making independent assessments.

Data extraction was performed independently by two reviewers, using a bespoke tool (See appendix), based on guidance from York University's Centre for Reviews and Dissemination.²⁹ Quality appraisal was based on nine criteria, relating to the ability of each study to address the research objectives (See appendix). This approach was developed using a

range of existing appraisal tools. Studies could receive an overall score of up to 23 points. After both reviewers had appraised each study, average study scores were calculated.

Data synthesis

Study findings were synthesised using a narrative approach, based on risk factors investigated. Meta-analysis was not performed due to study heterogeneity, in terms of populations, methods, risk factors and outcome measures. A harvest plot³⁰ was created to summarise results graphically, using Tableau Public data visualisation software³¹ (see Figure 2).

RESULTS

Thirty-three studies were included in the review (see Figure 1). One was a systematic review (with narrative synthesis) of observational studies (described in the introduction),⁵ 19 were individual level studies and 13 used ecological data (See appendix for study summaries).

Studies were conducted in the UK (14), New Zealand (4), Finland (3), pan-European (3), Taiwan (2) and one study each from Australia, Brazil, France, Japan, Korea, Sweden and the USA.

Quality assessment

Quality appraisal scores ranged from 8.5 (low methodological quality)³²⁻³³ to 21.5 (high methodological quality) for a systematic review.⁵ The overall mean quality assessment score

was 12.7 (possible range 0-23). Quality appraisal scores are illustrated by bar height in Figure 2.

Only one study considered a comprehensive range of confounders.⁵ Cross-sectional studies could not clearly establish temporal relationships between exposure and outcome variables.³⁴⁻

³⁵ Other studies were conducted over time periods ranging from 2 months³⁶ to 21 years.³⁷ The limited duration of many studies contributed to difficulties in establishing causation.

Individual level studies generally used small samples of participants with specific characteristics, which restricted the generalisability and validity of their results in relation to other population groups.³²⁻³³ Four studies used ecologic data units above the town or district level,^{3,38-40} which made it difficult to establish associations between exposures and outcomes.

Impact of socio-economic factors

Nineteen studies quantified associations between socio-economic factors and excess adverse winter health and social outcomes.^{2-3,5,36-38,41-53} As shown in Figure 2, there was no overall significant association between socio-economic deprivation and adverse winter health or social outcomes.

Composite deprivation indices were mostly based on census variables from the countries in which studies were conducted. UK measures included scores on the Townsend^{2,41-3} and Carstairs^{36,44} deprivation indices, the Scottish Index of Multiple Deprivation³⁸ and ACORN housing type.⁴⁵ No significant associations were reported between these variables and outcome measures, which included EWM (all-cause or cause specific), excess winter respiratory hospital admissions and hypothermia, at individual^{36,42} or ecological levels.^{2,38,41,43-45} In New Zealand, no significant associations were found between area-level

scores on the New Zealand Deprivation Index and EWM.^{37,49} A Taiwanese study found a composite measure of ‘social disadvantage’, comprising percentages of uneducated population, single parent families and aborigine population, to be a significant predictor of cardiovascular mortality after extreme cold days at township level. However, a second measure, termed ‘lack of economic opportunity’, including unemployment rate and percent of labourers working outside the country of residence, was not significantly associated with cardiovascular mortality after cold events.⁵⁰

Low income was found to show consistent, independent associations with adverse cold related adverse health outcomes, including EWM rates between European countries³ and within the New Zealand population,⁴⁹ secretory otitis media in Brazilian children,⁵² poorer self-assessed health status in UK households⁴⁶ and reduced food expenditure and calorie intake by American families.⁵³

Wilkinson et al. (2001) found no significant association between occupational group and EWM.⁴⁷ However, when comparing results between age groups, Donaldson and Keatinge (2003) found significantly higher mortality for working age males in the highest compared to the lowest occupational class ($p < 0.05$), but this trend was reversed in the retired age group.⁴⁸ Heyman et al. (2005) found occupational group to be significantly positively associated with self-assessed health, but this variable, along with low income, was displaced by measures of heating satisfaction and sense of mastery when these were added to the regression model.⁴⁶

Parental education was not significantly associated with allergic rhinitis (winter subtype) in Taiwanese children.⁵¹

Impact of housing

Sixteen studies, including one from an included systematic review,⁵⁴ quantified aspects of housing in relation to cold related health or social outcomes.^{3,35,39,42,44,46-47,49-51,54-58} Figure 2 suggests an overall positive association between aspects of housing and excess adverse winter health and social outcomes.

Two studies, conducted in the UK and New Zealand, found urban dwellers to be at significantly increased risk of winter respiratory hospital admissions⁴² or EWM,⁴⁹ respectively. A further UK study found no significant association between rurality and EWM.⁵⁴ However, in Taiwan, Chen et al. (2010) found rurality to be a significant predictor of cardio-vascular mortality after extreme cold days.⁵⁰ It is possible that different mechanisms mediate adverse winter health outcomes in urban and rural locations. Urban dwellers may be more exposed to pollution, whilst rural populations could have increased cold exposure due to factors including the inhabitation of harder to heat properties and reduced access to gas networks and electricity.

Several aspects of housing condition, including composite measures of housing quality;⁵⁵ low indoor temperatures;^{35,47,56,58} absence of, or reduced satisfaction with central heating^{44,46} and poor thermal insulation^{3,46-47} were significantly associated with adverse health outcomes. Croxford found differential impacts of aspects of poor housing between age groups.³⁵ Mason and Roys calculated the annual cost to the English National Health Service (NHS) of treating illnesses linked to cold housing as £192m based on data from 2008, using the Building Research Establishment calculator.⁵⁷

Two studies that investigated housing tenure found individuals in private rented accommodation were at increased risk of EWM, compared to social housing tenants⁴⁷ or home owners.⁴⁹ One study, conducted in France, found care home residents to have a higher

coefficient of seasonal variation in mortality compared to the general population of over 65 year olds.³⁹

Impact of fuel poverty

Only three studies quantified associations between composite measures of fuel poverty and cold related health outcomes.^{2-3,43} Overall, these indicated a consistent positive association between fuel poverty and excess adverse winter health and social outcomes (Figure 2). Two studies were conducted in the UK,^{2,43} with the first study being a pilot for the second. The authors developed a 'fuel poverty risk index', comprising enumeration district level data on low income, number of householders of pensionable age, low thermal efficiency housing and under-occupied housing. This was a significant predictor of excess winter hospital admissions for respiratory disease amongst the whole population of ≥ 65 year olds living in the London Borough of Newham (n= approximately 25,000; 3373 hospitalizations). A separate pan-European analysis of 14 EU countries found fuel poverty levels, measured using data on aspects of housing condition, affordability of home heating and energy efficiency levels, to be significantly and positively associated with EWM ($p = 0.005$).³

Impact of behavioural factors

Twelve studies investigated behavioural factors in relation to adverse winter health outcomes.^{3,32-4,40,42,51,53,59-62} This category of variables showed the least consistent associations with excess adverse winter health or social outcomes (Figure 2).

Smoking was significantly associated with adverse cold related health outcomes, including respiratory symptoms⁵⁹⁻⁶⁰ and hospital admissions,⁴² but not significantly with hypertension⁶²

and seasonal variations in EWM.³ The author of this latter study attributed the lack of significant association to the non-seasonal health impacts of behavioural factors.³

In relation to diet, low milk intake significantly increased the risk of hypertension in cold exposed workers (OR for higher milk intake 0.364; CI 0.141 to 0.942). Salt intake was not significantly associated with hypertension in the same study.⁶² Reduced food consumption by poor American families during cold periods was non-significantly associated with nutritional deficiencies and anaemia.⁵³

Donaldson et al. (2001) found differences in clothing insulation and number of items of clothing worn during outdoor excursions, but not number of clothing layers, to be significantly inversely associated with variations in cold-related mortality, between European regions.⁴⁰ Two additional studies found clothing to provide inadequate protection against occupational cold exposure.^{32,61}

Leisure time cold exposure was significantly positively correlated with self-reported health in men, but not significantly in women.³⁴ Two linked studies found outdoor occupational cold exposure to be associated with a significant increase in respiratory symptoms ($p < 0.05$),⁵⁹⁻⁶⁰ particularly amongst smokers.⁵⁹

Kotaniemi et al. (2003) found significantly greater prevalence of shortness of breath when undertaking outdoor exercise in respondents with asthma, allergies or bronchitis, compared to healthy individuals in Finland.⁶⁰ Novas (2002) found moderately active girls had significantly fewer respiratory symptoms compared to females with low or high levels of physical activity ($p < 0.05$).³³

DISCUSSION

Principal findings

To our knowledge, this is the first systematic review of observational evidence demonstrating associations between socio-economic, housing or behavioural factors, and health and social outcomes. Of the variables analysed, low income, measures of low indoor temperatures, fuel poverty and smoking were most consistently associated with EWM, morbidities or wider social outcomes.

Strengths and weaknesses of the review

This review identifies key modifiable factors of contemporary relevance associated with adverse winter health and social outcomes, based on evidence from observational research published since 2001. The synthesis of findings using a harvest plot enables a visual comparison of the volume of research and strength of evidence relating each category of potential risk factor investigated with adverse winter health or social outcomes. This is a novel use of the harvest plot, which was developed to provide a visual representation of evidence in relation to inequalities in the outcome of interventions.³⁰

Review limitations include the exclusion of qualitative and intervention studies, and observational research published prior to 2001, which may have provided additional aetiological insights of contemporary relevance. Due to resource constraints, the primary sift of papers located through database searches was performed by one researcher only, which potentially could have reduced the objectivity of study inclusion at this stage. However, an inclusive approach was taken to reduce potential bias. Finally, the heterogeneous nature of included studies prevented meta-analysis being performed, which potentially compromises the reliability of review findings.

Interpretation of findings in relation to review limitations and existing knowledge

Based on the limitations of this review, it is necessary to interpret results with caution.

However, similar to an earlier review by Telfar Barnard et al. (2008),⁵ the current study found inconsistent associations between measures of socio-economic status and adverse winter health outcomes. Our review found a stronger effect of housing condition compared to Telfar Barnard et al. (2008),⁵ which may be attributable to the inclusion of studies using larger ecologic units and a wider range of outcome measures.

Behavioural factors showed the least consistent associations with adverse winter health or social outcomes, possibly attributable to the cross-sectional design of most behavioural studies, preventing long term health outcomes being robustly assessed.

Strengths and weaknesses of the available evidence

Twenty-two out of thirty-three reviewed studies quantified wider health impacts of the exposure variables investigated. This indicates a greater consideration of cold related health outcomes beyond mortality. However, only two studies quantified other social outcomes, which included NHS costs associated with thermally inefficient housing⁵⁷ and social inequality in terms of reduced food expenditure and calorie intake by lower income families due to increased fuel expenditures during periods of cold weather.⁵³ Eighteen studies were conducted exclusively in the UK or Northern Europe, a likely reflection of the level of political interest. However, because the nature of causality for cold related health and social outcomes may differ internationally, more research is required that will enable interventions to be developed and targeted more effectively.

Methodological weaknesses of the available evidence include inadequate control for potential confounding factors in many studies and the relative absence of individual level studies conducted over a long enough duration for causality to be indicated. Studies using individual level data were generally based on small samples, which make it difficult to generalize their findings.

Implications for policy and practice

This review identified low income, aspects of housing condition, fuel poverty and smoking as being most consistently associated with adverse winter health or social outcomes. Certain demographic (age: children, or adults aged >65 years; sex: female),^{37,46,48} medical⁴² and functional factors^{42,60} were also significant predictors of cold related ill health. This information could be used to inform the development and targeting of interventions aimed at reducing adverse health and social impacts of cold weather. For example, targeting fuel efficiency initiatives at poorer households with young children, the old and infirm, and offering associated help and advice with smoking. However, any conclusions should be interpreted with consideration for the limitations of the available evidence.

Unanswered questions and future research

Future research needs to use individual level data, collected over longer time durations, with greater control for confounding variables and more consideration of a wider range of behavioural factors and social impacts. Research from a wider range of countries is also needed. A review of qualitative and intervention studies would enable a greater understanding of the causal pathways underlying cold weather related health and social

outcomes, which could then inform generation of potential interventions to reduce excess adverse winter health and social outcomes.

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Competing interests None.

Contributors

Funding for this project was obtained via a research proposal submitted to the ESRC by LMT, SM, EM and MW. LMT, SM, EM and MW discussed and agreed on all aspects of the study design. Data collection was performed by LMT, based on advice from Dorothy Newbury-Birch, Lecturer in Public Health Research; Shannon Robalino, Information Specialist; Erika Gavilett, Medical Librarian; and Helen Blanchett, Social Sciences Liaison Librarian, all from Newcastle University. Additional references were provided by Ron Campbell, Helen Stockton and Deborah Harrison, Policy and Research Officers at National

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What is already known on this topic

- There is increasing political interest in tackling modifiable mediators of adverse winter health and social outcomes.
- Research has identified various socio-economic, housing and behavioural factors associated with these adverse outcomes.
- This evidence has not been systematically reviewed.

What this study adds

- This study synthesises quantitative observational research of contemporary relevance on socio-economic, housing and behavioural factors associated with adverse winter health and social outcomes.
- The evidence indicates that low income, thermally inefficient housing, fuel poverty and smoking contribute to adverse winter health and social outcomes. However, more individual level studies, conducted over longer time durations, are needed to determine causal associations.

- This information can be used by policy makers to target interventions aimed at reducing some of the preventable adverse health and social consequences of cold weather, and by public health researchers to inform further research.

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