Socioeconomic and behavioural risk factors for adverse winter health and social outcomes in economically developed countries: a systematic review of quantitative observational studies

Louise M Tanner,1 Suzanne Moffatt,1 Eugene M G Milne,2 Susanna D H Mills,1 Martin White1,3

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 socioeconomic, housing and behavioural mediators of cold weather-related adverse 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 socioeconomic, housing or behavioural factors and cold weather-related adverse 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, housing conditions and composite fuel poverty measures were most consistently associated with cold weather-related adverse health or social outcomes.

Conclusions This review identified socioeconomic, housing and behavioural factors associated with a range of cold weather-related adverse health or social outcomes. 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. A review of qualitative and intervention studies would help to inform policies to reduce the adverse health and social impacts of cold weather.

Paradoxically, countries with colder winter climates generally have lower EWM rates.3 Northern European countries are well adapted to their low winter temperatures, due to having better quality, more thermally efficient housing.5 7 These countries are also generally wealthier and have increased healthcare expenditure, stronger social welfare systems and reduced rates of income inequality and deprivation compared to southern European countries, the UK and Ireland.3 Research also indicates increased behavioural adaptation to prevailing climatic conditions (eg, increased clothing protection) in countries with colder winters.5 This combination of socioeconomic, housing and behavioural factors is likely to moderate the adverse health and social impacts of cold weather, particularly among vulnerable groups.4

Political interest in modifiable risk factors for adverse winter health and social outcomes has increased over the last decade, particularly in the UK. 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).9 Fuel poverty is caused by a combination of factors, mainly low income, thermally inefficient housing and high energy prices.10 Fuel poverty has been associated with EWM, morbidities and adverse wider social outcomes including poor educational attainment, reduced emotional wellbeing and impaired lifestyle choices.11 Fuel poverty is widespread across the northern hemisphere,12 and in 2001, the UK government and devolved administrations became the first to develop an official ‘Fuel Poverty Strategy’ which aimed to eradicate fuel poverty in vulnerable households by 2010 and in all other households by 2016 through implementing initiatives to tackle the root causes of fuel poverty.13 However, the first target was missed. Since 2001, the European Union (EU) and most of its member states have developed their own fuel poverty policies.14 Strategies to alleviate fuel poverty have primarily involved improving household thermal efficiency standards and introducing legislation to protect consumers within energy markets.14 However, the absence of a universally agreed measure of fuel poverty, a lack of knowledge about its causes and disjointed implementation of fuel poverty policies between countries are arguably undermining the ability to address the issue at an

To cite: Tanner LM, Moffatt S, Milne EMG, et al. J Epidemiol Community Health 2013;67:1061–1067. doi:10.1136/jech-2013-202693
international level.\textsuperscript{15} In the southern hemisphere, most research and policy interest around fuel poverty has been in New Zealand, which is climatically similar to the UK, and experiences comparable rates of fuel poverty and EWM.\textsuperscript{16} Despite having no official fuel poverty strategy, New Zealand government energy strategies since 2007 have led to increased funding to improve thermal efficiency standards of New Zealand’s housing stock.\textsuperscript{17}

In 2008, a systematic review reported inconsistent associations between measures of housing conditions and socioeconomic status, and EWM and excess winter hospitalisations (EWH).\textsuperscript{4} The review presented here expands on previous findings by (1) integrating literature published after 2008 and (2) including evidence on behavioural factors and aspects of housing which have been linked to cold weather-related adverse health and social outcomes not included in the earlier review. The aim of this review is therefore to identify key modifiable factors associated with adverse winter health and social outcomes thereby enabling 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 that explored independent associations between socioeconomic, housing and behavioural risk factors of contemporary relevance and cold weather-related adverse 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)\textsuperscript{18} was also searched for relevant content.

Expert advisors from a range of third-sector, local authority, National Health Service (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 and 2011. The first official government Fuel Poverty Strategy was launched in the UK in 2001, after which other countries began producing such policies. Studies had to use primary observational or systematic review methods and present quantitative data on associations between socioeconomic, housing or behavioural variables, and adverse cold weather-related health or social outcomes in any human population groups from economically developed countries. Economically developed countries were defined as those included in the ‘high’ or ‘very high’ categories of the 2011 United Nations Human Development Index.\textsuperscript{19}

Measures of socioeconomic status included Townsend et al,\textsuperscript{20} and Carstairs and Morris\textsuperscript{21} deprivation indices, as well as a range of other indicators of socioeconomic status or deprivation at individual or ecological levels. Housing variables included measures of low internal temperatures, location (rural–urban status), occupancy level and tenure. Composite fuel poverty indicators were also included. Initial screening 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 (LMT, SDHM), using the inclusion and exclusion criteria. Reasons for exclusion 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 online supplementary appendix), based on guidance from the University of York’s (UK) Centre for Reviews and Dissemination.\textsuperscript{22} Quality appraisal was based on nine criteria, relating to the ability of each study to address the research objectives (see online supplementary appendix). No existing quality appraisal tools adequately covered all relevant areas, so a bespoke instrument was developed from existing tools and criteria used in a previous review of similar literature.\textsuperscript{23} Studies could receive an overall score of up to 23 points. After both reviewers had appraised each study, average study scores were calculated. Study characteristics and appraisal scores were recorded in summary tables (see online supplementary appendix).

**Data synthesis**

Study findings were synthesised using a narrative approach. Meta-analysis was not feasible as there were too few studies with sufficient homogeneity in terms of participant demographics, methods, risk factors and outcomes, to provide stable effect sizes.\textsuperscript{23}

**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),\textsuperscript{4} 19 were individual-level studies, and 13 used ecological data (see online supplementary appendix for study summaries). Compared to the 2008 review by Telfar Barnard et al,\textsuperscript{4} 25 additional studies were included in this review.\textsuperscript{3} 16 24–46 Eight of these have been published since 2008.\textsuperscript{38–45}

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.

Nineteen studies quantified associations between socioeconomic factors and excess adverse winter health and social outcomes; sixteen investigated the potential impacts of housing factors, twelve examined behavioural factors, and three used composite fuel poverty measures.

**Quality assessment**

Quality appraisal scores ranged from 8.5 (low methodological quality), awarded to a cohort study and a cross-sectional study,\textsuperscript{17 45} to 21.5 (high methodological quality) for a systematic...
The overall mean quality assessment score was 12.7 (possible range 0–23). Only one study considered a comprehensive range of confounders. Cross-sectional studies could not clearly establish temporal relationships between exposure and outcome variables. Other studies were conducted over time periods ranging from 2 months to 20 years. The limited duration of many studies contributed to difficulties in establishing causation. Individual-level studies generally involved small samples of participants with specific characteristics, which restricted the generalisability and validity of their results in relation to other population groups. Four studies used ecologic data units above the town or district level which made it difficult to establish associations between exposures and outcomes.

Study results
The main results from included studies are described here, classified into groups according to the observed relationships, based on an approach to data synthesis used in a previous review from two of the authors.

Studies demonstrating significant associations between measures of socioeconomic deprivation, housing or behaviour and cold weather-related adverse health or social outcomes
Low income was significantly associated with cold weather-related adverse health and social outcomes, including EWM, secretory otitis media in Brazilian children, and reduced food expenditure and calorie intake by American families. A pan-European ecological time series analysis found income inequality, a composite measure of material and social deprivation and reduced public healthcare expenditure to be associated with significantly higher relative EWM rates between countries.

Several aspects of housing conditions, including composite measures of housing quality; low indoor temperatures; absence of, or reduced satisfaction with central heating; and poor thermal insulation were associated with adverse winter or cold weather-related health outcomes.

Three studies found composite fuel poverty measures were significantly associated with adverse winter health outcomes. Two of the studies were conducted in the UK 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 among the whole population of ≥65-year-olds living in the London Borough of Newham (n=approximately 25 000; 3373 hospitalisations). A separate pan-European analysis of 14 EU countries found fuel poverty levels, measured using data on aspects of housing conditions, affordability of home heating and energy efficiency levels, to be significantly and positively associated with EWM (p=0.005).

Two studies, conducted in the UK and New Zealand, found urban dwellers to be at significantly increased risk of winter respiratory hospital admissions and EWM, respectively. Neither of these studies measured the effects of air pollution or crowding, which are likely to contribute to excess adverse winter health outcomes in urban compared to rural areas. A Taiwanese study found rurality to be a significant predictor of cardiovascular mortality after extreme cold days. Age, sex and
social disadvantage were controlled for in analyses, but differences in medical resource availability between urban and rural Taiwan, were not.

In relation to housing tenure, a UK study found private renters and home owners to be at significantly increased risk of EWM compared to social housing tenants. A New Zealand study found rented tenure to be associated with significantly increased risk of EWM relative to home owners, but data on type of rental (ie, in social or private housing) was not presented. The authors of this study speculated that reduced asset wealth, increased crowding and poorer quality housing may contribute to EWM among individuals in rented housing.

A study from France found care-home residents to have a higher coefficient of seasonal variation in mortality compared with the general population of over 65-year-olds. Smoking was significantly associated with increased respiratory symptoms in a cross-sectional study of the adult population of Finland aged 20–69 years, who completed self-reported questionnaires during the winter of 1995–1996, and with winter respiratory hospital admissions among 65–89-year-olds from 79 general practitioner practices in central England. A Korean occupational case-control study found low milk consumption was associated with significantly increased risk of hypertension in cold-exposed male workers (eg, OR for higher milk intake 0.36; CI 0.14 to 0.94). This was attributed to the high calcium content of milk, which is associated with lower blood pressure. Cold exposure severity and older age were also independently associated with increased risk of hypertension. Hypertension is a risk factor for cardiovascular disease and, therefore, increases the risk of mortality.

Two national cross-sectional surveys of 20–69-year-olds in Finland found outdoor occupational cold exposure to be associated with a significant increase in self-reported respiratory symptoms (p<0.05), particularly among smokers. One of these studies also found significantly greater prevalence of shortness of breath when undertaking outdoor exercise in respondents with asthma, allergies or bronchitis, compared with healthy individuals.

Studies reporting no effect of socioeconomic deprivation, housing, or behavioural factors on cold weather-related adverse health or social outcomes

In the UK, non-significant associations were found between Townsend and Carstairs Deprivation Indices, or the Scottish Index of Multiple Deprivation and adverse winter health outcomes, which included EWM (all-cause or cause-specific), excess winter respiratory hospital admissions and hypothermia, at individual and ecological levels. One of these studies found medical and functional factors to be more important predictors of winter respiratory hospital admissions among individuals aged 65 years and over. Another UK study found no clear association between socioeconomic status, measured using ACORN housing type, and excess winter morbidity, in terms of finished consultant episodes for ischaemic heart disease. However, individuals from ‘better-off retirement areas’ had highest excess winter morbidity rates, which supports a hypothesis that older individuals living in larger and therefore more difficult to heat housing are at increased risk of adverse winter health outcomes requiring healthcare utilisation. The authors of this study also speculated that reduced opportunities to engage in health behaviours in winter compared with the summer among individuals from higher socioeconomic groups may contribute to the lack of association between socioeconomic deprivation and excess winter morbidity. In New Zealand, no significant associations were found between area-level scores on the New Zealand Deprivation Index and EWM.

Using independent measures of socioeconomic status, no significant associations were found between occupational groups and EWM in a UK study, or between parental education and allergic rhinitis (winter subtype) in Taiwanese children.

The cost to the English NHS of treating illnesses linked to cold housing was estimated to be £192 m per annum based on data from 2008, using the Building Research Establishment Calculator. It is likely that a large proportion of this expenditure is used to treat older persons, based on demographic risk factors identified in other studies.

Self-reported smoking was not significantly associated with hypertension in cold-exposed male refrigeration workers in Korea, compared to work-matched workers not exposed to cold. Additionally, national smoking rates were non-significantly associated with seasonal variations in EWM between 14 European countries. The author suggested this may indicate that the adverse health impacts of behavioural factors are not specific to the winter season.

A national cross-sectional study in America found reduced food consumption by poor American families during cold periods was non-significantly associated with nutritional deficiencies and anaemia. A Korean case-control study found salt intake to be non-significantly associated with hypertension in male, cold-exposed workers.

A study in Japan found cold-exposed female cooperative workers were significantly more likely to wear one or more items of protective clothing compared to office workers, but had proportionally higher prevalence of many subjective cold-related symptoms. In another study, male outdoor workers from four professions in Finland reported professional footwear provided inadequate protection against slips and falls in cold climatic conditions.

Studies presenting inconsistent associations between socioeconomic deprivation, housing or behavioural exposures and cold weather-related adverse health or social outcomes

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 percentage of labourers working outside the country of residence, was not significantly associated with cardiovascular mortality after cold events.

When comparing results between age groups, a study from the UK found significantly more cold-related mortalities among 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. However, this finding may have been due to ill health selection effects that reverse social gradients at working ages. Another study found the 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, defined as the extent to which the individual feels in control of their life outcomes, when these were added to the regression model.

An international ecological study 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.
Leisure time cold exposure was significantly positively correlated with self-reported health in men from Finland aged 25–74 years, but this association was non-significant in women.16 The direction of the cause-and-effect relationship in males was unclear.

An Australian cohort study of female students aged 17–24 years found that moderately active females had significantly fewer respiratory symptoms compared with females with low or very high levels of physical activity over a 12-week winter period (p<0.05).37 The association between high physical activity and upper respiratory tract symptomatology was attributed to exercise-induced impairment of immune function.

DISCUSSION
Principal findings
This review synthesised observational evidence demonstrating associations between socioeconomic, housing and behavioural factors, and cold weather-related adverse health and social outcomes. It builds on the findings of an earlier review by including evidence relating to housing location, occupancy and tenure, as well as behavioural factors, and includes literature published after 2008. Of the variables analysed, low income, aspects of housing conditions and composite measures of fuel poverty were most consistently associated with mortality, morbidities or wider social outcomes in cold weather. Vulnerability factors including extremes of age, gender and comorbidities moderated the adverse health and social impacts of several exposure variables analysed.

Strengths and limitations 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.

Limitations of this review include the exclusion of qualitative and intervention studies, and observational research published prior to 2001, which may have provided additional aetiological insights of relevance. Due to resource constraints, the primary sifting through 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 from being performed, which potentially compromises the reliability of the review findings.54

Interpretation of findings in relation to review limitations and existing knowledge
Based on the limitations of this review, it is necessary to interpret the results with caution. A previous review from 2008 reported inconsistent associations between socioeconomic factors and aspects of housing condition, and EWM and EWH. The current study found low income, thermally inefficient housing and fuel poverty, which are all related, to be consistently associated with adverse winter health and social outcomes. The difference in results between studies may be attributable to different inclusion criteria and interpretation of findings between reviews.

The results from this review appear to support current hypotheses that poor quality housing conditions in countries with milder climates make homes more expensive to heat; this increases the risk of cold housing among low-income households, which increases the occurrence of adverse health and social outcomes, particularly among vulnerable populations.

Behavioural factors showed the least consistent associations with adverse winter health or social outcomes, possibly due to the non-seasonal effects of these factors and the cross-sectional design of most behavioural studies, preventing robust assessment of long-term health outcomes.

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 housing33 and social inequality in terms of reduced food expenditure and calorie intake by lower-income families due to increased fuel costs during periods of cold weather.24 Eighteen studies were conducted exclusively in the UK or northern Europe, which is probably a reflection of the level of political interest. However, because the nature of causality for cold-related health and social outcomes may differ internationally, and with data indicating EWM rates are generally higher in southern European countries,7 more research is required in such countries 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 longitudinal studies, which could provide stronger evidence of causality in relation to the exposure variables analysed. Studies using individual-level data were generally based on small samples, which make generalisability difficult.

Implications for policy and practice
This review has identified that composite and individual indicators of fuel poverty are most consistently associated with adverse winter health or social outcomes. This supports the need for more robust efforts to improve housing thermal efficiency standards in countries with high rates of excess adverse cold weather-related health and social outcomes. Certain demographic (age: children, or adults >65 years; sex: female; care-home residents; cold-exposed workers),16 31 34 35 41 medical42 and functional factors,35 42 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, offering associated help and advice with smoking and improving preventive measures aimed at care home residents and cold-exposed workers. However, any conclusions should be interpreted with caution, given the limitations of the available evidence.

Unanswered questions and future research
Research over the last decade has provided a better understanding of how societal factors lead to adverse health and social outcomes when cold weather occurs in milder climates. Further research into the potential interactions between socioeconomic and behavioural factors may be useful in supporting the development and targeting of seasonal behavioural interventions, which could increase the positive impacts of existing housing and income support programmes that are currently being implemented. 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 the development of interventions to reduce excess adverse winter health and social outcomes.
What is already known on this subject

- There is increasing political interest in tackling modifiable mediators of adverse winter health and social outcomes.
- Research has identified various socioeconomic, housing and behavioural factors associated with these adverse outcomes.
- An inclusive systematic review of this literature, including evidence relating to a comprehensive range of housing and behavioural factors, has not yet been performed.

What this study adds

- This study synthesises quantitative observational research of contemporary relevance (published from 2001) on socioeconomic, 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, further individual-level studies conducted over longer periods of time, are needed to determine causal associations.
- This information can be used by policy makers to help develop and 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.

Contributors Funding for this project was obtained via a research proposal submitted to the ESRC by LMT, SM, EMGM and MW. LMT, SM, EMGM 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 Energy Action; Angela Tod, Reader in Health and Social Care Research at Sheffield Hallam University and member of the Keeping Warm in Later Life Project Group, NHS Rotherham; and Tim Wright, Public Health Portfolio Lead and member of the County Durham and Darlington Healthy Homes Partnership. Data analysis and interpretation was performed by LMT, SDHM, SM, EMGM and MW. Mark Warwick, Computer Technician, provided graphical advice and support. LMT drafted the manuscript. SM, EMGM, SDHM and MW commented on and approved the final manuscript.

Funding LMT is funded by the Economic and Social Research Council (ESRC) as a member of ESRC’s North East Doctoral Training Centre. The views expressed in the publication are not necessarily those of ESRC. MW is funded in part as director of Fuse. Fuse is a UK Clinical Research Collaboration (UKCRC) Public Health Research Centre of Excellence. Funding for Fuse from the British Heart Foundation, Cancer Research UK, Economic and Social Research Council, Medical Research Council, the National Institute for Health Research, under the auspices of the UK Clinical Research Collaboration, is gratefully acknowledged. The views expressed in this paper do not necessarily represent those of the funders or UKCRC. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1 Fearne V. Excess winter mortality in England and Wales, 2010/11 (provisional) and 2009/10 [final]. UK: Office for National Statistics, 2011.
2 Rudge J, Gilchrist R. Excess winter morbidity among older people at risk of cold homes: a population-based study in a London borough. J Pub Health 2005;27:353–8.
3 Healy JD. Excess winter mortality in Europe: a cross country analysis identifying key risk factors. J Epidemiol Community Health 2003;57:784–9.
4 Telfar Barnard LF, Baker MG, Hales S et al. Excess winter morbidity and mortality: do housing and socio-economic status have an effect? Rev Environ Health 2008;23:203–21.
5 Keatinge WR. Winter mortality and its causes. Int J Circumpolar Health 2002;61:292–99.
6 Finelli L, Chaves SS. Influenza and acute myocardial infarction. J Infect Dis 2011;203:1701–4.
7 Healy J. Housing conditions, energy efficiency, affordability and satisfaction with housing: a pan European analysis. Housing Stud 2003;18:409–24.
8 EuroWinter Group. Cold exposure and winter mortality from ischaemic heart disease, cerebrovascular disease, respiratory disease, and all causes in warm and cold regions of Europe. Lancet 1997;349:1341–6.
9 Department of Energy and Climate Change. Social policy expert appointed to lead independent fuel poverty review. http://www.decc.gov.uk/en/content/cms/news/news/ pn11_0446omn11_044.aspx (accessed 23 May 2012).
10 Boardman B. Fuel poverty London: Belbom Press, 1991.
11 Marmot M, Geddes I, Bloomer E et al. The health impacts of cold homes and fuel poverty. London, England: Friends of the Earth/Marmot Review Team 2011;69.
12 Lidell C, Morris C. Fuel poverty and human health: a review of recent evidence. Energy Policy 2011;38:2987–97.
13 The UK Fuel Poverty Strategy. London, England: Department of Trade and Industry, 2001.
14 EU Fuel Poverty Network, EU: http://fuelpoverty.eu/resources/non-eu (accessed 5 Oct 2012).
15 Walker R, Thomson H, Liddell C. Fuel Poverty 1991 – 2012: Commemorating 21 years of fuel poverty policy and research. Ulster; York: University of Ulster; The University of York, 2013. http://fuelpoverty.eu/2013/03/12/fuel-poverty-booklet-launch/ (accessed 28 Jun 2013).
16 Davie GS, Baker MG, Hales S et al. Trends and determinants of excess winter mortality in New Zealand: 1980 to 2000. BMC Public Health 2007;7:263.
17 Howden-Chapman P, Viggers H, Chapman R et al. Tackling cold housing and fuel poverty in New Zealand: review of policies, research and health impacts. Energy Policy 2012;49:134–42.
18 National Energy Action, UK, Research database 2012. http://www.nea.org.uk/ policy-and-research/research-database (accessed 5 Oct 2012).
19 United Nations. Human Development Report 2011. New York: National Human Development Reports Unit. http://hdr.undp.org/en/media/HDR_2011_EN_Complete.pdf (accessed 5 Oct 2012).
20 Townsend P, Phillimore P, Beattie A. Health and deprivation: inequality and the North. New York: Croom Helm Ltd., 1988.
21 Carstairs VM, Morris R. Deprivation and health in Scotland. Aberdeen: Aberdeen University Press, 1991.
22 University of York, Centre for Reviews and Dissemination, UK. http://www.york.ac.uk/inst/crd/pdf/Systematic_Reviews.pdf (accessed 11 Oct 2012).
23 Caird JK, Williness CR, Steel P et al. A meta-analysis of driving performance and crash risk associated with the use of cellular telephones when driving. Accid Anal Prev 2008;40:1282–93.
24 Bhattacharya J, Deleaite T, Haider S et al. Heat or eat? Cold-weather shocks and nutrition in poor American families. Am J Pub Health 2003;93:1149–54.
25 Castagno LA, Lavinsky L. Otitis media in children: Seasonal changes and crash risk associated with the use of cellular telephones when driving. Accid Anal Prev 2008;40:1282–93.
26 Howesige V, McGregor H. Multiple deprivation and excess winter deaths in Scotland. J Soc Promot Health 2005;125:18–22.
27 Pedley DK, Paterson B, Morrison W. Hypothermia in elderly patients presenting to accident & emergency during the onset of winter. Scott Med J 2002;47:10–1.
28 Butler S, Williams M, Tukuitonga C et al. Problems with damp and cold housing among Pacific families in New Zealand. N Z Med J 2003;116:U494.
29 Critchley R, Gilbertson J, Grimley M et al. Living in cold homes after heating improvements: evidence from Warm-Front, England’s Home Energy Efficiency Scheme. Appl En. 2007;3:147–58.
30 Mitchell R, Blane D, Bartley M. Elevated risk of high blood pressure: climate and the inverse housing law. Int J Epidemiol 2002;31:831–8.
31 Donaldson GC, Rintamaki H, Naya S. Outdoor clothing: its relationship to geography, climate, behaviour and cold-related mortality in Europe. Int J Biometeorol 2001;45:45–51.
32 Inaba R, Miroh SM, Kunikawa J et al. Subjective symptoms among female workers and winter working conditions in a consumer cooperative. J Occup Health 2005;47:454–65.
33 Kim JY, Jung K, Hong YS et al. The relationship between cold exposure and hypertension. J Occup Health 2003;45:300–6.
34 Kotaniemi JT, Pallasho P, Sojyvani ARA et al. Respiratory symptoms and asthma in relation to cold climate, inhaled allergens, and irritants: a comparison between northern and southern Finland. J Asthma 2002;39:649–58.
35 Kotaniemi JT, Latvala J, Lundback B et al. Does living in a cold climate or recreational skiing increase the risk for obstructive respiratory diseases or symptoms? Int J Circumpolar Health 2003;62:142–57.
36 Makinen TM, Raatikka VP, Rytkonen M et al. Factors affecting outdoor exposure in winter: population-based study. Int J Biometeorol 2006;51:27–36.
Novas A, Rowbottom D, Jenkins D. Total daily energy expenditure and incidence of upper respiratory tract infection symptoms in young females. *Int J Sports Med* 2002;23:465–70.

Chen VY, Wu PC, Yang TC, et al. Examining non-stationary effects of social determinants on cardiovascular mortality after cold surges in Taiwan. *Sci Total Environ* 2010;408:2042–9.

Chen BY, Chan CC, Han YY, et al. The risk factors and quality of life in children with allergic rhinitis in relation to seasonal attack patterns. *Paediatr Perinat Epidemiol* 2012;26:146–55.

Hales S, Blakely T, Foster RH, et al. Seasonal patterns of mortality in relation to social factors. *J Epidemiol Community Health* 2010;66:379–84.

Phu Pin S, Golmard JL, Cotto E, et al. Excess winter mortality in France: influence of temperature, influenza like illness and residential care status. *J Am Med Dir Assoc* 2011;13:309.e1–7.

Jordan RE, Hawker JL, Ayres JG, et al. Effect of social factors on winter hospital admission for respiratory disease: a case-control study of older people in the UK. *Br J Gen Pract* 2008;58:400–2.

Croxford B. The effect of cold homes on health: evidence from the LARES study. In: Ormandy D. ed. *Housing and health in Europe: the WHO LARES project*. Oxford: Routledge, 2009:142–54.

Mason VR, Roys M. *The health costs of cold dwellings*. Garston, UK: Building Research Establishment, 2011, ED2792.

Gao C, Holmer I, Abeysekera J. Slips and falls in a cold climate: underfoot surface, footwear design and worker preferences for preventive measures. *Appl Ergon* 2008;39:385–91.

Heyman B, Harrington BE, Merleau-Ponty N, et al. Keeping warm and staying well. Does home energy efficiency mediate the relationship between socio-economic status and the risk of poorer health? *Housing Stud* 2005;20:649–64.

Mills SD, Tanner LM, Adams J. Systematic literature review of the effects of food and drink advertising on food and drink related behaviour, attitudes and beliefs in adult populations. *Obes Rev* 2013;14:303–14.

Wilkinson P, Landen M, Armstrong B. Cold comfort: the social and environmental determinants of excess winter deaths in England, 1986–1996. Joseph Rowntree Foundation. 2001.

Aylin P, Morris S, Wakefield J, et al. Temperature, housing, deprivation and their relationship to excess winter mortality in Great Britain, 1986–1996. *Int J Epidemiol* 2001;30:1100–8.

Rudge J, Gilchrist R. Measuring the health impact of temperatures in dwellings: Investigating excess winter morbidity and cold homes in the London Borough of Newham. *Energy Buildings* 2007;39:847–58.

Maheswaran R, Chan D, Fryers PT, et al. Socio-economic deprivation and excess winter mortality and emergency hospital admissions in the South Yorkshire Coalfields Health Action Zone, UK. *Public Health* 2004;118:167–76.

Watkins SJ, Byrne D, McDevitt M. Winter excess morbidity: is it a summer phenomenon? *J Public Health Med* 2001;23:237–41.

Donaldson GC, Keatinge WR. Cold related mortality in England and Wales; influence of social class in working and retired age groups. *J Epidemiol Community Health* 2003;57:790–1.

Walker E, Hernandez RV, Kattan MW. Meta-analysis: its strengths and limitations. *Cleve Clin J Med* 2008;75:431–9.