Health Climate Change impacts report card technical paper

2. Health effects of milder winters

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Introduction and scope

Cold-related mortality and morbidity remains an important public health problem in the UK and many other parts of the world. Health burdens have often reported to be higher in the UK compared to other countries with colder climates. This suggests that many of these impacts are preventable with appropriate protection measures. In the UK, very few of the health impacts are as a direct result of hypothermia, but rather due to cardiovascular and respiratory problems. Climate change leading to milder winters will likely result in a reduction in cold-related health burdens in the UK in future, although population ageing may temper this to some extent. Recent global increases in fuel prices may also have an influence due to people experiencing greater difficulties in adequately heating their homes during winter months.

This technical paper reviews the epidemiological evidence on the health effects of wintertime weather in the UK. It identifies individual and contextual-level risk factors that heighten vulnerability to cold and reviews the evidence for changes in cold risk due to recent climate changes, and also likely future burdens. The paper discusses the potential for current and future cold impacts to be reduced by adaptation measures and concludes by identifying gaps in current knowledge.

Evidence of current sensitivity to climate factors

Epidemiologic studies of cold-related health

Epidemiology studies generally quantify one of two different measures of cold-related health. One relates to assessment of the seasonal distribution of health events, whereby an excess wintertime effect is obtained by measuring the average number of daily health events occurring in the winter months compared to at other times of the year. The most commonly used metric is the Excess Winter Mortality (EWM) Index, which considers the average number of all-cause deaths occurring during December-March (for northern hemisphere countries) compared to the average number occurring in the preceding August-November and the following April-July.(1) This excess is observed to be high in the UK, Ireland and Portugal compared to many other parts of Europe, including the colder Scandinavian countries.(2) However, international comparisons can be difficult to interpret due to differences in the seasonal distribution of deaths between countries – for example, in England the cold period is largely concentrated in the months of December to March, which are the months used in the numerator of the EWM index, whereas in colder countries the cold period may last longer. There are also other problems with such an index – seasonal factors other than weather may also contribute to the winter excess (e.g. influenza) and the index can also be influenced by unusual mortality patterns at other times of the year used in the denominator of the calculation, such as during a heat-wave. The main advantages and disadvantages of using excess winter mortality indices to determine wintertime burdens are listed in box 1.

Box 1: Advantages and disadvantages of using an excess mortality index to determine wintertime burdens

Advantages:	**Disadvantages:**
• It is easy and quick to calculate. If daily or even seasonal mortality counts are available, the formula can be applied without advanced statistical methods. • It is easily understood by the lay public and policymakers. • It can measure the full excess at wintertime, without missing many deaths due to delayed effects.	• It is crude. Seasonal changes in health do not occur according to fixed calendar dates. • Not all deaths due to cold are during the winter, and not all of the winter excess is due to cold. • International comparisons are complicated by potential differences in the distribution of wintertime deaths and the length of the winter period. • The ratio may be sensitive to the periods used in the denominator, e.g. if summer months are included the occurrence of a heat-wave may artificially reduce the index. • It doesn't allow for identification of which weather factors are important for health or for the specific conditions, e.g. are cold-spells occurring early in the winter worse than later ones?

For the reasons listed, the EWM index is not an appropriate indicator of health burdens associated with wintertime weather. Indeed, there is very little correlation between recent ONS statistics on annual excess winter deaths for England and Wales, and the severity of wintertime weather experienced. Analysis of EWM to draw conclusions about cold-related health impacts can lead to spurious findings.(3)

By contrast, the second type of epidemiologic evidence measures the explicit effects of weather on health whilst controlling for underlying seasonal patterns. These studies are usually based on conducting regression analysis of data consisting of sequences of health events measured at regular intervals of time, for example the daily number of deaths in relation to daily fluctuations in temperature over a period of a few years. Because these time-series regression studies provide the best evidence of acute effects of cold exposure, they are the focus for the literature reviewed in this paper.

Mortality & morbidity outcomes

Time-series regression studies show that in many settings mortality levels rise in a gradual, often linear fashion in relation to a fall in ambient temperature during winter months. This risk is sometimes referred to as the cold slope, and the steepness of the slope may vary across cities and countries depending on differing climatic, demographic and socio-economic profiles.(4-6) In a time-series analysis of natural deaths in 15 European cities, the cold-related relative risk in London was higher than in the colder cities of Helsinki, Prague and Stockholm, but lower compared to most of the other cities studied.(4) However, such results do not take into account the frequency of cold days experienced and so do not necessarily reflect total cold attributable burdens. A recent international study that quantified attributable fractions reported that moderate cold was responsible for proportionally less deaths in the UK compared to China, Japan or Italy.(6) In UK specific studies, a 6% increase in all-cause deaths was observed in England & Wales for every 1°C fall in daily mean temperature within the top 5% of the coldest days of the year.(7) In major Scottish cities, a 1°C reduction in mean temperature below 11°C was associated with an increase in mortality of 2.9%, 3.4%, 4.8% and 1.7% from all-causes, cardiovascular, respiratory, and non-cardio-respiratory causes respectively.(8)

Low temperatures have also been associated with raised risk in morbidity outcomes in the UK, including emergency hospital admissions for respiratory diseases (9) and myocardial infarctions,(10) GP consultations for respiratory problems,(11) activation of implantable cardioverter defibrillators among cardiac patients,(12) and also delayed ambulance call response times.(13) Most recently, the utility of using data from the Emergency Department Syndromic Surveillance System was demonstrated to provide timely indication of public health impacts in relation to cold weather.(14)

Delayed effects

Cold effects can be delayed by a few days or weeks following initial exposure, originating the need to consider exposure effects over multiple days. In general, cold effects on cardiovascular diseases have been shown to be more immediate than on respiratory causes.(15) Unlike with hot weather, there is no evidence that there are additional impacts on health when cold conditions occur on consecutive days as part of a cold-spell.(16) Also unlike with heat-related deaths in the UK, there is little evidence of short-term displacement of cold-related deaths, indicating they do not predominantly occur in already frail individuals who may have been expected to die anyway within a short space of time.(17)

Snow and ice

In general, there are increased rates of emergency hospital admissions for falls associated with harsh winter conditions.(18) Hip fractures among elderly groups are only weakly associated with snow and ice conditions in the UK,(19-22) with the great majority of falls resulting in a fractured hip occurring indoors. Fractures of the forearm and wrist are more strongly linked to cold and icy weather.(23)

<u>Vulnerable groups</u>

A person's susceptibility to cold weather is affected by both individual and contextual-level risk factors.(24)

Age

The most important risk factor for cold-induced illness and death is advanced age.(25) An elevated mortality risk is observed with all age groups, but the risk increases steeply for elderly people. The elderly are less able to thermoregulate their bodies compared to other age-groups, and in other ways are also more susceptible to many of the effects of cold exposure.(24) Although snow and ice contribute to the risk of injuries and falls, the relationship is more complex when stratified by age. Younger, working-age adults may be most vulnerable to snow and ice-related fractures,(17) resulting in greater activity days lost.

Pre-existing illness

Underlying diseases can modify blood pressure, circulation and perspiration rates, leading to increased cold risk.(24) Evidence for the UK generally indicates that respiratory diseases show the strongest temperature-mortality/morbidity relationships, but cardiovascular outcomes contribute a higher attributable burden because of the greater frequency of cardiovascular events.(7) Specific cardiovascular diseases shown to be associated with cold include myocardial infarction (10) and stroke.(26) Among respiratory categories, chronic obstructive pulmonary disease (COPD) is strongly linked with wintertime weather and has been the outcome of intervention studies conducted within the home (27) and of preventative care informed by a health forecasting and alert system.(28) Many infectious diseases, including influenza, are seasonally distributed, but the contribution of weather factors to such outcomes is not clear.

Sex

Women may have slightly greater risk of cold-related death than men, but the difference is likely to be partly explained by differences in the age distribution – women live longer than men. They are also more likely to be living alone which can also heighten risk. An analysis of cold deaths in a cohort of elderly people from UK general practices found a greater risk in women: relative risk of 1.08 (95% CI 0.99 to 1.19) compared to men, after adjusting for age and region.(25)

Rurality

The evidence for differences in effects by rurality is varied and inconclusive. Excess winter mortality in the UK has not been found to vary by population density,(29) although living in a rural area may increase any effect of socio-economic deprivation.(7)

Socio-economic status and fuel poverty

Evidence on the effect of socio-economic status is inconsistent, despite expected relationships between poverty, poor home heating and wintertime health.(30) No clear modification of risk by socio-economic gradient has been reported in several UK studies.(7, 25, 31) In the UK, social housing is often well heated and more energy efficient than housing in the owner-occupier and privately rented sectors.(32) However, the 2012 Hills review of fuel poverty,(33) and other reviews relevant to the UK,(34, 35) refer to evidence on a range of health outcomes likely to be adversely affected by fuel poverty, including psychosocial wellbeing and quality-of-life measures.

Housing

Evidence on associations between housing and wintertime health is limited.(36) There is some observational evidence for the UK that vulnerability to cold is less in newer build and more energy efficient homes.(32) Analysis of data from the Health and Lifestyle Survey showed that, in Britain, housing quality tends to be worse in areas of colder climates, and that this leads to higher risk of hypertension.(37) In addition, a recent Cochrane Collaboration review on housing improvements concluded that interventions that improve thermal comfort in the home can lead to health improvements, especially when targeted at those with inadequate warmth and those with chronic respiratory diseases.(38) This review also suggested that dwellings which are affordable to heat are linked to improved health and social relationships and may reduce absences from school or work. Furthermore, simulation studies of home energy efficiency improvement measures indicate net positive health benefits related to indoor temperature and indoor air quality, although this may vary by setting.(39)

Regional differences

Variations in the distributions of the above health, demographic, socio-economic and built-environment characteristics are likely to explain most differences in cold risk observed between UK regions. The most recent UK evidence on regional variations in cold risk are provided by the London School of Hygiene & Tropical Medicine's evaluation of the

Department of Health Cold Weather Plan, as part of which epidemiologic assessment of retrospective data was conducted.(17) Adverse cold-related health impacts were observed in all regions, with the North East, North West and London regions experiencing the greatest relative increase in mortality. In all regions, impacts became apparent at fairly moderate values of mean temperature, indicating that ambient temperatures do not need to be particularly extreme before adverse effects occur. Evidence from Scotland suggests that other weather factors such as wind-chill have little additional effect on deaths once temperature has been modelled, reflecting the fact that temperature is the most important weather factor influencing wintertime health.(8) However, an apparent role for rainfall has been reported in explaining inter-town variations in mortality from ischaemic heart disease.(40) An assessment of GP consultations for respiratory conditions by elderly people in 16 locations across the UK observed the strongest risk in Norwich, although attributable fractions were highest in Edinburgh due to the Scottish city experiencing more cold days.(41)

Review of studies estimating current cold-related health impacts attributable to observed climate change (1970-2013)

Reductions in cold-related health impacts over recent decades have been reported in UK populations, although there is little information on the contribution that observed climate changes since the 1970s may have provided to such reductions. As well as long-term reductions in seasonal mortality,(42-44) deaths in London specifically related to cold weather declined in a broadly uniform fashion throughout the 20th century.(45) This study showed that the reduced vulnerability during the final period analysed (1986-1996) was consistent with the magnitude of reductions observed in the 3 earlier periods (all pre-1970s), suggesting that factors other than climate change leading to milder winters may have been the main drivers. An optimal detection analysis of deaths in England and Wales in those aged 50+ years reported that adaptation considerably enhanced reductions in cold-related deaths during 1976-2005, with an estimated decrease of 85 cold-related deaths per million population per year, but only 47 if no adaptation had taken place.(46)

One study from 1995 which used projections of future temperatures from general circulation models to estimate future numbers of cold deaths for England and Wales reported that mean surface temperatures would increase 0.9°C by 2010 (compared to the baseline period of 1968-1988) which would lead to 3310 less deaths during September-May, in the absence of any changes in health care or socio-economic conditions.(47) This estimate is lower than that of Alderson who predicted about 8000 deaths avoided for an increase of 1°C in average winter temperature, although this number relates to excess winter deaths rather than those due specifically to cold.(48)

As part of an assessment of the impact of climate change on winter road maintenance and traffic accidents in the West Midlands, it was reported that between 1999-2006 there had been a general downward trend in the annual number of accidents, whilst over the same period there was no overall warming trend evident in mean winter temperatures.(49) This suggests that recent improvements in accident rates are due to non-climate related factors.

Review of studies estimating future cold-related health impacts attributable to climate change during the periods 2010-2050 and 2050-2100

Estimates of current temperature-health risk profiles applied to projections of future local climate have been used to provide projections of future cold-related health burdens due to climate change, with the most realistic estimates being those which also consider changes in population vulnerability. For example, population ageing may amplify cold-related health burdens in future, whilst health protection and other adaptation measures may contribute to reducing future risk. Although cold spells may become more common in future due to increased climate variability, such sustained periods of low temperatures are not associated with additional mortality risk compared to individual cold days.(16)

A recent assessment for the whole of the UK using an ensemble of 9 climate model realisations based on the medium emissions scenario (SRES A1B) reported that, in the absence of any adaptation by the population, a mean annual *increase* in cold-related deaths of 3% would be observed by the 2020s compared to current levels, followed by a decrease of 2% by the 2050s compared to current levels.(50) Cold risk remained highest in the elderly, in particular those aged over 85 years. An increase in deaths was observed for the 2020s due to projected demographic changes (increased population size and ageing) offsetting any reduction in impacts due to warmer winters. Had population size and age structure been held constant, then a reduction in cold-deaths of 9% and 26% was projected by the 2020s and 2050s respectively. Reductions are observed in all regions of the UK, with the highest cold-related death rate being in Wales (61.1 deaths per 100,000 people by the 2050s) and the lowest rate in Northern Ireland (34.1 per 100,000 people), although the latter rate was based on the current temperature-mortality risk profile of the neighbouring North West region due to data unavailability. The UK-wide cold-related death rate was 62.3 per 100,000 people for the 2020s and 50.6 for the 2050s.

A previous assessment for England and Wales reported an annual decrease in cold deaths of 6353 by the year 2030 and 8922 by 2050, assuming no changes in health care and socio-economic conditions.(47) About 40% of these avoided deaths were in deaths due to ischaemic heart disease, with the rest mainly from cerebrovascular disease, chronic bronchitis and pneumonia. Hames and Vardoulakis showed a decrease of 24% in cold-related mortality over the period 2020s-2050s, based on current population levels.(51) Other work, which also did not model future demographic changes, observed a 25% reduction in cold-related by deaths by the 2050s.(52) Separate estimates have also been produced for London as part of a global assessment.(53)

The analysis of future burdens of traffic accidents in the West Midlands, using the UKCIP02 (UK Climate Impacts programme 2002) medium-high emission scenario, reported that a reduction in the number of days below 5°C, leading to less days with slippery winter roads, will result in a reduction in the number of traffic accidents by 12% compared to a current annual baseline of 2039 accidents.(49) For later periods, the paper reports a 43% reduction in accidents by the 2080s, although continuing improvements in vehicle technology and road safety may mean that this is a conservative estimate.

Going back to cold-related deaths, these were estimated to decrease by 26% over the period 2050s-2080s, assuming no population changes.(51) Hajat et al reported a 12% decrease in the UK by the 2080s compared to current levels, and a 40% decrease for the same period if future population size and ageing are not taken into account.(50) The UK-wide cold-related death rate for the 2080s was 40.9 per 100,000 people. An extension to this work reported that cold deaths in the UK by the 2080s will still outnumber heat deaths by a factor of over 4, assuming current susceptibility.(54) Although there are some arguments that climate change may not lead to a substantial reduction in winter mortality rates,(55) the overwhelming evidence from the UK, which currently has a much higher burden from cold-related mortality than from heat-related mortality, indicates that climate change will lead to a net reduction in temperature-related deaths due to any increase in heat-related impacts being offset by a greater reduction in cold burdens. However, the demographic changes expected in the UK this century may partly counter this.(50) Also, in the long-term, if temperatures continue to rise then heat-related impacts may eventually become more dominant.(56) There is little evidence from the UK on how climate change may affect rates of wintertime infections.

Potential for impacts to be avoided by adaptation measures

Although milder winters due to climate change will likely mean that cold-related health impacts will reduce in future, there are likely to be other factors that will contribute to the changes. Despite population ageing and a progressive increase in the prevalence of cardiorespiratory disease, vulnerability to cold has reduced over the course of the previous century.(45) Although not quantified, the reasons for this likely include developments in health care (including influenza vaccination),(57) improved nutrition during winter months, better support services, and improved housing.(42) Indoor temperatures have risen as a result of improvements in building materials and standards, such that even today the age of a property remains an important determinant of indoor exposure,(58) which in turn broadly correlates with the risk of winter mortality (32) and morbidity.(59) However, these trends may be undone by continuing increases in fuel prices. About half of the people in fuel poverty (i.e. households that require 10% or more of their income to achieve adequate warmth in the home) in England are over 60 years of age.(60)

Factors that have reduced outdoor exposure to cold are also likely to have played a role in the vulnerability reduction.(43) These include increased car ownership, climate-controlled transportation and shopping facilities, and improved clothing fabrics.(61) Measures such as windproofing bus shelters and better heating of waiting rooms could reduce the cold burden further.(62) It has been suggested that improved adaptation and acclimatisation to warmer summertime temperatures may increase vulnerability to cold in the future, although there is no evidence to support such maladaptation fears. Although the number of traffic accidents related to wintertime weather are projected to reduce in future, the study authors warn that if a warmer climate results in budget cuts for highway maintenance then this may run the risk of reversing the declining trends.(49)

Since the winter of 2011, England has had in operation a cold weather plan run by the Department of Health (https://www.gov.uk/government/publications/cold-weather-plan-for-england-2013). The plan provides advice for individuals, communities and agencies on how to prepare for and respond to severe cold weather, and initiates acute actions by health and social care professionals and other community organisations to strengthen the protection and support of vulnerable individuals when cold weather is forecast. As well as a recent process evaluation of this plan,(17) further qualitative information has led to updates to the plan which the authors describe as an example of pragmatic evidence-based policy making.(63) To date, however, there is little quantitative evidence on the effectiveness of such plans either from England or elsewhere in the world. This lack of quantitative evidence also applies to most other types of cold-related health intervention measures. The arguable exceptions to this are home energy efficiency strategies, where there is enough evidence to suggest that these confer health benefits to some population groups.(64-67)

Conclusions and evidence gaps

Although concerns about global warming have focussed recent attention on the dangers of exposure to hot weather, cold-related exposure remains a much greater public health problem in the UK. This may be exacerbated by population ageing and recent global increases in fuel prices leading to a greater inability among people to warm their homes adequately during cold weather. Although climate change is likely to lead to a reduction in future cold-related health impacts, intervention measures designed to minimise cold exposure and reduce fuel poverty will also play a key role in determining current and future health burdens due to cold weather. The following evidence gaps are identified.

- There is no consensus on the role, if any, that deprivation plays on cold-related mortality and morbidity.
- There is little evidence on the contribution that observed climate change since the 1970s has played on observed reductions in cold-related health burdens over recent decades.
- With perhaps the exception of home energy efficiency interventions, there is limited quantitative evidence on the effectiveness of adaptation measures in reducing cold-related health impacts.
- The importance of factoring-in spontaneous and planned adaptation options into estimates of future cold burdens is unclear and needs to be explored further.

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