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Original Research

Public health vulnerability to wintertime weather: time-series regression and episode analyses of national mortality and morbidity databases to inform the Cold Weather Plan for England

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ABSTRACT

Objectives: To inform development of Public Health England's Cold Weather Plan (CWP) by characterizing pre-existing relationships between wintertime weather and mortality and morbidity outcomes, and identification of groups most at risk.

Study design: Time-series regression analysis and episode analysis of daily mortality, emergency hospital admissions, and accident and emergency visits for each region of England.

Methods: Seasonally-adjusted Poisson regression models estimating the percent change in daily health events per 1 °C fall in temperature or during individual episodes of extreme weather.

Results: Adverse cold effects were observed in all regions, with the North East, North West and London having the greatest risk of cold-related mortality. Nationally, there was a 3.44% (95% CI: 3.01, 3.87) increase in all-cause deaths and 0.78% (95% CI: 0.53, 1.04) increase in all-cause emergency admissions for every 1 °C drop in temperature below identified thresholds. The very elderly and people with COPD were most at risk from low temperatures. A&E visits for fractures were elevated during heavy snowfall periods, with adults (16–64 years) being the most sensitive age-group. Since even moderately cold days are associated with adverse health effects, by far the greatest health burdens of cold weather fell outside of the alert periods currently used in the CWP.

Conclusions: Our findings indicate that levels 0 ('year round planning') and 1 ('winter preparedness and action') are crucial components of the CWP in comparison to the alerts. Those most vulnerable during winter may vary depending on the type of weather conditions being experienced. Recommendations are made for the CWP.

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Introduction

Cold-related mortality and morbidity remains a significant public health problem in many parts of the world, including the UK.[1] Thousands of deaths occur in the UK from cold weather each year.[2] In addition, many people visit GPs and hospitals during winter with a range of cold weather-related health problems.[3,4] Cold weather leads to increases in heart attacks, stroke, respiratory disease, influenza, falls and injuries, and hypothermia.[5–8]

Many of these impacts are predictable and largely preventable. England does not compare well with other northern European countries in this respect.[9] Countries with cooler winter climates are often better prepared for winter, with better-insulated, well-heated housing, and warm outdoor clothing.[10]

Prompted by these observations and recent harsh winters, Public Health England (PHE) introduced in 2011 a Cold Weather Plan (CWP) for England. The plan aims to avoid the adverse health effects of winter by raising public awareness and triggering actions by health and social care services and other public health agencies and professionals who are in contact with those most at risk from cold weather. The plan is underpinned by a system of cold weather alerts developed with the Met Office in order to trigger interventions when severe winter weather (either low temperatures or widespread snow and ice) is forecast. The CWP has great potential to save lives and to reduce annual pressures on health and social care systems during the busiest months of the year. However, implicit in such an assertion is that actions are implemented during the most harmful weather conditions and that those most vulnerable are correctly identified.

This paper presents findings from an epidemiologic analysis of retrospective data assessing the explicit effects of weather factors on wintertime health. The aim is to characterize the impacts of low temperatures and extreme weather events on mortality and morbidity outcomes in order to provide a baseline level of current cold-related health burdens against which any future impacts of CWP implementation can be compared. It identifies sub-groups of the population most at risk during wintertime weather, and provides new evidence on the health burdens associated with the alert thresholds used in the CWP.

Methods

Data

Health information was obtained from three national databases:

1. All deaths occurring in England during 1st Jan 1993–31st Dec 2006, obtained from the Office for National Statistics. More recent years of data were not available.
2. All emergency hospital admissions occurring in England during 1st April 1997–31st March 2011, obtained from the Health and Social Care Information Centre.
3. Visits to Accident & Emergency (A&E) departments in England during 1st April 2007–31st March 2011, obtained from the Health and Social Care Information Centre.

Each health outcome was aggregated by date and Government region to create a time-series of the daily number of events for each region of England. Based on expected risk groups, the series were stratified by the following age-bands: children (0–15 years), adults (16–64 years), and three elderly groups (65–74 years, 75–84 years, 85+ years). For mortality and hospital admissions data, the series were also stratified by the following disease groups: all cardiovascular diseases (CVD) [ICD10 codes: I00-I99], all respiratory diseases [J00-J99], chronic bronchitis and chronic obstructive pulmonary disease (COPD) [J40-J44] and external causes [V01–Y99]. For A&E data, the following diagnosis categories were considered: 'dislocation/fracture/joint injury or amputation', 'cardiac conditions', and 'respiratory conditions'. Data from other countries of the UK were not considered since the CWP is only operational in England.

The exposure data consisted of daily minimum, maximum and mean temperatures for the same time periods, with the mean temperature being derived from the average of the daily minimum and maximum values. These data were recorded by Met Office land surface stations obtained through the British Atmospheric Data Centre website. For each measure, one composite series was created for each region by combining data from stations recording measurements on at least 75% of days during the study period and using a previously published imputation method to deal with missing values.[11] On average, 20 stations contributed data to each regional series. Mean temperature was found to be a better predictor of cold-related health than either minimum or maximum temperature, and so is used here as the main exposure measure. Daily measures of resting snow depth for one site in each region were also obtained from the Met Office to broadly represent regional snowfall conditions.

Statistical analysis

Assessment of the acute (i.e. day-to-day) relationships existing between weather and health events consisted of two components:

1) Time-series regression analysis to characterize the temperature–health relationships occurring throughout the winter months.
2) Episode analysis to assess the impact of individual episodes of extreme weather, in particular periods of heavy snowfall.

The time-series regression analysis was conducted on the daily mortality and emergency hospital admissions data, using previously published modelling choices.[11] Regression models assumed a Poisson distribution for each outcome, with standard errors adjusted for overdispersion. Slow-changing seasonal patterns in the health counts (unrelated to temperature) and any secular trends were controlled for using splines of time, using 7 degrees of freedom per year of data analysed. Splines functions are a series of polynomial

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