Original Research

Changes in cold-related mortalities between 1995 and 2016 in South East England

G.C. Donaldson [a,*], C. Witt [b], S. Näyhä [c]

[a] National Heart and Lung Institute, Guy Scadding Building, Imperial College London, Dovehouse Street, London, SW3 6LY, United Kingdom
[b] Division of Ambulatory Pneumology, Charité — Universitätsmedizin Berlin, Berlin, Germany
[c] Centre for Environmental and Respiratory Health Research, University of Oulu, Finland

ARTICLE INFO

ABSTRACT

Objective: The aim of the study was to examine trends in cold-related mortalities between 1995 and 2016.

Study design: This is a longitudinal mortality study.

Methods: For men and women aged 65—74 years or those older than 85 years in South East England, the relationship between daily mortality (deaths per million population) and outdoor temperatures below 18 °C, with allowance for influenza epidemics, was assessed by linear regression on an annual basis. The regression coefficients were expressed as a percentage of the mortality at 18 °C to adjust for changes in mortality through health care. Trends in 'specific' cold-related mortalities were then examined over two periods, 1977—1994 and 1995—2016.

Results: In contrast to the early period, annual trends in cold-related specific mortalities showed no decline between 1995 and 2016. 'Specific' cold-related mortality of women, but not men, in the age group older than 85 years showed a significant increase over the 1995—2016 period, which was different from the trend over the earlier period (P < 0.01).

Conclusion: Despite state-funded benefits to help alleviate fuel poverty and public health advice, very elderly women appear to be at increasing risk of cold-related mortality—greater help may be necessary.

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Introduction

Cold exposure, either indoors or outdoors, is responsible for increased morbidity and mortality from cardiovascular and respiratory causes.[1] The mechanisms probably involve vasoconstriction of the surface blood vessels that forces plasma out of the circulatory system, thereby concentrating clotting factors in the blood and consequently increasing the risk of myocardial infarction and cerebrovascular stroke.[2] Cold weather will also promote survival of respiratory

viruses in nasal secretions originating from infected individuals that contaminate other people.[3] Excess winter mortality is seen across Europe and places a familiar winter burden on healthcare systems.[1]

Excess winter mortality (after allowance for influenza) fell between 1977 and 1994.[4] Similar findings have been reported in the Netherlands[5,6] and in London,[7] with a downwards but non-significant trend in Stockholm.[8] This fall was attributed to increased provision of central heating and car ownership and to changes in medical care and general health.[4] We now report, with an identical methodology, changes in winter mortality in the same area (South East England) and same population (men and women, aged 65—74 years) over the subsequent 21 years, 1995—2016, and examine an older age group (older than 85 years).

Methods

Data on daily deaths of men and women aged 65—74 years and older than 85 years in South East England were extracted using 9th and 10th International Classification of Disease (ICD) codes of 410.0—414.9 and I20—I25 for ischaemic heart disease (IHD), 430.0—438.9 and I60—I69 for cerebrovascular disease (CVD), 460.0—519.9 and J00—J99 for respiratory disease (RES) and 0—999.9 and A00—Y00 for all causes, respectively. For all causes, over the 1976—2016 period, there were 849,455 and 588,792 deaths of people aged 65—74 years and 641,930 and 1,386,278 deaths of those older than 85 years, for men and women, respectively.

A fifth-order polynomial was fitted to mid-year population data obtained from the Office for National Statistics (ONS) for each sex and age group to provide daily population estimates. Daily deaths divided by these population estimates provided mortality (daily deaths per million individuals). Adjustments were made for differences in coding instructions using ONS bridge-coding data between 1984 and 1994 and for differences between ICD-9 and ICD-10 after 2001.

Mean daily temperatures were calculated from hourly measurements at Heathrow Airport and obtained from the British Atmospheric Data Centre.

Regression coefficients of mortalities per 1 °C fall in temperature for days with temperatures between 0 and 18 °C to avoid overlap with the effects of heat were calculated for each year by linear regression.

The equation describing this relationship is as follows:

$M = (A * T) + C$, where M = mortality, T = temperature, A = regression coefficient and C = constant.

The mortality at 18 °C would be calculated as $M = (A * 18) + C$.

Owing to the delay between temperature and peak mortality, mortalities from IHD were lagged on temperature for the regressions by 2 days, CVD by 5 days, RES by 12 days and all causes by 3 days;[9] the delays may reflect the pathological processes, with myocardial infarction and ischaemic stroke causing rapid deaths, whereas respiratory infection takes time to develop and overcome defences. Allowance was made for influenza epidemics using mean influenza deaths in men and women older than 55 years averaged from 10 days before to 10 days after each day.

To allow for changes unrelated to temperature, such as improvements in healthcare, specific mortality was calculated as the increase in mortality per 1 °C fall in temperature divided by the estimated mortality at 18 °C. Changes in annual values with time were analysed by ordinary linear regression, with the F test for significance, for 1977—1994 and 1995—2016 periods, and with combined data, an interaction term was used to test for the difference in the slopes between the two periods.

Results

Fig. 1 shows that the climate in South East England has become milder over the recent decades and that deaths from influenza have generally decreased since the large epidemic that occurred in 1976. The percentage of women exceeds that of men in both age groups, with the percentage of the 65- to 74-year-old group declining and that of the group older than 85 years growing.

Fig. 2 shows that the annual increase in all-cause mortality per 1 °C fall in temperature continued to decline over the latest 1995—2016 period. Similar results were seen with major causes of mortality, IHD and CVD, although slightly less for RES. Estimates of mortality at 18 °C, an approximate temperature at which both the effects of heat and cold are minimal, also continued to decline. However, significant declines in IHD and all-cause annual specific mortality in the 1977—1994 period were not seen in the 1995—2016 period.

Fig. 3 shows changes in men and women, and separately for each sex, in the age category above 85 years. In the earlier 1977—1994 period, the declines in all-cause mortality, cold-related mortality, 18 °C mortality and specific mortality were similar to those seen in the younger age groups. Worryingly, in the more recent 1995—2016 period, mortality per 1 °C fall in temperature, mortality at 18 °C and specific cold-related mortality have risen significantly in women (P < 0.01).

Discussion

Mortality per 1 °C fall in temperature has continued to fall in the age group of 65—74 years over the 21 years since the last report.[4] This can be attributed to better medical care and healthier lifestyles as mortality at 18 °C has also fallen. Consequently, as a percentage, there was no significant change in specific mortality (the percentage of cold-related mortality). RES now contributes to most cold-related deaths, despite influenza immunisation, but other clinically important respiratory viruses such as coronaviruses, respiratory syncytial viruses and rhinoviruses still circulate in wintertime. The absence of any decline in specific mortality particularly after the introduction of winter fuel payments (a state benefit paid to all pensioners to help with heating costs) in 1997 could be due to a trend towards wearing more casual but less warm clothing and elderly people spending more time outdoors where they are exposed to the cold.

The limitations of this study should be mentioned. We did not use distributed lag non-linear models[10] that would have
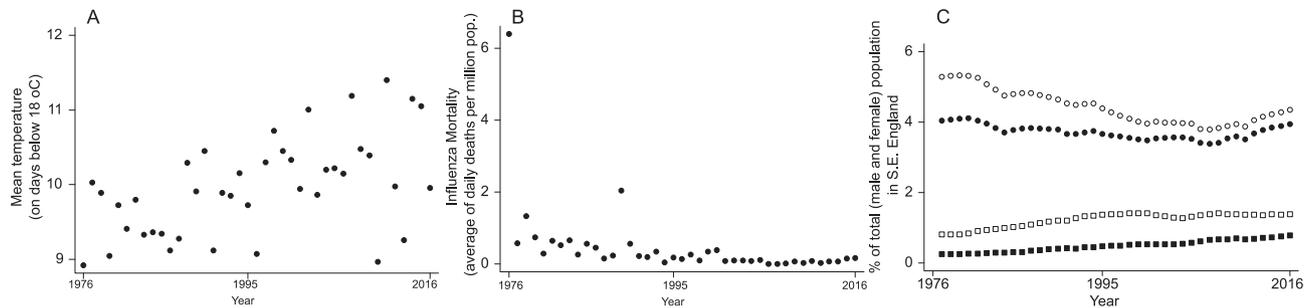
Fig. 1 — (A) Average daily temperature on days below 18 °C between 1976 and 2016. (B) Average daily mortality per million people from influenza between 1976 and 2016. (C) Men and women in 65- to 74-year-old group and age group older than 85 years as a percentage of total population in 1976—2016. ○ women 65—74, ● men 65—74, □ women 85+, ■ men 85+.
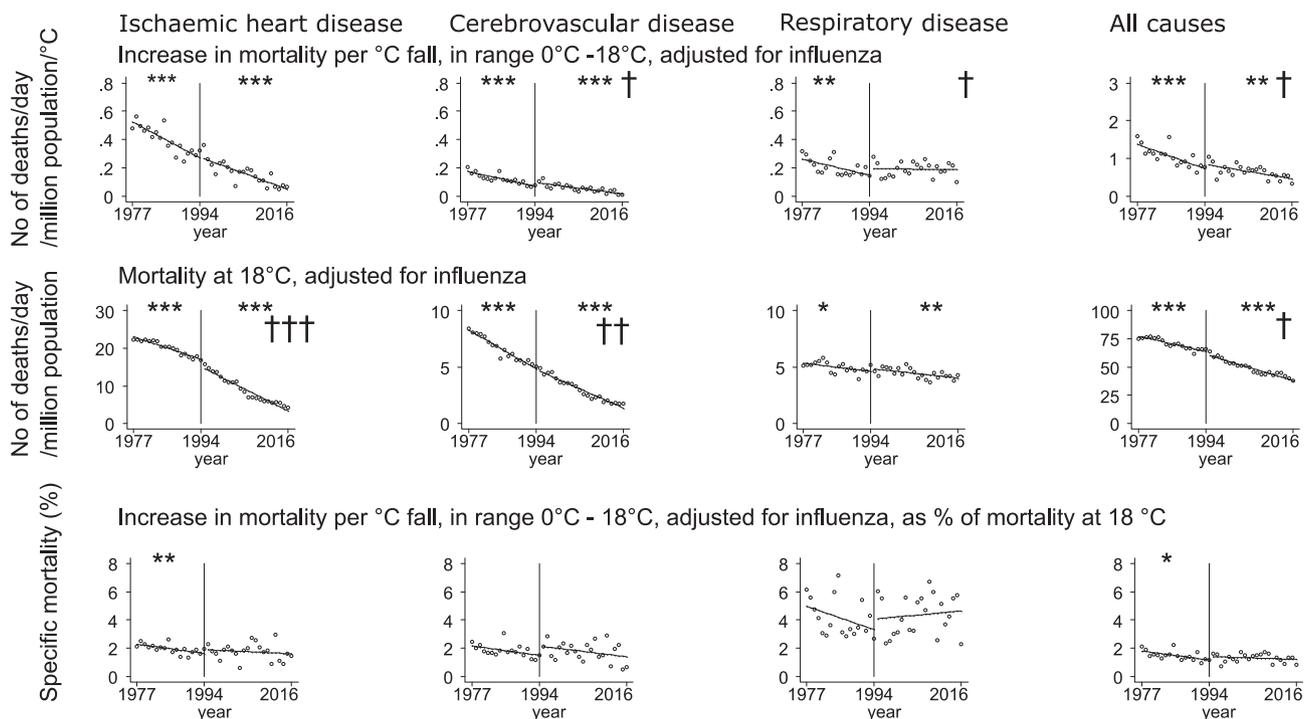

Fig. 2 — Mortality related to cold in people aged 65—74 years in South East England in 1977—2016 from all-cause mortality and ischaemic heart, cerebrovascular and respiratory diseases. * P < 0.05, **P < 0.01 and ***P < 0.001 for trends over the 1977—1994 and 1995—2016 periods separately. †P < 0.05, ††P < 0.01 and †††P < 0.001 for differences in the slope between the two periods.

better captured the temperature—mortality relationship because the multiple coefficients with the various lags would have complicated the assessment of trends over time. Our linear regression approach might underestimate or overestimate the mortality/temperature if the lag structure changed over time or if confounders disturbed the linearity of the relationship. This study used temperatures recorded at a single weather station to be consistent with the earlier study,[4] but it is possible that temperatures derived from multiple stations might have an improved estimation of the mortality—temperature relationship.

In contrast, cold-related specific mortality in women older than 85 years appears to be increasing. This group is growing in population size, and their age may make their admission to hospitals more likely than other groups, thus in part explaining the worsening winter pressures on the National Health Service. The seasonality of mortality has always been greater in older age groups partly because of the reduced thermal perception and body's heat-generating capacity. As exposure to the cold can occur both indoors and outdoors,[1,11] it may be worthwhile raising the age threshold for the winter fuel allowance and directing aid to neglected areas such as public transport waiting areas and community centres. Cold-related mortality particularly in those older than 85 years needs to be monitored.
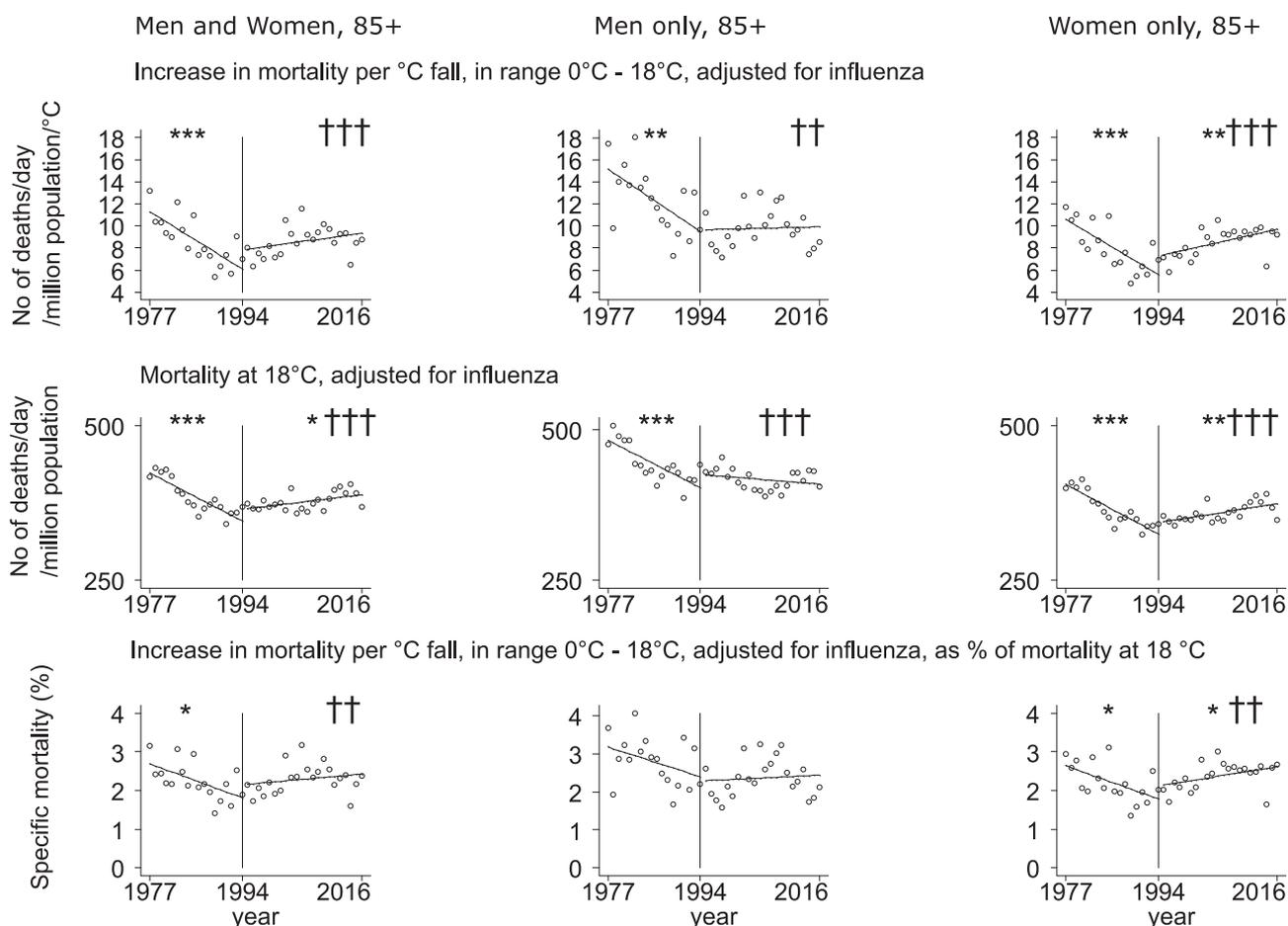
Fig. 3 — All-cause cold-related mortality in people, and men and women separately, older than 85 years in South East England in 1977—2016. *P < 0.05, **P < 0.01 and ***P < 0.001 for trends over the 1977—1994 and 1995—2016 periods separately. †P < 0.05, ††P < 0.01 and †††P < 0.001 for differences in the slope between the two periods.

Author statements

Ethical approval

Data were anonymous and aggregated, and thus, no participant approval was required. The study plan was approved by the Office for National Statistics before the data were obtained. Mortality and population data were obtained from the Office for National Statistics, and climate data, from the Meteorological Office.

Competing interests

The authors have no competing interests.

Patient involvement

None.

Author contributions

G.C.D. conceived the study and performed the analysis. G.C.D., C.W. and S.N. wrote and critically reviewed the manuscript. G.C.D. acted as the guarantor.

REFERENCES

1. Keatinge WR, Donaldson GC, Bucher K, Cordioli E, Dardanoni L, Jendritzky G, et al. Cold exposure and winter mortality from ischaemic heart, cerebrovascular, and respiratory disease, and all causes, in warm and cold regions of Europe. *Lancet* 1997;**349**:1341—6.

2. Keatinge WR, Donaldson GC. Cardiovascular mortality in winter. *Arctic Med Res* 1995;**54**(Suppl. 2):16—8.

3. Donaldson GC, Wedzicha JA. The causes and consequences of seasonal variation in COPD Exacerbations. *Int J COPD* 2014;**9**:1101—10.

4. Donaldson GC, Keatinge WR. Mortality related to cold weather in elderly people in southeast England, 1979—94. *BMJ* 1997;**315**:1055—6.

5. Kunst AE, Looman CWN, Mackenbach JP. The decline in winter excess mortality in The Netherlands. *Int J Epidemiol* 1991;**20**(4):971—7.

6. Ekamper P, Van Poppel F, Van Duin C, Garssen J. 150 Years of temperature-related excess mortality in The Netherlands. *Demogr Res* 2009;**21**:385—426.

7. Carson C, Hajat S, Armstrong B, Wilkinson P. Declining vulnerability to temperature-related mortality in London over the 20th century. *Am J Epidemiol* 2006;**164**(1):77—84.

8. Åström DO, Forsberg B, Edvinsson S, Rocklöv J. Acute fatal effects of short-lasting extreme temperatures in Stockholm, Sweden: evidence across a century of change. *Epidemiology* 2013 Nov 1;**24**(6):820—9.

9. Donaldson GC, Keatinge WR. Early increases in ischaemic heart disease mortality dissociated from, and later changes associated with, respiratory disease, after cold weather in south-east England. *J Epidemiol Community Health* 1997;**51**:643—8.

10. Gasparrini A. Modelling lagged associations in environmental time series data: a simulation study. *Epidemiology* 2016;**27**(6):835—42.

11. Keatinge WR, Coleshaw SRK, Holmes J. Changes in seasonal mortalities with improvement in home heating in England and Wales from 1964 and 1984. *Int J Biometeorol* 1989;**33**:71—6.