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Winter Excess Mortality: A Comparison between Norway and England plus Wales

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Summary

Seasonal fluctuations in mortality are associated with age, outdoor temperature, and influenza. The relative excess winter mortality is approximately twice as high in the UK compared with the Scandinavian countries. Using data from Norway and England plus Wales, this study compares the effect of age, temperature and influenza on winter excess mortality in the two countries. Bivariate analyses showed that the excess winter mortality (December–March) in England and Wales was nearly twice as high in old as in middle-aged people, and also markedly higher than in Norway, while the association between excess winter deaths and influenza was of a similar magnitude. In the British data only, a marked and statistically significant negative relationship existed between outdoor temperature and excess winter mortality, corresponding to an increase of approximately 3500 deaths in England and Wales (approximately 2/10 000 in the population aged 45 years and over) per 1°C reduction in winter temperature, after adjustment for age and influenza. Using data from 20 Western European countries, a highly significant positive correlation ($R = 0.71$, $p < 0.001$) was found between total mortality rates for the elderly (65 years and over) and relative excess winter mortality.

Keywords: Winter, Mortality, Seasonal variations, Temperature, Influenza, Age.

Introduction

Death during the winter is relatively more common in Britain than in most other countries in Western Europe [1]. The excess winter mortality is primarily attributed to seasonal variations in fatal coronary heart disease, stroke and respiratory diseases [2] which together account for a large proportion of deaths in elderly people. It also shows a relationship with influenza [3], social class [3] and per capita gross national product [4]. Higher winter mortality is related to high age [3], and hypothermia has long been suspected to be a causal factor because there is a relationship with outdoor temperature [3, 5]. However, the relatively few deaths labelled as due to hypothermia in the mortality statistics account for less than 2–3% of the excess winter deaths. Despite Norway being much colder than the British Isles in the winter, the excess winter mortality is substantially lower there [3, 4]. The primary objective of this study was to relate winter mortality to age, outdoor temperature, and influenza to make comparisons between Norway and England plus Wales.

Materials and Methods

Monthly data from August 1970 to July 1991 of all deaths (n = 12 154 000) and deaths attributed to influenza, broken down into three broad age bands (45–64, 65–74 and 75 years and above), and monthly mean temperature in London, were supplied for England and Wales by the Office of Population Censuses and Surveys. For Norway, information on age at death and month, year and cause of death (ICD7–9) was made available from the Norwegian Central Bureau of Statistics for the period 1966–86 on all Norwegians aged 45 and over at death (n = 774 700). Meteorological data for Norway were provided by the Norwegian Institute of Meteorology. Mortality data for Western European countries 1976–84 were extracted from [1] and [3]. Standardization of the mortality rate for the population aged 65 years and above against the overall age distribution in the same data was performed using the direct method.

Seasonal mortality was calculated for the winter (December–March, 122 days after adjustment for non-leap years), the preceding autumn (August–November, 122 days), and the successive spring/summer (April–July, 122 days) [6]. In both data sets, the number of autumn and spring/summer deaths was similar and showed little fluctuation (Figure 1). Time series analysis showed that the autumn and spring/summer deaths had the same relationship over time (the number of turning points of the series of differences did not deviate from the expected number, nor did test for trend reveal any deviation [7]). The average of the corresponding autumn and spring/summer deaths was therefore used as an estimate of the expected number of winter deaths within the same set of seasons. Relative excess winter mortality was estimated as:

$$\frac{\text{observed winter deaths} - \text{expected winter deaths}}{\text{expected winter deaths}}$$

For more detailed analyses of the relationship between temperature and deaths, the number of deaths in a month was

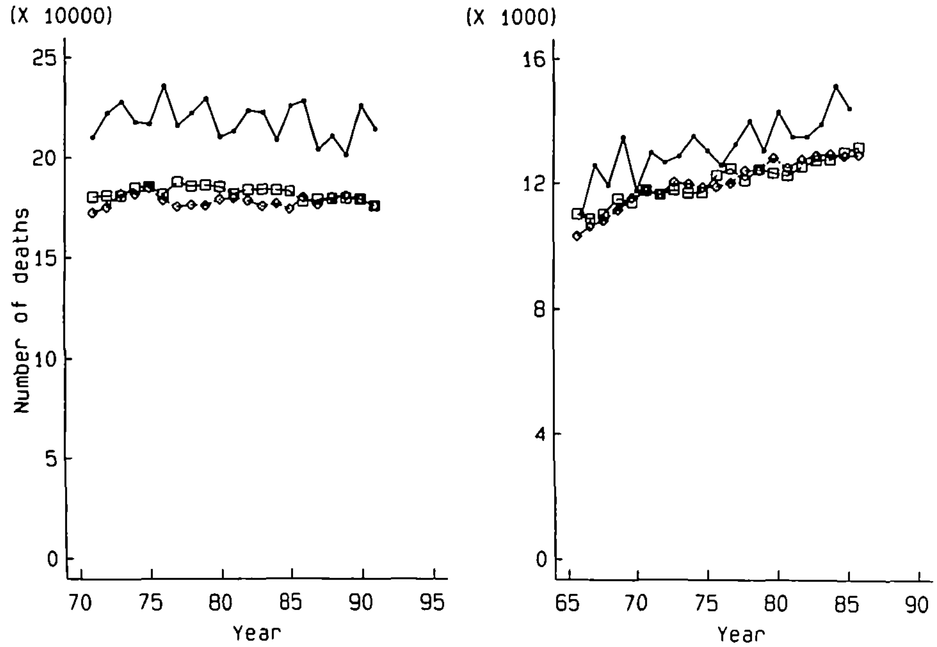

Figure 1. Winter (dots), autumn (diamonds) and spring/summer (squares) deaths by year in England and Wales (left) and Norway (right).

adjusted to a standardized month of length 365/12 days. The expected number of deaths (d_{exp}) in any month (m_i) was estimated as the mean number of deaths in the time span 6 months before to 6 months after the mid-point of the month under observation:

$$d_{exp} = \frac{1}{12}[0.5 * dm_{i-6} + \mathrm{sum}(dm_{i-5...i+5}) + 0.5dm_{i+6}]$$

Relative excess monthly mortality was then estimated as for the winter mortality.

Results

The autumn and spring/summer deaths showed little fluctuation and corresponded closely (Figure 1). As previously reported [3], the winter mortality in England and Wales was higher than in Norway with an excess winter mortality in 1970–91 of 807 700 (38 000 deaths per year), corresponding to a relative excess mortality of 21%. For Norway in 1966–1986 it was 11%.

Figure 1 indicates a weak statistically insignificant (the difference sign test of trend [7]) decline in relative winter excess mortality in England and Wales during 1970–91. Nor was there any change in winter mortality over time in the Norwegian data. For the 16 sets of seasons with data present for both countries, the relative excess winter mortality in the two countries was not correlated (Kendall tau = 0.18, 95%CI = −0.16–0.52), indicating that peaks and troughs in winter mortality occurred asynchronously.

Association with age. Relative excess winter mortality increased by age in both data sets and was higher in England and Wales than in Norway for all age categories. The difference between the oldest and youngest age categories was also larger in England and Wales than in Norway (Table I).

Table I. Winter and non-winter deaths (in thousands) by age in England and Wales 1970–91 and in Norway 1966–86

	Age groups (years)							
	England and Wales				Norway			
	45–64	65–74	75+	Total	45–64	65–74	75+	Total
Winter deaths	1001.9	1181.2	2406.5	4589.6	47.7	66.9	149.2	263.8
Non-winter deaths	1806.9	1998.4	3758.5	7563.8	91.0	124.8	260.5	476.3
Observed (O) minus expected (E) winter deaths	98.4	182.0	527.2	807.7	2.2	4.5	19.0	25.7
(O–E)/E	0.11	0.18	0.28	0.21	0.05	0.07	0.15	0.11

Table II. Winter and non-winter deaths (in thousands) in relation to influenza deaths

	Category of influenza deaths							
	England and Wales				Norway			
	1	2	3	Total	1	2	3	Total
Winter deaths	1461.1	1777.2	1351.3	4589.6	89.7	78.1	96.1	263.9
Non-winter deaths	2504.8	2890.3	2168.7	7563.8	167.4	143.3	165.5	476.2
Observed (O) minus expected (E) winter deaths	208.7	332.0	266.9	807.7	6.0	6.5	13.4	25.8
(O–E)/E	0.17	0.23	0.25	0.21	0.07	0.09	0.16	0.11

Association with influenza. For Norway, a total of 3446 (0.5%) death certificates had any mention of influenza, and most of these deaths, 76%, occurred during the winter. For England and Wales, the corresponding figures were 27 573 (0.2%) and 84%. Based on the overall number of such deaths during the winter months, each set of seasons was given a score of 1/2/3 according to the number of winter influenza deaths by tertile. In both data sets, the relative winter excess mortality was higher in winters with many influenza-associated deaths (Table II). The difference in relative excess winter mortality between winters with the highest and lowest numbers of influenza-related deaths had a similar magnitude in the two countries.

Effects of temperature. The climate in Norway shows marked regional differences, and for this analysis we only used data from eight counties located around Oslo, where the temperature readings had been made (adjusted 141 262 winter and 254 592 non-winter deaths, 12% relative excess winter mortality). Simple linear regression analyses showed a trend towards higher mortality in colder winters, and more markedly so in England and Wales (range mean winter temperature 3.2–7.2°C, beta = −0.012, 95%CI = −0.032–0.008) than in Norway (temperature range −6.1–1.1°C, beta = −0.008, 95%CI = −0.022–0.006).

Using aggregate means of 4-month periods could reduce the sensitivity and power of the analyses of the relationship between winter temperature and mortality. Using monthly data, restricted to December–March, simple linear regression disclosed a statistically significant relationship (beta = −0.021, 95%CI = −0.027 to −0.015, $R^2 = 0.44$) in the data from England and Wales (Figure 2), corresponding to a 2.1% increase in relative excess mortality per °C fall in average temperature. The residuals of this regression complied

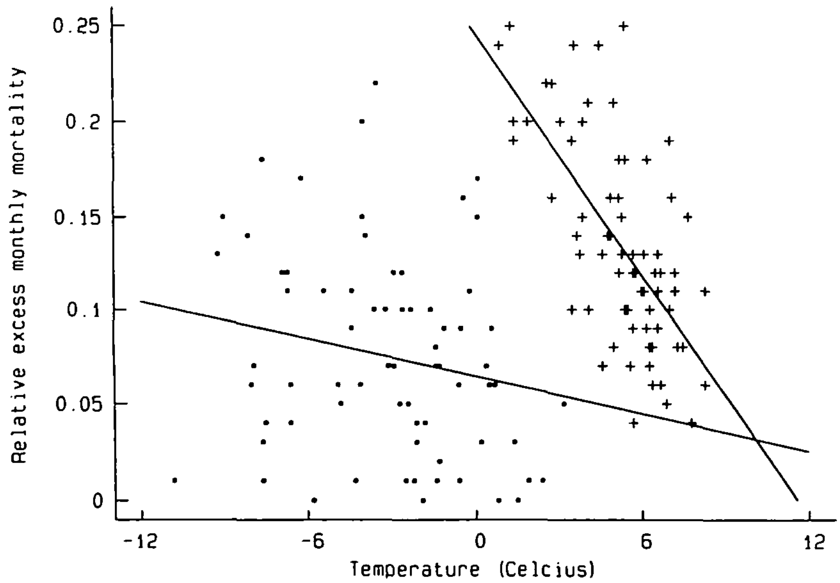

Figure 2. Monthly relative excess mortality in England and Wales (crosses) and Norway (squares) in the four winter months by mean monthly temperature, excluding outliers with monthly relative excess mortality outside the range (0–0.25) (9 data points in each data set).

Table III. Multiple logistic regression analysis of winter deaths in England and Wales and in South-east Norway

Variable	Coefficient	SE	Coefficient/ SE	Odds ratio (95%CI)
*England and Wales**				
Age (years)				
45–64	reference			
65–74	0.06	0.02	3.8	1.07 (1.03–1.10)
75+	0.15	0.02	9.8	1.16 (1.12–1.19)
Category of influenza				
1	reference			
2	0.04	0.01	3.0	1.04 (1.01–1.08)
3	0.09	0.02	5.4	1.09 (1.06–1.12)
Temperature (per °C)	−0.02	0.01	−2.7	0.98 (0.97–0.99)
South-east Norway†				
Age (years)				
45–64	reference			
65–74	0.02	0.01	1.9	1.02 (1.00–1.04)
75+	0.08	0.01	8.6	1.09 (1.07–1.11)
Category of influenza				
1	reference			
2	0.02	0.01	2.1	1.02 (1.00–1.05)
3	0.10	0.01	11.3	1.11 (1.09–1.13)
Temperature (per °C)	−0.003	0.002	−1.21	1.00 (0.99–1.00)

* Based upon 63 covariate patterns. Goodness of fit chi square = 24.02, 57 d.f., p = 1.0. No covariate stratum had influence above 0.5 or normalized residuals above 2.0 (ref).

† Based upon 52 covariate patterns (315 500 subjects) after exclusion of 8 strata (70 500 subjects, see text). Goodness of fit chi square = 59.04, 46 d.f., p = 0.09.

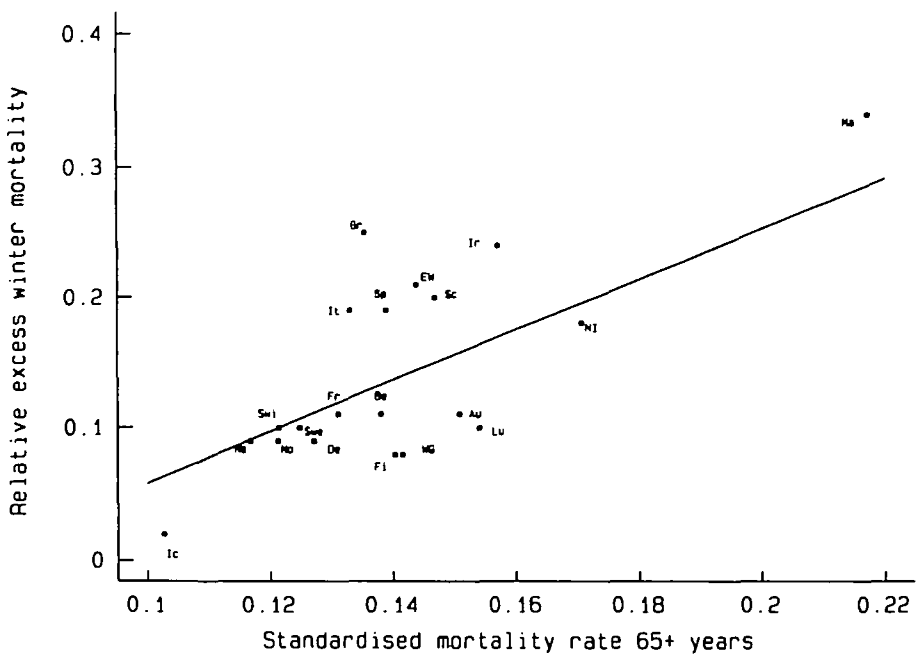

Figure 3. Standardized mortality rate for 65+ years in 1980 and relative excess winter mortality in 20 Western European countries in 1976–84. Regression line excluding data from Iceland, Greece and Malta. Au = Austria, Be = Belgium, De = Denmark, EW = England and Wales, Fi = Finland, Fr = France, Gr = Greece, Ir = Ireland, It = Italy, Lu = Luxemburg (1981 data), Ma = Malta, Ne = Netherlands, NI = Northern Ireland, No = Norway, Sc = Scotland, Sp = Spain (mortality rates for 1978, winter mortality data for 1976–79), Swe = Sweden, Swi = Switzerland, WG = West Germany (Portugal is missing due to lack of data).

well with the normal distribution and had a low and insignificant serial correlation. In the data from South East Norway, this association was much weaker and statistically insignificant (beta = −0.003, 95%CI = −0.007–0.001, R^2 = 0.04).

Multivariate analyses. The probability of a winter death versus a non-winter death was modelled by multiple logistic regression using age and influenza deaths as categorical explanatory variables, and mean winter temperature as an interval-scaled covariate. A good model fit was achieved for the British data (Table III), where all the three variables retained their statistical significance after multivariate adjustment. The fit did not improve by introducing interaction terms between age and temperature and influenza and temperature, respectively. Being in the oldest age band implied the highest probability of a winter death. According to this model, the difference between the lowest and the highest recorded temperature in England and Wales corresponded to a difference in excess winter deaths of about 15 000/year (approximately 3500 deaths per °C).

The model fit was less good for the Norwegian data (goodness of fit chi square = 125.7, 54 d.f., $p < 0.001$), but a satisfactory solution (Table III) was achieved by excluding eight covariate strata (70 500 subjects, 9%) with high influence (above 0.5) and/or normalized residuals above 2.0 [8]. This exclusion caused less than 20% change in the parameters.

Age and influenza remained significant after multivariate adjustment in both data sets, and the strength of the association between winter mortality and influenza was of a similar magnitude. However, for those ≥75 years, the odds of a winter death were markedly higher in England and Wales (1.16 adjusted) than in South-east Norway (1.09), and the 95% confidence intervals for the risk estimates in the two data sets did not overlap (Table III).

After multivariate adjustment, the most salient difference between the two data sets was the effect of temperature, which was statistically significant and marked in the British data, and low and insignificant in Norway (Table III).

Winter mortality in Norway and England and Wales in relation to total mortality in other Western European countries: The age-specific mortality of middle-aged and elderly people in England and Wales is higher than in many other countries in the Western World [9]. Age was the most important risk factor for a winter death (Table III). Under the hypothesis that winter excess mortality reflects the general health among elderly people in the population, we related relative winter excess mortality to age-specific mortality for the population aged 65 years and above for 20 Western European countries (Figure 3). A statistically significant correlation existed ($R = 0.75$, $p < 0.001$), also after excluding the data from Iceland, Greece, and Malta as potentially too influential ($R = 0.52$, $p = 0.03$ also after exclusion). The residuals of this analysis complied well with the normal distribution.

Discussion

The multivariate analyses indicated that the difference in winter mortality between Norway and England and Wales mainly relates to differences in the effects of age and outdoor temperature (Table III). The Norwegian data were restricted to South-east Norway, but the relative excess winter mortality here was of the same magnitude as for the country as a whole.

After multivariate adjustment, temperature emerged as an independent and significant risk factor of winter death in England and Wales only. The question whether the association between winter mortality and outdoor temperature is causal or spurious (owing to confounding variables) remains elusive, although evidence for pathophysiological explanations of the relationship between low ambient temperature and vascular diseases have been offered [10, 11]. Time series analysis gave no indication that the relative excess winter mortality in England and Wales has changed during the years 1970–91. However, Keatinge *et al.* [12], studying mortality rates between 1964 and 1984 in England and Wales for persons aged 70–74 years, found a reduction in winter excess mortality after adjustment for temperature. They related this to a decline in winter influenza epidemics and to the increase in the percentage of homes with central heating. An alternative explanation of such a decline in England and Wales would be that the susceptibility to succumb during the winter shows cohort effects similar to the one observed in Norway during the same period in the mortality from coronary artery disease [13]. Others [5, 14] have failed to observe a relationship between central heating and seasonal mortality.

Iceland has virtually no excess winter mortality and also the lowest mortality in elderly people in Europe [1], whereas both are very high on Malta (Figure 3). Mortality is influenced by the health of the population, the living conditions, and the health services provision. We detected a significant association between mortality from all causes and relative winter excess mortality among elderly people in Western Europe, but the data give no further indication of causality. In countries with a high excess winter mortality it should be a political issue to reduce it, but the means to achieve this are clearly ambiguous. According to the present study, age is the most important risk factor for a winter death. Cross-national, longitudinal studies might elucidate whether efforts which improve the health of elderly people would attenuate the association between winter mortality, low temperature and influenza and reduce the excessive winter mortality in many Western European countries.

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References

1. United Nations. *Demographic yearbook 1985*. New York: UN, 1987.
2. Bull GM, Morton J. Environment, temperature and death rates. *Age Ageing* 1978;**7**:210–24.
3. Curwen M. Excess winter mortality: a British phenomenon? *Health Trends* 1990;**22**:169–75.
4. McKee CM. Deaths in winter: can Britain learn from Europe? *Eur J Epidemiol* 1989;**5**:178–82.
5. Alderson MR. Season and mortality. *Health Trends* 1985; **17**:87–96.
6. Curwen M, Devis T. Winter mortality, temperature and influenza: has the relationship changed in recent years? *Popul Trends* 1988;**(54)**:17–20.
7. Kendall M, Ord JK. *Time Series*. Sevenoaks, Kent: Edward Arnold, 1990.
8. Hosmer DW, Lemeshow S. *Applied logistic regression*. New York: John Wiley & Sons, 1989.
9. Office of Population Censuses and Surveys. *Demographic review 1984*. Series DR No 2. London: HMSO, 1987.
10. Woodhouse PR, Khaw K-T, Plummer M. Seasonal variations of plasma fibrinogen and factor VII activity in the elderly: winter infections and death from cardiovascular disease. *Lancet* 1994;**343**:435–9.
11. Woodhouse PR, Khaw K-T, Plummer M. Seasonal variations of blood pressure and its relationship to ambient temperature in an elderly population. *J Hypertens* 1993;**11**:1267–74.
12. Keatinge WR, Coleslaw SRK, Holmes J. Changes in seasonal mortalities with improvement in home heating in England and Wales from 1964 to 1984. *Int J Biometeorol* 1989;**33**:71–6.
13. Sverre JM. Secular trends in coronary heart disease mortality in Norway, 1966–1986. *Am J Epidemiol* 1993; **137**:301–10.
14. Keatinge WR. Seasonal mortality among elderly people with unrestricted home heating. *BMJ* 1986;**293**:732–3.

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