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Excess winter deaths in Europe: a multi-country descriptive analysis

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Background: Winter deaths are a known health and social care challenge for many countries. A previous international comparison showed significant differences in excess winter deaths across Europe in the 1990s, with the northern countries having lower excess winter mortality than those in southern Europe. **Methods:** The Excess Winter Deaths Index (EWDI) is the ratio of deaths in the winter period (December to March) compared with deaths in the non-winter period. Data from the Eurostat database and national registries were used to calculate the EWDI for 31 countries in Europe across the time period 2002/2003 to 2010/2011. **Results:** National EWDI values show heterogeneity, with a broad pattern of increasing EWDI values from northern to southern Europe and increasing mean winter temperature ($r^2 = 0.50$, $P > 0.0001$). Malta, Portugal, Spain, Cyprus and Belgium all had an EWDI that was statistically significantly higher than the average EWDI for the other 30 European countries. There was no clear association between country-level EWDI and the level of inter-annual variability in winter temperature across Europe. **Discussion:** This article demonstrates the differences in EWDI that exist between European countries with implications for both research and policy. Many deaths may be avoidable as environmental, social and personal factors are known to contribute to winter mortality. We now need to work to better understand the causes of inter-country differences.

Introduction

The impact of cold weather on health has long been noted: 'If the winter be mild... the year is likely to prove healthy' observed Hippocrates in around 400 BC.¹ In 1858, Guy published an epidemiological investigation showing 'Great increases in diseases of the lungs and heart in cold weather'.² Despite this association between cold weather and ill-health being known for some time, populations across Europe still experience significantly more deaths in winter than non-winter months.^{3–5}

The immediate cause of most excess winter death is cardiovascular or respiratory diseases including seasonal respiratory infections, particularly in older people and those with chronic health problems.^{6–10} Analitis *et al.*⁴ compared the short-term effects of cold on mortality in 15 European cities, finding that a 1°C decrease in temperature was associated with a 1.35% increase in the daily number of total natural deaths. The greatest increase was seen in older age groups. This cold effect was found to be greater in warmer (southern) cities of Europe and persisted for up to 23 days with no evidence of mortality displacement.

Cold temperatures also result in significant morbidity including respiratory tract infections, mental health problems and exacerbations of existing musculoskeletal, cardiovascular and respiratory diseases.^{6–9} Reduced infant weight gain, delayed development and reduced educational attainment have been associated with cold conditions.⁶

Much debate remains around the determinants and prevention of excess mortality during cold weather.^{6,11–12} Several factors have been associated with differences in excess winter deaths between countries, including low GDP per capita, low national spending on healthcare, inequality, deprivation, fuel poverty, low income and urban dwelling.^{3,5,10,13} A recent report estimated that 22% of excess winter deaths in the UK can be attributed to cold housing,⁶ although the relative influence of other determinants is unknown. Some factors, including both winter temperatures and influenza, exhibit large inter-annual variation.

Despite the uncertainty surrounding determinants, the seasonal effect of cold weather on deaths is, at least historically, modifiable: several authors have reported a general declining trend in excess winter mortality in the last century.^{14–17} Excess winter deaths in England and Wales have dropped from a 5-year average of ~70 000 per winter in the early 1950s to ~27 000 in the late 2000s.¹⁷

Comparing magnitude and changes over time of excess winter deaths across Europe provides an approach that begins to identify the role of climate in winter mortality and helps in benchmarking individual countries' progress in reducing winter deaths.

Previous studies examining variation of excess winter death levels between countries have shown that rates vary widely. Healy³ found that average excess winter death rates (1988–97) varied from 10% in Finland to 28% in Portugal. There was a broadly increasing trend in excess winter deaths from northern to southern Europe; however, this study covered only 14 European countries. To the authors' knowledge, comparisons of excess winter deaths across Europe have not since been examined comprehensively.^{3,6}

Other approaches to examining excess deaths include modelling weekly deaths (e.g. Serfling models¹⁸), looking for an excess in observed deaths above a model-based threshold. Data are submitted by up to 18 European countries, or regions of countries, for analysis as part of the European monitoring of excess mortality for public health action (EuroMoMo) network.¹⁷ Many countries also undertake their own monitoring, e.g. England.¹⁹ The EuroMoMo approach to analysis has the advantage of taking into account the expected impact of seasonality on mortality; however, in this article, we were specifically interested in variation in the impact of seasonality between countries.

The main objective of this study was to quantify excess winter deaths across 31 European countries in the last 9 years—both for the period as a whole and the change over 9 years.

The second objective was to determine if excess winter death rates have changed in Europe since the 1990s.

It has been previously noted that higher excess winter death rates are generally seen in European countries with less severe winter climates. This 'paradox of excess winter mortality'³ was noted by both McKee (using 1976–84 data)⁵ and Healy (1988–97).³ Our third objective was therefore to assess the association between mean winter temperature and excess winter deaths, at country level, for 31 European countries to see if this relationship still held.

Some differences in excess winter deaths between countries could be explained by variability of winter weather rather than absolute temperature. Countries with wide inter-annual variability in mean winter temperatures could experience a higher number of deaths than those with more consistent year-to-year winter temperatures,²⁰ as human behaviours and adaptation (at individual level, such as clothing and use of indoor heating, or societal level) might be less well developed. McKee⁵ investigated the relationship between annual temperature range (using average monthly temperatures) and excess winter death for 18 European countries in 1976–84; no significant relationship was found. Our fourth objective was therefore to examine the relationship between excess winter deaths in the period 2002–11 and inter-annual winter temperature variability in Europe.

Methods

Definition of excess winter deaths and Excess Winter Death Index

The UK Office for National Statistics (ONS) defines excess winter deaths as the number of deaths that occurred in the winter period (December to March) minus the expected number of deaths for that period (based on average number of deaths that occurred in the preceding August to November and the following April to July).¹² In this article, a relative definition of winter mortality is used: the Excess Winter Death Index (EWDI), in which the number of excess deaths is divided by the number of expected deaths and expressed as a percentage. This approach is used by both the ONS²¹ and Healy³; it enables meaningful cross-country comparisons to be made using the following formula:

$$\text{EWDI}(\%) = \frac{\text{Winter deaths (Dec – Mar)} - 0.5 \text{ Non-winter deaths (Aug – Nov, Apr – Jul)}}{0.5 \text{ Non-winter deaths (Aug – Nov, Apr – Jul)}} \times 100$$

Data

The number of deaths reported each month in each of the 31 European countries assessed was obtained from the Eurostat database.²² These countries represented all 27 Member States of the European Union (EU) at the time of analyses (Croatia has since acceded) and the countries of the European Free Trade Association (EFTA; Iceland, Liechtenstein, Norway and Switzerland). Eurostat is the statistical office of the EU with a remit to provide member nations with data that enable comparisons between countries and regions. It is reliant on such information being submitted by countries.

At the time of download, data for the UK was only available from Eurostat up to June 2011. UK death data for July 2011 were therefore accessed directly from the ONS (England and Wales), the General Register Office for Scotland and the Northern Ireland Statistics Research Agency. Data for deaths in Greece was only available until December 2010 meaning estimates of excess winter deaths for winter 2010/2011 could not be calculated. Age-specific death counts were not available.

Country-level EWDIs, with 95% confidence intervals (CI), for the period 1988–97 were taken from Healy's 2003 paper (EWDI was termed 'coefficient of seasonal variation in mortality' in this article).³

Climatic data were taken from the Tyndall Centre TYN CY 1.1 data set,²³ the only Europe-wide, national-level, long-term data series available. This data set covers the time period 1961–90 and provides country-level average climate data. A 30-year mean winter temperature and the standard deviation of annual winter mean temperatures for the 30-year period were extracted. This data set defines winter as December, January and February.

Data analysis

Winter deaths may be affected by country-specific inter-annual temperature variability. To reduce the influence of this variability, a 9-year average EWDI was calculated for each country. An overall 9-year average EWDI was calculated for all 31 countries combined.

For ease of data display, and to allow neighbouring countries to be easily compared, countries were grouped according to United Nations (UN) geoscheme European sub-regions: Northern, Southern, Eastern and Western Europe.²⁴ Cyprus is allocated to Western Asia in the geoscheme so was re-allocated to Southern Europe for this analysis.

CIs (95%) were calculated for the country-level, 9-year EWDIs using the same method as the Public Health England 'Health Profiles'.²⁵ For each country, comparison was made between 9-year EWDI and a combined 9-year average EWDI for the 30 remaining European countries using *t*-tests. Specific adjustments for multiple testing were not undertaken; this should be taken into account in interpretation of the results.

To assess the change in EWDI over the period of winter 2002/2003 to winter 2010/2011, 3-year rolling average EWDIs with CIs²⁵ were calculated for each country and for all 31 countries combined. These were displayed graphically, with countries again grouped by sub-regions.

Formal testing to assess change over this 9-year period was undertaken for each country. Taking each year's EWDI as a single data point, data for the 3-year period 2002/2003–2005/2006 were compared with data for the 3 years 2007/2008–2010/2011. This assumes each EWDI calculated has no imprecision, allowing a more direct examination of change over time, focusing on inter-year variability in EWDI over the time periods examined. Comparisons can be made using a Student's *t*-test; a disadvantage of this approach is that it is likely to be substantially underpowered.

To assess whether excess winter deaths rates had changed in Europe since the 1990s, EWDIs from Healy's paper are reported.³

The association between country-level mean winter temperature and excess winter deaths was examined by plotting country-level 30-year mean winter temperature data from the Tyndall Centre TYN CY 1.1 data set²³ against 9-year, country-level EWDI. The relationship between inter-annual variability of winter temperature and excess winter deaths was assessed by plotting the Tyndall Centre data on standard deviation of annual country-level mean winter temperatures over a 30-year period with country-level 9-year EWDI. In both cases, strength of association was assessed through simple linear regression.

Results

Table 1 shows the total number of excess deaths and EWDI for the period of winter 2002/2003 to winter 2010/2011 for the 31 countries analysed, with EWDI values calculated by Healy.³ Over the winter periods from 2002/2003 to 2010/2011, there were an estimated 2 010 020 excess winter deaths across the 31 countries.

At country level, Malta had the highest proportion of excess winter deaths, with an EWDI of 28.3% (95% CI 25.3–31.4) for

Table 1 Total excess deaths and mean EWDI for Europe for the period 2002/2003–2010/2011

Country	Winter 1988/ 1989–Winter 1996/1997 ^a	Winter 2002/2003–Winter 2010/2011	
	EWDI (95% CI)	Total number of excess deaths	EWDI (95% CI)
Eastern Europe sub-region			
Bulgaria	n/a	53,547	17.0% (16.5–17.4)
Czech Republic	n/a	31,795	10.2% (9.8–10.7) ^b
Hungary	n/a	43,067	11.3% (10.8–11.7) ^b
Poland	n/a	110,794	10.2% (10.0–10.5) ^b
Romania	n/a	115,528	15.7% (15.4–16.0)
Slovakia	n/a	12,084	7.8% (7.2–8.5) ^b
Northern Europe sub-region			
Denmark	12% (10–14)	19,178	12.0% (11.4–12.7)
Estonia	n/a	5828	11.9% (10.7–13.0)
Finland	10% (7–13)	13,091	9.2% (8.5–9.8) ^b
Iceland	n/a	474	8.5% (5.2–11.9)
Ireland	21% (18–24)	11,219	13.9% (13.0–14.8)
Latvia	n/a	10,498	11.5% (10.6–12.3)
Lithuania	n/a	13,215	10.6% (9.9–11.4) ^b
Norway	n/a	14,650	12.2% (11.4–12.9)
Sweden	n/a	33,810	12.9% (12.4–13.4)
UK	18% (16–20)	261,830	15.9% (15.7–16.1)
Southern Europe sub-region			
Greece	18% (15–21)	27,014	9.8% (9.3–10.3) ^b
Italy	16% (14–18)	248,802	15.2% (15.0–15.4)
Malta	n/a	2440	28.3% (25.3–31.4) ^b
Portugal	28% (25–31)	74,704	25.9% (25.4–26.4) ^b
Slovenia	n/a	6103	11.3% (10.2–12.4)
Spain	21% (19–23)	198,861	18.6% (18.3–18.8) ^b
Cyprus ^c	n/a	2865	19.4% (17.2–21.7) ^b
Western Europe sub-region			
Austria	14% (12–16)	28,732	13.2% (12.6–13.8)
Belgium	13% (9–17)	46,370	15.7% (15.2–16.2) ^b
France	13% (11–15)	210,005	13.5% (13.3–13.8)
Germany	11% (9,13)	289,631	11.9% (11.8–12.1)
Liechtenstein	n/a	82	12.8% (3.0–23.7)
Luxembourg	12% (8–16)	1397	13.0% (10.5–15.5)
The Netherlands	11% (9–13)	48,174	12.3% (11.9–12.7) ^b
Switzerland	n/a	25,287	14.4% (13.7–15.0)
14 European countries reported in Healy, 2003 ⁹	16% (14–18)	1,479,005	14.5% (14.4–14.6)
All 31 countries	n/a	2,010,020	13.9% (13.8–13.9)

a: From Healy (2003).¹⁶

b: Significantly different from the average EWDI for the other 30 countries in the analysis.

c: Original classification—Western Asia

the period from winter 2002/2003 to winter 2010/2011. Slovakia had the lowest EWDI at 7.8% (95% CI 7.2–8.5) (Figure 1). Belgium, Cyprus, Malta, Portugal and Spain had statistically significantly higher EWDIs than the combined average EWDI for the other 30 countries for the 9-year period ($P < 0.05$) and Czech Republic, Hungary, Poland, Slovakia. Finland, Lithuania, Greece, The Netherlands had significantly lower EWDIs (table 1).

Graphs of 3-year rolling average EWDI for each country, by European sub-region, can be found in the supplementary material (Supplementary Figures a–d.). There was a statistically significant decline in EWDI from the period 2002/2003 to 2005/2006 to the period 2007/2008–2010/2011 for Estonia and Latvia.

Considering the 14 countries for which data for the 1988–97 period were available, the overall EWDI for all 14 countries combined decreased from 16% to 14.5%. As raw data were not available, formal statistical comparisons could not be undertaken; however, where 95%CI do not overlap it can be inferred that

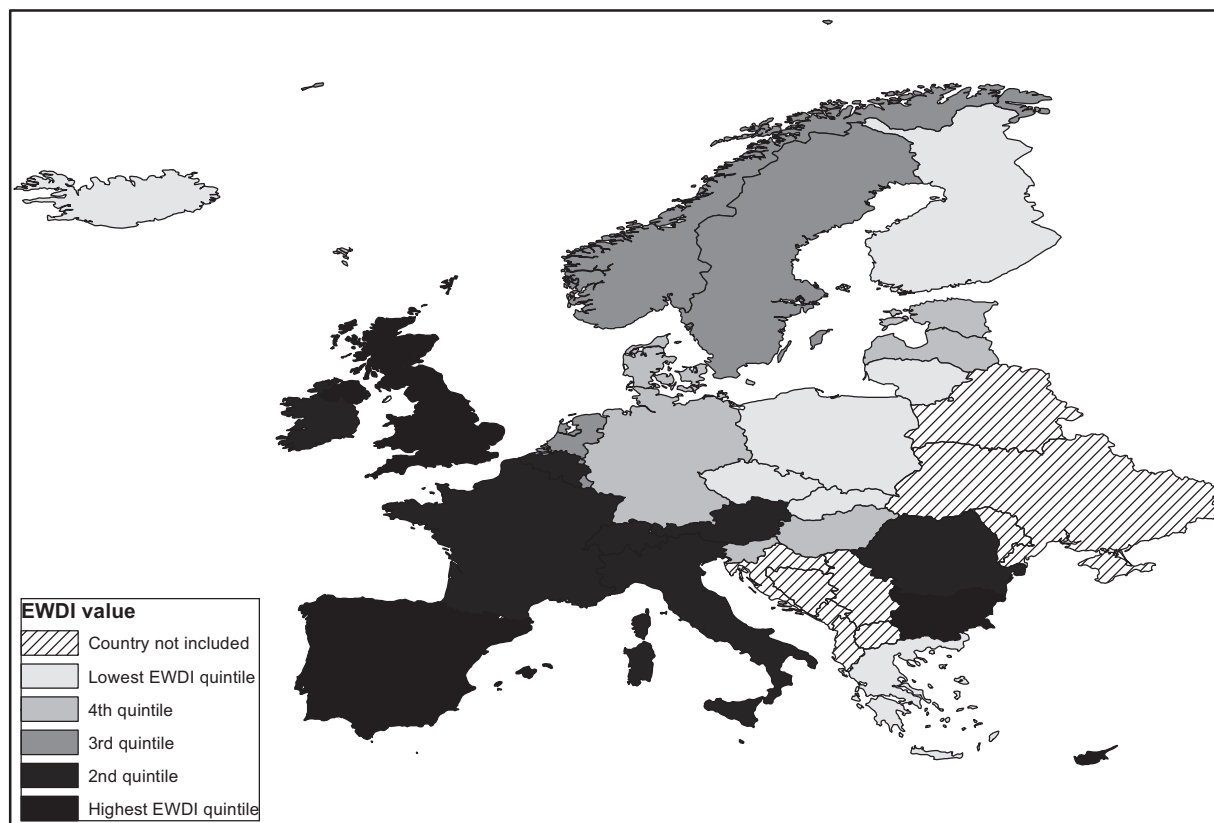


Figure 1 Map of 9-year country-level EWDI in 31 European countries, grouped by quintiles of equal count.

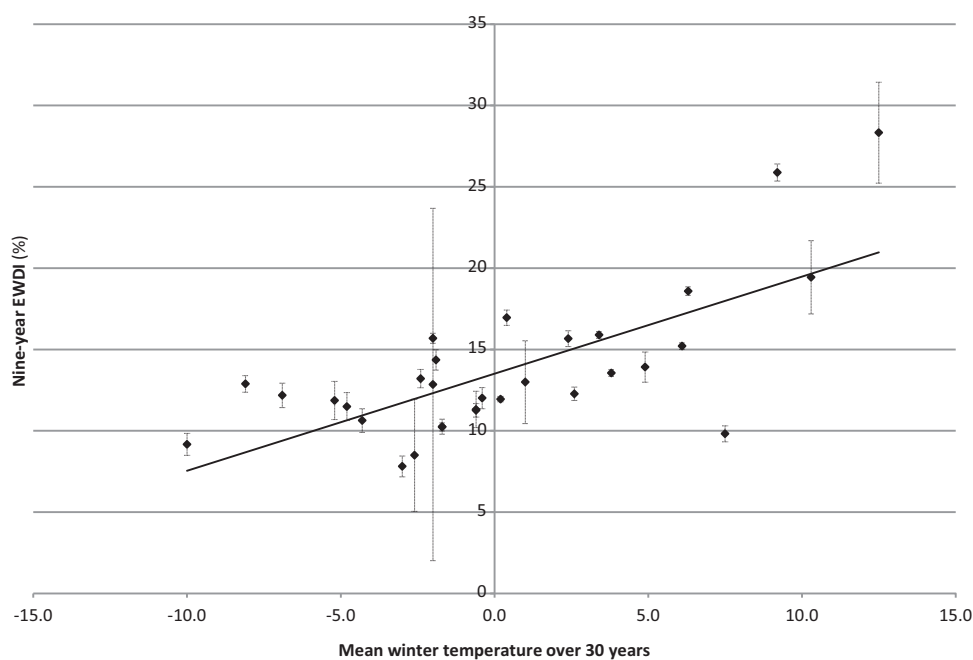


Figure 2 Scatter plot showing 30-year mean winter temperature against 9-year EWDI for 31 European countries. Error bars show 95% CIs for EWDI (as listed in Table 1)

there is a significant difference at the $P < 0.05$ level (though the inverse is not necessarily true).²⁶ Using this approach it can be seen that Greece, Ireland and Spain demonstrated a statistically significant reduction in 9-year EWDI between the two periods; Greece and Ireland demonstrated particularly marked reductions of 8.2% and 7.1%, respectively. For no country could a statistically significant increase in EWDI be inferred.

The impact of climate

There was a positive relationship between country-level mean winter temperature and country-level EWDI (figure 2; $r^2 = 0.50$, $P < 0.0001$). In general, the more southern countries were seen to have higher EWDIs.

Figure 3 examines the relationship between excess winter deaths and inter-annual variability in winter temperature across Europe.

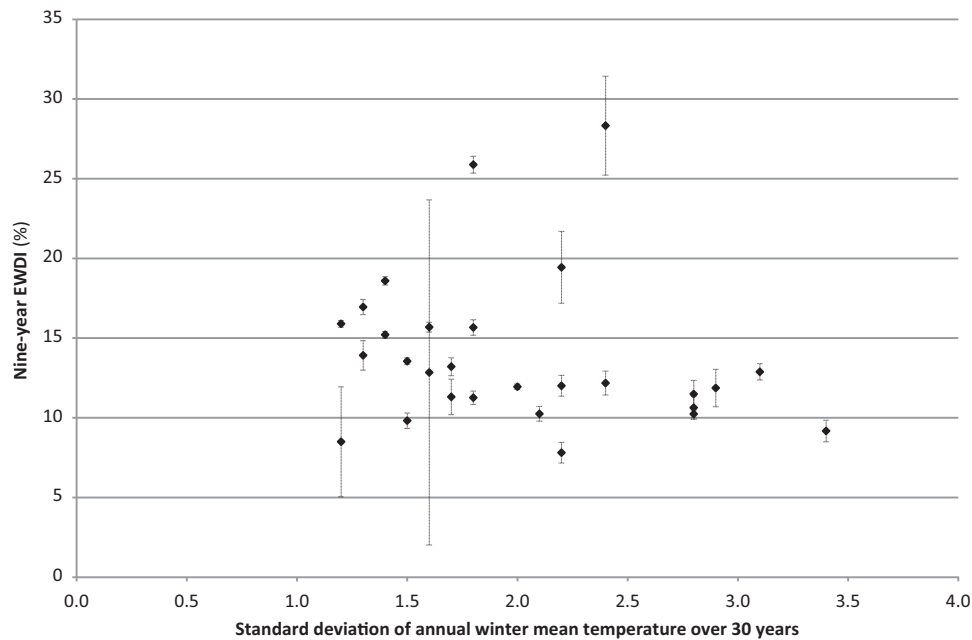


Figure 3 Scatter plot showing 30-year winter temperature variability (standard deviation of winter mean temperatures) against 9-year EWDI for 31 European countries. Error bars show 95% CIs for EWDI (as listed in Table 1)

There was no clear association between 9-year EWDI and standard deviation of annual winter temperature over 30 years.

Discussion

This article describes excess winter deaths across Europe over the last 9 years. To the authors knowledge, the next most recent examinations of excess winter deaths across Europe used data from 1988–97 and compared only 14 of the European Union countries.^{6,10}

Across Europe, over two million deaths can be attributed to excess winter mortality in the period 2002/2003 to 2010/2011. Overall for the 31 countries examined there was a slight decrease in EWDI between the annual average for 2002/2003 to 2004/2005 and the annual average for 2008/2009 to 2010/2011, which was also reflected in a number of individual countries (see online Supplementary appendices). The excess winter death paradox previously noted by Healy and McKee,^{3,5} of higher levels of excess winter death in the more temperate southern European countries than in the cooler northern ones, continues to be the case.

The suggestion that countries which experience greater inter-annual variability in winter temperatures (and not necessarily the lowest absolute winter temperatures) have greater excess winter death rates is not borne out by the data presented here. McKee previously found no association between annual temperature range (across the whole year) and excess winter mortality.⁵ Our analysis in a larger range of countries continues to support this.

There was also substantial variation seen in counties of similar climate (e.g. between Mediterranean countries), suggesting many winter deaths could be amenable to public health action. Despite experiencing some of the coldest winters in Europe, Scandinavian countries have lower EWDIs than most other countries in our analysis. We believe that EWDIs of Scandinavian countries are a target to which the UK and similarly economically developed countries of Europe should aspire since these countries have an approximately similar level of economic development and population health.

Approaches to successfully reducing excess winter deaths to reach such targets remain unclear. Factors which have been associated with variation in excess winter death include low GDP, low national spending on healthcare, inequality, deprivation, fuel poverty, cold housing, low income and urban dwelling.^{3,10,13} To what extent these

drive EWDI in Europe is unclear; however, a report by the ‘Marmot team’⁶ identified that 22% of excess winter deaths in the UK could be attributed to cold housing. It is plausible that the state of housing is a main contributing factor. Given the potential impact of tackling cold housing on excess winter deaths, this should be a central part of any cold weather plan.

Influenza epidemics are associated with excess mortality due to a number of causes beyond respiratory disease. Influenza immunization has been associated with substantially reduced risk of out of hospital primary cardiac arrest²⁷; this suggests that increasing immunization uptake in vulnerable groups could also be a key intervention in reducing excess winter deaths, indeed, successful seasonal influenza vaccination campaigns and a decline in influenza epidemics may have contributed to the previously reported general decline in excess winter mortality.^{14–16,20}

Strengths and limitations

This is the first study in 10 years to compare excess winter deaths in Europe; it is also the first article to make comparisons for the majority of European countries. We thus present the most up-to-date analysis of an important public health problem and do so using the EWDI, an accepted measure for assessing excess winter mortality.

The study makes use of inferential statistics for some comparisons (by necessity). There are different views on the appropriateness of using inferential statistics, and in particular, the use of CIs for population parameters.²⁸ We adopted the approach taken by Public Health England ‘Health Profiles’²⁵ for the calculation of confidence intervals but treated each EWDI estimate as a population parameter for the formal statistical analysis. It is recognized this is an area of ongoing debate.

EWDI is a ratio and therefore measures as much winter mortality excess or shortage as it does summer mortality excess or shortage. High EWDI could for instance be associated with factors preventing vulnerable populations from passing away in spring, summer and fall. Equally, a lower EWDI could be the result of high summer mortality due to heat waves. This can make interpretation of the results difficult, though it should be noted that to substantially affect the 9-year average and 3-year rolling average, these must have a particularly high impact or be an on-going issue. This may mean that countries with similar climates are the most appropriate groups

for international comparisons. The use of December to March as a defined winter period allows for a consistent comparison but may not correlate fully with meteorological conditions observed in each country.

The method used in this article and that of Healy³ depends on completeness of mortality reporting. Although this is known to be a problem in many developing countries, the European data used here are thought to be relatively accurate. Cause of death was not examined. Although this avoids commonly encountered issues around inconsistent coding of cause of death, it limited our ability to test potential causal mechanisms or associations with excess winter deaths that have been described elsewhere.^{3-4,6-10,14-16} We thus do not offer interpretative explanations of our findings.

Our analysis does not take into account differences in age profiles within or between countries due to availability of data. Countries such as the UK and Belgium have a higher proportion of people aged over 75 years compared with many eastern European countries,³¹ which show lower EWDIs than the UK and Belgium despite their lower levels of socioeconomic development. EWDI is not an age-standardized index and it may be that the increased vulnerability of older people over winter contributes to this higher mortality. Understanding whether differences in age structures substantially explain inter-country differences would help elucidate whether age standardization is necessary for appropriate international comparison.

Finally, we obtained climate data from the Tyndall Centre TYN CY 1.1 data set, the only Europe-wide, national, long-term data series available. The time period covered by the TYN CY 1.1 data set (1961–90) is not the same as the time period over which EWDI was examined (2002–11). We therefore make the assumption that the climate data reflects long-term patterns when making our comparisons.

Next steps

The extent to which excess deaths can be attributed to sudden extremes of weather, rather than the more general impact of lower temperatures throughout the winter period, is not yet well understood^{20,32} and represents a specific area for further investigation. The European Mortality Monitoring Project (EuroMOMO)¹⁷ seeks to monitor mortality in real-time across Europe and has the explicit aim of assessing the impact of extreme events. Combining EuroMOMO data with daily temperature information and known seasonal variations in death rates could further understanding and we encourage readers to investigate trends in their own nations.

Investigating differences in the major causes of excess winter deaths within and between countries is now a clear priority in understanding the mechanisms and wider determinants of excess winter death and effective interventions to reduce it. Such work is already underway at national and local level, including in the USA and UK.^{18,33} Comparing the data and trends identified in this article with country-level interventions to tackle winter mortality could identify best practice to be shared across Europe.

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Conflicts of interest: None declared.

Key points

- This is the first study to make European comparisons of excess winter death since the use of mortality data from 1988 to 1998.
- Similar patterns to those observed previously were seen, with countries with milder winters experiencing higher rates of excess winter deaths than those with more severe winters. A statistically significant relationship was found between mean winter temperature and country-level EWDI.
- There was also substantial variation seen in counties of similar climate (e.g. between Mediterranean countries), suggesting many winter deaths could be amenable to public health action.

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Do lifestyle, health and social participation mediate educational inequalities in frailty worsening?

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Background: Lower educated older persons are at increased risk of becoming frail as compared with higher educated older persons. To reduce educational inequalities in the development of frailty, we investigated whether lifestyle, health and social participation mediate this relationship. **Methods:** Longitudinal data of 14 082 European community-dwelling persons aged 55 years and older participating in the Survey on Health, Ageing, and Retirement in Europe (SHARE) in 2004 and 2006, were used. Associations of lifestyle (smoking behaviour and alcohol consumption), health (depression, memory function, chronic diseases) and social participation, with educational level and frailty worsening were investigated using regression models. In multinomial logistic regression analysis, mediators were added to models in which educational level was associated with worsening in frailty over 2 years follow-up. **Results:** In all countries, frailty worsening was more prevalent among lower as compared with higher educated persons, although odds ratios were only statistically significant in five of the 11 countries included [ORs varying from 1.40 (95% CI: 1.06–1.84) to 1.61 (95% CI: 1.21–2.14)]. Except for smoking behaviour and memory function, the factors under study all showed associations with educational level and frailty worsening that met the conditions for mediation. After inclusion of the four relevant mediators, attenuation of odds ratios varied between 4.9 and 31.5%. **Conclusion:** While lifestyle, health and social participation were associated with frailty worsening over 2 years among European community-dwelling older persons, only small to moderate parts of educational inequalities in frailty worsening were explained by these factors.

Introduction

Frailty develops as a consequence of age-related decline in many physiological systems, which collectively results in vulnerability to sudden health status changes.¹ Due to ageing in Western

populations, an increased number of older persons will become frail in the upcoming years. According to the often-used definition of Fried,² currently, 37% of community-dwelling persons aged >55 years are pre-frail and about 4% are frail,³ with percentages increasing to 51 and 26% respectively for those aged >70 years.⁴