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Concurrence of monthly variations of mortality related to underlying cause in Europe

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Abstract

Study objective – **The study aimed to examine the concurrence in the variation of monthly numbers of deaths in summer and winter from the four main underlying causes – respiratory, circulatory, neoplastic, and all others – in four countries. In particular, the hypothesis that most non-respiratory concurrent deaths are miscoded respiratory deaths and that a large proportion of the winter mortality currently attributed to circulatory disorders should be attributed to respiratory causes was considered.**

Design – **Mortality data were analysed graphically in relation to cause. Each of the four series of monthly data underwent time series analysis to remove autocorrelation, seasonality, and secular trends. Associations between paired causes of death and between multiple series (using Kendall's coefficient of concordance) were then examined after modelling.**

Setting – **Monthly deaths (65 years and over) related to underlying cause were examined for England and Wales (nine years), The Netherlands (nine years), Denmark (10 years), and Portugal (10 years – all ages). Weekly data for England and Wales (51 weeks) were also analysed.**

Main results – **All combinations of monthly deaths related to underlying cause were strongly associated in all four countries. This concurrence was evident down to the lowest monthly values so that all seasonally related deaths above the minimum monthly value can be used as an estimate of the "concurrent" proportion. Associations involving deaths from neoplasm were weakest. Concurrence was evident even on a weekly analysis (England and Wales). Concurrent deaths in England and Wales accounted for 31·1% of respiratory, 16·0% of circulatory, 3·5% of neoplastic, 14·1% of deaths from other causes, and 14·2% for all deaths combined. The equivalent percentages for concurrent deaths from all causes were 8·4% in the Netherlands, 9·3% in Denmark, and 16·8% in Portugal.**

Conclusions – **Concurrence, which was present in each of the underlying causal groups in each of the four national data sets examined, suggests a common cause separate from the underlying cause that has been used in the presentation of mortality statistics. If the person concerned had not died at that time, as a result of this cause, he would not have died from the recorded underlying cause. Most of these non-respiratory concurrent deaths are miscoded. As a consequence, a large proportion of winter mortality currently attributed to circulatory disorders should be attributed to other causes, probably respiratory. More intensive research into the contribution made by acute respiratory diseases is proposed. The proportion of concurrent deaths varied in the**

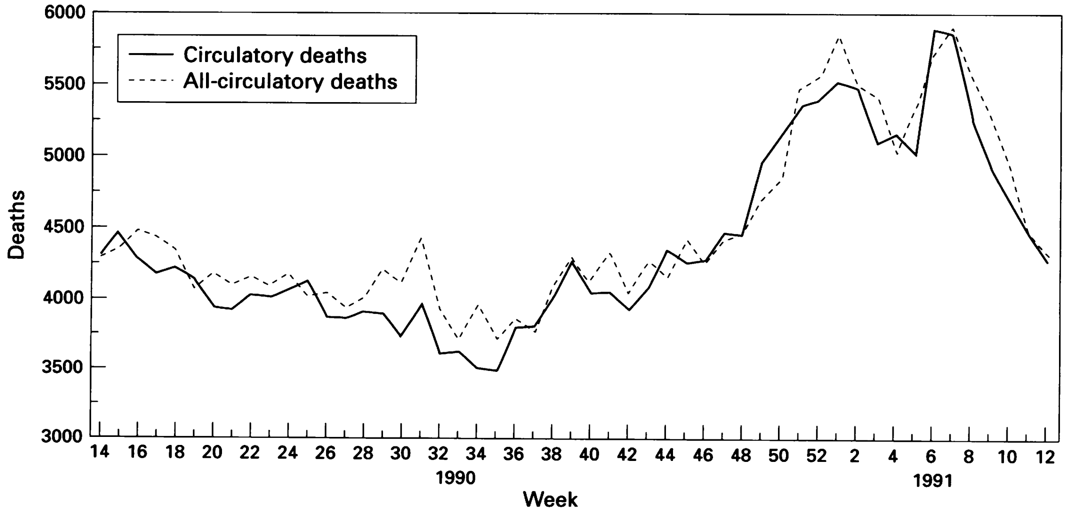

Figure 1 Deaths due to circulatory causes compared with those due to all causes minus circulatory causes. England and Wales weekly data for all those aged ≥65 years, 1990–91.

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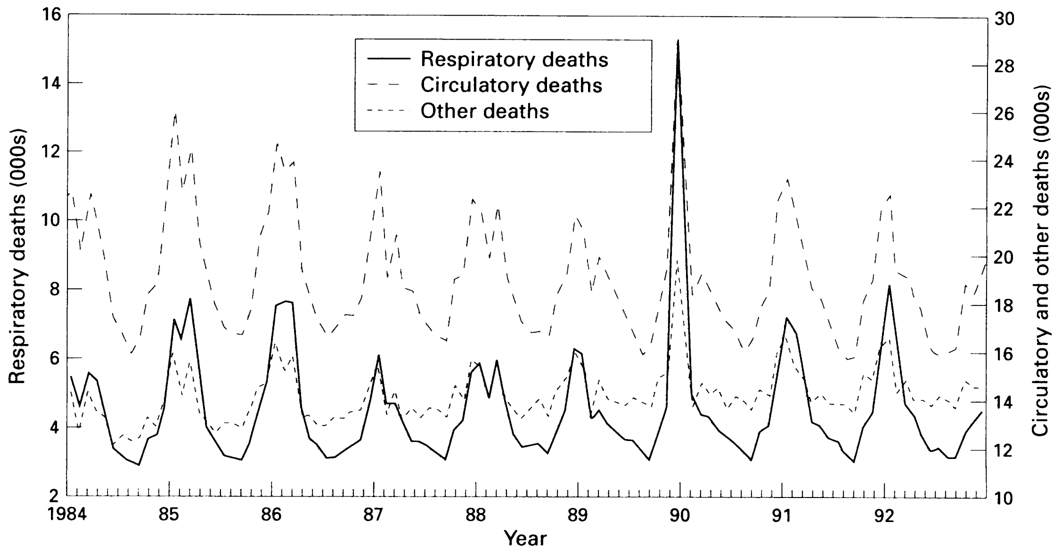

Figure 2 Deaths due to respiratory, circulatory, and other causes. England and Wales monthly data for all those aged ≥65 years, 1984–92.

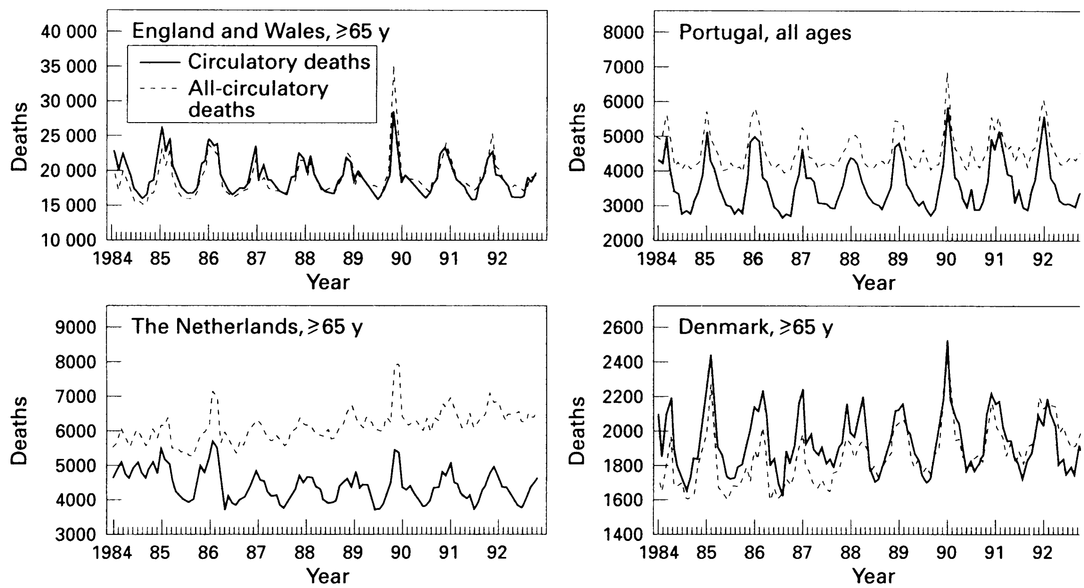

Figure 3 Deaths due to circulatory causes compared with those due to all causes minus circulatory causes. Monthly data 1984–92.

four countries thereby limiting the validity of simple comparisons of national mortality statistics.

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The relationship between variations in the monthly numbers of deaths in the four main underlying causal groups (cardiovascular, respiratory, neoplastic, and others) was examined over 10 years (1984–93) in four European countries (England and Wales, The Netherlands, Denmark, and Portugal).

Momimyama,[1] undertook a detailed comparison of mortality patterns over many years. She showed that in the western world in the last century there were summer peaks, mainly due to gastrointestinal infections, which gradually subsided with improving hygiene and exposed an increasing (relatively) winter peak. During winter and summer peaks, increased mortality was evident in a number of underlying causal groups. The similarity during winter in patterns of mortality related to underlying cause has been shown in more recent European studies,[2-4] specifically for deaths from ischaemic heart disease and respiratory causes.[5]

We undertook this examination of patterns of mortality because we had noticed a similarity between the graph showing weekly deaths from circulatory disease and that of deaths from all other causes (fig 1) – a similarity that was evident regardless of the time of year. We hypothesised that if such a close contemporary association affected all four main causal groups of death, it would suggest the presence of a set of causal factors that impact on all causes of death but are not disclosed in the conventional preparation of mortality statistics by a single underlying cause.

We use the term "concurrence" to describe the close monthly association between deaths in each of the causal groups and we estimate the numbers of deaths attributable to concurrent factors using the minimum monthly baseline value usually found in August.

Excess winter deaths have been the focus of investigation at least since the early work by Farr[6] in the last century. However, these studies have been based on comparing the three or four winter months with the other eight or nine months of the year. We suggest that "concurrence" is the result of seasonally related factors that operate throughout the year and that the concept of a winter excess leads to an underestimation of its importance.

Methods

Four sets of data were used as follows:

- England & Wales – the number of deaths by month in 1984–92 in people aged ≥65 years allocated to the four main underlying causal groups (respiratory, circulatory, neoplastic, and other).
- The Netherlands – the number of deaths by month in 1984–92 in people aged ≥65 years allocated to the four groups.
- Denmark – the number of deaths by month in 1983–92 in people aged 65 years and over allocated to the four groups.
- Portugal – the number of deaths by month in 1983–92 in people (all ages) allocated to the four groups.[7]

Each national monthly data set was standardised to a 30·5 day average. The association between the number of monthly deaths in each of the underlying causes was first examined graphically. Concurrence is a relative concept so in figure 2 the scales have been chosen to maximise its perception. Time series analyses were undertaken by applying the Box-Jenkins method of modelling,[8] using the *Minitab* statistical package.[9] With this approach, any trends and autocorrelation were removed from each series of monthly deaths related to cause. The relation between each pair of time series was then investigated by calculating the cross correlation function for the two series of residuals from the individual models.[10] Kendall's coefficient of concordance was calculated to measure the extent of concurrence between the series of residuals referable to all four causes of death.

In each national data set, we calculated the average monthly number of deaths in each year and for each cause. The percentage excess of this average value over the minimum monthly value was used as an estimate of deaths attributable to seasonal factors. We argue (see discussion), that these deaths provide a minimum estimate of the deaths caused by the common set of causal factors which account for concurrence.

Results

The monthly distribution of deaths from respiratory, circulatory, and other causes (neoplasms omitted) in England and Wales is given in figure 2. There is obvious concurrence between the series in respect of the annual winter peaks and summer troughs. Neoplastic deaths show an underlying increasing trend in this series and the cyclic variation is less evident.

The strong relationship between monthly circulatory deaths and deaths from all other causes combined is shown for the four national data sets in figure 3. Concurrence is evident at all times of the year in each country. In The Netherlands and Denmark, deaths from non-circulatory causes increased gradually over the nine years. In Portugal and The Netherlands they contributed a larger proportion to total deaths. The peaks that occurred in both circulatory and non-circulatory deaths in the winter of 1989–90 coincided with an influenza epidemic in all countries.

The strength of association between each pair of various combinations of cause-specific series of monthly residual values after modelling is given for each national data set in table 1. With the exception of the paired comparisons involving neoplasms in Denmark, the coefficients correlating the residual deaths in the same month (that is, zero lag) for one cause with any other were very high indeed, and all very highly significant. The values associated with the relationship with deaths from neoplasms and other causes of death, even though generally highly significant, were smaller than the others. In a separate examination of the associations in the four summer months, correlation coefficients, with a few exceptions, were highly significant though a little weaker.

The Kendall concordance coefficients for residuals referrable to all four causes were all very highly significant.

Table 1 Cross correlation coefficients (zero lag) and coefficients of concordance (CC) for combinations of residuals of monthly deaths by underlying cause after modelling

Country	Respiratory v all – respiratory	Circulatory v all – circulatory	Neoplasm v all – neoplasm	Other v respiratory + circulatory + neoplasm	Respiratory v circulatory	Respiratory v neoplasm	Respiratory v all other	CC With neoplasm	CC Without neoplasm
England and Wales	0·900	0·926	0·742	0·961	0·881	0·672	0·904	0·807	0·900
The Netherlands	0·759	0·576	0·415	0·407	0·672	0·327	0·551	0·511	0·663
Denmark	0·732	0·758	0·303	0·672	0·733	0·205	0·601	0·594	0·771
Portugal	0·844	0·879	0·512	0·866	0·826	0·407	0·809	0·723	0·855

Table 2 Analysis of deaths related to cause and proportion of deaths over monthly minima

Underlying cause	*Mean monthly no*	*% of all deaths*	*Concurrent deaths*	
			% of cause	*% of total*
England and Wales:				
Circulatory	19 172	50·3	16·0	8·1
Respiratory	4597	12·1	31·1	3·8
Neoplastic	8627	22·6	3·5	0·8
All other	5702	15·0	14·1	2·1
All causes	38 098	100·0	14·2	
The Netherlands:				
Circulatory	4413	41·7	11·8	4·9
Respiratory	817	7·7	25·2	1·9
Neoplastic	2953	27·9	2·0	0·6
All other	2399	22·7	6·5	1·5
All causes	10 582	100·0	8·4	
Denmark:				
Circulatory	1945	51·2	11·7	6·0
Respiratory	309	8·1	25·6	2·1
Neoplastic	901	23·7	5·1	1·2
All other	643	16·9	7·6	1·3
All causes	3798	99·9	9·3	
Portugal:				
Circulatory	3630	44·1	21·7	9·6
Respiratory	360	4·4	37·5	1·7
Neoplastic	1414	17·2	6·5	1·1
All other	2829	34·4	13·1	4·5
All causes	8232	100·1	16·8	

Correlation coefficients of the observed values of monthly deaths were very similar to those based upon the residuals obtained after modelling, except where neoplasms were involved. With neoplasms, the correlation coefficients obtained were greater than those obtained when using observed values. In all major respects, the results from England and Wales and Portugal were similar: those from The Netherlands and Denmark were also similar to each other but slightly weaker than in the other two countries.

The mean number of monthly deaths related to each underlying cause is given for each country in table 2. The table includes the percentage of all deaths attributable to each cause and the proportion of deaths attributable to concurrence as we have defined it – that is, the percentage by which the mean exceeds the minimum monthly number averaged over the separate years.

In England and Wales, concurrent deaths accounted for 14·2% of all deaths, 3·5% of neoplastic deaths, 31·1% of respiratory deaths, and 16·0% of circulatory deaths. In Portugal, 16·8% of deaths were concurrent. This is based on deaths in all age groups, however, and thus the distribution of deaths between underlying causes differ from that in England and Wales. In The Netherlands and Denmark, concurrent deaths were substantially lower for each cause except neoplasms than those for England and Wales, amounting to 8·4% and 9·3% of all deaths respectively.

In all four countries, these concurrent deaths accounted for at least one quarter of respiratory deaths but those recorded as circulatory deaths made higher contributions to the total deaths than those attributable to the other causal categories combined; and those recorded as neoplastic deaths made minimal contributions.

The estimates of proportions of concurrent deaths in the populations studied here are equivalent to 63 000, 16 000, 10 700 and 4200 deaths annually in England and Wales, Portugal, The Netherlands, and Denmark.

Discussion

The results presented show a highly concurrent relationship between deaths in the individual causal groups in all four countries over approximately 10 years. This degree of concurrence was also evident in an introductory examination of weekly data from England and Wales. The main inference from this concurrence is that at any one time there is a common set of causal factors that impacts on all underlying causes regardless of the causal category to which they have been assigned for the presentation of mortality statistics.

We have used the minimum monthly number of deaths as the baseline to present data about concurrent deaths. We believe this constitutes a minimum estimate of the importance of the set of causal factors implied by concurrence. This belief is based on the following:

- If no seasonally related factors existed, monthly deaths would be randomly distributed about the mean.
- There is little variation in minimum monthly values from one year to the next.
- Correlation coefficients for associations between different causes of death are still high, even in summer. The point at which the temporal association of deaths is random, therefore, must be below the minimum monthly number.
- The magnitude of the winter mortality peaks (all causes) varies relative to the constant minimal summer value. This strongly sug-

gests the existence of causal factor(s) that act independently of those implied by the label defining the underlying cause of death.

- There is no compensatory fall or increase in minimum monthly values after the highest and lowest winter peaks respectively. Any compensatory reductions in the numbers of deaths in March, April, and May after a winter peak (for example in 1990 after the 1989 influenza peak) will not affect the estimated number of total concurrent deaths in any one year, since this is based on the difference between the annual and minimum monthly number of deaths.

IMPLICATIONS

For the presentation of mortality statistics, deaths are attributed to a single underlying cause. Individually, however, people who die concurrently as a result of the common set of causal factors described here would not have died from that underlying cause at that time. Nor is there any evidence to suggest that the underlying illness from which each person was suffering was necessarily in a terminal phase. The estimates of total concurrent deaths attributed to these common causal factors (63 000 deaths per year in England and Wales) considerably exceeds the number of deaths attributed to influenza even during the most serious epidemics, and in addition, deaths that may be attributable to particulate pollution.[11]

DEATH CERTIFICATION

If approximately 14% of all deaths in England and Wales are concurrent and attributable to a cause other than the underlying cause, it is not surprising that the recorded underlying cause is often incorrect. Goldacre,[12] has recently reviewed this situation. Like Curb *et al*,[13] he found least disagreement between the recorded underlying cause and other sources of information about the medical histories for those certified as dying from neoplasms, and greatest disagreement for those certified as dying from heart disease. Our estimates of 3·5% concurrent deaths in neoplasms and 16% in circulatory disorders are in keeping with and explain these observations. Whether the proportion miscoded is 3·5% or 16%, it does not matter which other conventional underlying cause is chosen, it will still be wrong.

In an examination of mentioned causes (Part I) on death certificates,[14] lower respiratory infections appear on 29·5% compared with only 5% attributed as the underlying cause. Coding protocols have been based on the assumption that acute lower respiratory infections were almost always a secondary coincident and not a primary cause of death. The results here refute this belief. A proportion of the 14% of concurrent deaths may be recruited from the omitted 24·5% of respiratory deaths recorded in Part I of the certificate.

INTERNATIONAL IMPLICATIONS

We have estimated that the concurrent deaths account for 16% of deaths attributed to circulatory disease and 14% of deaths from all the other causes in England and Wales. The proportions in Portugal were similar while those for The Netherlands and Denmark were smaller. These differences are independent of any international variations in coding protocols and in the distributions of concurrent deaths by underlying cause. They also undermine the credibility of conventional mortality statistics (based on underlying cause), seriously limiting their usefulness in regional and national comparative studies. This applies particularly to deaths attributed to circulatory disease as the underlying cause.

AETIOLOGY OF CONCURRENCE

The small number of increased deaths often described as the winter excess is a small proportion of all concurrent deaths. Temperature, pollution, and influenzal illnesses have been associated, to varying degrees, and perhaps causally, with these excess winter deaths. Excess deaths associated with influenzal outbreaks are well known.[15,16] Winter mortality peaks have been shown in association with respiratory syncytial and influenza viruses,[17] and mortality in the elderly is closely associated with the combined incidence of acute respiratory disease[18] in summer and winter. Increased mortality in summer has been shown to be associated with respiratory allergens, pollution, summer infections, and high temperatures (above 16°C).[4] Each of the causal agents has its own specific time period of action and results in deaths occurring contemporaneously, regardless of the underlying cause to which they are attributed.

In a study of predictors of mortality in the elderly, Casiglia *et al*[19] have shown that impaired respiratory function is of much greater importance than cardiac related risk factors as a predictor of death. Because the contribution of acute respiratory illness is cardinal we believe the most fruitful area for further research lies in unravelling its epidemiology. The results reported here support the hypothesis that nonrespiratory concurrent deaths are miscoded. As a consequence, a large proportion of winter mortality currently attributed to circulatory disorders should be attributed to other causes, probably respiratory. That most concurrent deaths are miscoded respiratory deaths could be tested by an examination of all mentioned respiratory deaths in Part I of the death certificate on lines parallel to the study described here for deaths by underlying cause.

Mackenbach[20] has called for increased investigation of cause specific mortality over time in order to gain a better understanding of the transition from the "age of pestilence and fever" through the "age of receding pandemics" to the "age of degenerative and man made diseases" (Omran[21]). Our study, though considering a recent nine year series only, suggests that even in developed countries the end of the "epidemiological transition" has not yet been reached. If most concurrent deaths are a result of respiratory infections they may be preventable.[22]

The stimulus for investigating mortality statistics has come from our studies of the relationships between mortality and acute respiratory illness based on material provided by the general practitioners contributing to the Weekly Returns Service who we are pleased to acknowledge. The Office of Population Censuses and Surveys have been particularly helpful in the provision of mortality data. We are grateful to Dr Jose Falcao, Professor van der Zee, and Dr K Duel for access to the Portugese, Dutch, and Danish data respectively. Particular thanks are due to Mrs Joan Dainty for manuscript preparation. Finally, we are grateful to the Department of Health who provided the financial support to the Birmingham Research Unit and who have given permission to publish.

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