High death rates: more deaths or earlier deaths?

ROBERT R. WEST, PhD, FSS
Senior Lecturer in Epidemiology, Department of Epidemiology and Community Medicine
University of Wales College of Medicine, Cardiff

In the epidemiological study of disease frequencies (in many fatal diseases) we commonly begin with the mortality statistics; the so-called ‘hard’ statistics. The analysis of death rates by age, sex, race, social class, occupation, country, country of birth and their variations in time may help to provide clues as to the aetiology of the disease and hence to help with the formulation of hypotheses that can be tested in more formal case control and cohort studies. However, the well-known variations in death rates, even in some of the most common diseases, may be misinterpreted. Such misinterpretation appears to have led to a search for unlikely explanations for the commonly observed variations, and to the formulation of inappropriate hypotheses regarding the contributory ‘causes’ of disease.

An association between an epidemiological characteristic and a disease may suggest a factor (underlying the characteristic) which causes the disease. However, if the measure of disease frequency is mortality, as is often the case, an alternative hypothesis which should be considered is that the factor promotes death from previously initiated disease but does not cause the disease. Descriptive studies of disease frequency based on mortality data should therefore seek to clarify whether high death rates indicate relatively more deaths (more disease) or relatively early (younger) deaths.

The example examined here is ischaemic heart disease (IHD), the leading cause of death in this country [1]. The broad geographical variations within the country, mortality low in South and East and high in North and West, are well known to epidemiologists, clinicians and the public. Major epidemiological studies have searched over many years for a factor (an agent or ‘toxin’) that might cause more heart disease in the North and West [2,3]. The geographical variations of heart disease mortality data are re-examined here with the principal objective of enquiring whether high death rates indicate more deaths (more disease) or earlier deaths (shorter life). This gives direction as to whether future, more detailed, epidemiological studies seek a factor that might cause heart disease or a factor that might promote early (younger) death to explain the geographical variation.

Methods

The basic data are age and sex specific death rates in the 54 (new) counties of England and Wales for the three years 1980–82, surrounding the recent census, as published by OPCS [4]. Counties are ranked for IHD mortality (ICD 410–414) according to their standardised mortality ratios (SMRs)—the single summary statistic most frequently used to describe the mortality experience of a defined population. The five counties with highest ranking SMRs might be termed ‘high’ mortality counties, the five medium ranking ‘middle’ and the five lowest ranking ‘low’.

Age specific death rates of ‘high’, ‘middle’ and ‘low’ mortality counties are presented graphically both for IHD and for all causes and the relationships examined. It should be appreciated that there is nothing sacrosanct about any specific age grouping (eg 55–64 years): these conventional age groups are for statistical convenience in summarising the overall (any age) mortality experience in an acceptably small number of comparable units. Age grouping imposes artificial constraints. True inter-population comparisons are of deaths in whole populations and of deaths at any age.

Results

There are 54 counties of England and Wales with a median population of 640,000, ranging from Powys with 111,000 to London metropolitan county with 6,755,000. The five counties with highest heart disease SMR for men are Greater Manchester, Cleveland, West Glamorgan, West Yorkshire and Durham; where SMR is the single statistic conventionally used to summarise the local disease-specific mortality experience by comparison with the country as a whole. These five counties are easily recognised as ‘high’ heart disease mortality counties. The five ‘low’ mortality counties with lowest ranking heart disease SMR for men are Oxfordshire, Suffolk, Hertfordshire, Buckinghamshire and East Sussex.

The pooled age-specific death rates for the ‘high’, ‘middle’ and ‘low’ mortality groups of five counties are presented graphically in Figure 1. A point on the figure (eg 8.48 deaths/1000 men/annum at age 60 in ‘high’ mortality counties) really represents the average death rate for men in the decade of age 55–64 inclusive. Consequently, the conventional joining of points to form a smooth curve represents approximations of the ‘true death rates’ in all the (theoretically) infintesimally small age groups. The upper ends of the curves are drawn
dotted because the oldest age groups (85+) are ‘open ended’; they have been centred on age 87, 88 and 89 for ‘high’, ‘middle’ and ‘low’ mortality county groups respectively by closer inspection of population age distributions in those counties.

The crucial step in interpretation of differences in heart disease mortality between these three groups of counties lies in the reading of Figure 1. The differences may be read ‘vertically’; as at age 70 the age-specific death rates are 18.72, 15.92 and 13.50 per 1000 men per annum respectively (line AB on Figure 1). The difference between ‘high’ and ‘middle’ rates is 2.80, and between ‘middle’ and ‘low’ rates is 2.42; the ratios above and below ‘middle’ are 1.18 and 0.85 respectively. These ratios may be read as meaning that the ‘high’ mortality counties have nearly 18 per cent more deaths and the ‘low’ mortality counties have nearly 15 per cent fewer deaths than average. Alternatively, the difference may be read ‘horizontally’; at about 60 years the horizontal separations of the smoothed curves are approximately 2.7 and 2.1 years respectively for ‘high’ to ‘middle’ and ‘middle’ to ‘low’ (line CD on Figure 1). For comparison with the above ‘vertical’ interpretations, the separation of the smoothed curves may be read as meaning that ‘high’ mortality counties have IHD deaths about 2.7 years earlier and ‘low’ mortality counties have IHD deaths about 2.1 years later than average. ‘Vertical’ and ‘horizontal’ differences centred on four ages are summarised in Table 1; in the former the excess in ‘high’ mortality counties reduces markedly with age, and the deficit in ‘low’ mortality counties is fairly independent of age, but in the latter the age at death disadvantage in ‘high’ mortality counties varies relatively little, and the advantage in ‘low’ mortality counties varies relatively little, and the advantage in ‘low’ mortality counties is constant over the four decades.

The interpretations have been presented thus far as alternatives, which is an over-simplification. It is quite possible that the difference between ‘high’, ‘middle’ and ‘low’ mortality counties is a combination of more heart disease and ‘younger’ death from heart disease; for example, in the Figure the point represented by 27.47 deaths/1000 men/annum at age 80 in ‘low’ mortality counties might be equivalent to perhaps 28.0 deaths/1000 men/annum at age 78 in ‘middle’ and perhaps 28.5 deaths/1000 men/annum at age 76 in ‘high’ mortality counties (line EF in Figure 1).

The relevance of distinguishing between the two judgements as to how two smoothed curves differ, ‘vertically’ or ‘horizontally’, lies in the consideration of whether men in ‘high’ mortality counties have more heart disease (greater prevalence; hypothesis 1) or whether men in those counties die of their prevalent heart disease and perhaps of other diseases earlier (younger deaths; hypothesis 2).

Table 1. Differences between ‘high,’ ‘middle’ and ‘low’ IHD mortality counties: England and Wales, males, 1980-82. (These differences may be read from Figure 1).

| Difference in heart disease mortality | 50  | 60  | 70  | 80  |
|--------------------------------------|-----|-----|-----|-----|
| ‘Vertical’ difference                |     |     |     |     |
| (in deaths/1000 p.a.)                |     |     |     |     |
| middle to high                       | +0.86 | +1.86 | +2.80 | +4.59 |
| (43%)                                | (28%) | (18%) | (15%) |     |
| middle to low                        | -0.47 | -1.08 | -2.42 | -3.85 |
| (17%)                                | (16%) | (15%) | (12%) |     |
| ‘Horizontal’ difference               |     |     |     |     |
| (in years)                           |     |     |     |     |
| middle to high                       | -3.3 | -2.7 | -2.3 | -2.0 |
| (7%)                                 | (5%) | (3%) | (3%) |     |
| middle to low                        | +2.0 | +2.1 | +2.1 | +2.0 |
| (4%)                                 | (4%) | (3%) | (3%) |     |

Figure 2 shows the all-cause mortality in the same ‘high’, ‘middle’ and ‘low’ mortality counties. The shapes are similar to those of the previous Figure. However, the variations of all-cause mortality between counties (in adults) can logically only be a matter of ‘horizontal’ variations, either ‘younger’ or ‘older’ deaths (CD in Figure 2), since all cause mortality includes all of us—in time. Table 2 gives the proportions of deaths attributed to heart disease in the same six age groups as were used in the preparation of the Figures. The differences observed (about +2.5 and -5.0 per cent on weighted average) are small by comparison with the ‘vertical’ differences of age-specific death rates in Table 1 (about +22 and -15 per cent on weighted average) and clearly indicate that

Fig. 1. Age-specific death rates for ischaemic heart disease: ‘high’, ‘middle’ and ‘low’ groups of counties of England and Wales, males 1980-82.
Fig. 2. Age-specific death rates for all-cause mortality: 'high', 'middle' and 'low' (for IHD mortality) groups of counties of England and Wales, males 1980-82.

'low' and 'high' mortality counties have relatively similar age-specific proportions of heart disease deaths. Because the differences in all-cause mortality can be differences only in age at death, the consistency of the proportions of deaths (in each of the six age groups) between 'lower', 'middle' and 'higher' mortality counties render hypothesis 1 less likely and hypothesis 2 more likely. The data would imply that the difference in heart disease mortality between counties is principally one of age at death. These analyses were done also for women and starting with SMR64 (instead of SMR85) and including Scottish Regions yielding broadly similar results.

Table 2. Proportional mortality in 'high', 'middle' and 'low' mortality counties: England and Wales, males 1980-82.

| Age group (years) | SMR | SPMR |
|------------------|-----|------|
| 35-44            | 0.32|      |
| 45-54            | 0.43|      |
| 55-64            | 0.40|      |
| 65-74            | 0.35|      |
| 75-84            | 0.30|      |
| 85+              | 0.23|      |

Table 3. 'High' and 'low' IHD mortality counties according to SMR and to SPMR: England and Wales, males 1980-2.

Discussion

All men are mortal; it is only a matter of time before each gets his death certificate. The layman appears to be more inclined to express intergroup differences in terms of 'years of life lost (gained)' than the clinician, who tends to
express such differences in terms of ‘numbers of lives lost (gained) . . . ’, and epidemiologists seem to have been guilty of misleading clinicians in this way. It is clear from the medical literature that comparisons of age-specific death rates have frequently been ‘vertical’ comparisons; implying ‘more’ or ‘fewer’ deaths. This is because of the constraint imposed when comparisons are made within defined age groups and not between whole mortality experiences. Even more frequently, ‘vertical’ comparisons have been reported simply on the basis of SMRs, which only summarise sets of age-specific death rates. This paper has shown how a whole mortality experience of a population can be represented as a series of death rates within infinitesimally small age steps or as a continuous age mortality figure, and how comparisons between populations can be made of the whole mortality experiences of the populations.

In applying this analysis to IHD mortality, it emerged that much of the inter-county variation was ‘horizontal’ because the age-specific proportions of mortality attributed to the disease are relatively constant from one county to another. Appreciation that the principal differences between ‘high’ and ‘low’ IHD mortality counties are differences in the ages at which the populations die is highly relevant when researchers examine ‘causes’ of the mortality differences. There is little evidence that an ‘agent’ causes heart disease in the North and West of the country (reviewed elsewhere [7-9]). It is more likely that the ‘agent’ affects the IHD mortality through an initiating or triggering mechanism, but it should be remembered that the all-cause mortality is also being affected in a broadly similar manner.

In conclusion, comparison of SMRs implies a comparison of age-specific death rates (usually in about six age decades) but the practice of comparing only the SMRs tends to restrict the comparison into the ‘vertical’ dimension and by so doing the researcher often falsely concludes that high (or low) SMRs indicate ‘more’ (or ‘fewer’) deaths rather than ‘younger’ (or ‘older’) death. Every time we see SMRs compared we should remember that each summarises a very large set of infinitesimally narrow age-specific death rates and, furthermore, every time we compare SMRs we should consider whether they mean ‘more’ deaths or ‘earlier’ deaths, or a combination.

Summary

In the analysis of mortality statistics high age-specific death rates could be interpreted as meaning more deaths (more disease), but they could equally well be interpreted as meaning earlier deaths (death at younger age). The distinction markedly affects the choice of hypotheses that may be advanced to explain variations in person, time and place and the design of subsequent, more detailed field studies to test the hypotheses. Furthermore, the majority of descriptive papers make no comparisons with a control disease and thereby break one of the ground rules of epidemiology. This paper shows how, in the example of the geographical variations within England and Wales of ischaemic heart disease, a control may be simply introduced and that much of the observed variation is not in the proportion who suffer heart disease deaths but is in the age at which deaths occur.

References

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