# Mortality by deprivation and cause of death in England and Wales, 1999-2003

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**The relationship between deprivation and mortality is long established and many studies report higher death rates in more deprived areas. This article examines recent patterns of mortality and deprivation and illustrates these for leading causes of death. Results are considered by age group, sex and region. Mortality rates increased with deprivation for both sexes but the relationship was generally stronger for males. The strongest positive relationships with deprivation were mostly found for smoking-related causes. Those living in the least deprived areas had similar mortality rates, independent of region. There was more geographical variation in mortality for those in the most deprived areas with highest rates generally in the north.**

## Introduction

The link between poverty and health is well established,[1-3] and many studies have also shown a clear relationship between deprivation and death rates, with more deprived areas having worse mortality than the less deprived.[4–7]

Some studies have also considered the relationship between deprivation and mortality in the English regions and Wales, to attempt to determine whether socio-economic factors can explain the geographical differences in death rates which have been consistently identified over the last 150 years.[8–10]

Other studies have also considered whether the gradients of increasing mortality with deprivation seen in all causes of death combined, are still present when cause-specific death rates are considered.[8,11,12]

ONS and its predecessor organisations have a long history of reporting on geographical inequalities in mortality, originally through the annual reports of the Registrar General dating back to 1837, and also via Decennial Supplements to these reports. The most recent of these supplements, *Geographic Variations in Health*, examined variations in the relationship between deprivation and mortality in the countries of Great Britain and the English regions for all deaths, and selected causes.[13]

This analysis found that for both sexes there was a strong positive relationship between deprivation and death rates for all causes combined, ischaemic heart disease and lung cancer, while suicides and deaths from all cancers, stroke, and accidents showed a rather weaker relationship. There were also geographical differences in death rates

between populations with similar levels of deprivation, with areas in the north generally having higher mortality than those in the south.

This article continues the ONS tradition of regular reporting on socio-economic and geographical inequalities in mortality. Analysis has been undertaken to examine the relationship between deprivation and leading causes of death in England and Wales using mortality data from 1999–2003, and to consider how this relationship varies across the English regions and Wales. The association between deprivation and mortality is also examined by sex and age group.

## Methods

### Cause of death

The causes selected for analysis were based on the leading causes of death in England and Wales. These were defined in a recent article which presented several alternative definitions based on different methods of grouping causes of death together.[14] For this analysis a definition of leading causes was selected where cancers are included by site but all accidents are grouped together. Cancers were examined separately because research has shown that relationships with deprivation and geographical distributions can vary greatly according to site.[15, 16] The standard ONS ranking list of leading causes examines accidents by type but for this analysis all accidents were grouped together because of the smaller number of deaths in this category.

Lists of the ten leading causes, based on numbers of deaths in England and Wales, were produced for males and females for all ages and those aged 15–64. Causes were included in this analysis if they were among the top ten for either sex or either age group.

Two of these leading causes of death have been excluded from this article (suicide and injury/poisoning of undetermined intent, and cirrhosis & other diseases of the liver). The relationship between suicide and deprivation has already been examined in an article in *Health Statistics Quarterly* 31.[17] An analysis of trends and geographical variations in alcohol-related deaths (which include deaths from liver cirrhosis) is planned for a future *Health Statistics Quarterly* article which will also include a deprivation analysis.

From 1979 to 2000 ONS coded causes of death using the Ninth Revision of the International Classification of Diseases (ICD-9) but in 2001 the Tenth Revision (ICD-10) was introduced. This marked the biggest change in mortality coding in England and Wales in over 50 years. The change in revision means that data for many causes of death are not comparable before and after 2001. The impact of the change has been examined using bridgecoded data for 1999 (deaths that were coded using both ICD-9 and ICD-10). Comparability ratios based on these data have been reported.[18]

For this analysis deaths over a five year period from 1999–2003 were included. This provided data two years either side of 2001, the census year for which deprivation scores were available. As this period included years when deaths were coded using both ICD-9 and ICD-10 there was a potential for discontinuity. The results of the bridgecoding study were used to identify the causes of death for which data were not comparable between revisions. For these causes, deaths were selected using ICD-10 only, for a four-year period from the bridgecoded data for 1999 and then annual mortality files from 2001 to 2003. There were two causes where the change in ICD revision did not have an impact – ischaemic heart disease and accidents.

Records were selected using the final underlying cause of death from annual files of deaths registered in each calendar year. The causes of death examined, and their ICD-9 and ICD-10 codes, are presented in Box One.

## Box one

| Cause of death | ICD-9 | ICD-10 |
|---|---|---|
| All cancers (malignant neoplasms –MN) | | C00–C97 |
| MN of oesophagus | | C15 |
| Colorectal cancer: | | |
| MN of colon, rectosigmoid junction, rectum and anus | | C18–C21 |
| Lung cancer: | | |
| MN of trachea, bronchus and lung | | C33–C34 |
| MN of female breast | | C50 |
| MN of ovary | | C56 |
| MN of prostate | | C61 |
| MN of lymphoid, haematopoietic and related tissue | | C81–C96 |
| Dementia and Alzheimer's Disease | | F01, F03 & G30 |
| All circulatory diseases | | I00–I99 |
| Ischaemic heart disease | 410-414 | I20-I25 |
| Stroke (cerebrovascular diseases) | | I60–I69 |
| All respiratory diseases | | JOO–J99 |
| Accidents | E800–E928 (excluding E870–E879) | V01–X59 |

### Carstairs deprivation scores

In the 1980s Vera Carstairs and Russell Morris developed an index designed to be used for health analysis which measured relative material deprivation in small areas.[4] The first set of Carstairs scores were based on results from the 1981 Census and were subsequently updated following the 1991 Census.

Carstairs deprivation scores have now also been calculated by ONS using four data items from the 2001 Census –overcrowding, no car ownership, residents unemployed or in Social Class IV and V. (As the National Statistics Socio-Economic Classification replaced Social Class in the 2001 Census the closest equivalents to classes IV and V were actually used.) The calculation of these scores was described in an article in *Health Statistics Quarterly* 31, which also illustrated the geographical distribution of deprivation in 2001.[19] The 2001 Carstairs scores for wards in England and Wales are available on the National Statistics website: www.statistics.gov.uk/statbase/Product.asp?vlnk=14068
The article in Health Statistics Quarterly 31 also considered the conceptual and practical considerations which helped determine the choice of deprivation index for this analysis. When used for health analysis different deprivation indices have shown a high degree of correlation.[20,21] Carstairs was selected for this analysis because the index has been used in previous ONS studies,[13,15,22] as well as having widespread usage in much health research.[23-27] Carstairs scores could also be calculated at ward-level for which population estimates were available.

For this study, deaths were assigned to the same boundaries as the Carstairs scores (2001 Census Standard Table wards) using the May 2005 National Statistics Postcode Directory. Wards in the City of London and Isles of Scilly were aggregated to local authority level and so 8,797 areas were included in the analysis.

Ward Carstairs scores were ranked from least deprived to most deprived and then divided into fifths (quintiles), tenths (deciles) and twentieths,

based on ward population size, so that each deprivation category contained approximately the same number of people. Each deprivation twentieth therefore represents five per cent of the population of England and Wales, while the quintiles and deciles represent 20 and 10 per cent of the population respectively. Each ward was thus assigned to one of five deprivation quintiles, one of ten deprivation deciles and one of 20 deprivation twentieths. Mortality data for each ward were aggregated according to these categories.

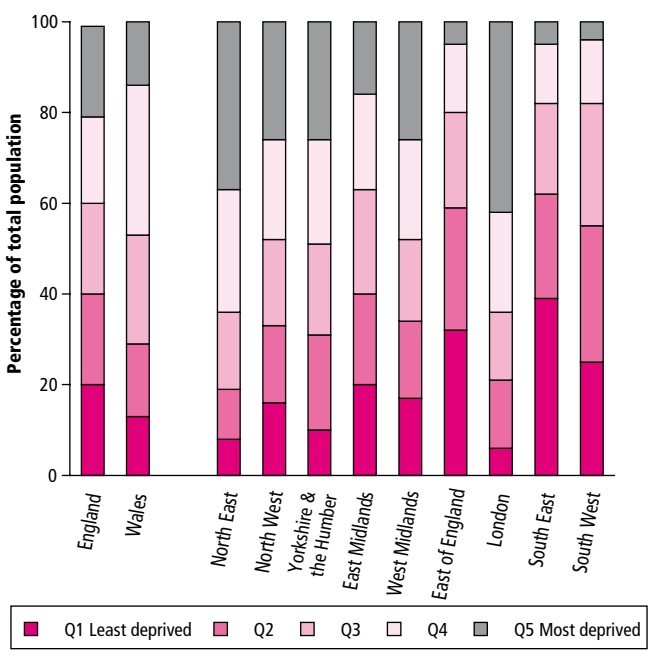
## Populations

The Carstairs scores were divided into quintiles, deciles and twentieths using 2001 experimental population estimates for wards.[28] When these populations were aggregated to deprivation quintiles considerable variation across the English regions and Wales was seen. In London, for example, 42 per cent of the population in 2001 lived in the most deprived fifth of wards while in the South West only 4 per cent lived in this most deprived quintile (Figure 1). The South East and East of England also had less than 10 per cent of their population living in the most deprived fifth of wards. While almost two-fifths of the population of the South East lived in the least deprived quintile of wards, in the North East and London fewer than one in ten people lived in these areas. The East Midlands was the region with a distribution closest to the England and Wales average with around twenty per cent of its population in each deprivation quintile.

One result of these variations is that mortality rates in some quintiles in some regions are based on much smaller populations and numbers of deaths than in others, e.g. Quintile 5 in the South West. This also results in confidence intervals sometimes varying considerably in width for different deprivation quintiles within the same region.

For the calculation of mortality rates the 2001 ward population estimates were aggregated to deprivation twentieths, deciles and quintiles. The 2001 figures were multiplied by five to provide person years at risk for the calculation of mortality rates for 1999–2003. For cause-specific rates for 1999 and 2001–2003 the populations were multiplied by four.

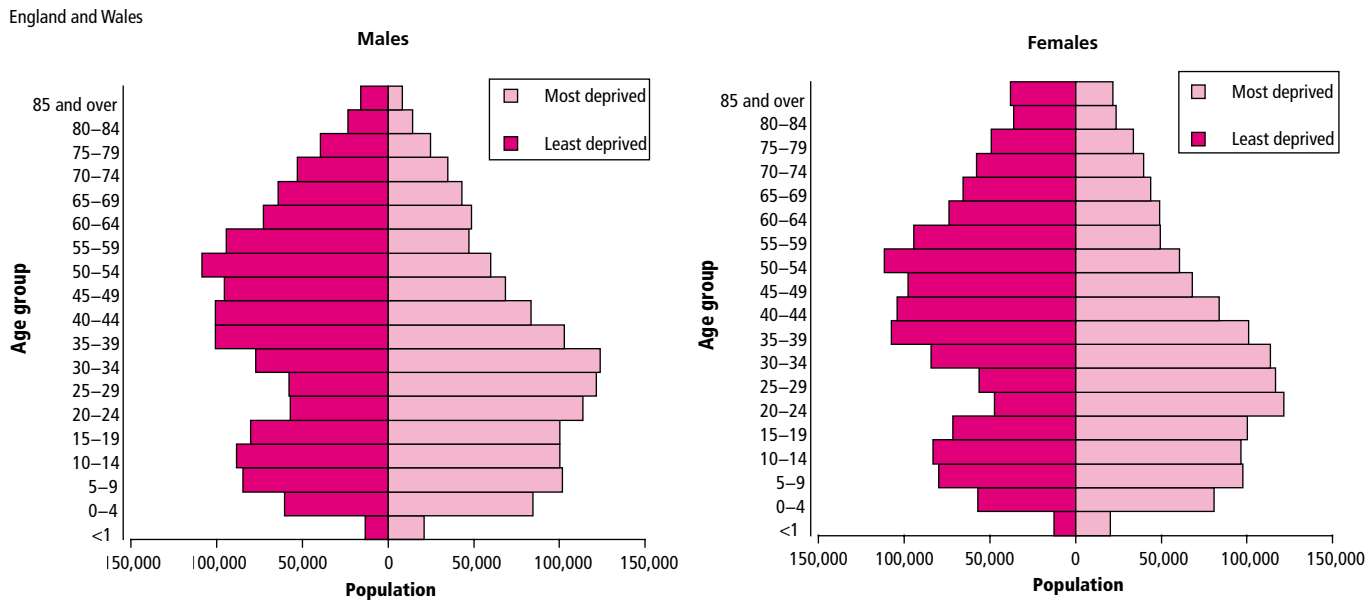
**Figure 1** Distribution of 2001 population by quintiles of Carstairs deprivation scores




## Mortality rates

Directly age-standardised mortality rates were calculated for all the analyses presented in this article. Direct age-standardisation takes into account differences in the age structures of populations meaning that comparisons can be made over time, between areas and between the sexes. Rates in this article were standardised using the European Standard Population.

**Figure 2** 2001 Population distribution by deprivation twentieth



The importance of age-standardising in this analysis can be seen from Figure 2, which illustrates the age structures of the most deprived and least deprived twentieths of the population. The total population of each of these deprivation categories is similar (around 2.6 million) but their age structures are very different, with the most deprived wards having a much younger age distribution. For males, in every age group before age 40 the most deprived wards have a larger population than the least deprived. This pattern reverses from age 40. The picture for females is similar although the least deprived wards have the larger population from age group 35–39 onwards.

### Age groups

For all the causes of death analysed, the relationship between deprivation and mortality was considered at all ages. As previous research has shown that deprivation has a stronger relationship with death rates at younger ages than on the elderly,[6,7,9] many of the causes were also analysed for the age group 15–64 (which was also consistent with earlier ONS analysis[13]). For some causes, where there are only a small proportion of deaths under age 65 (such as prostate cancer and Alzheimer's disease and dementia), the analysis was restricted to deaths at all ages. For deaths from all circulatory diseases and all cancers, where there are government targets to reduce mortality rates in those aged under 75, results were also calculated for the age group 0–74.

### Results presented

Results for all of the age ranges examined (all ages, 15–64, 0–74) are reported only for all causes combined. For specific causes results are included only for selected age groups. Results for England and Wales are presented for all the causes analysed but figures for the English regions and Wales are only included for selected causes. All results calculated in the analysis have however been made available on the National Statistics website at: www.statistics.gov.uk/

Confidence intervals (at the 95 per cent level) were calculated for each death rate and these are also available on the website. Results are presented using deprivation twentieths for England and Wales, and deprivation deciles and quintiles for the English regions and Wales.

Ratios are reported to indicate differentials between mortality rates in the most deprived and least deprived areas. These were calculated by dividing the death rate in the highest deprivation category (most deprived) by the death rate for the lowest category (least deprived).

### Comparisons with earlier data

The Decennial Supplement, *Geographic Variations in Health*, included a deprivation analysis which looked at the relationship between selected causes of death in Great Britain in 1991–1993 with Carstairs scores based on data from the 1991 Census.[13] Only the age group 15–64 was examined. Results were presented for Great Britain using deprivation twentieths and for England, Wales, Scotland and the English regions using deprivation quintiles.

Although this article has examined the causes of death included in the Decennial Supplement, for the same age group, the two sets of results cannot be directly compared to see if there have been absolute changes in mortality rates for deprivation categories. This is because:

1. The Carstairs scores are based on results from two different censuses. As the scores measure relative deprivation at each census they cannot be used to measure absolute changes in deprivation.

2. A deprivation index which was comparable across the countries of the UK was not available in 2001. Analysis for this article was therefore restricted to England and Wales. Results for England and Wales for 1999–2003 cannot be compared with figures for Great Britain for 1991–1993, especially as death rates in Scotland are generally much higher than in the other countries of the UK.

3. The method of aggregating wards into deprivation twentieths and quintiles was not the same in 2001 as in 1991. In the earlier analysis each twentieth or quintile of deprivation was based on 5 or 20 per cent of the total number of wards. In 2001 each deprivation twentieth or quintile instead represents 5 or 20 per cent of the total population of England and Wales. Both methods are valid but we considered that the interpretation of results is more straightforward using the latter approach. This results in each deprivation category in England and Wales having an equal population. The alternative approach creates deprivation categories with equal numbers of wards but varying sizes of population.

4. Cause-specific results will be affected by the change in classification from ICD-9 to ICD-10 in 2001.

Although the geographical distribution of deprived wards was very similar between 1991 and 2001, some wards will have changed deprivation category between these time points and there were also many boundary changes to the wards used in each census.

## Results: All causes of death combined

### England and Wales

For both sexes it is clear that increasing deprivation is associated with higher mortality rates. For deaths at all ages male mortality rates showed a clear linear relationship with deprivation (Figure 3a). As deprivation increased mortality rates were higher (each twentieth represented a rise in mortality rates of between 13 and 60 deaths per 100,000 population). The increases became steeper with the most deprived areas. The death rate among the 5 per cent of the population living in the most deprived wards was 1.7 times higher than for the 5 per cent living in the least deprived areas (1,113 compared to 651 deaths per 100,000 population).

For females, the death rate was 1.5 times higher for those in the most deprived wards compared to those in the least deprived (706 and 479 deaths per 100,000 population respectively) (Figure 3a). The relationship was not quite as straightforward as for males as mortality rates in the least deprived areas remained more similar and did not always increase between deprivation twentieths. As with males the biggest increases in death rates were in the most deprived wards (deprivation twentieths 19 and 20).

In the age group 15–64 the relationship between mortality rates and deprivation was even more pronounced than for all ages (Figure 3b). For men there was still a strong positive relationship with rates, which increased particularly sharply in the most deprived areas. Men in the most deprived twentieth of wards had a death rate which, at 543 deaths per 100,000 population, was 2.8 times higher than the rate in the least deprived wards (196 deaths per 100,000). For women the relationship with deprivation was also stronger at ages 15–64 than at all ages. Rates were higher in each successive deprivation twentieth with steepest increases in the more deprived areas. The death rate for women in the most deprived wards was 2.1 times the rate in the least deprived wards (280 and 132 deaths per 100,000 respectively).

Although absolute comparisons of rates for 1999–2003 with those previously published by ONS for 1991–1993 cannot be made, the relative pattern of the relationship between mortality and deprivation appeared generally similar between the two time periods.

**Figure 3a** Age-standardised death rates for all causes of death by deprivation twentieth, all ages, 1999–2003

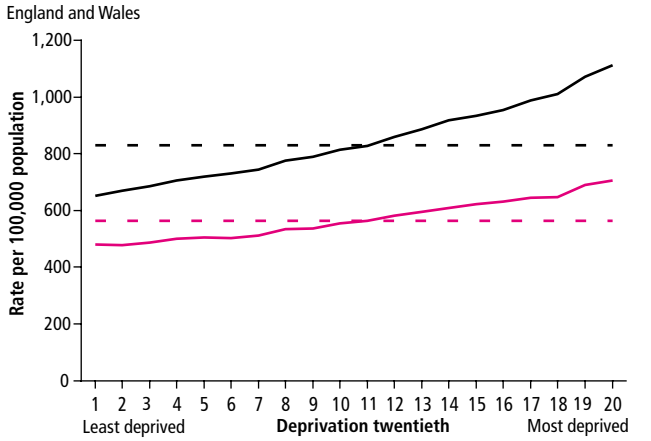



**Figure 3b** Age-standardised death rates for all causes of death by deprivation twentieth, ages 15–64, 1999–2003

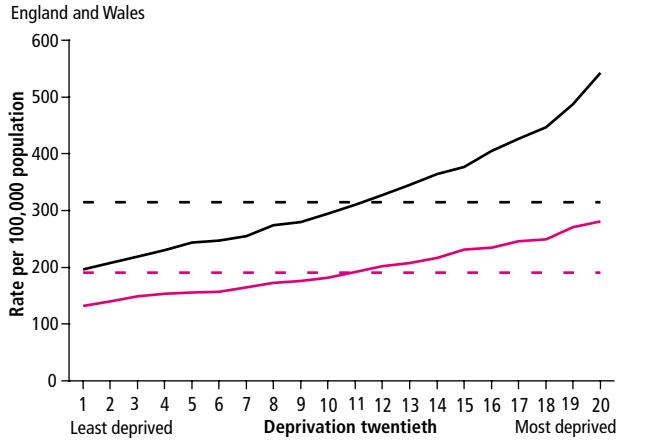
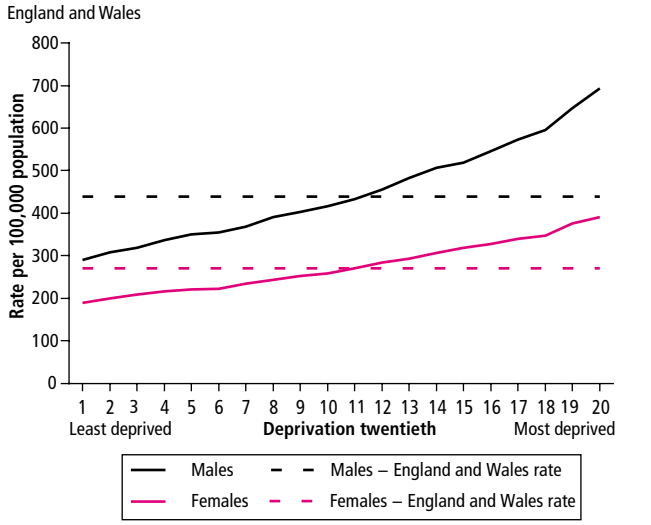



**Figure 3c** Age-standardised death rates for all causes of death by deprivation twentieth, ages 0–74, 1999–2003




The results for the age group 0–74 (Figure 3c) appear as a slightly attenuated version of those for ages 15–64. The ratio between death rates in the most and least deprived wards was also 2.1 for females, but was slightly less for males (2.4 rather than 2.8).

The results presented in Figure 3 also show that differences in mortality rates between the sexes are greater in more deprived areas than in less deprived areas. In the age group 15–64, for example, the death rate for men in the most deprived twentieth was almost twice the rate for women. In the least deprived twentieth the death rate for men was only one and a half times higher than the rate for women.

## English regions and Wales

To compare differences in mortality by deprivation to differences in mortality by geographical region, death rates for Government Office Regions in England, and for Wales, were calculated for 1999–2003. In Figure 4a these rates are presented ranked in order of male mortality rates. Male rates for all ages were lowest in the South West and highest in the North East (748 and 935 deaths per 100,000 population respectively). These areas also had the lowest and highest rates for females – 510 and 634 deaths per 100,000. The South East and East of England also had low mortality rates and rates in the North West were almost as high as in the North East.

The results for these ten areas can be compared to death rates calculated for ten deprivation categories. Male all age death rates for all causes ranged from 660 deaths per 100,000 population for the tenth of the population living in the least deprived wards to 1,092 per 100,000 for the ten per cent in the most deprived wards (Figure 4b). For females, death rates by deprivation decile ranged from 479 to 697 per 100,000 population. These differences were therefore greater than those seen in the geographical variation between the English regions and Wales. For males, the death rate in the region with the highest mortality was 1.3 times higher than in the region with the lowest death rate, but the rate for the tenth of the population living in the most deprived wards was 1.7 times higher than the rate for the tenth of the population living in the least deprived wards. The rate for females in the region with the highest mortality was 1.2 times higher than in the region with the lowest rate, while the rate in the most deprived deprivation decile was 1.5 times higher than in the least deprived.

Differences in mortality rates between the sexes were also more pronounced in the results for deprivation deciles than in those for regions. For all causes combined, male all age death rates were around one and a half times higher than female death rates in all the English regions and Wales (ratios ranged from 1.47 to 1.50). With the deprivation deciles the ratio between male and female death rates increased with deprivation. Ratios ranged from 1.38 in Decile 1 to 1.57 in Decile 10.

For males, each English region and Wales had a similar pattern with a strong gradient of rising all age mortality rates with increasing deprivation (Figure 5). Rates in the least deprived fifth of wards varied relatively little between areas (from 649 deaths per 100,000 population in the South West to 712 deaths per 100,000 in the North West). There was more variation in death rates in the most deprived areas (Quintile 5): the North West and London had the highest and lowest rates (1,156 and 959 deaths per 100,000 respectively).

Geographical patterns for females were broadly similar to those for males, with increasing mortality rates with increasing deprivation (Figure 5). As with males, there was relatively little geographical variation in death rates among those living in the least deprived wards but in the most deprived wards rates varied more, ranging from 605 deaths per 100,000 in London to 756 deaths per 100,000 in the North West.

**Figure 4a** Age-standardised death rates all ages, 1999–2003

Government Office Regions of England, and Wales

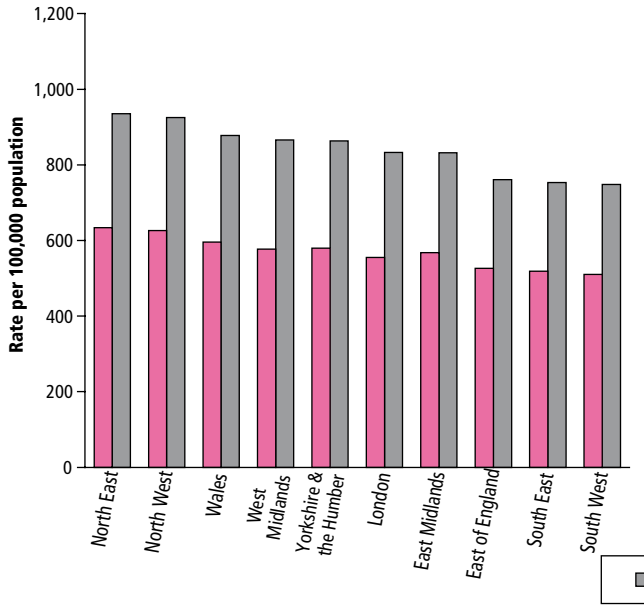
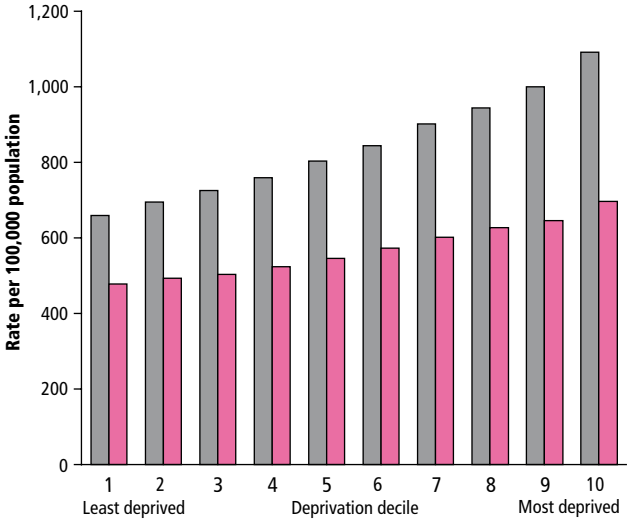



**Figure 4b** Age-standardised death rates by deprivation decile, 1999–2003

England and Wales

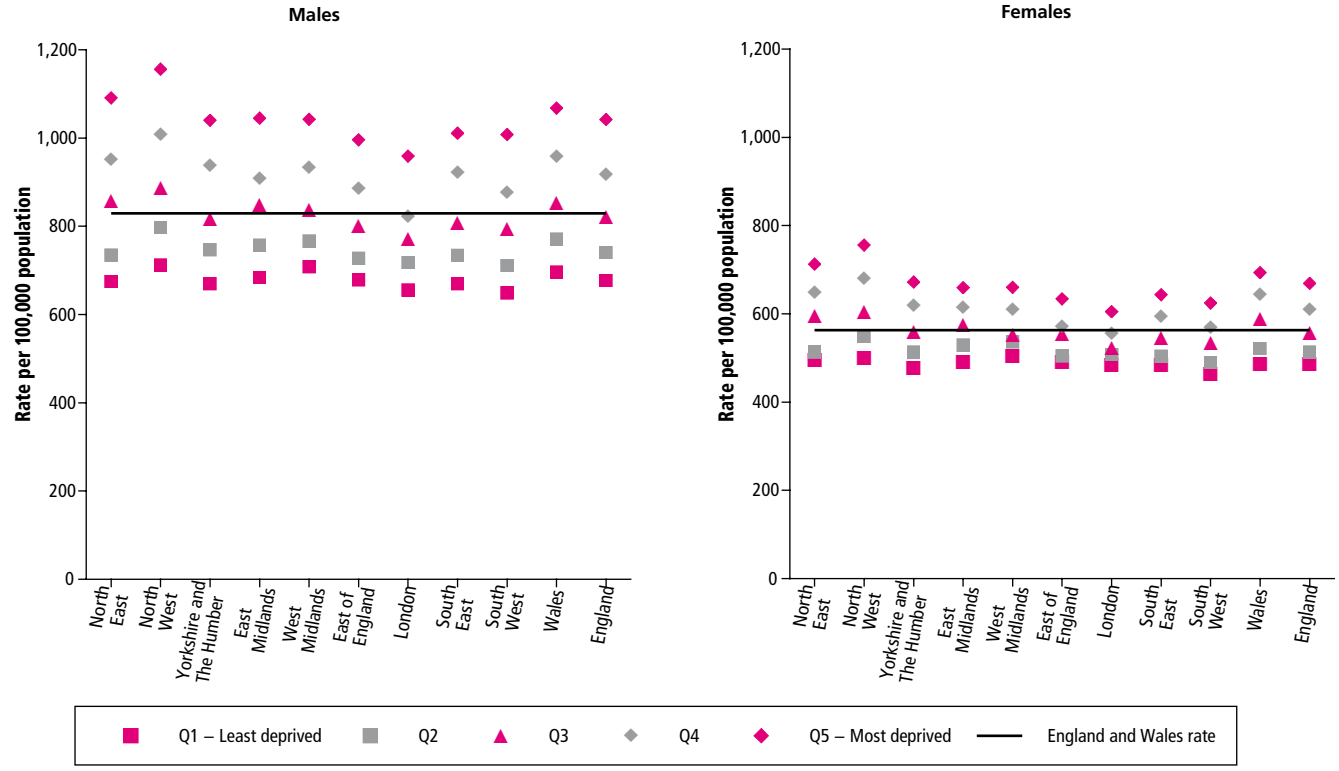



The North West had the highest death rates in every deprivation category for both sexes. The North East and Wales had the next highest death rates in the most deprived two quintiles for both sexes. London had the lowest death rates for both sexes in Quintiles 3, 4 and 5.

These geographical patterns are not completely consistent with the familiar north/south divide in mortality rates seen in Figure 4a. The North West and North East generally did have the highest mortality rates in the more deprived quintiles but in the least deprived quintile there was far

**Figure 5** Age-standardised death rates, all causes by sex and deprivation quintile, all ages, 1999–2003

Government Office Regions of England, and Wales



less geographical variation and rates in these regions were similar to, or even lower than, rates in other areas.

Results are particularly interesting for London as for both sexes it had the lowest, or almost the lowest, death rates in each deprivation quintile of all the English regions and Wales. Overall mortality rates though, as illustrated in Figure 4a, show that death rates in London were higher than in the other southern regions of England: the South East, South West and East of England. This pattern differs from earlier ONS results for 1991–1993.[13] In that period male all cause death rates for the age group 15–64 were higher in London for Quintile 5 than in the South East, South West and East of England. Female rates in all four regions in Quintile 5 were similar. In 1999–2003 death rates in London for those aged 15–64 were lower than in all other regions for both sexes in the three most deprived deprivation quintiles.

## Results: All Circulatory Diseases

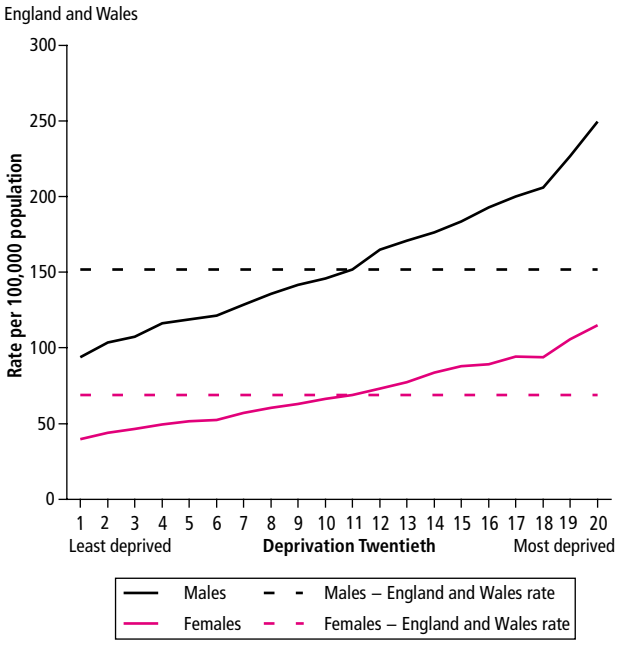
Mortality rates for all circulatory diseases were calculated for all three age groups but are presented here for 0- to 74-year-olds only. This is the age range used in the Government target to reduce circulatory disease death rates by two-fifths by 2010.[29]

In England and Wales there was a strong positive relationship between circulatory disease death rates and deprivation for both males and females (Figure 6 and Table 1). For both sexes the gradients increased particularly sharply in the most deprived areas (deprivation twentieths 19 and 20). For females, the death rate in the most deprived twentieth was almost three times higher than in the least deprived twentieth. For males the rate was 2.7 times higher.

The relationship between mortality and deprivation was also seen in the results for English regions and Wales. For both sexes, all areas had death rates from circulatory diseases which increased with deprivation (Table 2). For females, death rates in Quintile 5 were more than double

**Figure 6**

**Age-standardised death rates for all circulatory diseases by deprivation twentieth, ages 0–74, 1999 and 2001–2003**




rates in Quintile 1 in every English region and Wales. This was also the case for males, except in Wales and the East of England where the ratios between rates in the most and least deprived quintiles were both 1.9.

Regional patterns were similar to those for all causes, with more variation in rates in Quintile 5 than in Quintile 1. The lowest rates for each quintile were generally in London while the highest rates, at least for the more deprived quintiles, were in Wales, the North East and North West.

**Table 1**

**Age-standardised death rates for circulatory diseases by deprivation twentieth, sex and age group, 1999–2003**

England and Wales

Rate per 100,000 population

| | Deprivation twentieth | | | | | | | | | | | | | | | | | | | | England and Wales rate | Ratio[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Least deprived | | | | | | | | | | | | | | | | | | | Most deprived | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | | |
| All circulatory diseases, ages 0–74[1] | | | | | | | | | | | | | | | | | | | | | | |
| Males | 93.7 | 103.6 | 107.5 | 116.2 | 118.9 | 121.5 | 128.6 | 135.6 | 141.5 | 145.8 | 151.7 | 164.8 | 171.1 | 176.5 | 183.7 | 192.7 | 200.3 | 205.9 | 226.9 | 249.8 | *152* | *2.7* |
| Females | 39.8 | 43.9 | 46.6 | 49.6 | 51.6 | 52.2 | 56.9 | 60.3 | 62.8 | 66.3 | 68.7 | 73.2 | 77.5 | 83.6 | 88.1 | 89.4 | 94.1 | 94.0 | 105.9 | 115.0 | *68.8* | *2.9* |
| Ischaemic heart disease, ages 15–64[2] | | | | | | | | | | | | | | | | | | | | | | |
| Males | 35.4 | 40.4 | 42.3 | 48.1 | 48.5 | 50.1 | 52.1 | 57.7 | 60.4 | 62.2 | 66.5 | 73.6 | 74.6 | 80.2 | 82.7 | 89.8 | 93.3 | 97.5 | 108.1 | 123.4 | *66.5* | *3.5* |
| Females | 6.7 | 8.1 | 10.0 | 10.8 | 10.8 | 10.8 | 12.6 | 13.4 | 14.5 | 15.4 | 17.5 | 19.1 | 18.9 | 21.5 | 24.0 | 25.0 | 26.4 | 26.7 | 33.0 | 36.9 | *17.1* | *5.5* |
| Stroke, all ages[1] | | | | | | | | | | | | | | | | | | | | | | |
| Males | 62.5 | 62.3 | 60.8 | 63.9 | 63.2 | 64.6 | 65.9 | 66.1 | 67.0 | 69.2 | 71.6 | 71.4 | 71.6 | 71.7 | 74.8 | 76.3 | 77.3 | 77.9 | 84.2 | 91.4 | *69.9* | *1.5* |
| Females | 61.3 | 57.8 | 59.9 | 60.2 | 59.9 | 60.2 | 57.1 | 61.6 | 60.8 | 62.5 | 63.0 | 64.2 | 63.5 | 64.9 | 67.2 | 66.5 | 64.6 | 65.3 | 70.3 | 69.3 | *62.7* | *1.1* |
| Stroke, ages 15–64[1] | | | | | | | | | | | | | | | | | | | | | | |
| Males | 7.9 | 8.8 | 8.7 | 9.2 | 10.0 | 10.6 | 11.2 | 11.8 | 11.0 | 13.0 | 13.0 | 14.3 | 14.3 | 14.7 | 16.2 | 18.6 | 19.3 | 19.1 | 22.8 | 28.7 | *13.6* | *3.6* |
| Females | 6.4 | 6.3 | 7.3 | 8.0 | 7.4 | 8.2 | 8.5 | 9.6 | 9.9 | 9.8 | 10.4 | 10.0 | 11.2 | 12.2 | 14.1 | 14.0 | 14.3 | 15.3 | 17.4 | 16.8 | *10.5* | *2.6* |

1. 1999 and 2001–2003.
2.1999–2003.
3. Ratio between rates in most deprived and least deprived deprivation twentieths.

**Table 2** **Age-standardised death rates for all circulatory diseases and ischaemic heart disease by deprivation quintile, sex and age group, 1999–2003**

Government Office Regions of England, and Wales — Rate per 100,000 population

| | Males | | | | | | Females | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All circulatory diseases, ages 0–74[1] | | | | | Ratio[3] | All circulatory diseases, ages 0–74[1] | | | | | Ratio[3] |
| | 1 | 2 | 3 | 4 | 5 | | 1 | 2 | 3 | 4 | 5 | |
| North East | 98.5 | 126.3 | 154.8 | 183.1 | 223.2 | *2.3* | 48.3 | 57.6 | 73.0 | 87.7 | 109.0 | *2.3* |
| North West | 116.5 | 144.6 | 168.1 | 203.1 | 250.6 | *2.2* | 49.0 | 64.3 | 77.8 | 96.0 | 116.9 | *2.4* |
| Yorkshire and the Humber | 109.2 | 125.3 | 153.4 | 179.2 | 214.3 | *2.0* | 45.3 | 55.5 | 67.0 | 86.0 | 98.1 | *2.2* |
| East Midlands | 107.0 | 131.3 | 153.4 | 181.1 | 219.0 | *2.0* | 48.0 | 57.1 | 69.1 | 88.8 | 102.6 | *2.1* |
| West Midlands | 109.7 | 130.3 | 155.0 | 184.9 | 223.0 | *2.0* | 46.6 | 57.7 | 68.1 | 86.1 | 103.4 | *2.2* |
| East of England | 106.0 | 120.2 | 141.2 | 167.6 | 201.2 | *1.9* | 44.7 | 52.4 | 64.0 | 73.1 | 92.3 | *2.1* |
| London | 99.9 | 118.4 | 137.1 | 159.0 | 200.8 | *2.0* | 41.1 | 53.9 | 61.0 | 73.2 | 88.2 | *2.1* |
| South East | 100.9 | 123.3 | 146.3 | 176.7 | 210.4 | *2.1* | 43.7 | 54.0 | 65.3 | 82.6 | 93.2 | *2.1* |
| South West | 97.0 | 114.0 | 138.8 | 168.3 | 206.8 | *2.1* | 40.9 | 49.3 | 61.8 | 73.4 | 96.6 | *2.4* |
| Wales | 118.9 | 144.5 | 169.2 | 193.6 | 222.5 | *1.9* | 48.8 | 58.0 | 75.0 | 91.4 | 112.2 | *2.3* |
| England | 104.6 | 125.1 | 149.4 | 179.5 | 219.3 | *2.1* | 44.8 | 55.0 | 67.1 | 83.9 | 101.0 | *2.3* |
| England and Wales rate | *152.0* | | | | | | *68.8* | | | | | |
| | Ischaemic heart disease, ages 15–64[2] | | | | | Ratio[3] | Ischaemic heart disease, ages 15–64[2] | | | | | Ratio[3] |
| | 1 | 2 | 3 | 4 | 5 | | 1 | 2 | 3 | 4 | 5 | |
| North East | 41.5 | 52.8 | 70.0 | 83.6 | 109.1 | *2.6* | 11.0 | 12.1 | 17.9 | 22.8 | 33.1 | *3.0* |
| North West | 47.4 | 62.3 | 72.2 | 93.9 | 124.3 | *2.6* | 10.0 | 14.7 | 19.8 | 27.1 | 37.8 | *3.8* |
| Yorkshire and the Humber | 45.8 | 53.4 | 69.0 | 83.2 | 105.2 | *2.3* | 9.6 | 11.9 | 17.5 | 24.4 | 29.6 | *3.1* |
| East Midlands | 42.4 | 53.8 | 65.3 | 82.9 | 107.5 | *2.5* | 10.2 | 11.8 | 17.2 | 24.0 | 33.8 | *3.3* |
| West Midlands | 43.1 | 51.6 | 69.0 | 82.2 | 109.6 | *2.5* | 9.3 | 11.8 | 16.1 | 24.1 | 32.8 | *3.5* |
| East of England | 43.0 | 47.9 | 61.4 | 75.8 | 91.3 | *2.1* | 8.8 | 11.3 | 15.3 | 18.1 | 20.1 | *2.3* |
| London | 35.8 | 48.5 | 56.5 | 67.4 | 89.9 | *2.5* | 7.7 | 10.6 | 13.2 | 16.1 | 24.0 | *3.1* |
| South East | 37.8 | 50.4 | 63.8 | 80.8 | 95.4 | *2.5* | 8.2 | 12.3 | 15.4 | 21.1 | 25.4 | *3.1* |
| South West | 39.1 | 47.9 | 62.8 | 76.5 | 88.0 | *2.3* | 7.2 | 10.6 | 15.5 | 17.8 | 29.1 | *4.0* |
| Wales | 48.2 | 60.3 | 69.1 | 87.4 | 111.7 | *2.3* | 11.3 | 12.3 | 19.6 | 24.6 | 35.9 | *3.2* |
| England | 41.2 | 51.6 | 65.3 | 81.1 | 104.4 | *2.5* | 8.8 | 11.9 | 16.4 | 22.1 | 30.2 | *3.4* |
| England and Wales rate | *66.5* | | | | | | *17.1* | | | | | |

1. 1999 and 2001–2003.
2. 1999–2003.
3. Ratio between rates in most deprived and least deprived deprivation quintiles.

## Ischaemic heart disease

Death rates for ischaemic heart disease also had a strong positive association with deprivation, which is especially evident in the age group 15–64 (Table 1). As with deaths from all causes and from all circulatory diseases, the gradient of increase in mortality rates with deprivation was particularly steep in the most deprived tenth of the population (deprivation twentieths 19 and 20).

For women aged 15–64, the death rate from ischaemic heart disease in the most deprived wards was 37 per 100,000 population. This was five and a half times higher than the rate in the least deprived wards, however that was from a relatively low base-line of seven deaths per 100,000. The rate for men was three and a half times higher in the most deprived areas.

In all regions, mortality rates for men in Quintile 5 were more than double the rates in Quintile 1, with the biggest ratios in the North East and North West where rates were 2.6 times higher (Table 2). For women, the lowest rate in the most deprived wards was in the East of England (20 deaths per 100,000). This area had the lowest ratio between rates in Quintiles 5 and 1 (2.3). Rates were highest in Quintile 5 in the North West (38 per 100,000) but the ratio between highest and lowest was greatest in the South West where the ischaemic heart disease death rate for 15- to 64-year-olds was four times higher in Quintile 5 than in Quintile 1.

### Stroke

There was a positive association between death rates from stroke and deprivation in England and Wales, although for females the relationship was rather weak at all ages (Table 1). For males, all age death rates increased particularly steeply with the most deprived areas – deprivation twentieths 19 and 20. The death rate from stroke was 1.5 times higher in the most deprived wards compared to the least deprived. For females, death rates actually fell between the 19th and 20th twentieths, although not significantly. The ratio between rates for females in the most and least deprived wards was 1.1.

The relationship between death rates from stroke and deprivation was stronger in the younger age group, 15–64 (Table 1). The male rate for the most deprived wards was over three and a half times higher than that for the least deprived wards. For females the difference was over two and a half times.

Regional results are not presented for deaths from stroke but all regions had a clear gradient of increasing mortality rates with increasing deprivation.

## Results: All cancers

As with circulatory diseases there is a Government target to reduce deaths rates from cancer among the under 75s (by a fifth by 2010),[29] and rates for ages 0–74 are presented here. Rates from cancer increased with deprivation for both males and females (Figure 7 and Table 3). Although rates in the most deprived twentieth were slightly lower than in deprivation category 19 for both sexes, these differences were not significant. The death rate was 1.7 times higher in the most deprived wards for males than in the least deprived wards. The ratio for females was 1.4.

All of the English regions and Wales had cancer mortality rates which increased with deprivation. As with the results for England and Wales, ratios between highest and lowest rates were greater for males than females. For males in the North East and North West, death rates in Quintile 5 were 1.7 times greater than in Quintile 1 (Table 4). In London though the ratio was only 1.4. For females in London and the East of England, rates in Quintile 5 were only 1.2 times higher than in Quintile 1 (Table 4). As with males the biggest differences were in the two northern regions of England where rates were 1.5 times higher in the most deprived wards compared to the least deprived.

**Figure 7** Age-standardised death rates for all cancers by deprivation, ages 0–74, 1999 and 2001–2003

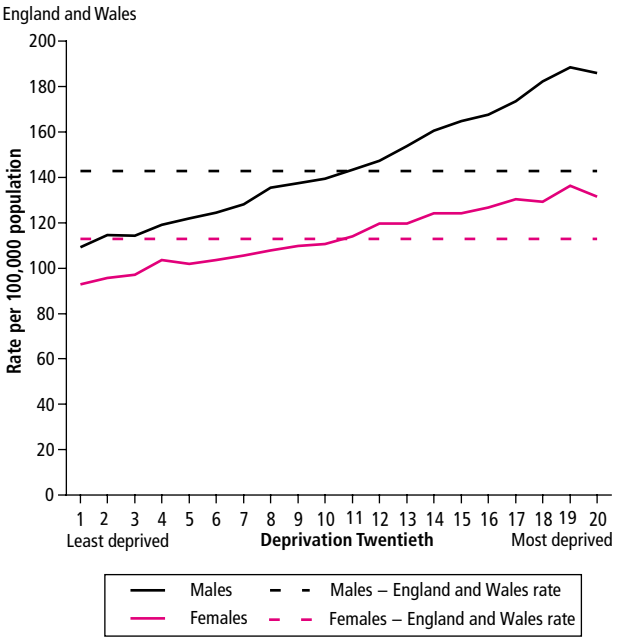



**Table 3** Age-standardised death rates for cancers by deprivation twentieth, sex and age group, 1999 and 2001–2003

England and Wales — Rate per 100,000 population

| | Deprivation twentieth: Least deprived 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | Most deprived 20 | England and Wales rate | Ratio[1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| All cancers, ages 0–74 | | | | | | | | | | | | | | | | | | | | | | |
| Males | 109.1 | 114.6 | 114.4 | 119.1 | 122.0 | 124.5 | 128.1 | 135.5 | 137.5 | 139.5 | 143.5 | 147.4 | 153.7 | 160.5 | 164.7 | 167.7 | 173.5 | 182.2 | 188.6 | 185.9 | *142.7* | *1.7* |
| Females | 92.9 | 95.7 | 97.1 | 103.6 | 102.0 | 103.5 | 105.5 | 107.7 | 109.9 | 110.6 | 114.0 | 119.8 | 119.6 | 124.1 | 124.2 | 126.6 | 130.5 | 129.3 | 136.3 | 131.4 | *112.8* | *1.4* |
| Cancer of the oesophagus, all ages | | | | | | | | | | | | | | | | | | | | | | |
| Males | 10.1 | 11.0 | 11.5 | 11.4 | 12.1 | 12.5 | 13.2 | 12.8 | 11.9 | 13.0 | 13.6 | 14.5 | 14.6 | 14.2 | 14.6 | 14.8 | 15.5 | 14.8 | 15.5 | 13.6 | *13.1* | *1.3* |
| Females | 4.0 | 4.3 | 4.4 | 4.0 | 4.5 | 4.9 | 4.8 | 5.3 | 4.7 | 5.0 | 5.4 | 5.9 | 5.6 | 5.5 | 5.6 | 5.2 | 6.0 | 5.2 | 5.9 | 5.4 | *5.0* | *1.4* |
| Colorectal cancer, all ages | | | | | | | | | | | | | | | | | | | | | | |
| Males | 21.8 | 22.6 | 22.1 | 22.5 | 22.7 | 24.2 | 22.5 | 23.1 | 24.0 | 25.4 | 25.0 | 24.5 | 25.8 | 26.4 | 26.5 | 26.7 | 26.7 | 27.2 | 27.7 | 25.3 | *24.4* | *1.2* |
| Females | 14.4 | 14.1 | 15.0 | 15.1 | 14.7 | 14.6 | 15.4 | 15.2 | 15.4 | 14.6 | 15.3 | 15.8 | 15.4 | 15.2 | 15.3 | 15.4 | 15.1 | 15.4 | 15.3 | 14.6 | *15.1* | *1.0* |
| Lung cancer, all ages | | | | | | | | | | | | | | | | | | | | | | |
| Males | 34.8 | 37.3 | 39.7 | 43.0 | 43.5 | 44.7 | 47.8 | 51.3 | 54.4 | 54.7 | 58.1 | 60.2 | 62.5 | 68.3 | 71.4 | 72.6 | 77.4 | 83.0 | 87.2 | 89.0 | *57.1* | *2.6* |
| Females | 17.1 | 17.8 | 18.5 | 20.7 | 21.0 | 22.2 | 23.6 | 24.5 | 25.7 | 26.0 | 28.4 | 30.3 | 31.0 | 35.3 | 34.9 | 38.0 | 41.3 | 41.9 | 47.6 | 44.6 | *28.6* | *2.6* |
| Lung cancer, ages 15–64 | | | | | | | | | | | | | | | | | | | | | | |
| Males | 11.8 | 14.3 | 13.5 | 16.4 | 16.7 | 17.6 | 17.8 | 21.2 | 21.9 | 23.4 | 24.6 | 27.0 | 26.9 | 29.4 | 31.0 | 33.4 | 34.8 | 38.8 | 42.3 | 43.1 | *24.1* | *3.7* |
| Females | 7.2 | 8.1 | 8.6 | 10.7 | 10.3 | 10.9 | 11.5 | 12.4 | 12.5 | 13.2 | 14.6 | 15.9 | 16.4 | 18.9 | 17.8 | 21.3 | 23.0 | 23.4 | 26.6 | 22.8 | *14.6* | *3.2* |
| Breast cancer, all ages | | | | | | | | | | | | | | | | | | | | | | |
| Females | 30.6 | 30.3 | 30.8 | 32.9 | 30.1 | 30.4 | 30.7 | 31.8 | 30.2 | 30.5 | 30.5 | 32.2 | 29.9 | 30.3 | 32.1 | 29.6 | 30.9 | 29.7 | 30.1 | 29.1 | *30.7* | *1.0* |
| Ovarian cancer, all ages | | | | | | | | | | | | | | | | | | | | | | |
| Females | 10.8 | 10.8 | 11.0 | 11.4 | 11.7 | 11.5 | 11.5 | 11.0 | 11.1 | 12.0 | 11.4 | 11.0 | 11.1 | 11.7 | 11.1 | 11.3 | 10.6 | 10.1 | 9.8 | 9.6 | *11.1* | *0.9* |
| Prostate cancer, all ages | | | | | | | | | | | | | | | | | | | | | | |
| Males | 29.2 | 28.8 | 28.7 | 28.0 | 27.8 | 28.4 | 26.8 | 28.2 | 28.7 | 28.0 | 26.8 | 27.5 | 27.5 | 27.3 | 27.4 | 25.1 | 26.0 | 25.9 | 25.9 | 25.8 | *27.5* | *0.9* |
| Cancer of lymphoid, haematopoietic and related tissue, ages 15–64 | | | | | | | | | | | | | | | | | | | | | | |
| Males | 8.6 | 8.9 | 8.6 | 8.8 | 9.2 | 8.7 | 9.0 | 9.6 | 9.7 | 8.7 | 8.7 | 9.4 | 10.5 | 10.3 | 10.5 | 9.7 | 9.9 | 10.8 | 10.8 | 11.3 | *9.5* | *1.3* |
| Females | 5.5 | 6.1 | 5.1 | 6.1 | 5.7 | 5.4 | 6.7 | 6.9 | 5.8 | 6.1 | 6.3 | 6.7 | 6.7 | 6.1 | 6.6 | 6.1 | 6.4 | 7.1 | 6.6 | 7.1 | *6.2* | *1.3* |

1. Ratio between rates in most deprived and least deprived deprivation twentieths.

**Table 4** **Age-standardised death rates for all cancers and lung cancer by deprivation quintile, sex and age group, 1999 and 2001–2003**

Government Office Regions of England, and Wales — Rate per 100,000 population

| | Males | | | | | | Females | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All cancers, ages 0–74 | | | | | Ratio[1] | All cancers, ages 0–74 | | | | | Ratio[1] |
| | 1 | 2 | 3 | 4 | 5 | | 1 | 2 | 3 | 4 | 5 | |
| North East | 117.7 | 138.9 | 154.5 | 174.4 | 205.2 | *1.7* | 97.5 | 106.7 | 116.8 | 129.5 | 142.4 | *1.5* |
| North West | 121.8 | 135.6 | 153.7 | 179.3 | 205.2 | *1.7* | 100.6 | 110.8 | 122.5 | 133.2 | 151.7 | *1.5* |
| Yorkshire and the Humber | 117.0 | 129.7 | 142.6 | 172.8 | 181.6 | *1.6* | 93.4 | 104.3 | 115.3 | 125.0 | 134.4 | *1.4* |
| East Midlands | 109.5 | 123.3 | 139.5 | 157.0 | 177.5 | *1.6* | 96.6 | 105.1 | 111.6 | 122.9 | 131.1 | *1.4* |
| West Midlands | 114.1 | 126.4 | 143.0 | 160.4 | 178.7 | *1.6* | 95.5 | 102.7 | 111.2 | 122.0 | 122.8 | *1.3* |
| East of England | 112.8 | 125.0 | 137.5 | 148.8 | 166.5 | *1.5* | 97.4 | 105.4 | 111.5 | 115.2 | 116.1 | *1.2* |
| London | 111.6 | 127.8 | 132.7 | 140.1 | 161.2 | *1.4* | 97.2 | 103.9 | 108.8 | 110.8 | 117.5 | *1.2* |
| South East | 115.5 | 124.6 | 143.1 | 160.5 | 174.3 | *1.5* | 98.2 | 104.2 | 114.1 | 127.8 | 130.2 | *1.3* |
| South West | 110.2 | 125.9 | 135.5 | 153.5 | 175.7 | *1.6* | 94.1 | 101.5 | 110.2 | 114.6 | 130.6 | *1.4* |
| Wales | 110.4 | 127.7 | 143.2 | 161.9 | 190.2 | *1.7* | 100.9 | 103.9 | 113.6 | 131.8 | 139.4 | *1.4* |
| England | 114.4 | 127.4 | 141.8 | 161.5 | 181.8 | *1.6* | 97.1 | 104.7 | 113.5 | 122.7 | 131.4 | *1.4* |
| England and Wales rate | *142.7* | | | | | | *112.8* | | | | | |
| | Lung cancer, ages 15–64 | | | | | Ratio[1] | Lung cancer, ages 15–64 | | | | | Ratio[1] |
| | 1 | 2 | 3 | 4 | 5 | | 1 | 2 | 3 | 4 | 5 | |
| North East | 11.2 | 19.5 | 26.0 | 29.5 | 48.6 | *4.3* | 8.5 | 12.1 | 15.5 | 23.0 | 33.2 | *3.9* |
| North West | 15.8 | 21.5 | 28.0 | 35.9 | 47.4 | *3.0* | 8.5 | 12.3 | 16.3 | 22.9 | 31.5 | *3.7* |
| Yorkshire and the Humber | 13.7 | 19.9 | 26.8 | 36.9 | 40.7 | *3.0* | 9.6 | 11.8 | 17.2 | 21.3 | 26.5 | *2.8* |
| East Midlands | 11.1 | 17.2 | 22.0 | 29.5 | 36.7 | *3.3* | 8.3 | 10.6 | 13.0 | 18.0 | 24.9 | *3.0* |
| West Midlands | 14.1 | 17.6 | 25.6 | 30.6 | 38.3 | *2.7* | 8.3 | 9.6 | 12.2 | 16.4 | 19.9 | *2.4* |
| East of England | 13.9 | 16.6 | 23.9 | 24.2 | 34.1 | *2.5* | 9.0 | 12.2 | 15.3 | 14.8 | 17.5 | *1.9* |
| London | 12.9 | 18.7 | 22.1 | 23.8 | 31.6 | *2.4* | 9.0 | 11.8 | 11.6 | 14.9 | 16.2 | *1.8* |
| South East | 14.7 | 18.9 | 23.2 | 33.2 | 42.4 | *2.9* | 8.5 | 11.4 | 14.0 | 18.7 | 23.6 | *2.8* |
| South West | 13.3 | 16.1 | 20.5 | 26.7 | 38.6 | *2.9* | 8.3 | 10.1 | 12.0 | 15.4 | 24.2 | *2.9* |
| Wales | 13.7 | 17.5 | 25.7 | 26.2 | 37.2 | *2.7* | 9.1 | 11.1 | 13.5 | 18.7 | 26.1 | *2.9* |
| England | 14.0 | 18.3 | 24.1 | 30.6 | 39.6 | *2.8* | 8.6 | 11.3 | 14.1 | 18.6 | 23.9 | *2.8* |
| England and Wales rate | *24.1* | | | | | | *14.6* | | | | | |

1. Ratio between rates in most deprived and least deprived deprivation quintiles.

## Cancer of the oesophagus

Although death rates from cancer of the oesophagus generally increased with deprivation the pattern was not as clear as for deaths from all causes or from all cancers (Table 3). For all ages, and for both sexes, rates in the most deprived twentieths were higher than in the least deprived twentieths but rates did not increase consistently with deprivation.

## Colorectal cancer

There was no apparent relationship between female death rates from colorectal cancer and deprivation (Table 3). All age female rates were around 14–15 deaths per 100,000 population in each deprivation twentieth. This pattern was also similar for the 15–64 age group.

Male death rates did increase with deprivation and although these increments were not consistent across deprivation categories, the all age rate in the most deprived wards was 1.2 times higher than that in the least deprived wards (Table 3).

## Lung cancer

Unlike some of the other cancers analysed, lung cancer death rates showed a clear positive association with deprivation (Table 3). The rates for men aged 15–64 generally increased with each deprivation twentieth with particularly big increases in the most deprived categories. The rate in the most deprived twentieth was 3.7 times higher than the rate in the least deprived twentieth. For women, the gradient of increasing lung cancer rates with deprivation was almost as strong as for men, although rates did decrease between deprivation categories 19 and 20. The rate for the most deprived wards was 3.2 times higher than that in the least deprived wards. As the rate was highest in the 19th deprivation category though, the ratio of rates between this twentieth and the least deprived areas was the same as for men (3.7). Ratios between highest and lowest rates were the same (2.6) for both sexes for all ages (Table 3).

All of the English regions and Wales also had a clear pattern of increasing lung cancer death rates with deprivation for both sexes (Table 4). As with all causes and all cancers there was relatively little geographical variation in death rates in the least deprived wards. London and the North East were the areas with the lowest and highest rates for men in Quintile 5 for ages 15–64: 31.6 and 48.6 deaths per 100,000 respectively. The North East consequently had a rate which was 4.3 times higher in Quintile 5 than in Quintile 1, while in London the ratio between highest and lowest was 2.4. The same pattern was also seen for women: the lung cancer death rate in Quintile 5 was 1.8 times that in Quintile 1 in London. In the North East the rate for the most deprived areas was 3.9 times higher than that for the least deprived wards.

## Female breast cancer

There was no relationship between deprivation and death rates for female breast cancer (Table 3). For all ages, rates ranged from 29 to 33 deaths per 100,000 but there were almost no significant differences between deprivation twentieths. There was also no relationship at younger ages, 15–64, nor in the English regions and Wales (data not shown).

The fact that there was no relationship between death rates and deprivation does not however mean that there is no relationship between breast cancer incidence and socio-economic circumstances. This is discussed later in this article in the section, 'Comparisons with other studies'.

### Cancer of the ovary

Death rates for ovarian cancer showed no relationship with deprivation (Table 3). Although rates in the most deprived twentieths were slightly lower than in the least deprived categories these differences were not significant. Death rates for those aged 15–64 also showed no relationship with deprivation.

### Prostate cancer

Death rates from prostate cancer show a slight inverse relationship with deprivation as the all age rate in the most deprived twentieth was statistically significantly lower than in the least deprived twentieth – 25.8 and 29.2 deaths per 100,000 respectively (Table 3).

As with breast cancer, incidence of prostate cancer, and mortality resulting from it, have different relationships with deprivation (see discussion in section on 'Comparisons with other studies').

### Cancer of lymphoid, haematopoietic and related tissue

At younger ages a small positive relationship between deprivation and deaths from these cancers was seen (Table 3). For both sexes, death rates for those aged 15–64 did not increase consistently with deprivation but there was an upward gradient. For both men and women rates in the 20th deprivation category were 1.3 times higher than in the least deprived category. Death rates for all ages though showed a less clear relationship with deprivation.

## Results for other leading causes

### Dementia and Alzheimer's disease

Death rates from Dementia and Alzheimer's disease showed no relationship with deprivation (Table 5). Deaths were only analysed for all ages and although rates varied between deprivation categories most of these variations were not significantly different.

### Respiratory disease

Death rates from respiratory diseases for those aged 15–64 increased with each deprivation twentieth (Table 5). In this age group the death rate for men in the most deprived wards was over five times higher than the rate in the least deprived wards (40.5 and 7.9 deaths per 100,000 respectively). The rate for women was almost four times higher in the 20th deprivation category compared to the least deprived wards. This relationship was attenuated at all ages, but for both sexes rates in the most deprived wards were around double those rates in the least deprived.

Respiratory disease rates for the 15–64 age group increased with each deprivation quintile in each English region and Wales for both sexes. The male rate in Quintile 5 in the North East was five times the rate in Quintile 1 but in London the rate was only 2.8 times higher in Quintile 5 (Table 6). There was similar variation for females: the death rate in London for the most deprived wards was 2.3 times higher than the least deprived. In the North West though the rate in Quintile 5 was 4.8 times higher than the rate in Quintile 1.

**Table 5** **Age-standardised death rates for selected causes by deprivation twentieth, sex and age group, 1999–2003**

England and Wales — Rate per 100,000 population

| | Deprivation twentieth | | | | | | | | | | | | | | | | | | | | England and Wales rate | Ratio[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Least deprived | | | | | | | | | | | | | | | | | | | Most deprived | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | | |
| Alzheimer's disease and dementia, all ages[1] | | | | | | | | | | | | | | | | | | | | | | |
| Males | 15.3 | 15.0 | 14.4 | 15.8 | 14.3 | 15.4 | 14.0 | 15.8 | 13.8 | 17.3 | 15.7 | 15.9 | 15.8 | 16.2 | 13.4 | 16.2 | 17.2 | 16.0 | 17.5 | 15.6 | *15.5* | *1.0* |
| Females | 21.0 | 18.5 | 19.4 | 18.8 | 18.6 | 17.1 | 17.2 | 18.7 | 16.8 | 20.7 | 18.2 | 18.7 | 18.6 | 19.6 | 16.7 | 18.9 | 18.5 | 17.6 | 19.8 | 18.4 | *18.6* | *0.9* |
| Respiratory diseases, ages 15–64[1] | | | | | | | | | | | | | | | | | | | | | | |
| Males | 7.9 | 8.2 | 9.9 | 9.4 | 10.9 | 11.2 | 12.0 | 14.7 | 15.0 | 16.0 | 17.7 | 17.9 | 20.7 | 22.2 | 23.4 | 26.2 | 28.6 | 32.5 | 36.7 | 40.5 | *18.0* | *5.1* |
| Females | 6.4 | 6.4 | 6.6 | 6.7 | 8.6 | 7.4 | 9.7 | 10.2 | 11.6 | 11.2 | 12.8 | 14.6 | 14.6 | 17.0 | 17.6 | 18.8 | 20.2 | 21.7 | 22.7 | 25.2 | *12.8* | *3.9* |
| Accidents, ages 15–64[2] | | | | | | | | | | | | | | | | | | | | | | |
| Males | 18.2 | 18.4 | 20.4 | 20.4 | 20.6 | 19.1 | 19.5 | 19.2 | 18.3 | 20.0 | 21.5 | 20.7 | 23.2 | 23.4 | 22.4 | 25.4 | 26.2 | 25.5 | 28.9 | 29.6 | *21.8* | *1.6* |
| Females | 5.3 | 5.9 | 6.7 | 5.5 | 5.2 | 6.1 | 6.0 | 5.7 | 5.7 | 5.6 | 6.1 | 6.5 | 7.1 | 6.6 | 6.8 | 7.5 | 7.4 | 7.3 | 8.0 | 7.8 | *6.3* | *1.5* |

1. 1999 and 2001–2003.
2. 1999–2003.
3. Ratio between rates in most deprived and least deprived deprivation twentieths.

**Table 6** **Age-standardised death rates for respiratory diseases and accidents by deprivation quintile, sex, ages 15–64,1999–2003**

Government Office Regions of England, and Wales — Rate per 100,000 population

| | Males | | | | | | Females | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Respiratory diseases[1] | | | | | Ratio[3] | Respiratory diseases[1] | | | | | Ratio[3] |
| | 1 | 2 | 3 | 4 | 5 | | 1 | 2 | 3 | 4 | 5 | |
| North East | 117.7 | 138.9 | 154.5 | 174.4 | 205.2 | *1.7* | 97.5 | 106.7 | 116.8 | 129.5 | 142.4 | *1.5* |
| North East | 7.5 | 8.4 | 18.8 | 20.7 | 37.3 | *5.0* | 5.8 | 9.8 | 11.9 | 18.1 | 25.1 | *4.3* |
| North West | 9.6 | 13.5 | 19.3 | 25.4 | 43.3 | *4.5* | 6.2 | 10.9 | 15.5 | 20.9 | 29.8 | *4.8* |
| Yorkshire and the Humber | 7.6 | 11.9 | 16.6 | 24.4 | 29.8 | *3.9* | 6.6 | 9.1 | 12.0 | 18.2 | 22.1 | *3.3* |
| East Midlands | 10.0 | 12.8 | 16.2 | 22.1 | 35.8 | *3.6* | 7.2 | 8.7 | 15.4 | 18.9 | 23.4 | *3.3* |
| West Midlands | 8.2 | 13.1 | 15.4 | 23.6 | 32.9 | *4.0* | 6.3 | 7.8 | 10.0 | 16.4 | 22.3 | *3.5* |
| East of England | 8.2 | 11.7 | 15.6 | 22.3 | 31.7 | *3.9* | 5.8 | 7.9 | 12.5 | 14.7 | 21.7 | *3.7* |
| London | 10.8 | 12.8 | 17.4 | 20.2 | 30.7 | *2.8* | 7.1 | 9.1 | 9.9 | 12.6 | 16.0 | *2.3* |
| South East | 9.2 | 11.9 | 16.0 | 28.1 | 34.3 | *3.7* | 7.4 | 10.1 | 13.8 | 16.2 | 21.2 | *2.9* |
| South West | 7.7 | 11.7 | 15.8 | 20.3 | 35.2 | *4.6* | 5.5 | 7.8 | 10.5 | 12.4 | 22.5 | *4.1* |
| Wales | 9.4 | 11.9 | 16.6 | 22.0 | 27.0 | *2.9* | 5.2 | 8.8 | 12.4 | 19.2 | 23.7 | *4.6* |
| England | 8.8 | 12.2 | 16.6 | 23.2 | 34.6 | *3.9* | 6.5 | 9.0 | 12.5 | 16.7 | 22.2 | *3.4* |
| England and Wales rate | *18.0* | | | | | | *12.8* | | | | | |

| | Males | | | | | |
|---|---|---|---|---|---|---|
| | Accidents[2] | | | | | Ratio[3] |
| | 1 | 2 | 3 | 4 | 5 | |
| North East | 13.1 | 13.8 | 16.5 | 20.5 | 25.1 | *1.9* |
| North West | 19.9 | 18.8 | 22.3 | 27.0 | 35.7 | *1.8* |
| Yorkshire and the Humber | 19.3 | 21.4 | 19.4 | 23.1 | 27.1 | *1.4* |
| East Midlands | 22.1 | 23.0 | 24.0 | 25.9 | 30.5 | *1.4* |
| West Midlands | 19.6 | 19.0 | 18.7 | 22.4 | 24.9 | *1.3* |
| East of England | 21.2 | 22.6 | 22.7 | 26.7 | 34.1 | *1.6* |
| London | 13.0 | 13.5 | 13.9 | 16.7 | 22.5 | *1.7* |
| South East | 18.6 | 20.0 | 20.0 | 23.0 | 27.1 | *1.5* |
| South West | 19.5 | 19.2 | 20.0 | 25.8 | 34.5 | *1.8* |
| Wales | 18.8 | 23.1 | 24.4 | 30.7 | 40.6 | *2.2* |
| England | 19.4 | 19.4 | 19.8 | 22.9 | 27.0 | *1.4* |
| England and Wales rate | *21.8* | | | | | |

1. 1999 and 2001–2003.
2. 1999–2003.
3. Ratio between rates in most deprived and least deprived deprivation quintile.

### Accidents

Death rates from accidents increased with deprivation, particularly for men in the age group 15–64 (Table 5). Rates remained relatively stable until the 10th deprivation category but by the most deprived twentieth the rate was 1.6 times higher than that in the least deprived wards. Death rates for women, which were much lower than for men, appeared to have a weaker association with deprivation and are therefore not presented.

Although all areas had higher death rates for males aged 15–64 in Quintile 5 than Quintile 1 patterns were not as clear as for all causes of death (Table 6). Some regions, such as the North West and the West Midlands, had rates in Quintile 2 which were lower than Quintile 1. Unlike all causes combined, where there was little variation in death rates in the least deprived quintile, for accidents there was considerable regional variation in all quintiles. In Quintile 1 rates ranged from 13.0 deaths per 100,000 population in London to 22.1 deaths per 100,000 in the East Midlands. The rate in Quintile 5 in London (22.5 deaths per 100,000) was only slightly higher than the rate in Quintile 1 in the East Midlands. The highest rate in the most deprived quintile was in Wales (40.6 deaths per 100,000).

The more variable nature of these results could be at least partly due to the relatively small number of deaths involved.

## Discussion

### Summary of main findings

The results presented here reflect those reported in many earlier studies: that people living in more deprived areas have higher mortality rates than those living in less deprived areas. In this analysis this was true for both sexes and for all of the age ranges considered – all ages, 15–64 and 0–74. The all age death rate for males living in the most deprived wards in England and Wales was 1.7 times higher than for males living in the least deprived wards. The female death rate was 1.5 times higher in the most deprived areas than in the least deprived.

The relationship between deprivation and mortality rates was more pronounced at younger ages than for all ages. The death rate for men aged 15–64 in the most deprived wards was 2.8 times the rate in the least deprived wards. The death rate for women in the same age range in the most deprived areas was 2.1 times the rate for those in the least deprived areas.

Of the leading causes of death, mortality rates for both sexes clearly increased with deprivation for circulatory diseases, ischaemic heart disease, stroke, all cancers, lung cancer, respiratory diseases, and accidents. The gradients of increase differed between causes though. The

association with deprivation was less clear for deaths from colorectal cancer and cancers of the oesophagus and lymphoid, haematopoietic and related tissue. Death rates from dementia and Alzheimer's disease and ovarian, breast and prostate cancer either had no association with deprivation or the relationship was slightly inverse.

For deaths from all causes, the relationship between deprivation and mortality rates was stronger for males than females. For deaths from ischaemic heart disease and all circulatory diseases though the gradients of increasing mortality with deprivation were steeper for women. The difference in mortality rates between the sexes generally also increased with deprivation.

For causes where the national results showed a clear gradient of increasing mortality with deprivation this relationship was also observed in the regions of England and Wales. There were however geographical differences in mortality rates between deprivation quintiles. Death rates for those living in the least deprived wards in Quintile 1 showed relatively little variation compared to the more deprived quintiles. Thus the 20 per cent of the population in the least deprived wards of England and Wales tended to have similar mortality rates no matter in which region they were living.

Regional variation increased with deprivation and death rates for the most deprived wards in Quintile 5 were generally highest in the North East and North West. These areas had the biggest differences in mortality rates between the least and most deprived wards. London often had the lowest mortality rates in each deprivation quintile.

The difference in mortality rates between deprivation categories was greater than the geographical variation between rates in the nine English regions and Wales. Death rates for the tenth of the population living in the most deprived wards were 1.7 times higher for males, and 1.5 times higher for females, than rates for the tenth of the population living in the least deprived wards. The ratios between the regions with the highest and lowest mortality rates were 1.3 for males and 1.2 for females.

## Comparisons with other studies

The results reported here generally reflect previous studies which have reported that mortality in more deprived areas is higher than in less deprived areas. The reasons for this have been the subject of much debate, particularly regarding whether deprived areas have higher mortality simply because of the characteristics of the people who live in them, or whether there is an effect of geography over and above the socio-economic condition of the population. It has been reported that the clear positive relationship between mortality and area deprivation disappears, at least for men, once allowance has been made for individual socio-economic circumstances.[30] High mortality thus appears to be the result of personal not community disadvantage. It was later noted though that this study allowed for individual socio-economic factors which were essentially the same as those used to construct the area based deprivation measure, so that there were inevitable strong correlations between the two.[31] It has been argued that area deprivation has an effect on mortality which is independent of personal deprivation as areas can be disadvantaged by factors such as access to transport, shops and leisure facilities and may suffer from environmental pollution and social disorganisation.[31]

Like ours, many studies have shown that the association between deprivation and all cause mortality rates is stronger for males than females[5,6,8,32] and it has been suggested that this may indicate that deprivation could be a stronger proxy for health risk behaviour in men than in women.[5] Our analysis found that while the pattern for many of the leading causes was similar to all causes combined, the reverse was true for ischaemic heart disease and all circulatory diseases. For these causes the gradients of increasing mortality with deprivation were steeper for females than males. This finding was consistent with previous studies,[8,13] and although the reasons for it remain unclear, explanations may lie in the different underlying factors which most affect male and female mortality.

For deaths from all cancers the relationship between mortality and deprivation appeared stronger for males although it has been observed that this effect is partly a result of the distribution of deaths by cancer site between the sexes.[13] For males, lung cancer deaths (which are highly associated with deprivation) make up a higher proportion of all cancers than for females. Deaths from breast cancer, which have no relationship with deprivation, make up a high proportion of all female cancer deaths. The strong positive correlation between lung cancer mortality and deprivation is mirrored in the reported relationship between lung cancer incidence and deprivation.[15] The same is not true for some of the other cancers analysed however. Female breast cancer incidence shows a clear inverse relationship with deprivation. It has been reported that incidence is about 30 per cent higher in the least deprived areas compared to the most deprived.[15] While there appears to be no clear relationship between mortality from breast cancer and deprivation, it has been consistently found that survival rates are higher for women from less deprived areas than for women from more deprived areas.[22] The same is true for prostate cancer where incidence rates have been reported which are 45 per cent higher in the least deprived areas compared to the most deprived.[15] We found though only a rather weak inverse relationship between prostate cancer mortality rates and deprivation.

Our analysis also reflects previous studies which have shown that the effects of deprivation on mortality are seen more clearly at younger ages and are attenuated at older ages.[6,7,9] It has been suggested that this could partly be the result of migration patterns in the elderly, for example when sick people move to nursing homes.[9] Life expectancy figures for wards, published by ONS, have shown that the presence of nursing homes or similar 'medical and care' communal establishments can have a great impact on mortality in small populations.[33] Relatively low life expectancy results were found in some of the least deprived wards where a large proportion of their population had been resident in 'medical and care' communal establishments.

Our study found that the variation in mortality between deprivation deciles was greater than inequalities in death rates between the nine English regions and Wales. This finding is consistent with another recent study in England and Wales.[7] The geographical patterns of mortality by deprivation we identified did not consistently follow the 'north/south' divide in overall mortality illustrated in Figure 4a. While the highest rates in the most deprived quintiles were generally in the northern regions of England, London often had the lowest mortality rates in each deprivation quintile. This was despite the capital having overall mortality rates which were higher than in the other southern regions of England. This appears to be the result of London having such a large proportion of its population living in the most deprived areas. In 2001, 42 per cent of Londoners were resident in wards which were among the fifth of areas in England and Wales with the worst deprivation scores. As this quintile has the highest death rates, overall mortality in London was reduced to a level below that of the other southern regions. This suggests that deprivation therefore at least partly explains the regional pattern of mortality in England and Wales.

Other studies have also reported mortality rates for London that were relatively low in relation to levels of deprivation,[32,34,35] although this effect was not apparent in the analysis undertaken by ONS for 1991–1993.[13] It has been suggested that deprivation indices may tend to overestimate disadvantage in London[35] and our results could support this. It may also indicate that Carstairs scores are a poorer measure of

deprivation in London in 2001 than they had been in earlier censuses. The Carstairs index includes car ownership in its measure of deprivation and it has been suggested that this is less likely to be an indicator of low income in central London (where public transport is highly developed) than in rural areas, where car ownership may be essential for everyday life.[34] Other reasons have been proposed as to why mortality might be low in London relative to deprivation, including a selection process which leads to healthier people being concentrated in the capital.[35] It has also been suggested that there might be a migration effect with old people in ill health leaving London while young healthy people are attracted to the capital by its cultural and financial resources.[32]

Mortality rates in the most deprived areas were generally highest in the North East and North West regions, which other studies have also reported.[8,13] An analysis which used the ONS Longitudinal Study reported that long-term disadvantage was an important predictor of mortality in all English regions and Wales but that the gradients were steeper in the north than the south.[10]

While many studies have described the relationship between deprivation and mortality, fewer have attempted to explain the underlying reasons for the resulting inequalities. One paper that did attempt to address why mortality is higher in poorer areas of England and Wales estimated that of the excess deaths in the most deprived local authorities, about 85 per cent were due to smoking-related diseases.[9] From our analysis of the leading causes of death it is clear that smoking plays a key role in the relationship between deprivation and mortality. Lung cancer, for example, which has a clear association with smoking had death rates which strongly correlated with deprivation. Some deaths from ischaemic heart disease and stroke are also attributed to smoking (particularly at younger ages) as are proportions of deaths from pneumonia and chronic obstructive lung disease (included in the all respiratory disease category).[36] We also found a positive relationship with deprivation for mortality rates from these causes. Causes which have no reported link with smoking, such as cancers of the breast, ovary and prostate[15] either had mortality rates which did not increase with deprivation or the relationship was slightly inverse.

## Limitations

A limitation of all studies which consider mortality using an area based deprivation score, rather than an individual based measure such as Social Class or income, is that the results are subject to the 'ecological fallacy', i.e. the assumption that the population within an area shares the same environmental characteristics. Not everyone who lives in a deprived area is deprived however and not all deprived people live in deprived places. Ecological studies such as this one still have a valid role however in adding to the understanding of health inequalities. It has been argued that ecological information is not a substitute for individual data but provides a means for '…testing for the combined effects of compositional and contextual influences.' [37]

Carstairs and Morris acknowledged that the deprivation scores they had developed were subject to the ecological fallacy but they argued that for an outcome such as mortality, there is an area effect in addition to an individual effect, as measured, for example, by Social Class.[20] They also pointed out that Social Class categories are not themselves homogenous, and are likely to contain people with widely differing occupations and incomes.

The possible limitations of the Carstairs scores for measuring deprivation in London have been noted above but it has also been argued that the index is less valid in rural areas because the experience of deprivation in rural areas is different to urban areas.[35] It has also been reported that rural areas have more heterogeneous populations than urban areas. Thus the effect of deprived people in poor health in rural areas tends to be masked by less deprived healthier people living in the same area.[38]

The analysis we have undertaken was based on the ward of usual residence at the time of death. Migration effects, especially in the elderly, may however mean that people die in areas which may differ substantially from where they lived earlier in life. Such life course effects cannot be accounted for in an analysis like this, nor can the effects of disadvantage in early life which, it has been reported, may be important in predicting mortality from some causes.[39]

The choice of deprivation indicator and means of measuring mortality may also produce different results when considering the relationship between the two. When used for health analysis, different deprivation indices have shown a high degree of correlation[20,21] but cause specific mortality patterns have been shown to depend on the choice of deprivation index,[11] especially when measures of material deprivation were compared to indicators of social fragmentation.

Mortality rates have been reported here using directly age-standardised rates, standardised using the European Standard Population. Age-standardisation was essential as the age structures of the population of the most and least deprived areas were so different (Figure 2). The choice of method, or of the weights used in direct standardisation, may however influence results. As such substantial differences between deprivation categories were reported for many of the leading causes of death it is unlikely though that using a different method of reporting would have radically altered the underlying patterns we have illustrated.

The association between mortality and deprivation has been reported in this article by the presentation of death rates for individual deprivation categories (twentieths for England and Wales and deciles and quintiles for English regions and Wales). This allows the relationship with mortality to be considered across the whole spectrum of deprivation. Ratios have also been presented to indicate differentials between most and least deprived areas, but these may appear more extreme for those causes where mortality rates were low. Other reporting methods, such as correlation coefficients, could be used to give a summary of the gradients of mortality rates by deprivation.

For the results for England and Wales each of the twenty deprivation categories has approximately the same population. In the results for quintiles within English regions and Wales however, population sizes vary between deprivation categories (as illustrated in Figure 1). This means that death rates may be based on very different sized populations, both within region by deprivation quintile, and between regions for equivalent deprivation categories. Confidence intervals have been calculated for these rates (published on the National Statistics website), and can be used to assess whether differences between rates are statistically significant. Other reporting methods, such as the relative slope index of inequality,[40] which takes into account variations in population size of the deprivation categories, could be considered for the future reporting of inequalities in mortality rates.

Carstairs scores have now been calculated using data from three successive censuses. Results in this article indicate that the 2001 index continues to be an effective means of measuring the relationship between deprivation and mortality at national level. Some of the regional results however may indicate that alternative variables should be considered to effectively measure recent material deprivation. Other deprivation indices could be used to examine inequalities in mortality, including the Indices of Multiple Deprivation, if the conceptual and practical challenges their use presents can be overcome.[19]

The question of how much deprivation explains the regional variations in mortality, which have existed for so long in England and Wales, has not been addressed in this study and this debate is likely to continue. A modelling approach could be used to explore the interaction between region and deprivation using more formal statistical methods. This study

has added to the existing literature on the relationship between mortality and deprivation by illustrating recent patterns for the leading causes of death, at both national and regional levels. How these patterns have changed over time, and whether the relationship between deprivation and cause-specific death rates has worsened or improved in recent years, however currently remains unexamined.

## Key findings

- People living in more deprived areas had higher mortality rates than those living in less deprived areas. The all age death rate for males in the most deprived wards in England and Wales was 1.7 times higher than that in the least deprived wards. The female death rate was 1.5 times higher.
- The relationship between deprivation and death rates was stronger at younger ages than for all ages. The death rate for men aged 15-64 in the most deprived wards was 2.8 times the rate in the least deprived wards. For women the rate was 2.1 times higher.
- Mortality rates for both sexes increased with deprivation for all circulatory diseases, ischaemic heart disease, stroke, all cancers, lung cancer, respiratory diseases, and accidents. The relationship with deprivation was less clear for deaths from colorectal cancer and cancers of the oesophagus and lymphoid, haematopoietic and related tissue. Death rates from dementia and Alzheimer's disease and ovarian, breast and prostate cancer either had no correlation with deprivation or the relationship was slightly inverse.
- For all causes of death combined, male mortality rates were higher than for females and this difference between the sexes increased with increasing deprivation.
- The 20 per cent of the population living in the least deprived wards of England and Wales tended to have similar mortality rates no matter in which region they were living.
- Death rates for those living in the most deprived fifth of wards were generally highest in the North East and North West. These areas had the biggest differences in mortality rates between the least and most deprived wards. London often had the lowest mortality rates in each deprivation quintile.
- The difference in mortality rates between deprivation deciles was greater than the geographical variation in death rates between the nine English regions and Wales.

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