Why is mortality higher in poorer areas and in more northern areas of England and Wales?

M R Law, J K Morris

Abstract

***Study objective*—To identify and quantify the factors responsible for the differences in mortality between affluent and deprived areas, the north and the south, and urban and rural areas in England and Wales.**

***Design*—A multiple Poisson regression analysis of cause specific mortality in the 403 local authority districts, each classified by deprivation (using the Jarman Index), latitude (from 50° to 55° north) and urbanisation, adjusting for age, sex, and proportion of ethnic minorities.**

***Setting*—England and Wales 1992.**

***Main results*—All cause mortality was 15% higher in the districts comprising the most compared with the least deprived tenth of the population, 23% higher in the most northern (55°) than in the most southern (50°) districts, and 4% higher in metropolitan (within large cities) than rural districts. Nationally these differences were associated with 40 000, 65 000, and 15 000 excess deaths respectively. More than two thirds of the overall excess mortality with deprivation, latitude, and urbanisation was from three diseases—ischaemic heart disease, lung cancer, and chronic bronchitis and emphysema. The excess mortality from these and other diseases closely matched that predicted from differences according to deprivation and latitude in smoking, heavy alcohol consumption, *Helicobacter pylori* infection, and temperature, and thus could be attributed to these causes. About 85% of the overall excess mortality with deprivation was attributable to heavier smoking and 6% to heavier alcohol consumption, but diet varied little. Deaths more directly related to deprivation (such as those caused by *H pylori* infection, drug misuse, psychoses) accounted for an estimated 12% of the excess deaths, but variation in provision and uptake of healthcare services only 1%. The direct effects of deprivation are more strongly related to morbidity than mortality. Of the difference in mortality with latitude, about 45% was attributable to differences in smoking, and 25% to climate (mainly the association of cardiovascular and respiratory disease with cold). The differences with urbanisation were mainly because of smoking.**

***Conclusions*—Differences in the prevalence of smoking account for much of the variation in mortality between areas. Alcohol accounts for some, diet little. The more direct material effect of deprivation contributes to the variation in mortality but is particularly important with respect to differences in morbidity.**

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Department of Environmental and Preventive Medicine, Wolfson Institute of Preventive Medicine, St Bartholomew's and the Royal London, School of Medicine and Dentistry, Charterhouse Square, London EC1M 6BQ

Correspondence to:
Dr Law.

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Social and economic inequalities are associated with differences in health,[1 2] and more deprived areas have higher death rates.[3–8] The inequality in the distribution of wealth,[9 10] and the inequality in mortality between rich and poor areas and rich and poor people,[11–13] have increased. The relation of poverty to poor health and high mortality is partly indirect, caused by associated differences in smoking and other "behavioural" factors, and partly related directly to the environment of poorer people[1–4]: the incidence of tuberculosis for example is strongly associated with overcrowding and increased between 1988 and 1992 in poorer districts but not in more affluent districts.[14] Variation in levels of health care provision may also contribute to the differences in mortality between areas.[15 16] In this paper we aim to quantify the differences in cause specific mortality between rich and poor areas, and the relative importance of the various factors responsible.

Mortality is higher in the north of England than the south independently of deprivation (the "north-south divide")[17] and we also quantify the reasons for this. In addition we examine mortality differences between urban and rural areas.[18]

The approach we have adopted is, for factors recognised to cause disease (such as smoking, alcohol consumption, diet, cold temperature, *Helicobacter pylori* infection), to determine the size of the relation with cause specific mortality from published data, to determine the differences in these factors between rich and poor areas or northern and southern areas from published data, and to predict differences in cause specific mortality between groups of districts attributable to the differences in each factor in turn. The extent to which the overall difference in mortality can be accounted for is then determined. This approach favours factors that can be quantified and measured (such as those listed above). Stress and certain other factors may differ on average between rich and poor districts, and may increase mortality, but cannot easily be measured; their importance must be assessed indirectly from the differences in mortality that are not explained by the factors that can.

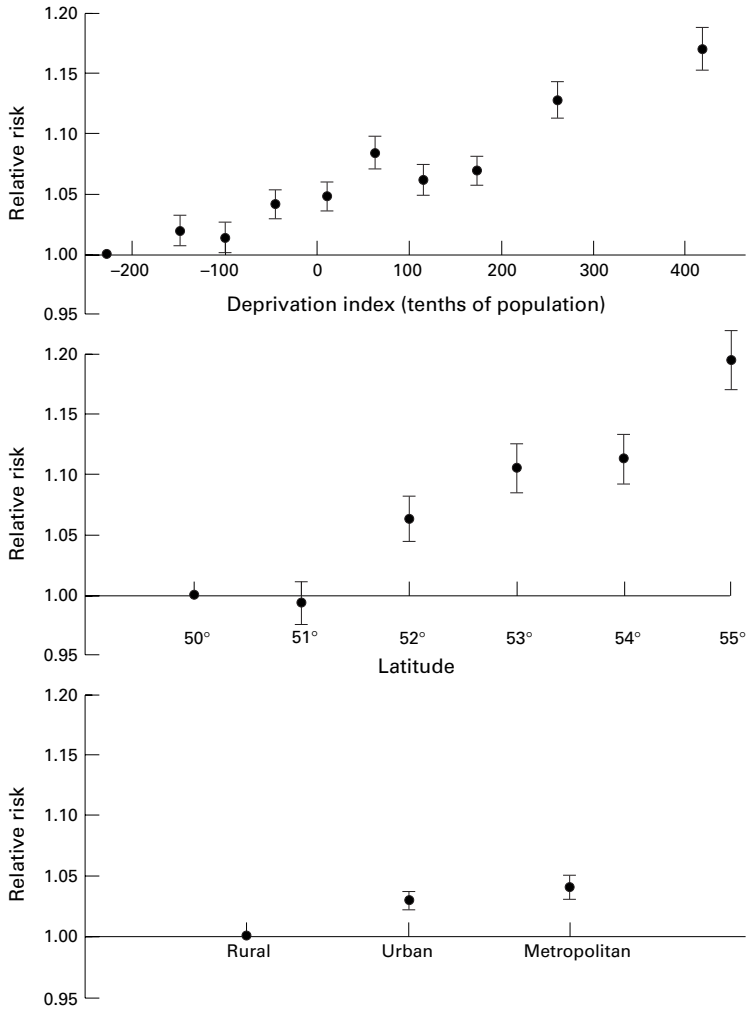

Figure 1 All cause mortality in 403 local authority districts in England and Wales according to deprivation, latitude, and urbanisation, showing risk (95% confidence intervals) in each group of districts relative to that in the lowest group.

Methods

We used computerised data supplied by the Office of National Statistics (ONS) relating to the 403 local authority districts of England and Wales (median population 102 000). We classified the districts according to each of the three factors:

(1) *Socioeconomic deprivation*. We used the Jarman Index,[19] a census-based index of the degree of deprivation of an area (three such indices are commonly used, they are similar in their correlation with mortality[5]). Scores for the 403 districts were provided by Professor Jarman, derived by combining 10 items of data from the 1991 census on poor quality housing, overcrowding, population mobility, and low income groups (unemployed and low social class residents, etc).[19] The districts, ranked by these scores, were arranged into 10 groups of similar total population, taking scores of one to 10 from the least to the most deprived tenth of the population.

(2) "*North-south divide*". The line of latitude (in degrees north of the Equator) closest to the majority of the population in each district was determined using an atlas. The districts were divided into six groups, from 50° to 55° latitude (one district at 56° was included with those at 55°).

(3) *Urbanisation.* We used the ONS division of districts into three groups—69 "metropolitan" districts (within large cities—London and the six Metropolitan counties), 224 predominantly urban districts (towns) and 110 predominantly rural. While deprivation and latitude were treated as continuous variables, urbanisation could not as there was not a suitable marker of its extent; it was treated as a categorical variable with separate metropolitan-rural and urban-rural comparisons.

CALCULATION OF RISK

In each district we determined by sex and five year age group (over all ages) the number of deaths in 1992 from 44 specific causes. The 44 causes were those that were available by district from ONS and that were certified as responsible for more than 500 deaths in England and Wales in 1992. We adopted three additional categories of all cancers, all circulatory diseases, and all accidents other than those specified separately; the total of 47 categories accounted for 92% of all deaths in 1992. Multiple Poisson regression analyses were performed to estimate the size of the associations of mortality from the 47 causes and all causes with each of deprivation, latitude, and urbanisation. Because the risks of certain diseases in ethnic minorities are different from those in the white population we included as variables in the multiple regression the percentage of residents in each district (from the 1991 census) who were (a) Indian, Pakistani or Bangladeshi and (b) African, Caribbean or "other black". The regression coefficients were expressed as age and sex adjusted relative risks between the two most extreme groupings of districts.

Poisson regression was used in preference to the usual logistic regression.[20] The frequent instances of few or no deaths from specific causes in certain age/sex groups in individual districts often meant that logistic regression models could not be fitted, particularly in analyses involving relatively uncommon diseases. With the more common diseases the two models gave similar estimates of relative risk according to deprivation, latitude, and urbanisation, but the goodness of fit was better (χ^2 smaller) for the Poisson regression models.

PREDICTED ESTIMATES OF RISK BASED ON FOUR EXPOSURES

For diseases associated with four exposures, cigarette smoking, alcohol consumption, *H pylori* infection, and (with latitude) cold climate, the observed values of risk in relation to deprivation and latitude were compared with predicted values. Predicted relative risk was calculated according to the prevalence of the exposure (p_1 in one group of districts, p_2 in another) and its associated relative risk (r in exposed, 1 in unexposed) as: $[p_1r + (1-p_1)1]/[p_2r + (1-p_2)1]$

Age adjusted prevalence data on smoking in the north of England compared with the south, and in manual workers (likely to live in poorer

Table 1 Variation in all cause death rates (1992) between 403 local authority districts

	Relative risk according to*		
	Deprivation	*North-south*	*Urbanisation*
Relative risk (95% CIs) between extreme groups	1.15 (1.13,1.16) (most *v* least deprived 10%)	1.23 (1.21,1.24) (55° *v* 50° latitude)	1.04 (1.03,1.05) (metropolitan *v* rural)
Number of deaths avoided in 1992 (% of all deaths) if all districts had the mortality rates of the best group	40 000 (7)	65 000 (12)	15 000 (3)

*Relative risk for each determinant adjusted for differences in the other two, age, sex, and the proportion of ethnic minorities.

districts) compared with non-manual workers (likely to live in affluent districts) were available for 1972[21] (20 years before the mortality data). Results were similar if more recent prevalence data were used, but we used the earlier data because mortality from smoking related diseases reflects smoking habits of many years previously.[22] For the same reason we used the earliest available data on differences in *H pylori* infection (1978[23]) and alcohol consumption (1980[21]), although the results were similar using more recent data. The prevalence of moderate levels of alcohol consumption varied little according to deprivation or latitude,[21] only the prevalence of high alcohol consumption (≥ 7 units per day) in men varied with deprivation. Predicted differences in mortality were therefore small for all alcohol related diseases except those substantially more common in heavy than moderate drinkers (cirrhosis of the liver[24] and cancers of the mouth and pharynx[25]).

Published estimates of relative risk were used for disease related to smoking,[26] heavy alcohol consumption,[24 25] and *H pylori* infection.[27 28] The risk in a typical smoker in the higher risk group was taken to be 15% greater than that in the lower risk group because of greater cigarette consumption per smoker (about 5–10% greater in non-manual compared with manual workers[21 29]), higher tar yield of cigarette, and younger age at starting smoking. Predicted relative risk estimates for diseases associated with cold climate[30] were calculated using age adjusted estimates of the excess winter mortality in England and Wales (December to March relative to the other eight months).[31]

Table 2 Statistically significant associations between cause specific mortality and socioeconomic deprivation across 403 local authority districts

Cause of death (ICD-9 code)*	*Relative risk† (95% CIs) most v least deprived 10%*	*Excess risk (% of total)*
Less common in deprived districts		
breast cancer (174)	0.92 (0.85,1.00)	−1
senile dementia (290, 331)	0.81 (0.74,0.88)	−3
Parkinson's disease (332)	0.75 (0.65,0.87)	−1
pneumonia (480-6) - age ≥65	0.95 (0.90,1.00)	−1
road traffic accidents (E810-9): vehicle occupants	0.63 (0.52,0.77)	−1
More common in deprived districts		
Cancers		
mouth, pharynx (140-9)	1.60 (1.28,2.02)	1
oesophagus (150)	1.14 (1.01,1.30)	1
stomach (151)	1.43 (1.29,1.59)	4
rectum (154)	1.21 (1.06,1.37)	1
larynx (161)	1.58 (1.14,2.18)	1
lung (162)	1.54 (1.46,1.62)	22
cervix (180)	1.72 (1.37,2.17)	1
kidney (189)	1.31 (1.09,1.57)	1
not specified elsewhere§	1.26 (1.18,1.36)	5
Circulatory diseases		
ischaemic heart disease (410-4)	1.19 (1.16,1.22)	33
stroke (430-8)	1.04 (1.00,1.07)	3
not specified elsewhere ‖	1.10 (1.05,1.16)	4
Other diseases		
diabetes (250)	1.09 (0.98,1.21)‡	1
immune disorders (mainly AIDS) (279)	2.55 (1.61,1.22)	1
psychoses, drug misuse (291−319)	1.36 (1.16,1.59)	2
pneumonia (480-6): age <65	2.11 (1.58,2.82)	2
chronic bronchitis and emphysema (490-2, 494-6)	1.42 (1.34,1.51)	13
peptic ulcer (531-3)	1.12 (0.97,1.29)‡	1
cirrhosis of the liver (571)	1.71 (1.44,2.04)	3
External causes		
road traffic accidents (rta) (E810-9): pedestrians	1.63 (1.27,2.09)	1
falls (E880-8)	1.30 (1.11,1.53)	1
accidents (E800-949) except rta and falls (mainly poisoning, burns and drowning)	1.46 (1.17,1.82)	1
suicide (E950-9, E980-9)	1.44 (1.24,1.67)	2
All other causes	1.09 (1.04,1.14)	2
All causes	1.15 (1.13,1.16)	100 (=40 000 deaths)

*No statistically significant association with cancers of the colon, pancreas, skin, uterus, ovary, prostate, bladder and brain, lymphoma, myeloma, leukaemia, rheumatic heart disease, venous thromboembolism, hernia/intestinal obstruction, chronic renal failure, multiple sclerosis, motor neurone disease, and rheumatoid arthritis. Asthma and hypertensive heart failure showed a significant association under age <65.
†Adjusted for differences in age, sex, latitude, urbanisation, and proportion of ethnic minorities.
‡p=0.10, but statistically significant (p<0.001) under age 65.
§Mainly site unknown or unspecified (159, 199), biliary tract (156), pleura (163).
‖ Mainly heart valve disorders (424), heart failure (428), ill defined heart diseases (429), atherosclerosis (440), ruptured aortic aneurysm (441), and peripheral vascular disease (443).

We took the excess mortality in the north of England compared with the south attributable to the temperature difference to be one third these, because the average temperature difference between the north and south of England throughout 1992 (2.1°C[32]) was one third the average temperature difference in England and Wales between the colder and warmer months (6.3°C[32]).

KEY POINTS

- Mortality is 15% higher in the most deprived than the most affluent districts (40 000 excess deaths).
- Differences in smoking accounts for about 85% of the excess, alcoholism 6%, direct effects of deprivation 12%, but with fewer nursing homes in poor areas there are 10% less deaths.
- Mortality is 23% higher in the north than the south (65 000 excess deaths).
- Smoking accounts for about 45% of these excess deaths, colder climate 25% (or possibly more).
- Mortality is 4% higher in large cities than rural areas (15 000 excess deaths), mainly because of smoking.

Results

All cause mortality increased with deprivation, latitude and urbanisation across the 403 districts (fig 1). It was 15% higher in the districts comprising the most socioeconomically deprived than the most affluent tenth of the population, 23% higher in the most northern (55° latitude) than the most southern (50°) districts, and 4% higher in metropolitan than rural districts ($p<0.001$). If death rates in all districts had been reduced to those in the lowest group there would have been 40 000, 65 000, and 15 000 fewer deaths respectively (table 1).

DISEASES RESPONSIBLE FOR THE MORTALITY DIFFERENCES

Table 2 shows the differences in cause specific mortality according to deprivation. The relative risks are first shown—the ratio of mortality in the most deprived to the most affluent tenth of the population as estimated from the linear regression. Absolute excess risk is then shown, as the percentage of the total of 40 000 excess deaths (table 1) attributable to each specific cause of death. Deprivation was statistically significantly associated, positively or negatively, with 27 of the 47 causes of death examined. However, three of these, ischaemic heart disease, lung cancer and chronic bronchitis and emphysema, were responsible for 68% of the excess deaths but only 37% of all deaths.

Table 3 shows data relating to the "north-south divide". Latitude was significantly associated with 21 causes of death. The same three diseases (ischaemic heart disease, lung cancer, chronic bronchitis and emphysema) were responsible for 73% of the 65 000 excess deaths, and stroke was responsible for 15%. Urbanisation (table 4) was significantly associated with 19 causes of death, but again the above three diseases accounted for most of the excess deaths.

VARIATION IN EXCESS MORTALITY WITH AGE

The strength of the association between all cause mortality and deprivation varied with

Table 3 Statistically significant associations between cause specific mortality and latitude across 403 local authority districts

Cause of death (ICD-9 code if not in table 2)*	*Relative risk† (95% CIs) 55° v 50°*	*Excess risk (% of total)*
Less common in northern districts		
skin cancer (172-3)	0.66 (0.53,0.81)	−0.4
breast cancer	0.93 (0.86,1.00)	−1
prostate cancer (185)	0.86 (0.79,0.94)	−1
immune disorders (mainly AIDS)	0.24 (0.15,0.38)	−0.3
venous thromboembolism (451-3)	0.77 (0.65,0.93)	−0.4
pneumonia (480-6): age <65	0.78 (0.60,1.00)	−0.1
More common in northern districts		
Cancers		
mouth, pharynx	1.31 (1.07,1.60)	0.4
stomach	1.42 (1.29,1.55)	2
rectum	1.18 (1.06,1.32)	1
larynx	1.47 (1.12,1.95)	0.3
lung	1.31 (1.25,1.37)	8
kidney	1.23 (1.05,1.45)	0.4
not specified elsewhere (mainly site unknown)	1.18 (1.10,1.25)	2
Circulatory diseases		
ischaemic heart disease	1.46 (1.43,1.49)	50
stroke	1.30 (1.26,1.35)	15
Other diseases		
senile dementia	1.35 (1.25,1.46)	3
pneumonia: age ≥65	1.11 (1.05,1.17)	2
chronic bronchitis and emphysema	1.66 (1.58,1.75)	13
chronic renal failure (580-9)	1.44 (1.20,1.72)	1
External causes		
road traffic accidents:		
vehicle occupants	1.60 (1.35,1.90)	1
pedestrians	1.39 (1.11,1.74)	0.5
falls	1.64 (1.42,1.90)	1
All other causes	1.13 (1.09,1.18)	5
All causes	1.23 (1.21,1.24)	100 (=65 000 deaths)

*No statistically significant association with the remaining 26 causes of death (table 2).
†Adjusted for differences in age, sex, deprivation, urbanisation, and proportion of ethnic minorities.

Table 4 Statistically significant associations between cause specific mortality and urbanisation across 403 local authority districts

Cause of death (ICD-9 code if not in table 2)*	*Relative risk† (95% CIs) metropolitan v rural*	*Excess risk (% of total)*
Less common in urban districts		
uterine cancer (179, 182)	0.77 (0.64,0.94)	−1
stroke	0.97 (0.94,0.99)	−9
diabetes	0.92 (0.85,1.00)	−3
senile dementia	0.89 (0.83,0.95)	−6
multiple sclerosis (340)	0.64 (0.49,0.82)	−1
chronic renal failure (580-9)	0.86 (0.74,1.00)	−1
External causes		
road traffic accidents (rta):		
vehicle occupants	0.47 (0.41,0.54)	−6
falls	0.83 (0.73,0.95)	−2
accidents except rta and falls (mainly poisoning, burns, and drowning)	0.85 (0.74,0.97)	−1
suicide	0.79 (0.71,0.89)	−4
More common in urban districts		
Cancers		
stomach	1.15 (1.06,1.24)	5
pancreas (157)	1.14 (1.04,1.25)	4
lung	1.21 (1.16,1.36)	30
Circulatory diseases		
ischaemic heart disease	1.05 (1.03,1.07)	31
Other diseases		
Parkinson's disease	1.15 (1.03,1.30)	3
chronic bronchitis and emphysema	1.28 (1.23,1.34)	32
pneumonia: (age ⩾65)	1.21 (1.16,1.27)	25
cirrhosis of the liver	1.23 (1.07,1.41)	3
peptic ulcer	1.15 (1.03,1.29)	3
All causes	1.04 (1.03,1.05)	100 (=15 000 deaths)

*No statistically significant association with the remaining 28 causes of death (table 2).
†Adjusted for differences in age, sex, deprivation, latitude, and proportion of ethnic minority residents.

age. The relative risk was 1.54 (95% confidence intervals 1.50, 1.59) under age 65 but 1.07 (1.06, 1.09) at aged 65 and over ($p<0.001$). The absolute number of excess deaths was also greater under age 65. Relative risk estimates in deprived compared with affluent districts were statistically significantly greater under than over age 65 for 16 specific causes of death (table 5), including the three diseases responsible for most of the excess mortality over all ages.

The association of all cause mortality with latitude varied much less with age—relative risk 1.27 under age 65 and 1.21 at age 65 and over ($p<0.001$). The association with urbanisation was smaller under the age of 65 (relative risk 1.02) than 65 and over (1.04, $p=0.01$).

Table 5 Associations between cause specific mortality and socioeconomic deprivation across 403 local authority districts that varied in magnitude significantly with age

	Relative risk† (95% CIs) most v least deprived 10%	
Cause of death (ICD-9 code if not in table 2)*	*under age 65*	*age 65 and over*
Cancers		
mouth, pharynx	2.13 (1.44,3.15)	1.37 (1.03,1.82)
larynx	3.20 (1.72,5.95)	1.21 (0.83,1.76)
lung	2.00 (1.80,2.23)	1.42 (1.34,1.51)
Circulatory diseases		
hypertensive heart failure (401-5)	2.24 (1.41,3.57	0.85 (0.71,1.02)
ischaemic heart disease	1.73 (1.63,1.85)	1.11 (1.08,1.14)
stroke	1.70 (1.49,1.95)	0.99 (0.96,1.03)
not specified elsewhere	1.37 (1.16,1.62)	1.08 (1.02,1.13)
Other diseases		
diabetes	2.46 (1.83,3.31)	0.97 (0.86,1.08)
immune disorders (mainly AIDS)	2.88 (1.61, 1.22)	—
psychoses, drug misuse	4.23 (2.90,6.18)	1.07 (0.90,1.27)
pneumonia	2.11 (1.58,2.82)	0.95 (0.90,1.00)
chronic bronchitis and emphysema	2.58 (2.13,3.11)	1.34 (1.26,1.42)
asthma (493)	1.52 (1.04,2.21)	0.95 (0.73,1.25)
peptic ulcer	2.47 (1.51,4.02)	1.03 (0.89,1.20)
cirrhosis of the liver	2.39 (1.89,3.01)	1.11 (0.85,1.44)
falls	1.99 (1.33,2.99)	1.20 (1.00,1.43)
All other causes	1.57 (1.44,1.72)	0.96 (0.92,1.01)
All causes	1.54 (1.50,1.59)	1.07 (1.06,1.09)

*No statistically significant variation for the remaining 33 causes of death (table 2).
†Adjusted for differences in age, sex, latitude, urbanisation, and proportion of ethnic minorities.

FACTORS RESPONSIBLE FOR THE MORTALITY DIFFERENCES

Table 6 shows the predicted estimates of relative risk according to deprivation and latitude attributable to differences in smoking, heavy alcohol consumption, *H pylori* infection, and cold weather. There is remarkably close agreement between the predicted and observed risk estimates, taking the confidence limits of the latter (tables 2 and 3) into account. The exceptions are, for deprivation, significantly lower observed than predicted relative risk estimates for stroke and peptic ulcer, and for latitude, significantly higher observed than predicted values for ischaemic heart disease and stroke, lower for peptic ulcer. But the differences in the four factors account for much of the excess mortality.

The close matching between predicted and observed risk estimates for the four major exposures (table 5) allows the excess mortality from some diseases to be assigned to those exposures (apportioned appropriately when the excess was attributed to more than one). The direct causes of the excess mortality from certain other diseases can be inferred.

Deprivation (table 7)

The excess mortality from smoking related diseases in deprived districts is about 85% of the overall excess. As this excess mortality closely matched that predicted from the differences in smoking (table 6), it can reasonably be attributed to smoking. Similarly, heavy alcohol consumption accounted for about 6% of the overall excess.

Some of the excess mortality can be considered attributable to direct consequences of poverty (whereas smoking related diseases are related only indirectly in that poor people smoke more). Deaths in this category include

Table 6 Predicted estimates of relative risk of diseases according to deprivation and latitude, based on corresponding differences in smoking, heavy alcohol consumption, H pylori infection, and temperature, and observed values of the same relative risks (from tables 2 and 3)

	Predicted relative risk based on				
Deprivation (most v least deprived 10%)	*Smoking (51% v 39%)*	*Heavy* alcohol consumption (15% v 8%)*	*H pylori infection (66% v 45%)*	*All†*	*Observed relative risk*
Cancers					
mouth, pharynx, larynx	1.46	1.17	—	1.71	1.59
stomach	1.16	—	1.30	1.51	1.43
lung	1.44	—	—	1.44	1.54
other smoking related‡	1.23	—	—	1.23	1.24
Circulatory diseases					
ischaemic heart disease	1.20	—	—	1.20	1.19
stroke	1.15	—	—	1.15	1.04
not specified elsewhere	1.15	—	—	1.15	1.10
Other diseases					
chronic bronchitis and emphysema	1.43	—	—	1.43	1.42
peptic ulcer	1.26	—	1.40	1.59	1.12
cirrhosis of the liver	—	1.50	—	1.50	1.71
Latitude (55° v 50°)	*Smoking (49% v 42%)*	*Temperature difference (2°C)*	*H pylori infection (56% v 47%)*	*All†*	
Cancers					
mouth, pharynx, larynx	1.33	—	—	1.33	1.37
stomach	1.13	—	1.13	1.28	1.42
lung	1.31	—	—	1.31	1.31
other smoking related‡	1.16	—	—	1.16	1.18
Circulatory diseases					
ischaemic heart disease	1.16	1.08	—	1.25	1.46
stroke	1.12	1.09	—	1.22	1.30
Other diseases					
pneumonia: age >65	—	1.18	—	1.18	1.11
chronic bronchitis and emphysema	1.31	1.18	—	1.55	1.66
peptic ulcer	1.20	—	1.17	1.40	(1.10)§

*≥7 units/day.
†The combined relative risk is the product of the individual ones (eg 1.14×1.17=1.71).
‡Oesophagus, kidney, site unknown.
§Not statistically significant.

those related to *H pylori* infection (strongly associated with overcrowding in childhood[33]), accidents and suicide, psychoses and drug misuse, and pneumonia under the age of 65 (likely to reflect homelessness, drug misuse, and AIDS). These causes accounted for about 12% of the excess mortality in deprived districts.

Table 7 Estimates of the direct causes of the 40 000 excess deaths in socioeconomically more deprived districts than the most affluent districts

	Excess risk (%)	*Estimate of attributable mortality*
Smoking		
lung cancer	22	
cancers of mouth, pharynx, larynx	1	
stomach cancer	1	
other smoking related cancers	7	
chronic bronchitis and emphysema	13	about 85%
ischaemic heart disease	33	
stroke	3	
circulatory diseases not specified elsewhere	4	
Alcohol		
cirrhosis of the liver,	3	
alcohol related cancers	1	about 6%
accidents/suicide part of	5	
Deprivation/poverty		
psychoses, drug misuse	2	
AIDS	1	
pneumonia (under age 65)	2	
H pylori infection:		about 12%
stomach cancer	3	
peptic ulcer	1	
accidents/suicide part of	5	
Provision and uptake of health care services		
diabetes, hypertensive heart failure, asthma	1	1%
Fewer nursing homes		
senile dementia	−3	
Parkinson's disease	−1	about −10%
pneumonia: age ≥65	−1	
stroke (over age 65) about	−6	
All above causes		about 95%

The excess mortality from diabetes, hypertensive heart failure, and asthma can be attributed to differences in the provision and uptake of health care services, in view of evidence linking mortality from these causes with the quality of health care,[6 15] and evidence of poorer service provision on average in inner city general practices,[34] and of lower use of insulin in diabetics resident in deprived areas.[35] However, these causes accounted for only 1% of the overall excess mortality.

Mortality from senile dementia, Parkinson's disease, and (in persons aged 65 and over) pneumonia was lower in deprived areas, and the excess mortality from stroke was below the value predicted from differences in smoking (table 5). Many patients dying from these diseases have probably suffered a long chronic illness that necessitated moving to a nursing home, and the prevalence of nursing home accommodation in deprived inner city areas is low. The lower mortality from these diseases in deprived areas may be attributable to enforced changes of residence by sick people.[36]

Latitude (table 8)

Smoking accounted for about 45% of the excess mortality according to latitude. Differences in temperature accounted for an estimated 25% of the excess mortality, mainly reflecting higher mortality from circulatory and respiratory diseases with colder climate. About 30% of the excess mortality was not explained, mainly because of failure to account for all the excess from heart disease and stroke.

Table 8 Estimates of the direct causes of the 65 000 excess deaths in more northern than the most southern districts

	Excess risk (%)	*Estimate of attributable mortality*
Smoking		
lung cancer	8	
stomach cancer	1	
other smoking related cancers	3	about 45%
chronic bronchitis and emphysema	8	
ischaemic heart disease	19	
stroke	7	
Climate		
chronic bronchitis and emphysema	5	
pneumonia	2	
ischaemic heart disease	9	
stroke	5	about 25%
fewer skin cancers	−0.4	
accidents	2	
H pylori infection		
stomach cancer	1	1%
All above causes		about 70%

Table 9 Estimates of the direct causes of the 15 000 excess deaths in metropolitan/urban than rural districts

	Excess risk (%)	*Estimate of attributable mortality*
More common in urban districts		
Smoking		
smoking related cancers	32	
chronic bronchitis and emphysema	32	about 95%
ischaemic heart disease	31	
Alcohol		
cirrhosis of the liver	3	3%
Less common in urban districts		
Restricted speed of motor vehicles		
road traffic accidents:vehicle occupants	−9	−9%
Provision and uptake of health care services		
diabetes	−3	−4%
chronic renal failure	−1	
Fewer nursing homes		
stroke	−9	
senile dementia	−6	about −15%
multiple sclerosis	−1	
All above causes		about 70%

Diet accounted for little or none of the variation in mortality with latitude or deprivation. Dietary fat and serum cholesterol, as well as blood pressure, show little or no variation with social class or income, nor between the north or south of England.[37–39] Consumption of fruit and vegetables, or dietary carotenes and vitamin C as markers for these, is a little greater in richer than poorer people, and in the south than the north,[37–39] but given the relation between fruit and vegetable consumption and ischaemic heart disease,[40] the difference in consumption would be associated with an excess heart disease mortality of no more than 1–2%.

Urbanisation (table 9)

Smoking is more prevalent in urban than rural areas,[41] and the greater mortality from lung cancer and chronic bronchitis and emphysema in metropolitan and urban districts indicate a higher prevalence of smoking sufficient to explain the excess mortality from ischaemic heart disease. The lower mortality from stroke, senile dementia, and multiple sclerosis in large cities, like that in deprived areas, is attributed to a relative lack of nursing home accommodation. The excess mortality from diabetes and chronic renal failure in rural areas can be attributable to differences in health care facilities in view of evidence that diabetic patients in rural areas were less likely to attend a hospital diabetic clinic or to receive insulin,[42] and evidence of higher mortality from chronic renal failure in areas remote from hospital renal units.[16] About 30% of the excess mortality was not explained, mainly because of failure to account for the excess mortality from pneumonia in metropolitan and urban districts.

Discussion

Mortality was 15% higher in the most deprived than the most affluent districts, 23% higher in the north than the south, and 4% higher in metropolitan than rural districts. In each case three diseases, ischaemic heart disease, lung cancer, and chronic bronchitis and emphysema (all smoking related) account for most of the excess deaths.

Smoking emerges as by far the single most important factor determining the variation in mortality between districts with respect to deprivation, latitude, and urbanisation. Its effect moreover has if anything been underestimated. An important consideration is the likelihood that a person will stop smoking after the early clinical manifestations of serious diseases—angina or non-fatal infarction with ischaemic heart disease, effort dyspnoea or winter bronchitis with chronic bronchitis and emphysema, or a non-fatal stroke. Poorer people may be less likely to heed these warnings to stop smoking. In a study of smokers who survived myocardial infarction 63% of smokers of higher and 38% of lower educational level ($p=0.02$) stopped smoking.[43] Thus smoking may be more important than we have estimated in explaining the excess mortality in deprived areas. The cohort studies of social class and mortality may also have underestimated the importance of smoking in concluding that differences in smoking accounted for some but not all the variation in mortality from smoking related diseases,[44–48] for the above reason and because these studies generally made no allowance or insufficient allowance for differences according to deprivation in the number of cigarettes smoked by each smoker, tar yield of cigarettes or age of starting smoking—all important determinants of risk.

Temperature differences were estimated to account directly for about 25% of the variation in mortality with latitude. Other data confirm a strong relation across districts between cold climate and ischaemic heart disease mortality taking other risk factors into account.[49 50] About 40% of the excess mortality from ischaemic heart disease and stroke at higher latitude was unexplained; this also might be because of the colder climate if, for example, housing in the north was less well insulated or provision of heating was less abundant in the north; only data on outdoor temperatures were available for use in our analysis.

The finding that excess mortality in deprived districts is greater at younger than older ages (table 5) is not surprising; socioeconomic differences in mortality attenuate in old age.[51] Several factors contribute. The size of the relation between smoking related diseases (especially cardiovascular diseases) and smoking is

greater at younger than older ages.[26] Fewer people smoke in old age, particularly past the age of 75.[52] These two smoking related factors are also likely to explain the attenuation with age of the relation between latitude and mortality. Other factors contribute to the attenuation of the effect of deprivation, one of which is migration. Older people often move to different areas when they become ill, sometimes to live with relatives or into residential accommodation (which is scanty in deprived districts); this mixing will attenuate the association. The ethnic minority communities, at higher risk of death and concentrated in poorer districts, are relatively young. Some causes of death that are common in deprived districts are rare over the age of 65, such as drug misuse, AIDS, homelessness, and falls (which are mainly occupational), while alcoholics tend to die young. Unemployment, higher in poor districts, is associated with a twofold risk of death.[53]

Our results indicate that "behavioural" factors (mainly smoking) account for most of the excess mortality in poorer districts, and the more direct "material" effects of poverty account for less (about 12%). The finding that little of the overall excess mortality remains unexplained is against a substantial effect of stress and other factors that are difficult to measure in accounting for the higher mortality in deprived districts. It is probable however that the direct effects of poverty on health are much stronger in relation to morbidity than to mortality. Depression, more common in deprived areas,[54] will cause much excess morbidity despite the relatively small excess mortality from suicide. Similar comments apply to alcoholism. In one area deprivation accounted for 66% of the variation among wards in limiting longstanding illness but only 21% of the variation in mortality.[8] Health differences according to deprivation are greater with respect to morbidity than mortality.

In conclusion, smoking is the most important cause of the variation in mortality in different districts according to deprivation, latitude, and urbanisation. Policies that discourage smoking, such as higher taxation on cigarettes, will reduce the variation in smoking,[55] and hence the variation in mortality across districts. Factors more directly related to deprivation contribute to the excess mortality in deprived areas, but are particularly important in relation to morbidity.

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