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Introduction

Health expectancies (HEs) combine mortality and health-related data to produce measures of life spent in various states of health. The Office for National Statistics (ONS) reports two such measures: healthy life expectancy (HLE) and disability-free life expectancy (DFLE) for the UK and its four constituent countries; these measures are important indicators of national health status over time. While differences in HEs between the constituent countries are evident, comparisons at this geographical scale conceal more sizeable differences at finer spatial scales, such as between local authorities, and electoral wards within these authorities.

Reducing inequalities in health is a public health priority; however, there is limited information relating to health expectancies at sub-national levels during inter-censal periods. As the demand for sub-national health metrics, such as HEs, is increasing to assist in the assessment of need, the planning and provision of services, and policy impact monitoring, this limitation represents a significant gap in the available knowledge base.

The most recent analyses reporting sub-national HEs compared electoral wards and local authorities using Census 2001 data (Rasulo *et al.* 2007; ONS report, 2007; ONS report, 2006). However, electoral ward analyses proved particularly problematic due to the substantial variation among wards in population size; for very small wards, this prevents the calculation of meaningful health expectancy estimates.

This report aims to support health-related planning at the small area level by estimating DFLE for Middle Super Output Areas (MSOAs). An advantage of these areas for statistical purposes is their relative homogeneity in population size.

Background

Period life expectancy (LE) is a measure of the expected length of life, based on current mortality rates within a population. By extension, HEs partition LE into years spent in favourable and unfavourable health states. DFLE, which is reported here, divides expected years of life into periods spent with and without disability. This measure reflects the duration of disability before death, and as such better indicates the health status of a population than measures of longevity alone (Rasulo *et al.* 2007).

While national estimates of HEs provide a snapshot of the morbidity experience of a whole population, they do not reveal the heterogeneity of experience within it. As such, favourable averages for large populations may be disproportionately influenced by extremes of health experience within smaller geographical groupings. For example, in the period 2000–2002 (centred on 2001), a four year difference between the highest (61.7 years in England) and lowest (57.7 years in Wales) average DFLE figures at birth for males at national level hides the much greater difference evident at Government Office Region (GOR) level at 7.6 years (ONS, 2006). Similarly, in the period 1999–2003 (centred on 2001) the DFLE differential at electoral ward level was 31 years (ONS, 2007). These contrasts clearly indicate the disparity present at lower level geographies and provide more relevant metrics to support needs assessment, priority setting and monitoring performance of policies targeted at local populations.

Electoral wards (referred to as electoral divisions in Wales) are the building blocks of administrative geography in the UK. Wards have been used extensively in health analysis but there are a number of limitations to their use. While electoral ward level analyses of LE and HE provide additional insight into the scale of health inequalities within larger sub-national areas and nationally, comparison between these geographical areas is problematic due to large variations in population size: for example, ward populations in 2001 ranged from only 995 to 35,767, with a mean of 5,952. In addition, it is difficult to draw comparisons between wards over time as their boundaries are unstable. For example, there were over 3,000 ward boundary changes in England and Wales between 1991 and 2001.

Introduced in England, Northern Ireland and Wales at the Census 2001, Output Areas (OAs) are the smallest geography of the Census 2001. Built from clusters of adjacent postcodes, they were designed to have similar population sizes, have stable boundaries and be socially homogeneous (based on housing tenure and dwelling type). OAs are aggregated into Lower Layer Super Output Areas (LSOAs) with an average population of 1,500 and a minimum population size of 1,000, and Middle Layer Super Output Areas (MSOAs) with an average population of 7,200 people and a range of 5,001 to 15, 326 people.

This article reports DFLE for MSOAs in England based on 2001 Census data. It includes DFLE at birth for individual MSOAs, as well as quintiles of MSOAs based on DFLE values, with 95 per cent confidence intervals for males and females. Individual MSOAs are referred to by the name of the local authority in which they fall, followed by a three digit number. Estimates at birth and at age 65 are also provided for quintile groupings based on a measure of relative area deprivation, the Index of Multiple Deprivation (IMD) 2004. The geographical and deprivation related patterns in health inequalities are described.

Methods

Data Sources

This study uses the Census 2001 for prevalence of limiting long-term illness, and death registration data over the period 1999 to 2003 (centred on 2001). Five years of mortality and population data were pooled in order to achieve the minimum sample size required for the calculation of meaningful LE estimates. Using three years of aggregated data to calculate LE at this small area level, as is practice for national estimates, is likely to result in overestimated LE and wider confidence intervals than desired, because the likelihood of having age bands with no deaths increases as population size decreases.

Measurement of area deprivation

Area deprivation was measured using the Indices of Multiple Deprivation 2004 (IMD 2004) which combines information on seven distinct domains, such as income and employment (Communities and Local Government, 2004). Each domain consists of a number of indicators which relate primarily to data from the Census 2001. The domains were constructed to reflect the different dimensions in which deprivation can be experienced and each can be used alone in analyses relating to the type of deprivation they describe. For the overall index the domains are weighted to reflect their relative importance (see Box 1), then combined to produce an overall deprivation

measure. Each English LSOA was assigned domain-specific and overall IMD scores. For this analysis, the IMD score for each MSOA was derived by taking the mean of the scores for the group of LSOAs making up that particular MSOA. These scores were used to rank and then group MSOAs into quintiles of relative deprivation for further analysis.

Box 1 Index of Multiple Deprivation 2004

Domain	Weight
Income deprivation	22.5%
Employment deprivation and disability	22.5%
Health deprivation and disability	13.5%
Education, skills and training deprivation	13.5%
Barriers to housing and services	9.3%
Crime	9.3%
Living Environment deprivation	9.3%

Source: Communities and Local Government (2004)

Calculation of life expectancy

Standard abridged life table methods were used to calculate LE (Chiang, 1968). The tables were constructed for individual MSOAs and for each area deprivation quintile using data on all-cause mortality by sex and five-year age bands (0–4, 5–9….85 and over) over the period 1999 to 2003, and the corresponding MSOA level population according to the Census 2001. The population data from the Census 2001 was multiplied by five to derive the number of person-years consistent with the number of years covered by death registrations.

The 95 per cent confidence interval (CI) for each area was calculated using the revised Chiang method (Chiang II), allowing the calculation of the variance of the mortality rates for those age bands with no deaths registered in the analysis period. This method is the approved standard for ONS outputs of life expectancy at sub-national level (Toson and Baker, 2003).

Calculation of disability-free life expectancy

DFLE was calculated using the Sullivan method (Jagger, 1999). For each MSOA and area deprivation quintile, the prevalence of self-reported absence of disability by sex and for each five-year age band was calculated from the responses to the limiting long-term illness question at the Census in 2001 (See Box 2). The prevalence rates were multiplied by the corresponding person-years lived during a given age interval to calculate the total person-years lived in that age interval

without disability. DFLE at a particular age interval was then calculated by adding up the persons-years lived without disability from that age interval to the final interval, divided by the number of people surviving to the age interval from the size of a synthetic cohort assumed at birth.

Estimates of LE and DFLE at birth and at age 65 were also calculated at the person level.

Box 2 Census 2001 question on Limiting Long-term Illness:

Do you have any long-term illness, health problem or disability which limits your daily activities or the work you can do? Include problems which are due to old age: Yes/No

Mortality rates and the prevalence of disability were calculated using the Census 2001 population as a proxy for annual mid-year population estimates (MYPE) since the latter are not available at MSOA level for all the years included in the deaths registrations.

MSOAs were ranked according to DFLE values (highest to lowest) and non-overlapping 95 per cent confidence intervals were used to judge significant differences between them.

Distribution of DFLE at birth and of MSOAs within IMD Quintiles

To assess the geographical distribution of DFLE at birth, MSOAs were ranked according to descending DFLE values and divided into five distinct groupings (quintiles), such that the fifth of MSOAs with the highest DFLE were in quintile 1 while those with the lowest were placed in quintile 5. For each quintile, the proportion of MSOAs within regions was examined. Similarly, the distribution of MSOAs within regions was examined for each area deprivation quintile.

Measures of inequality in DFLE

England

Two approaches were used to assess health inequalities across England. First, for each DFLE quintile described above, the median LE and DFLE values were calculated. Then the gap in DFLE and DFLE relative to LE between quintile extremes was used to assess the inequality in DFLE and in the proportion of life spent without disability respectively. The second approach provides a measure of deprivation-related health inequality by comparing DFLEs at birth and at age 65 in the least deprived and most deprived fifths of MSOAs.

Comparisons were drawn between quintile extremes using the median DFLE instead of the mean, since outliers have a biasing effect on the latter, that is they disproportionately ‘inflate’ or ‘deflate’ group means and standard deviations. In addition, the median is more representative of the ‘average’ LE and DFLE values since the distribution of LE and DFLE within these quintiles is not symmetrical.

Within Government Office Regions

MSOAs were grouped by GOR membership. The median DFLE for each GOR was calculated and the gap between the highest and lowest values was used to assess the level of inequality in DFLE present at regional level. As with DFLE quintiles, the distribution of DFLE within GORs is also skewed and median values provide a more accurate reflection of the 'average' for each region.

Additionally, a comparison of the highest and lowest DFLE values within regions may be distorted by the fact that extreme values are influenced by local factors such as the proportion of an MSOA population living in communal establishments. This influence is likely to affect southern GORs more as they have a higher proportion of people aged 65 and over living in communal establishments compared to the north (author's analysis). To overcome this, the gap between the 5th and 95th percentile DFLE, which contains 90 per cent of MSOAs in each GOR, was used to assess the regional variation in DFLE. The median absolute deviation was also used to examine the degree of within-region variability. This method provides a more robust measure of dispersion compared to the standard deviation because it is more resilient to the effect of outliers.

Issues in the calculation of small area estimates of LE and DFLE

There are two major challenges in producing LE at small area level. First, due to the level of detail of mortality data required to calculate LE, it is very likely that some age bands in some areas will have no deaths. The contribution of these age bands to the variance in mortality is zero and this leads to increases in standard errors and the width of 95 per cent CIs. This is particularly problematic at birth since every age band contributes to the standard error (SE) of LE at birth, which reduces the precision of these estimates and therefore the reliable detection of significant differences between areas.

Toson and Baker (2003), however, showed that SEs for populations of 5,000 and above are not adversely affected by having age bands with no deaths. This population threshold was set by ONS as the standard below which sub-national LE estimates will not be calculated. In contrast to wards, all MSOAs meet this population threshold at the person level, but not for sex-specific populations. For the calculation of LE at birth for each sex therefore, multiplying the 2001 MSOA person-years by five to match the period covered by death registrations provides sex-specific population counts exceeding this threshold. However, from age 65 onwards, the sex-specific population in the majority of MSOAs do not meet the threshold. As such, LE and DFLE at age 65 for individual areas as well as for quintiles of DFLE are not reported in this article.

Second, LE estimates for small areas are likely to lack stability due to random variation in the number of deaths. To minimise the effect of this variation, five years of mortality data (that is 1999–2003) were pooled to ensure a sufficient number of death events. However, since the population count was taken at a single point in time, multiplying each age band five-fold can result in some having deaths but a zero population count.

Methodological adjustments to LE calculations

Not all MSOAs had the full complement of information needed to compute estimates of LE. In MSOAs where there were no deaths or population in the final age band (that is 85 years and over), the calculation of variance was not possible. To overcome this, the equivalent sex-specific mortality

rate in the particular GOR within which these MSOAs are located was inserted into the calculation. Also, where there were deaths but no population or the number of deaths exceeds the population, the number of deaths was assumed to be correct. A population figure was then calculated for the age band in question by dividing the number of deaths in the MSOA by the corresponding GOR death rate. These adjustments were made for males in Tower Hamlets 021, Plymouth 018, St. Edmundsbury 005, and for both sexes and at the person level in Blyth Valley 006.

These adjustments were not applied in three MSOAs for two reasons. First, for males in Basingstoke and Deane 021 and South Oxfordshire 009, there were neither deaths nor populations in the final age band and a decision was taken not to simply impute the GOR specific rate (an assumption would also have to be made for disability status if GOR death rates are imputed). Second, since the person-years lived in the final age band is calculated by dividing the number of survivors in the age band by the corresponding mortality rate, this could not be calculated for Cannock Chase 010 as there were no survivors from age band 80–84 to 85 and over. As previously described, the total person-years lived at a particular age interval, used in calculating DFLE, is dependent on the contribution of person-years lived without disability from that age interval to the final. Thus, in these three MSOAs where person-years were missing in the final age band, DFLE could not be calculated for all age intervals. However, to allow the calculations to proceed in other age bands, the final age bands in these MSOAs were assumed to contribute zero person-years to the total number of person-years lived without disability.

Issues with implausible life expectancy estimates

Visual examination of LE estimates at birth for males and females suggested implausible values in some areas and were treated as potential outliers. These outliers were identified using a box plot which suggested that at birth, LE values below 62.2 for males and above 92.7 years for females were extreme outliers. Although reported in this article, female LE at birth and consequently DFLE in the following MSOAs are treated as outliers: Swindon 018, Gloucester 010, and St. Edmundsbury 005. For males, LE and DFLE at birth in Manchester 009 and Leicester 024 areas are treated as outliers.

On further investigation, outliers above the box plot threshold were found to arise from implausibly low mortality rates in final age bands. Consequently, excessively high numbers of person-years were generated in these age bands and also contributed to the total person-years lived in the younger age bands, thereby overestimating LE at birth. In contrast, outlying areas below the threshold had implausibly high mortality rates in final age bands, fewer person-years than would be expected in their final age bands; the latter resulting in underestimated LE estimates at birth.

Adjustments to the DFLE calculation

Similarly to LE, the calculation of DFLE was not possible where everyone in an age band had limiting long-term illness (LLTI) i.e. the disability-free prevalence rate equals zero or, where no one had a LLTI, i.e. disability-free rate equals 1. Since there is no justification for imputing GOR prevalence rates in these cases, disability-free rates were set at 0.01 and 0.99 respectively. For an example of this practice, please refer to the HE wards report in the following link: http://www.ons.gov.uk/ons/taxonomy/index.html?nscl=Subnational+Health+Expectancies

A similar approach to that taken in the life tables described above was also used to allow the DFLE calculations to proceed in Basingstoke and Deane 021, South Oxfordshire 009 and Cannock Chase 010.

Results

The detailed DFLE estimates for MSOAs in England (1999-2003) are available on the Office for National Statistics website.

The estimates for males and females can be found here: Males and Females table and for all persons here: All Persons table

DFLE (with associated 95 per cent confidence intervals) and accompanying LE estimates are reported for males and females at birth and at the person level at birth and at age 65. To aid interpretation, these estimates are presented along with contextual variables such as the proportion of the population in each MSOA aged 65 and over living in medical and care establishments and IMD 2004 quintiles of relative deprivation.

Distribution of MSOAs within quintiles based on DFLE values

For both sexes there was a clear north-south geographical divide in the distribution of MSOAs across DFLE quintiles: those with the highest DFLE values were predominantly located in the South East, East of England and South West; those with the lowest values were mainly located in the North East, North West, and Yorkshire and The Humber. Figures 1 and 2 show the DFLE and IMD quintile distribution of English MSOAs.

DFLE for males at birth show that 42 per cent of MSOAs in the South East, 32 per cent in the East of England and 22 per cent in the South West were placed in the quintile with the highest values (quintile 1); but only 3 per cent in the North East and 7 per cent in the North West were in this quintile. In contrast, while 54 per cent of MSOAs in the North East, 38 per cent in the North West and 30 per cent in Yorkshire and the Humber were placed in the quintile with the lowest values (quintile 5), only 4 per cent in both the East of England and the South East, and 7 per cent in the South West were in this quintile. Similar results were observed for females (see table 1).

Figure 1 **Middle Layer Super Output Areas in England by DFLE at birth for males, 1999 to 2003 and the Index of Multiple Deprivation, 2004**

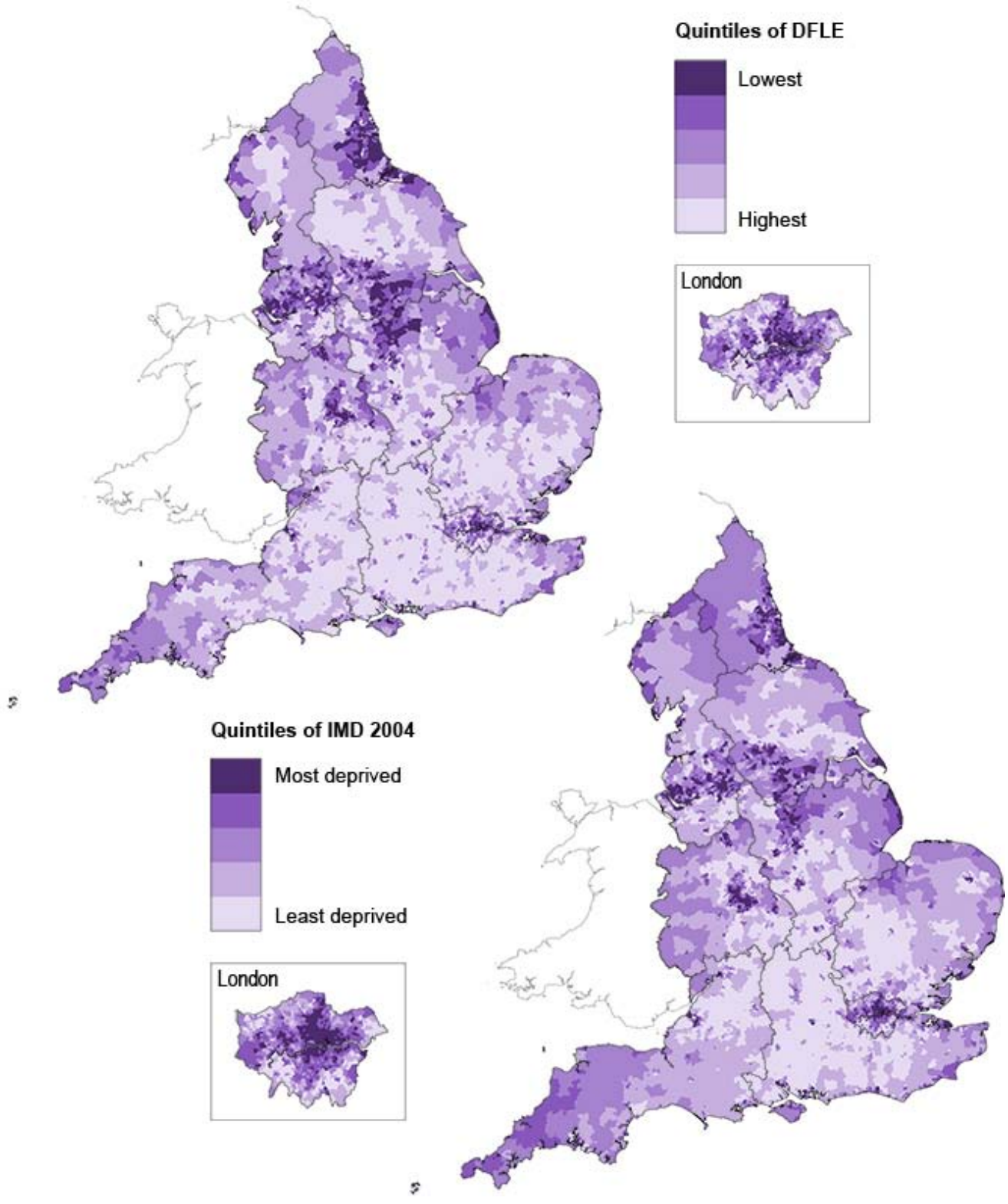


Figure 2 **Middle Layer Super Output Areas in England by DFLE at birth for females, 1999 to 2003 and the Index of Multiple Deprivation, 2004**

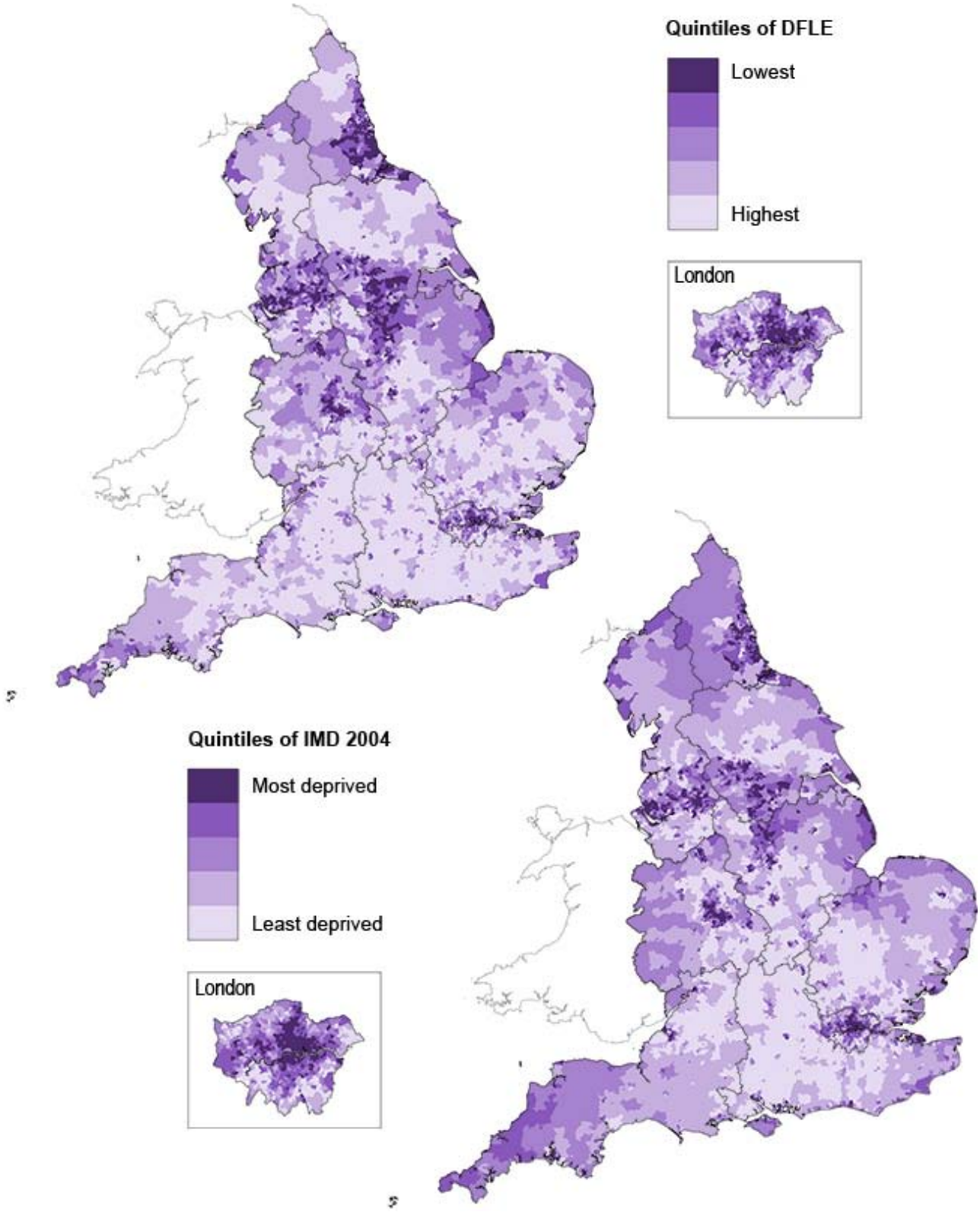


Table 1 Distribution of MSOAs by DFLE quintiles and Government Office Region, males and females at birth, 1999–2003

England
Percenta ges

	GOR	Quintile 1 (Highest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (Lowest)
Males at birth	East Midlands	16.6	21.7	20.1	22.1	19.4
	East of England	32.2	29.7	22.8	11.7	3.5
	London	18.0	17.1	19.3	26.3	19.2
	North East	3.2	8.8	12.0	22.5	53.5
	North West	6.6	12.8	17.7	24.5	38.4
	South East	42.0	22.4	18.4	13.2	3.9
	South West	21.7	29.8	25.3	16.4	6.8
	West Midlands	12.0	19.6	18.2	23.9	26.3
	Yorkshire and The Humber	10.4	14.3	23.9	21.0	30.4
Females at birth	East Midlands	13.1	21.0	23.1	22.2	20.5
	East of England	29.6	30.3	23.9	13.2	3.0
	London	16.7	16.5	20.4	25.3	21.1
	North East	3.5	9.1	13.5	23.7	50.3
	North West	7.2	12.3	17.6	23.6	39.4
	South East	43.7	22.2	17.8	12.8	3.5
	South West	26.8	30.2	24.2	14.0	4.9
	West Midlands	10.2	20.1	17.1	25.0	27.5
	Yorkshire and The Humber	11.2	15.1	21.5	23.2	29.0

DFLE at birth in the highest and lowest ranked MSOAs

For the purpose of the following analyses, the highest and lowest ranked areas only refer to the top and bottom ten areas respectively. The rankings exclude areas with outlying LE estimates.

For males DFLE at birth was highest in Kensington and Chelsea 016 (73.9 years). This figure is 29.8 years higher than in Manchester 013, the MSOA with the lowest DFLE at birth (44.1 years). For females DFLE at birth was highest in Kensington and Chelsea 012 (74.4 years) and lowest in Liverpool 039 (48.2 years), a gap of 26.2 years.

Among the highest ranked areas, not all differences between the highest ranked and the other MSOAs within this grouping were significant. For example, while DFLE at birth for males in Kensington and Chelsea 016 was significantly higher than those in Guildford 016, Kensington and Chelsea 012, Bromley 021, Kensington and Chelsea 010, St Albans 005, Guildford 011, Basingstoke and Deane 021 it was not significantly different from those in South Bucks 002, and Westminster 019. Similar results were found among the lowest ranked areas and for females (Tables 2 and 3).

Table 2 Life expectancy and disability-free life expectancy in the highest and lowest ranked MSOAs: by DFLE, males at birth, 1999–2003

England — Years/Percentages

	MSOA	GOR	LE	DFLE	Lower 95% confidence interval	Upper 95% confidence interval
Highest ranked	Kensington and Chelsea 016	London	89.3	73.9	*73.0*	*74.8*
	South Bucks 002	South East	82.8	72.7	*72.0*	*73.4*
	Westminster 019	London	83.1	72.6	*71.5*	*73.8*
	Guildford 016	South East	83.3	72.3	*72.1*	*72.4*
	Kensington and Chelsea 012	London	82.5	72.1	*72.0*	*72.1*
	Bromley 021	London	83.0	71.9	*71.0*	*72.8*
	Kensington and Chelsea 010	London	82.9	71.7	*71.2*	*72.2*
	Guildford 011	South East	81.2	71.6	*71.5*	*71.7*
	St Albans 005	East of England	83.2	71.6	*70.9*	*72.3*
	Basingstoke and Deane 021	South East	77.9	71.2	*71.1*	*71.3*
Lowest ranked	Easington 003	North East	71.2	46.7	*46.2*	*47.2*
	Barnsley 014	Yorkshire and The Humber	72.5	46.6	*46.2*	*47.1*
	Blackpool 007	North West	67.6	46.6	*45.8*	*47.3*
	Bolton 016	North West	65.9	46.5	*45.5*	*47.5*
	Easington 006	North East	72.1	45.7	*45.3*	*46.1*
	Liverpool 023	North West	66.6	45.6	*44.6*	*46.6*
	Liverpool 024	North West	67.1	45.6	*44.6*	*46.6*
	Wirral 011	North West	66.7	45.3	*44.8*	*45.8*
	Wirral 016	North West	66.7	44.4	*43.7*	*45.1*
	Manchester 013	North West	62.5	44.1	*43.2*	*45.0*

Table 3 Life expectancy and disability-free life expectancy in the highest and lowest ranked MSOAs: by DFLE, females at birth, 1999–2003

England — Years/Percentages

	MSOA	GOR	LE	DFLE	Lower 95% confidence interval	Upper 95% confidence interval
Highest ranked	Kensington and Chelsea 012	London	87.1	74.4	*73.7*	*75.0*
	Richmond upon Thames 007	London	87.1	73.8	*73.8*	*73.9*
	Wycombe 020	South East	88.5	73.8	*73.1*	*74.5*
	Kensington and Chelsea 008	London	86.4	73.8	*73.7*	*73.9*
	St Albans 005	East of England	89.0	73.7	*73.6*	*73.8*
	Leeds 001	Yorkshire and The Humber	88.6	73.6	*73.5*	*73.7*
	Kensington and Chelsea 016	London	91.3	73.5	*73.0*	*74.1*
	Waverley 016	South East	86.4	73.4	*73.3*	*73.5*
	Kensington and Chelsea 018	London	87.9	73.2	*73.1*	*73.3*
	Guildford 018	South East	85.5	73.2	*73.0*	*73.4*
Lowest ranked	Manchester 010	North West	72.5	50.8	*50.2*	*51.4*
	Wigan 010	North West	73.8	50.7	*50.3*	*51.2*
	Manchester 013	North West	72.4	50.7	*49.9*	*51.6*
	Liverpool 022	North West	73.1	50.7	*49.8*	*51.5*
	Bolton 016	North West	75.9	50.7	*50.1*	*51.2*
	Liverpool 044	North West	74.1	50.5	*49.9*	*51.2*
	Liverpool 037	North West	73.5	50.5	*50.2*	*50.7*
	Easington 006	North East	76.8	49.9	*49.6*	*50.3*
	Liverpool 024	North West	72.4	49.6	*49.0*	*50.2*
	Liverpool 039	North West	72.5	48.2	*48.0*	*48.3*

Relative DFLE at birth in the highest and lowest ranked MSOAs

As with absolute DFLE, the proportion of life spent without disability was also characterised by a north to south polarity; MSOAs with the highest DFLE relative to LE were predominantly located in the southern GORs and those with the lowest in the north (see tables 4 and 5).

For males relative DFLE at birth was highest in Basingstoke and Deane 021 (91.5 per cent) and lowest in Easington 006 (63.3 per cent). For females at birth, it was highest in Richmond upon Thames 009 (87.5 per cent) and lowest in Easington 006 (65.0 per cent).

Among those areas ranked with the highest absolute DFLE at birth, not all were ranked highest in relative DFLE. In fact for males, only Basingstoke and Deane 021 was ranked highest in both absolute and relative terms. A similar picture occurs for the lowest ranked areas: only Barnsley 018, Easington 006 and Wirral 011 were ranked in the lowest grouping in both absolute and relative DFLE. Thus, areas observed to have much higher or lower absolute DFLE are not always indicative of longer or shorter proportions of life without disability.

For females at birth, none of the highest ranked areas by DFLE were similarly ranked in proportional terms. Among the lowest ranked areas according to absolute DFLE, only Liverpool 039, Bolton 016 and Easington 006 were also ranked lowest in relative terms.

Table 8 Proportion of life spent without disability: by Government Office Region and sex, 1999–2003

England — Years/ Percentages

	GOR	Median LE	Median DFLE	Lower 95% confidence interval	Upper 95% confidence interval	DFLE as a proportion of LE (%)
Males at birth	East Midlands	76.1	61.9	*61.5*	*62.3*	*81.4*
	East of England	77.3	64.7	*64.3*	*64.9*	*83.7*
	London	75.6	61.6	*61.1*	*62.0*	*81.4*
	North East	74.6	56.8	*56.2*	*57.5*	*76.1*
	North West	74.7	59.2	*58.5*	*59.5*	*79.2*
	South East	77.4	65.1	*64.9*	*65.4*	*84.1*
	South West	77.5	63.7	*63.4*	*63.9*	*82.2*
	West Midlands	75.5	60.9	*60.4*	*61.5*	*80.6*
	Yorkshire and The Humber	75.6	60.6	*60.1*	*61.2*	*80.2*
	England	76.3	62.3	*62.2*	*62.5*	*81.7*
Females at birth	East Midlands	80.7	64.5	*63.9*	*64.7*	*79.9*
	East of England	81.8	66.5	*66.3*	*66.8*	*81.3*
	London	80.9	63.9	*63.6*	*64.3*	*79.0*
	North East	79.4	60.3	*59.7*	*60.8*	*75.9*
	North West	79.7	61.8	*61.4*	*62.3*	*77.5*
	South East	81.7	67.4	*67.1*	*67.6*	*82.4*
	South West	81.9	66.3	*66.1*	*66.5*	*81.0*
	West Midlands	80.6	63.3	*62.7*	*63.7*	*78.6*
	Yorkshire and The Humber	80.6	63.4	*62.9*	*63.7*	*78.6*
	England	81.0	64.7	*64.6*	*64.9*	*79.9*

Quintile level analysis of DFLE at birth

For both sexes there were substantial inequalities in DFLE at birth between the highest and lowest quintiles of areas; however, the gap was significantly wider for males than for females. While males in the fifth of MSOAs with the highest DFLE at birth could expect to spend an additional 12.5 years free from disability than those in the bottom fifth, for females this inequality was only 11.2 years.

In each quintile females had a higher DFLE at birth than males; however, they also spent a higher proportion of life with a disability (table 9). In quintile 1, males at birth could expect to spend 84.9 per cent of their life without disability, compared with only 75.9 per cent in quintile 5. For females the equivalent proportions were 82.9 per cent compared with 74.3 per cent respectively.

DFLE at age 65 was not calculated for each quintile of DFLE values, since estimates were not calculated for individual areas at this age.

Table 9 Summary statistics of DFLE quintiles for MSOAs, 1999–2003: males and females at birth

England — Years/ Percentages

	Quintiles of DFLE	Median LE	Median DFLE	Lower 95% confidence interval	Upper 95% confidence interval	DFLE as a proportion of LE (%)	Minimum DFLE	Maximum DFLE
Males at birth	Highest- 1	79.2	67.2	*67.1*	*67.3*	*84.9*	65.9	73.9
	2	77.6	64.7	*64.7*	*64.8*	*83.4*	63.5	65.9
	3	76.3	62.3	*62.3*	*62.4*	*81.7*	61.0	63.5
	4	74.6	59.3	*59.2*	*59.4*	*79.5*	57.3	61.0
	Lowest- 5	72.1	54.7	*54.5*	*54.8*	*75.9*	44.1	57.3
	Range between Quintiles 1 and 5	7.1	12.5	*12.4*	*12.7*	*9.0*	21.8	16.6
	England	76.3	62.3	*62.2*	*62.5*	*81.7*	44.1	73.9
Females at birth	Highest- 1	83.4	69.2	*69.1*	*69.2*	*82.9*	67.9	74.3
	2	82.0	66.9	*66.8*	*66.9*	*81.5*	65.8	67.9
	3	81.0	64.7	*64.7*	*64.8*	*79.9*	63.6	65.8
	4	79.8	62.1	*62.0*	*62.2*	*77.8*	60.3	63.6
	Lowest- 5	78.0	57.9	*57.8*	*58.1*	*74.3*	48.2	60.3
	Range between Quintiles 1 and 5	5.4	11.2	*11.0*	*11.4*	*8.6*	19.7	14.0
	England	81.0	64.7	*64.6*	*64.9*	*79.9*	48.2	74.3

Distribution of MSOAs within IMD 2004 quintiles

For both sexes there were clear regional differences in the distribution of MSOAs in the least and most deprived quintiles; 44.8 per cent of MSOAs in the South East, 32.5 per cent in the East of England and 19.4 per cent in the South West were members of the least deprived quintile. In contrast, only 4.7 per cent in the North East and 10.0 per cent in the North West were in this group. The regional pattern was reversed for the most deprived quintile: while 42.1 per cent of MSOAs in the North East, 33.4 per cent in the North West and 30.5 per cent in Yorkshire and the Humber were placed in this quintile, only 5.0 per cent in the East of England, 4.1 per cent in the South East and 6.6 per cent in the South West were in this group.

Table 10 Distribution of MSOAs by IMD 2004 quintiles and Government Office Regions, 1999–2003

England
Percentages

GOR	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
East Midlands	21.7	19.8	20.7	20.7	17.2
East of England	32.5	28.9	20.6	13.0	5.0
London	9.9	14.4	19.0	28.9	27.8
North East	4.7	9.9	18.7	24.6	42.1
North West	10.0	16.1	18.8	21.8	33.4
South East	44.8	21.4	17.6	12.1	4.1
South West	19.4	29.6	24.5	19.9	6.6
West Midlands	12.5	20.8	19.9	20.5	26.3
Yorkshire and The Humber	9.8	16.0	21.9	21.8	30.5

DFLE at birth and at age 65 by area deprivation

Absolute DFLE

For both sexes there was an inverse relationship between relative deprivation and DFLE; as relative deprivation increased, the number of years lived without disability decreased. (See Figures 3 & 4).

The gap in DFLE at birth between quintile extremes was significantly greater for males than for females. While males at birth in the least deprived areas could expect to spend an additional 12.6 years without disability compared with those in the most deprived areas, the equivalent inequality for females was 10.9 years.

At age 65 inequality in DFLE was still present and differences by sex, though much narrower than at birth, were significant. Males in the least deprived areas could expect to spend an extra 4.0 years without disability compared with those in the most deprived areas; for females the equivalent gap was 3.8 years.

As described earlier, it was not possible to calculate DFLE at age 65 for quintiles based on DFLE values because DFLE was not estimated for individual MSOAs at this age. In contrast, DFLE at age 65 was calculated for each quintile of area deprivation as this was not dependent on individual DFLE values at this age.

Figure 3 **Life expectancy (LE) and disability-free life expectancy (DFLE) for males at birth by quintiles of relative deprivation: MSOAs in England, 1999–2003**

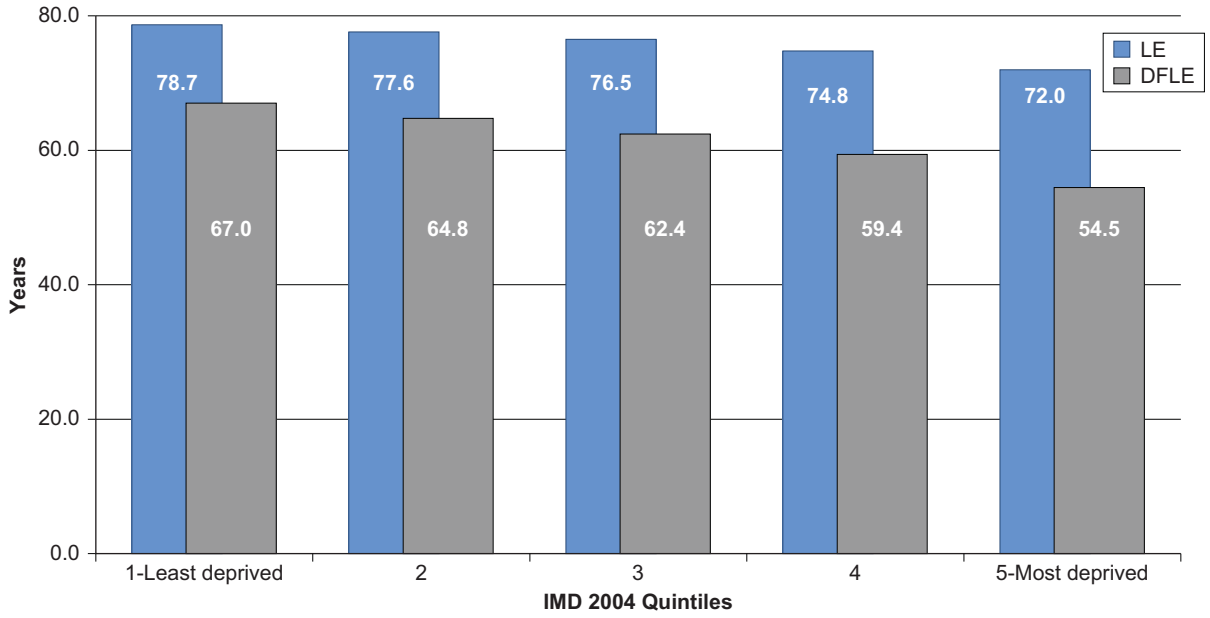
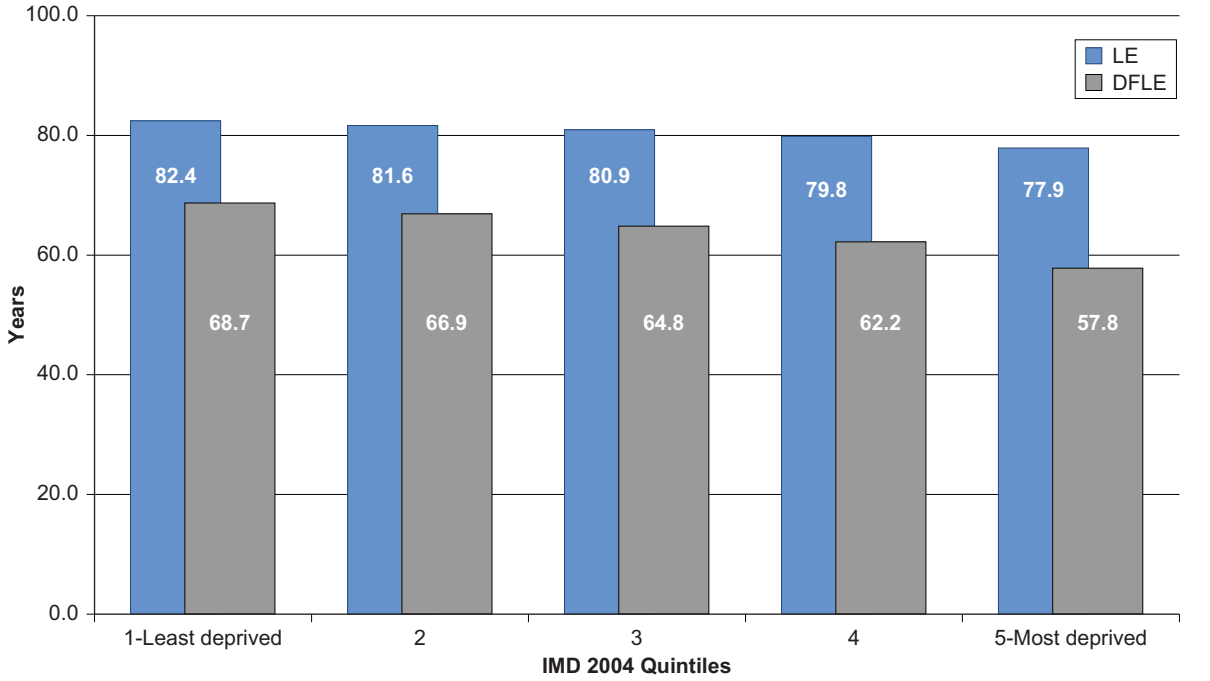


Figure 4 **Life expectancy (LE) and disability-free life expectancy (DFLE) for females at birth by quintiles of relative deprivation: MSOAs in England, 1999–2003**



Relative DFLE

In all deprivation quintiles at birth and at age 65, females spent a higher proportion of life with disability than males. In the least deprived areas, males at birth could expect to spend 85.2 per cent of their life without disability, compared with only 75.7 per cent in the most deprived areas. For females the equivalent proportions were 83.3 per cent compared with 74.2 per cent respectively. However, the advantage of men in relative DFLE at national level is modified by level of area deprivation; females in quintiles 1, 2 and 3 spend a larger proportion of their life free of disability than males in quintiles 4 and 5.

At age 65 the inequality in relative DFLE between the deprivation extremes was considerably wider than at birth: males in the least deprived areas could expect to spend 56.6 per cent of their remaining life without disability compared with only 41.0 per cent in the most deprived areas. For females the equivalent proportions were 53.0 per cent and 39.1 per cent respectively. (See Figures 5 & 6). The similar modifying effect of area based deprivation on the national pattern by sex observed at birth was also present at age 65.

Figure 5 **Proportion of life spent without disability for males by age and quintiles of relative deprivation: MSOAs in England, 1999–2003**

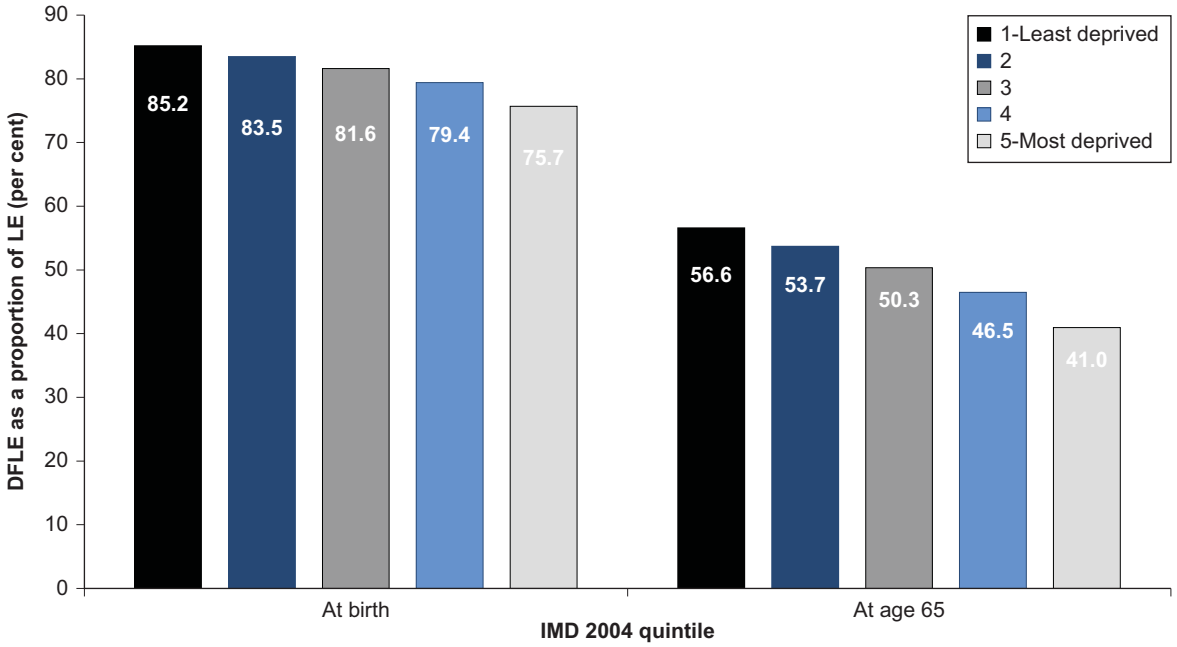
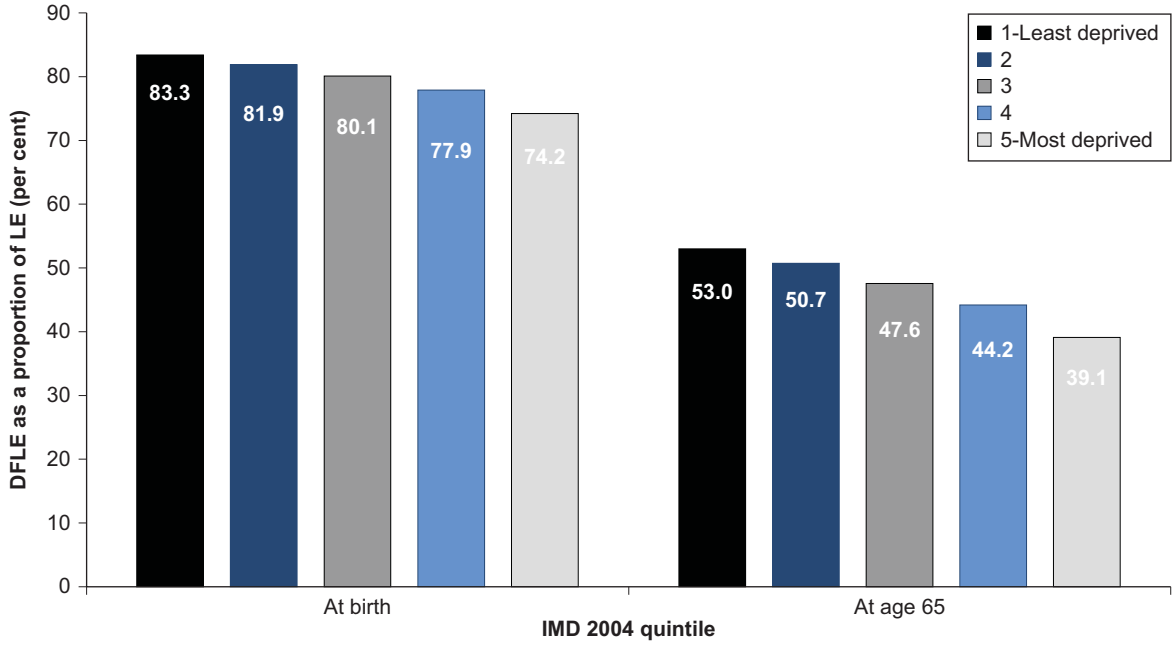


Figure 6 **Proportion of life spent without disability for females by age and quintiles of relative deprivation: MSOAs in England, 1999–2003**



The scale of inequality in DFLE varied across adjacent deprivation quintiles; the inequality in DFLE at birth and at age 65 between quintiles 4 and 5 for both sexes, was considerably wider than that between any other two adjacent quintiles. These gaps were also wider for males than for females (table 11).

Comparison with national figures

The absolute and relative DFLE at birth for males in England was considerably higher than that for those living in the most deprived areas: 61.7 years (81.2 per cent) compared with only 54.5 years (75.7 per cent) respectively. For females the equivalent figures were 64.2 years (79.7 per cent) compared with only 57.8 years (74.2 per cent) respectively.

In contrast, males and females in the least deprived areas had a higher DFLE at birth than the corresponding national estimates. At age 65 a similar pattern was observed (table 11).

Table 11 Life expectancy and disability-free life expectancy: by area deprivation, males and females at birth, and at age 65, 1999–2003

England — Years/ Percentages

	IMD 2004 Quintile	LE	DFLE	Lower 95% confidence interval	Upper 95% confidence interval	DFLE as a proportion of LE (%)
Males at birth	1-Least deprived	78.7	67.0	*67.0*	*67.0*	*85.2*
	2	77.6	64.8	*64.8*	*64.8*	*83.5*
	3	76.5	62.4	*62.4*	*62.4*	*81.6*
	4	74.8	59.4	*59.4*	*59.4*	*79.4*
	5-Most deprived	72.0	54.5	*54.5*	*54.5*	*75.7*
	Range	6.7	12.6	*12.5*	*12.6*	*9.5*
	England	75.9	61.7	*61.7*	*61.7*	*81.2*
Males at age 65	1-Least deprived	17.4	9.8	*9.8*	*9.9*	*56.6*
	2	16.8	9.0	*9.0*	*9.1*	*53.7*
	3	16.2	8.2	*8.1*	*8.2*	*50.3*
	4	15.4	7.2	*7.1*	*7.2*	*46.5*
	5-Most deprived	14.3	5.9	*5.8*	*5.9*	*41.0*
	Range	3.0	4.0	*3.9*	*4.0*	*15.6*
	England	16.1	8.0	*8.0*	*8.1*	*50.1*
Females at birth	1-Least deprived	82.4	68.7	*68.7*	*68.7*	*83.3*
	2	81.6	66.9	*66.8*	*66.9*	*81.9*
	3	80.9	64.8	*64.8*	*64.8*	*80.1*
	4	79.8	62.2	*62.2*	*62.2*	*77.9*
	5-Most deprived	77.9	57.8	*57.8*	*57.8*	*74.2*
	Range	4.5	10.9	*10.8*	*10.9*	*9.1*
	England	80.5	64.2	*64.2*	*64.2*	*79.7*
Females at age 65	1-Least deprived	20.2	10.7	*10.7*	*10.7*	*53.0*
	2	19.7	10.0	*9.9*	*10.0*	*50.7*
	3	19.3	9.2	*9.1*	*9.2*	*47.6*
	4	18.7	8.3	*8.2*	*8.3*	*44.2*
	5-Most deprived	17.7	6.9	*6.9*	*7.0*	*39.1*
	Range	2.5	3.8	*3.7*	*3.8*	*13.9*
	England	19.1	9.0	*9.0*	*9.0*	*47.2*

Differences in the distribution of MSOAs across DFLE and IMD 2004 quintiles

The distribution of MSOAs within DFLE and IMD 2004 quintiles was such that those with the highest DFLE were not always placed in the least deprived areas, nor were those with the lowest all placed in the most deprived areas. Nevertheless, MSOAs placed in quintiles 1 and 5 by DFLE estimates predominantly occupied the same area deprivation quintile.

There was a clear difference by sex in the proportion of MSOAs equivalently placed on both quintile measures: for males, 74.0 per cent of MSOAs in DFLE quintile 1 were placed in the least deprived areas, while the equivalent proportion for females was only 69.3 per cent. The sex differences were much narrower for the most deprived areas in quintile 5: for males, while 83.6 per cent of MSOAs in DFLE quintile 5 were in the most deprived areas, the equivalent proportion for females was 81.9 per cent.

Discussion

This report measures DFLE at birth and at age 65 for males and females at the small area level. It has identified inequalities in both the number of years and proportion of life spent without disability between area groupings based on level of absolute DFLE and the IMD 2004 measure of area deprivation. It represents the first use of English MSOAs in estimating LE and DFLE by the ONS.

For both sexes there was a clear north-south divide in the regional density of MSOAs across quintiles of both DFLE and relative deprivation: MSOAs with the highest DFLE at birth were predominantly located in southern regions while those with the lowest had a greater density in the north; the most advantaged MSOAs were concentrated in southern regions and consequently had the highest DFLE at birth and at age 65

While the geographical variation in DFLE may in part be due to differences in the contextual characteristics of northern and southern MSOAs, it is likely to be influenced more by the underlying spatial differences in their socioeconomic composition. Several studies suggest that material disadvantage at an individual level accounts for most but not all spatial inequality in measures of health (Joshi *et al.* 2000; Woods *et al.* 2005). It is also widely accepted that the historical spatial variation in the employment structure in England, with a higher concentration of heavy industries (dominated by manual occupations) in the north, is partly responsible for area differences in health. People exposed to the hazards associated with these occupations as well as their families are more likely to experience material deprivation and less likely to adopt healthy lifestyle behaviours (Joshi *et al*. 2000). This article has not attempted to separate the relative contributions of contextual and individual level characteristics on observed geographical variations in DFLE.

The pattern of inequality found in this study is broadly consistent with previous research: DFLE at birth and at age 65 varied inversely with relative deprivation. The gap in DFLE at birth between the least and the most deprived areas was substantial and greater for males than for females. The gaps were still present at age 65; the magnitudes, however, were considerably smaller than at birth and the sex differences were much narrower.

In relative terms, females spent a higher proportion of life with disability than males across all deprivation quintiles. Compared to absolute DFLE, for both sexes the gap in relative DFLE

between the least and the most deprived areas was wider at age 65 than at birth, and these gaps were greater for males than females. However, level of deprivation has an important modifying influence on the national pattern of relative DFLE by sex. The relative DFLE of women living in more affluent areas is higher than that of men living in more deprived areas.

For males the scale of inequality in DFLE at birth between quintile extremes was slightly greater for area deprivation than for DFLE. While males in the least deprived areas spent an additional 12.6 years without disability compared with those in the most deprived areas, the equivalent DFLE quintile gap was 12.5 years. For females the reverse was the case: the gap in DFLE at birth between quintile extremes was wider for DFLE than for area deprivation (11.2 compared with 10.9 years respectively). These differences are explained by the fact that males in DFLE quintiles 1 and 5 were more likely to occupy the same quintile of area deprivation than their female counterparts. For both sexes, over a quarter of MSOAs with the highest DFLE values were not in the most affluent areas, highlighting the fact that the measure of deprivation used leaves some of the variations in DFLE between areas unexplained and other latent factors outside the scope of the IMD 2004 are likely to contribute to these differences. Nevertheless, the concentration of disability in highly deprived areas confirms the importance of ecological deprivation in discriminating DFLE at the small area level.

While ward level analyses represent an alternative approach to estimating DFLE at small area level, wards are heterogeneous in terms of spatial scale and population size. The stability, accuracy and precision of measured health events between area comparisons and across the entire population of wards are therefore uncertain, reducing the scope for objective interpretation for policy purposes. For example, in a previous report (ONS Report, 2006), the sex-specific population counts in some wards were too small to allow calculation of DFLE at birth by sex even after temporal aggregation of five years of data. These limitations, however, were not encountered at MSOA level as the population count in each area was sufficiently large to compute DFLE at birth at the person level and by sex with temporal aggregation.

Another advantage of MSOA level analyses, as opposed to ward level, is the scope to track changes in health inequalities over time; MSOA boundaries were not designed for frequent change, hence ensuring spatial consistency and more meaningful comparison over time.

A further advantage of estimating HEs at MSOA level is the consistent level of precision in estimates compared with wards. The wide margins of error at ward level makes comparisons between individual areas difficult; for example, in the analyses covering the period 1999 to 2003, the average width of CI for ward DFLE at birth was 3.8 years for males and 3.6 years for females, while for individual areas the widest CIs were 25.2 years for males and 29.9 for females (ONS, 2007). The equivalent widths at MSOA level were much narrower: on average 1.1 years and 1.0 year for males and females respectively and at worst only 5.1 and 6.6 years for males and females for individual areas.

A possible source of bias in these analyses is the relative density of nursing and residential care homes across areas. For both sexes GORs in the south had a higher proportion of people aged 65 and over in these institutions, while the proportion of females was higher than males (author's analysis). The inclusion of the institutional population is therefore likely to reduce DFLE more in the most affluent areas than the most deprived and act to narrow the gap in inequality between these

areas. Nevertheless, in a previous study, Bebbington and Darton (1996) found that the overall effect of adjusting for the institutional population was small.

Conclusions

The estimation of health indices for small areas is important for resource allocation and for effective monitoring and planning purposes, since many services are implemented and delivered locally.

This report provides estimates of LE and DFLE at birth and at age 65 for individual MSOAs and measures of geographical and deprivation-related health inequalities in England for the period 1999–2003. For both sexes there are significant differences in DFLE at birth and at age 65 based on these two measures, while differences by sex were also present. We have illustrated the relative advantages of MSOAs over wards in estimating DFLE for small areas; their relative homogeneity in terms of population size and structure means that estimates are more precise and better inference between areas can be drawn. There is also scope for monitoring changes in health inequalities as MSOAs were designed to undergo minimal boundary changes over time.

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Amenable mortality as an indicator of healthcare quality – a literature review

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Abstract

Background

In 2008, the Office for National Statistics (ONS) suggested that research should be undertaken into whether amenable mortality – deaths considered avoidable due to medical intervention – could be used as an indicator of healthcare quality. The aim of this paper is to review the literature on amenable mortality in order to determine the extent to which the observed fall in amenable mortality is due to the healthcare system.

Methods

The literature reviewed covers mainly the Organisation for Economic Co-operation and Development (OECD) countries and can be broadly categorised into: (a) trends across OECD countries (b) pooled time series cross-country analyses of OECD countries and (c) cross-section or time series analyses within countries.

Results

There is no consensus in the literature on exactly what constitutes amenable mortality, thereby making the concept in itself imprecise. However, there has been a fall in amenable mortality in the past few decades in most OECD countries including the UK. Since the fall in amenable mortality has been at a faster rate than that of 'unavoidable' mortality, some studies have directly attributed this to the healthcare system. Others have tested the relationship between healthcare outcomes and healthcare inputs to determine the magnitude and direction of the relationship.

No study has explicitly used a healthcare activity or quality variable in their analyses. This implies that the evidence that amenable mortality is an indicator of healthcare quality is far from overwhelming or clear.

Conclusions

At this stage, it is premature to use amenable mortality in ONS's healthcare output calculations. We welcome comments from those interested in this field, and suggestions to improve understanding in this area.

Editor's note

This article originally appeared on the ONS website on 30 March 2010 at http://www.statistics.gov.uk/cci/article.asp?id=2397. It is reproduced here to disseminate the findings more widely and make the content readily available to readers of HSQ. As the original article was quality assured by selected members of the UK Centre for the Measurement of Government Activity (UKCeMGA) quality assurance panel for Healthcare, additional peer review was not considered necessary before publication in HSQ.

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Introduction

The ONS is responsible for producing estimates of public service output and productivity, and therefore publishes measures of healthcare output and productivity for the UK (ONS 2010; ONS 2008; ONS 2006; ONS 2004). Healthcare output is measured using healthcare activity, and adjusted for quality using the following indicators:

- short-term survival and health gain following treatment in hospital, including health effects of shorter waiting time
- outcomes from primary medical care
- assessment of patient experience

As part of the work to improve the measure of healthcare output, ONS proposed an investigation of amenable mortality as an indicator of healthcare quality (ONS 2008).

Background

In recent decades in the UK, the rate of amenable mortality, that is deaths considered avoidable due to medical intervention, have fallen. In England and Wales, the age-standardised mortality rate (takes into account differences in the age structure of populations and allow comparison over time and between sexes) for all causes considered amenable to medical intervention decreased by around 43 per cent for males and 38 per cent for females between 1993 and 2005 (Wheller *et al*. 2007).

This raises an obvious question – how much, if any, of the observed decline in amenable mortality can be attributed to the healthcare system? The answer, however, is not obvious since apart from healthcare, there is a wide range of socio-economic and lifestyle factors that influence health outcomes.

The Department of Health (DH) in a recent paper on quality adjustments to healthcare output (DH 2007) estimated what would happen if the entire observed decline in amenable mortality in England were due to the National Health Service (NHS). DH valued each life year saved at £30,000 to calculate the addition to NHS output. They found that, between 2000 and 2005, the resulting increase in NHS output would equal approximately £2.9 billion and add approximately 1 per cent per annum to the output series. DH notes however that:

- there is no evidence that the decline in amenable mortality can be attributed entirely to the NHS
- amenable mortality might be declining (i) due to an increase in NHS activity (ii) an improvement in NHS quality. If the entire fall in amenable mortality is attributed to the NHS and thereby added to the output series, this could result in double counting since NHS activity is already included in the output series
- current quality indicators, especially survival after hospital treatment, might already be picking up the impact of declining amenable mortality on healthcare output

In order to include amenable mortality in ONS's healthcare output calculations, there is a need to validate the relationship between amenable mortality and healthcare. In other words, what proportion of the decline in amenable mortality can be attributed to the healthcare system and,

more importantly, is it possible to assess how much of the decline is due to an increase in activity and how much to an improvement in quality?

Aim of the paper

The primary aim of this paper is to review the literature on amenable mortality in order to determine the extent to which the observed fall in amenable mortality is due to the healthcare system. This is in line with the principle set out in the Atkinson Review (2005) which states that 'the output of the government sector should in principle be measured in a way that is adjusted for quality, taking account of the attributable incremental contribution of the service to the outcome.'

This paper also identifies gaps in the literature and suggests directions for future research. The implications of the findings for the work of the ONS on healthcare output and productivity are also discussed. Only studies that focus on OECD countries are covered.

Results from the literature

What constitutes amenable mortality is not clear

Amenable mortality can broadly be defined as deaths occurring before age 75 from causes that are considered amenable to medical intervention (Wheller *et al*. 2007). Examples include breast cancer, cancer of colon and rectum, leukaemia, gastric and duodenal ulcer, and hypertensive diseases. There is, however, no consensus in the literature on exactly what constitutes amenable mortality (Wheller *et al*. 2007; Nolte and McKee 2004). Advances in medical care mean that diseases that are considered amenable to medical intervention keep changing over time. Additionally, the 'cut off' age can vary depending on the condition in question. For instance, some authors set the age limit for diabetes mellitus under 50 because the preventability of deaths at older ages from diabetes remains controversial, while the age limit for whooping cough and measles might be set under 15 since deaths other than in childhood from these diseases are likely to reflect the presence of other disease processes (Nolte and McKee 2008).

While some studies focus on deaths amenable to medical intervention, others also include deaths considered preventable due to primary care or public health policies (often termed 'preventable mortality') such as lung cancer, illicit drug use disorders, transport accidents, and Hepatitis B. With preventable mortality however, individual lifestyle factors and socio-economic factors might play a proportionately larger role when compared to healthcare factors, thereby making it harder to separate the impact of healthcare from other factors. Nevertheless, the role of public health policies in mitigating deaths from preventable causes cannot be ignored altogether.

The literature also uses the term 'avoidable mortality' which may refer to (i) amenable mortality or (ii) both amenable and preventable mortality. This paper is not restricted to studies that cover amenable mortality but also includes those that discuss preventable mortality.

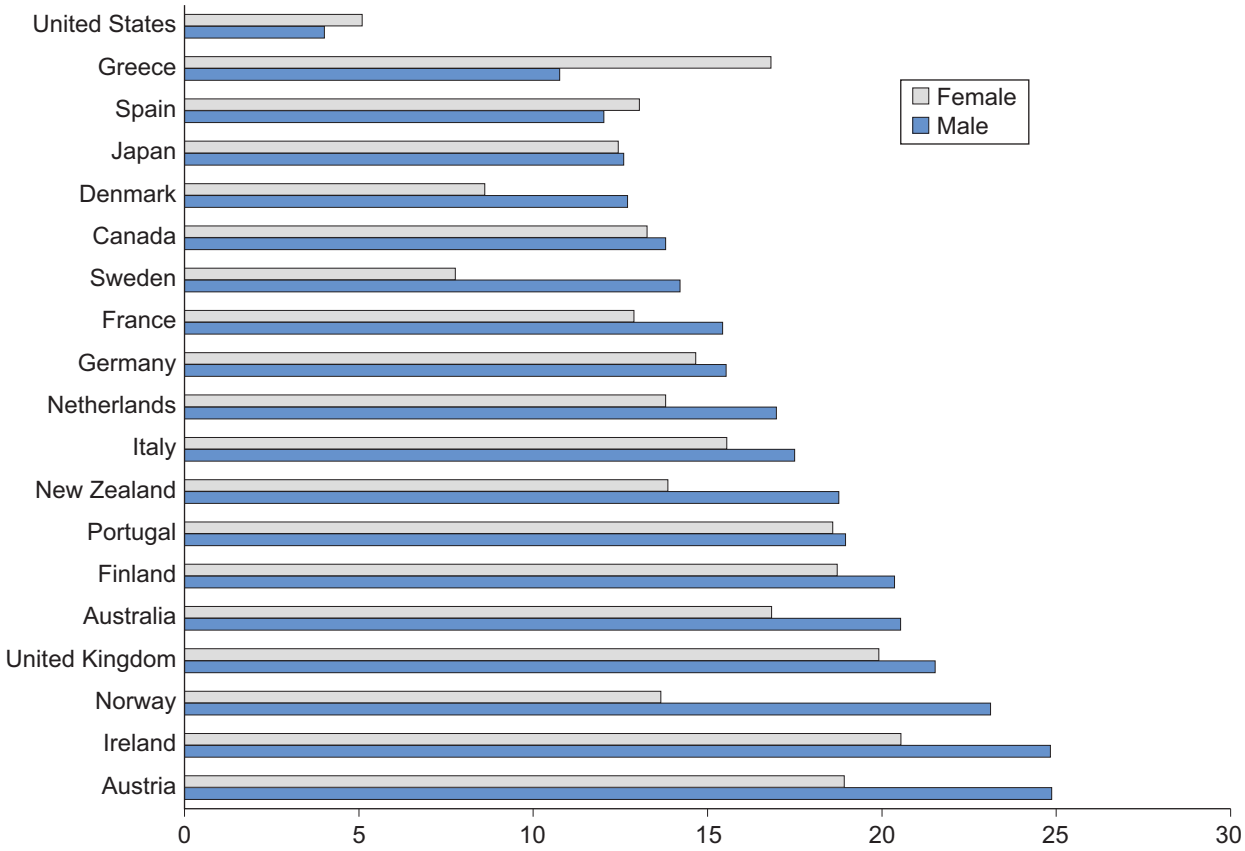
Trends in amenable mortality

The vast majority of the literature on amenable mortality discusses trends across or within countries. As mentioned before, this review is limited to OECD countries with a particular focus on the UK.

Declining rates of amenable mortality across OECD countries

Nolte and McKee (2008) carried out a comprehensive study of amenable mortality in 19 OECD countries between 1997/98 and 2002/03. They calculated the age-standardised death rates among males and females from selected causes and found a clear decline in amenable mortality in all countries (Figure 1). Among males, the average fall was 17 per cent, while for females it was 14 per cent. The USA showed the smallest decline, 4 per cent among males and just over 5 per cent among females. In the UK, the decline was 22 per cent for males and 20 per cent for females. It is important to acknowledge that the starting levels of mortality in these countries are different. However, the main point here is the observed decline in amenable mortality rates.

Figure 1 **Decline in amenable mortality amongst males and females aged 0–74. Nineteen OECD countries, 1997/98–2002/03**



Source: Nolte and McKee (2008)

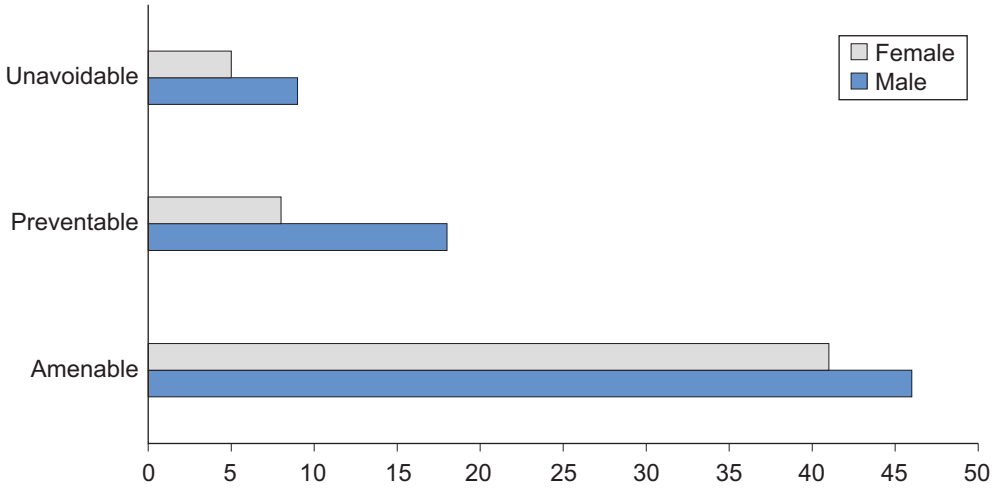
Declining rates of amenable mortality in England and Wales

Wheller *et al.* (2007) measured the rate of avoidable mortality in England and Wales between 1993 and 2005 and concluded that there was a fall in both amenable and preventable mortality.

Figure 2 shows the decline in amenable, preventable and unavoidable mortality using the Page, Tobias and Glover (2006) definition of avoidable mortality. Between 1993 and 2005, mortality from amenable causes decreased by 46 per cent and 41 per cent for males and females respectively; from preventable causes by 18 per cent for males and 8 per cent for females; and unavoidable causes by 9 per cent among males and 5 per cent among females.

The authors conclude that the 'decreases in mortality from avoidable causes are unlikely to simply be the result of a general decrease in mortality rates and that medical interventions are likely to have contributed positively to reductions in avoidable mortality, as are public health initiatives, though perhaps to a lesser extent'.

Figure 2 **Decline in amenable, preventable and unavoidable mortality amongst males and females aged 0–74 in England and Wales, 1993–2005**



What the trends tell us

There is a clear decline in amenable mortality in most OECD countries, including the UK. Some studies have directly attributed the decline to the healthcare system. However, Nolte and McKee (2008) point out that 'amenable mortality should not be mistaken as a definitive evidence of differences in effective healthcare but rather as an indicator of the potential weaknesses in healthcare that can be investigated in more depth.'

The following sections will discuss those studies that have tested the magnitude and direction of the relationship between healthcare inputs and healthcare outcomes. The results will determine how much, if any, of the fall in amenable mortality can be attributed to the healthcare system.

Empirical evidence of the relationship between health outcomes and inputs

The most common method employed to test the relationship between health outcomes (for example, life expectancy) and health inputs is a health production function. Studies reviewed in this section can be split into (i) pooled time series cross-country analyses of OECD countries and (ii) cross-section or time series analyses within countries. Not all studies reviewed have tested the relationship between healthcare inputs and amenable mortality *per se* – some have focused on the impact of healthcare on mortality in general.

The equation in Box 1 shows a typical health production function estimation. In order to determine if amenable mortality can be attributed to the healthcare system, the set of medical variables in the equation should ideally include indicators or measures of healthcare activity and healthcare quality.

Box 1 Health Production Function

$$H_{it} = \alpha_i + \beta M_{it} + \gamma E_{it} + \varepsilon_{it}$$

H is a measure of health outcome;

M captures medical or healthcare variables;

E is a list of non-medical variables;

subscripts i and t represent country and time;

the sign on β and γ gives the direction of the relationship between the respective health input and health outcome, and their values give the magnitude;

ε is the error term;

α picks out any country fixed effects – it is important to account for the fact that each country has different characteristic features and this term holds constant those characteristics that vary across countries but are fixed over time.

Variables used in the analyses

Health outcome variables: A range of indicators, often split by gender, have been used to capture the health outcome variable. These include life expectancy at birth, life expectancy at age 65, infant mortality, premature mortality, mortality rate, premature mortality from specific diseases and age-adjusted death rate.

Health input variables: The predominant healthcare input variable used in the literature is healthcare expenditure or healthcare expenditure *per capita*. In addition, health supply variables such as the number of doctors, hospital beds, type of health system, immunisation coverage, and physicians *per capita* have also been used in some studies. It is important to note that a healthcare expenditure variable does not explicitly capture either activity or quality aspects of the healthcare system and therefore does not directly answer the question at hand.

Socio-economic and lifestyle variables: Socio-economic factors including education, Gross Domestic Product (GDP) *per capita*, income distribution, age structure, unemployment rate, pollution, marriage, and crime have been used in the analyses. Individual and lifestyle factors such as tobacco, alcohol and sugar consumption, diet, fruit intake, and pre-existing health conditions have also been used.

The purpose of the studies reviewed

The primary purpose of the studies reviewed has been to assess the role of healthcare as a determinant of population health outcomes after controlling for socio-economic and individual lifestyle factors. Some have tested for differences in value for money and effectiveness of healthcare across OECD countries.

Three points worth noting here are:

1. Time lag: Most studies have ignored the time lag problem – improvements in medical care might only show effects on mortality after a certain period of time.

2. Disease incidence: Only a very small proportion of studies have taken into consideration the issue of disease incidence. It is important to account for this since the decline in amenable mortality could be due to a decline in incidence of disease as opposed to a decline in case fatalities. Treurniet *et al.* (1999) have shown that regional variations in mortality in the Netherlands were partly explained by disease incidence variations and that incidence-adjusted mortality rates might be more suited to explain variations in healthcare quality across regions.

3. Use of healthcare expenditure variable: Most studies reviewed have used healthcare expenditure as the main healthcare input variable in their analyses. In addition to not directly answering the question at hand, this poses a methodological problem – higher expenditure could often be found in areas with high mortality rates because resources are diverted to such areas. This makes it harder to separate cause from effect and therefore needs to be taken into account while estimating the relationship. Only a few studies have utilised the appropriate methodology to tackle this problem.

Evidence from pooled time series analyses across OECD countries

The studies discussed in this section will demonstrate that the evidence that variations in health outcomes can be explained by variations in health inputs is mixed.

Some studies found a weak or no association between the healthcare input variables and health outcomes (Mackenbach 1991; Poikolainen and Eskola 1988; Kunst *et al*. 1988). For instance, Mackenbach (1991) found no association between *per capita* healthcare expenditure and GDP-

adjusted average SMR (Standardised Mortality Rates) from amenable conditions for 11 European Community countries between 1980 and 1984.

Others found a statistically significant and negative relationship between healthcare variables and mortality indicators (Macinko *et al.* 2003; Joumard *et al.* 2008) while some found that socio-economic factors and/or individual lifestyle factors (Arah *et al.* 2005; Or 2000) have a higher magnitude of impact:

- One study on the impact of primary care systems on health outcomes (Macinko *et al*. 2003) in OECD countries found that the strength of a country's primary care system is negatively associated with all-cause premature mortality and cause-specific premature mortality (asthma and bronchitis, emphysema and pneumonia, cardiovascular disease, and heart disease) even after controlling for macro-level (GDP *per capita*, total physicians per 1,000 population, per cent of elderly) and micro-level (average number of ambulatory care visits, *per capita* income, alcohol and tobacco consumption) determinants of health. Primary care system characteristics were assessed using a common set of indicators – regulation, financing, primary care provider, access, longitudinally, first contact, comprehensiveness, coordination, family-centred, community-oriented.
- In another study, though healthcare coverage, immunisation and collective health expenditure were found to have negative effects on mortality and premature death, it was alcohol, tobacco and fat consumption that were significantly associated with higher all-cause mortality and premature death (Arah *et al.* 2005)
- The importance of socio-economic factors is demonstrated in a study (Or 2000) that finds the rise in the employment share of white collar workers and the rise in *per capita* income to have played the greatest role in the reduction of premature mortality between 1970 and 1992 across 21 OECD countries

Evidence from country-specific analyses

The studies reviewed in this section are restricted to analyses within a country and often attempt to explain subnational variations. Most found that socio-economic factors more than healthcare variables explain the decline in amenable mortality.

Evidence from OECD countries

A study of the USA (Thornton 2002) showed that additional medical care utilisation was relatively ineffective in lowering mortality and increasing life expectancy and the most important factors that influenced death rates related to socio-economic status and lifestyle. Similarly, studies of France (Jougla *et al.* 1987) and the Netherlands (Mackenbach *et al.* 1988) showed weak and inconsistent relationships between health status and health supply variables.

Evidence from the UK

Studies of the UK on the impact of the NHS on reducing amenable mortality are scarce. Earlier studies of England and Wales (Bauer and Charlton 1986; Charlton *et al.* 1983) did not directly test for the relationship between healthcare input and healthcare outcomes (Carr-Hill *et al.*1987).

One recent study (Martin *et al.* 2008) has tackled the inherent methodological problem while estimating a health production function – the need to account for the fact that higher expenditure is often found in areas with higher mortality rates. The main aim of this paper was to determine if extra spending gives rise to better health outcomes, after controlling for need. In that respect, the study does not test the relationship between amenable mortality and healthcare activity *per se*. Their results, however, show that healthcare expenditure has a positive effect on outcomes in five care programmes – cancer, circulation problems, respiratory problems, gastro-intestinal problems and diabetes. This study is a starting point for future research on amenable mortality in the UK - if the methodology is applied to test the relationship between mortality from amenable conditions and healthcare activity and quality, the findings would greatly reduce the current gap in the literature.

What the empirical analyses tell us

No study reviewed so far has explicitly used a healthcare activity or quality variable in their analyses. Therefore, it is rather difficult to draw definitive conclusions about the relationship between amenable mortality and the healthcare system. In addition, there is a lack of discussion in the literature about what variables could be used to capture healthcare activity and quality. Healthcare expenditure and supply variables can act as a proxy for healthcare activity and quality. However, studies that tend to use this variable are attempting to answer a different question – value for money. Additionally, since most studies have not corrected the inherent methodological problem while estimating a health production function using healthcare expenditure, it is harder to draw clear conclusions.

Conclusions

There is no consensus in the literature on exactly what constitutes amenable mortality, thereby making the concept in itself imprecise. However, there has been a clear fall in amenable mortality in the past few decades in most OECD countries including the UK. Since the fall in amenable mortality has been at a faster rate than that of unavoidable mortality, some studies have directly attributed this to the healthcare system. Others have tested the relationship between healthcare outcomes and healthcare inputs to determine the magnitude and direction of the relationship.

Since no study has explicitly used a healthcare activity or quality variable in their analyses, the evidence that amenable mortality is an indicator of healthcare quality is far from overwhelming or clear. Though healthcare expenditure can implicitly capture healthcare activity and healthcare quality, the use of this variable is more appropriate to determine value for money across regions. In order to test the relationship between healthcare input and amenable mortality, variables that are directly related to activity and quality of healthcare are essential. It would be ideal if disease incidence is also taken into account.

The fact that most studies have not corrected the inherent methodological problem in estimating a health production function using health expenditure might explain the commonly reported weak and inconsistent results for the healthcare input variables. Though there is strong evidence in the literature for socio-economic and individual lifestyle factors, the magnitude of the impact might be reduced with appropriate methodology and model specification.

At this stage, it is premature to use amenable mortality in ONS's healthcare output calculations. We welcome comments from those interested in this field, and suggestions to improve understanding in this area.

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