THEORY AND METHODS

Impact of nursing home deaths on life expectancy calculations in small areas

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Study objective: The drive to tackle health inequalities at the local level has increased interest in mortality data for small populations. There is some concern that nursing homes may affect measures of mortality for small populations, but there has been little in depth analysis of this.

Design and setting: Deaths between 1997 and 2001 and population figures from the GP register (Exeter) database and census 2001 were used to produce life expectancy (LE) figures for all electoral wards in West Sussex. The proportion of those dying within each ward that had been residents of nursing homes was calculated and the relation between these variables and deprivation investigated.

Results: There was a significant linear relation between nursing home deaths and LE ($p < 0.0001$), which explained 36% of variation in LE between wards. Deprivation accounted for around 35% of the variation in LE ($p < 0.0001$) but was not correlated with nursing home deaths ($p \geq 0.0982$). Multiple linear regression shows that over 60% of the variation in LE at ward level can be explained by both nursing home deaths and deprivation ($p < 0.0001$) and that the two variables explain similar proportions of this variation. The relation between LE and nursing home deaths within wards grouped by deprivation suggests that the impact of nursing homes is strongest in deprived wards.

Conclusions: This finding has important implications for LE calculations in small populations. Further investigation is now needed to examine the impact of nursing homes in other areas, on other mortality measures, and in larger populations.

The drive to tackle health inequalities and the move to localised policy making have increased interest in small area mortality data. Many commentators believe life expectancy (LE) is the best indicator of variation in health status.^{1,2} In the UK there is now has a national target to reduce LE differentials.³

Bremner has argued for a move away from the convention of reporting LE data only for large, socially heterogeneous aggregates such as UK local authority (LA) areas in England and Wales (average population 138 000) and there is now considerable interest in calculating LE in small areas, such as UK electoral wards (average population 5800 persons) to describe local variations in health and identify health inequalities.⁴

Eayres and Williams have recently produced a methodology for LE in small areas, showing that a reasonable degree of confidence can be maintained down to 5000 person years at risk.⁵ The British Office for National Statistics (ONS) also recently published a similar methodology and plans to publish LE figures at electoral ward level. This measure has previously been calculated and made available by a number of local groups, for example the Trent Public Health Observatory.

However, when using LE in small populations, the effects of nursing homes must be considered, as people in such homes tend to be frailer than the general population of equivalent age and studies have shown that the age specific death rates in nursing homes are higher than those found in the general population.^{6,7} The LE model is driven by age specific death rates rather than the age of death itself, so areas with nursing homes will tend to have higher deaths rates in the older age bands and thus lower LE figures.

In Canada Veugelers has shown that selective migration of frail elderly people to nursing homes can affect local estimates of LE in small areas (average size 14 677 persons),⁸ and Williams showed nursing home deaths were a potential

source of bias when calculating standardised mortality ratios (SMRs) for English electoral wards.⁹ In March 2002 the English Department of Health noted that the calculation of LE at ward level "is strongly influenced by factors such as the number of old people's homes in the ward",¹⁰ and in September 2003 the ONS remarked that the presence of nursing homes in a ward may lead to local migration effects that could influence mortality rates.¹¹

Nursing homes also affect other types of mortality calculations. For example, the proportion of nursing home patients is one of a number of case-mix factors that can affect mortality rates calculated for GP practices (which are similar in size to UK electoral wards).^{12–14}

This paper examines the impact of the uneven distribution of nursing homes on LE calculations for small areas, such as UK electoral wards.

METHOD

The West Sussex area

Data for all wards in West Sussex during the period 1997–2001 were used for this study. On 31 March 2001, the GP Register (Exeter) database showed the population of West Sussex to be 788 767 (compared with a 2001 census population of 753 612), organised into seven LAs and 155 electoral wards. Ward populations ranged from about 1100 to 14 000. West Sussex is a relatively affluent county in the south east of England with both urban and rural areas and small pockets of deprivation along the coast. The south coast towns are popular retirement areas, and this has resulted in the county having a higher than average proportion of people aged 75+ (10.5% compared with the national average of 7.6%,

Abbreviations: LE, life expectancy; LA, local authority; ONS, Office for National Statistics; SMR, standardised mortality ratio; PHMF, Public Health Mortality Files; DETR, Department of the Environment, Transport and the Regions

Figure 1 Life expectancy and percentage of nursing home deaths: wards in West Sussex.

2001 census). Worthing LA has the highest proportion of people aged 85+ in England and Wales (4.6%) and Arun LA has the fourth highest (4.2%).¹⁵

West Sussex has around 120 nursing homes with about 4200 beds according to the National Care Standards Commission (April 2003). The 2001 census showed 2924 West Sussex residents lived in nursing homes, distributed unevenly between the seven LAs. Worthing had 6.7 nursing home residents per 1000 people, the highest level in the country, whereas the rate in Crawley was 1.1 per 1000, within the bottom quintile for England and Wales. Census figures also show variation in nursing home populations between wards in West Sussex, ranging from 0% to 4.6% of the ward population.

Mortality

The Public Health Mortality Files (PHMF) for 1997 to 2001 provided data on all deaths in West Sussex over this period. The ONS produce these files every month and also an annual summary, creating an electronic record of all deaths. As it is a legal requirement within the UK to register deaths within five days, the PHMF provides a complete record. Deaths were assigned to wards using postcode of residence and postcode to ward lookup files from the NHS Information Authority's Organisation Codes Service.

Details of all nursing homes operational in West Sussex between 1997 and 2001 were compared with the PHMF for this period. Deaths were flagged where postcode of residence matched that of a nursing home and then the address text was checked to ensure this was indeed a nursing home and not another address sharing the same postcode. The proportion of those dying within each ward that were residents of nursing homes, referred to as "nursing home deaths", was calculated.

Population

At the time of this study 2001 census data were not fully available for wards. Ward population numbers were obtained from the Exeter database, extracted on 31 March 2001 and

Table 2 Multiple linear regression: deprivation indices, nursing home deaths, and life expectancy

Independent variables: % nursing homes deaths and	Coefficient of determination with 95% confidence intervals (r^2)	Ratio of standardised coefficients (nursing homes/deprivation)
Jarman	0.672(0.582 to 0.763)*	1.010
Townsend	0.685(0.596 to 0.774)*	1.047
DETR income	0.647(0.553 to 0.742)*	1.027
DETR employment	0.595(0.495 to 0.696)*	1.025

*Significant beyond the 0.01% significance level ($p < 0.0001$).

allocated to wards using the same postcode lookups. The resulting total ward populations were then adjusted within each five year age band to 2001 census LA totals to reduce the impact of list inflation. List inflation is thought to have little impact on LE calculations at ward level as the age bands in which Exeter tends to overestimate the population are those where mortality rates are usually very low.¹⁶

Life expectancy

Life expectancy at birth was calculated for all 155 wards for 1997–2001 using the adjusted Chiang method. Using a five year average ironed out annual fluctuations in mortality and achieves a minimum population of over 5000 person years at risk for all wards, as recommended to maintain an acceptable standard error.⁵

Life expectancy was calculated for persons, rather than separately by gender. This also increases the effective population size, achieving an acceptable margin of error. A single LE figure for each ward is also easier to interpret.

Deprivation

Deprivation is known to affect LE and so may confound the relation between this and nursing home deaths. Four measures of deprivation have been included: the Jarman underprivileged area score (1991), the Townsend material

Table 1 Relation between deprivation indices and life expectancy

Index of deprivation	Pearson correlation coefficient with 95% confidence intervals (r)	Coefficient of determination with 95% confidence intervals (r^2)
Jarman	−0.597 (−0.478 to −0.695)	0.356 (0.229 to 0.483)*
Townsend	−0.575 (−0.448 to −0.678)	0.331 (0.201 to 0.460)*
DETR income	−0.588 (−0.467 to −0.689)	0.346 (0.218 to 0.474)*
DETR employment	−0.591 (−0.471 to −0.691)	0.350 (0.222 to 0.478)*

*Significant beyond the 0.01% significance level ($p < 0.0001$).

Table 3 LE calculated for populations formed according to the proportion of nursing home deaths in the ward of residence and the deprivation score of that ward

Electoral wards grouped by proportion of nursing home deaths	LE of deprived wards (n = 52)	LE of middle wards (n = 51)	LE of affluent wards (n = 51)
No nursing home deaths	80.2 (79.7 to 80.6)	81.9 (81.5 to 82.4)	82.7 (82.2 to 83.2)
0% < wards < 10%	79.3 (78.6 to 80.0)	81.6 (81.0 to 82.2)	82.2 (81.5 to 82.8)
10% ≤ wards < 20%	79.0 (78.5 to 79.6)	80.2 (79.6 to 80.9)	81.4 (80.9 to 81.9)
20% ≤ wards < 30%	78.3 (77.8 to 78.7)	79.9 (79.4 to 80.4)	80.6 (79.9 to 81.3)
30% ≤ wards < 40%	77.5 (76.8 to 78.2)	79.6 (78.8 to 80.5)	79.0 (77.2 to 80.7)
Wards 40% and over	74.6 (73.7 to 75.4)	77.5 (76.5 to 78.5)	79.0 (78.3 to 79.6)

deprivation score (1991), and the income and employment domains from the Department of the Environment, Transport and the Regions (DETR) index of multiple deprivation 2000.¹⁷ In addition a composite deprivation score was calculated for each ward by adding together that ward's ranks within West Sussex for each of the four deprivation indicators.

Statistical techniques

The relation between LE, nursing home deaths and deprivation was investigated by use of linear regression and multiple linear regression using SPSS and Microsoft Excel.

As the standard error of LE estimates for small areas can vary substantially, regressions were weighted according to population size. In this way large wards, with smaller estimates of standard error, carry more weight in the regression analysis than smaller wards where estimates of LE are likely to be less accurate.

In addition the composite deprivation score was used to group the most deprived and affluent wards and those wards in the middle. Wards were also placed into one of six bands according to the proportion of nursing home deaths in that area, creating 18 categories of wards. Populations and deaths were pooled for the wards within each of the 18 categories and LE figures were calculated for each.

Ethics and data protection

This study formed part of the routine work of the West Sussex Public Health Observatory and as such did not require research or ethical approval. The mortality and census data used are regularly used within the observatory and data protection procedures were followed throughout the project.

RESULTS

Over the study period (1997–2001), there were 46 478 deaths in West Sussex, of which 40 964 (88.1%) were of people who died aged 65+ and 9163 (19.7%) were of residents of nursing homes. LE figures showed considerable variation between

wards. Overall LE for West Sussex was 79.7 years, with wards ranging from 70.0 to 84.9 years. The standard error of these ward estimates ranged from 0.56 to 2.86 years, giving 95% confidence limits ranging from ± 1.09 to 5.60 years.

The distribution of nursing home deaths among the 155 wards was as follows: no nursing home deaths in 54 wards, less than 10% in 19 wards, 10%–19% in 26 wards, 20%–29% in 25 wards, and 30%–39% in 14 wards. Seventeen wards had over 40% and in one of these the figure was 77%.

As expected, the mean age of deaths in nursing homes (86.3 years, $n = 9163$, $SD = 8.4$) was significantly higher than those not in nursing homes (77.2 years, $n = 37315$, $SD = 14.4$). A normal test to compare these means shows them to be significantly different at the 0.1% significance level ($z = 82.1$, $p < 0.0001$). Overall 73% of deaths in nursing homes were of women, compared with 56% of all deaths and 69% of deaths of those aged 85+.

Life expectancy and nursing home deaths

Using linear regression, weighted by the population of the wards, we found a significant inverse relation between LE and the proportion of nursing homes deaths in an electoral ward ($r = -0.601$, $r^2 = 0.362$, $p < 0.0001$), as shown in figure 1. Residuals from this line of regression display a near normal distribution (mean = 0.16, $SD = 1.78$), supporting the linear relation and the validity of using a parametric test. Electoral wards with a high proportion of nursing homes deaths tend to have a lower LE. The coefficient of determination (r^2) indicates that around 36% of the variation in LE between wards can be explained by nursing home deaths.

Deprivation and life expectancy

Linear regression, again weighted by population size, between LE and deprivation (as measured by Jarman, Townsend, and the DETR income and employment domains) shows a consistent and significant relation, as shown in table 1. Residuals from these regressions display near normal distributions. The coefficient of determination indicates that about 33% to 36% of the variation in LE between wards can be explained by deprivation.

Deprivation and nursing home deaths

No significant correlation ($p \geq 0.0982$) was found between the distribution of nursing home deaths and the four deprivation variables in both parametric (Pearson's) and non-parametric tests (Spearman's rank and Kendall's τ).

Deprivation, nursing homes, and life expectancy

Table 2 shows the results of a population weighted multiple linear regression between deprivation, nursing home deaths, and the ward LE figures.

The combination of nursing home deaths and a deprivation variable can explain between 60% and 69% of the variation in ward level LE. In all four cases the two variables are close in

Key points

- The local distribution of nursing homes can have a strong impact on life expectancy figures for small populations.
- Life expectancy figures for electoral wards in West Sussex show as strong a correlation with nursing homes as they do with deprivation, yet these two variables show no correlation with each other.
- This relation must now be confirmed through similar analysis in other areas. The impact of nursing homes on other measures of mortality and in larger populations should also be investigated.

strength, as indicated by the ratios of the standardised coefficients (calculated by dividing the β value for the nursing home variable by that for deprivation) being close to one.

Life expectancy by nursing home deaths for deprived and affluent wards

Table 3 compares LE for 18 categories of ward, defined according to the proportion of nursing home deaths, and the level of deprivation within the ward of residence.

In each deprivation group there is a graduated differential between LE and the proportion of nursing home deaths; the higher the percentage the lower the LE. The impact of nursing home deaths appears greater in deprived areas—LE for deprived wards with no nursing home deaths and those with more than 40% differs by 5.6 years. The affluent and middle groups show a difference of 3.7 and 4.4 years respectively.

DISCUSSION

This study has shown that within West Sussex nursing home deaths have a significant impact on LE calculations at ward level. It is estimated that in an electoral ward where 25% of those dying are nursing home residents LE will be reduced by about two years. Therefore LE calculations are likely to be inflated in small areas without nursing homes. This finding suggests that the proportion of nursing home deaths must be considered when presenting and interpreting LE calculations in small areas.

It is now necessary to replicate the findings of this study for other areas to establish whether the pattern in West Sussex is found in other areas where nursing homes are common. Preliminary work has shown a very similar relation between nursing home deaths and LE for wards in nearby Croydon, but more research is needed. The impact of other types of communal care establishments may also warrant further investigation, for example residential homes and hospices.

The mean age of death of nursing home residents is higher than that of the general population, yet it is important to remember that an influx of elderly residents will not increase LE. The age specific death rates of nursing home residents are higher than those in the general population and LE calculations are affected by age specific death rates rather than by age of death.

Another important observation is that most nursing home deaths are of women. Therefore the impact of nursing home deaths on LE may differ between figures published for women and for men. This requires further study, and is an important consideration for those wishing to calculate separate LE figures for men and women at ward level.

At ward level in West Sussex the impact of nursing home deaths on LE seems to be as strong as that of deprivation. It has been shown that about 36% of the variance in LE figures

can be explained by nursing home deaths and 35% by deprivation indicators. This has important implications for those who plan to use LE as a measure of health status or as an indicator of deprivation; the pattern shown by LE figures at ward level is as much a measure of nursing home deaths as it is of deprivation.

Griffiths and Fitzpatrick examined the relation between the income and employment domains of the DETR index of multiple deprivation 2000 and LE.¹⁸ Raleigh and Kiri have done the same with the Jarman index.¹⁹ Both studies suggest that for LAs in England around 45% of the variation in LE can be explained by deprivation indices. Our work suggests that this relation is a little less strong for West Sussex wards, possibly because of the confounding effect of nursing homes.

This study has only examined the effect of nursing home deaths at ward level but these deaths are also unevenly distributed between larger populations, such as LAs. Therefore LE figures, routinely published for LAs, may be affected by nursing home deaths. Further work is needed to investigate this possibility. The effect of nursing homes should also be considered when analysing trends in LE, as changes in the distribution of nursing homes over time could affect the observed trend.

The effect of nursing homes on other measures of mortality should also be investigated. Williams *et al* have shown that SMRs at ward level were also affected by nursing home deaths.⁹ SMRs weight all deaths equally regardless of age, while LE methodologies place more weight on younger deaths. As a result SMRs could be more affected by nursing home deaths than LE. Preliminary work in West Sussex suggests that almost 60% of the variation in all cause SMRs at ward level may be explained by nursing home deaths. Although commonly used, SMRs may also be susceptible to nursing home bias in larger populations.

SMRs are sometimes produced for all deaths under 75, a technique that will reduce the impact of nursing homes. A similar technique can be used for LE, though having a maximum value of 75 years substantially changes the appearance of the figure and arguably reduces its appeal as a measure that is easily understood by a variety of audiences. It also affects sensitivity, as a large proportion of all deaths are excluded from the analysis, along with much of the variation in mortality between areas.

Other approaches could be used to reduce the impact of nursing homes. For example deaths of nursing home residents and the corresponding nursing home population could be removed from the calculations, or nursing home residents and deaths could be reassigned to their former area of residence. The latter option was used by Veugelers in Canada but is complicated in the UK by the lack of data on nursing home residents⁸; we have neither an accurate record of the nursing home population nor any information on former area of residence.

To enable further investigation of this phenomenon, the ONS PHMF could routinely identify nursing home deaths. Currently where place of death is a communal establishment (which includes nursing homes) it is marked with a code. However, place of residence is not coded in this way, although this could easily be done. More thorough monitoring of the nursing home population, and information on the former address of nursing home residents, would also enable more robust analysis.

While the relation between nursing home deaths and mortality indices must be better understood, whether this relation should be considered to be problematic may depend on how the mortality figures are to be used. Where LE is to be used as a proxy for deprivation, or as a measure of health status, nursing home deaths may well confound the underlying trend. In other situations, perhaps where LE is to be

Policy implications

- The impact of nursing homes must be considered before life expectancy figures for small areas are published or used in decision making. The same caution should be applied to other measures such as SMRs when used for small populations.
- To facilitate further analysis in this area the deaths of nursing homes residents could be made more easily identifiable and routinely monitored. There is potential for these to be marked on UK mortality files.

used as an indicator of local demands on health services, including the effect of nursing home deaths might be essential for the analysis.

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