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Excess winter morbidity among older people at risk of cold homes: a population-based study in a London borough

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Abstract

Background Fuel poverty frequently affects older low-income households, in homes that are difficult to heat. Excess winter deaths occurring in Britain are widely attributed to effects of cold. This pilot study examined the demonstrability of a relationship between older people's health and fuel poverty risk, using morbidity data.

Methods An observational, population-based study was made of 25 000 residents aged ≥65 years in the London Borough of Newham (LBN). Using Hospital Episode Statistics (HES) data over 1993–1997, anonymized at enumeration district (ED) level, we calculated excess winter morbidity, based on emergency hospital episodes for all respiratory diagnosis codes. EDs were variously aggregated after ranking against a proposed Fuel Poverty Risk Index (FPR), including factors of energy inefficient housing, low income, householder age and under occupation.

Results FPR is a predictor of excess winter morbidity. In particular, FPR was observed showing a significant relationship with high winter morbidity counts for 2 of 4 years studied. Using FPR as a two-level factor (high and non-high), the model provides odds ratios: for 1993, winter/summer morbidity ratio for high FPR is 1.7 higher than the corresponding ratio for non-high FPR [95% confidence interval (CI) = 1.1–2.7], and for 1996, the odds ratio is 1.6 (95% CI = 0.9–2.8). In a regression with grouped EDs, having allowed for FPR, no other variables in our set contribute to the difference between winter and summer morbidity counts.

Conclusions Results may indicate supporting evidence of a relationship between energy inefficient housing and winter respiratory disease among older people, with public health implications for increasing health-driven energy efficiency housing interventions.

Keywords: cold, excess winter morbidity, housing, older people

Introduction

The link between outdoor temperatures and excess winter deaths is widely acknowledged. Despite a relatively mild climate, the excess winter mortality ratio is high in Britain, compared with countries with similar or colder climates. On average, there are 40 000 such deaths here annually.[1] The reason for high numbers in Britain may be the extent of homes that are energy inefficient and, therefore, difficult to keep warm. Fuel poverty, which is described as the inability to afford adequate warmth, depends on the building fabric and heating system as well as household income.[2] However, there is limited evidence directly linking health outcomes with low indoor temperatures or fuel poverty. Housing intervention studies are rarely able to pinpoint the nature and size of health gains resulting from specific housing improvements, because of small sample size and methodological limitations.[3] There are frequently ethical problems attached to carrying out intervention studies involving housing improvements where it is necessary to deny these to the control group. To determine the health impact and cost effectiveness of housing interventions, costs to the health services of poor housing conditions need to be identified. The study described here aimed to examine whether some costs of cold housing as a consequence of fuel poverty could be demonstrated through a population study, considering available morbidity data.

Recent epidemiological studies have investigated the relationship of excess winter mortality with aspects of housing and income that can be related to fuel poverty. The Eurowinter Group found independent associations with home heating and outdoor cold stress.[4] Aylin *et al.*[5] confirmed inverse associations of respiratory excess winter mortality with outdoor temperature and central heating ownership in Britain. Wilkinson *et al.*[1] examined cardiovascular excess winter mortality in relation to socioeconomic status and indoor temperature determinants. Using predicted home temperatures, they found that coldest homes were associated with more risk of excess winter

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deaths than the warmest, but suggested that the scale of potential public health benefits of energy efficiency interventions is not yet established.[1]

Despite accumulated research into links between ill health and poor housing, whether cold, damp or overcrowded, the evidence base needs enhancing to help define the cost effectiveness and long-term impact of specific housing interventions.[6] Mortality statistics are easier to access than morbidity data but represent only the tip of an iceberg in terms of cold weather effects on health, which is recognized as a serious public health and inequalities issue.[7]

Methods

The fuel poor are most likely to be among the older population, particularly those living alone, and excess winter mortality statistics are generally discussed in terms of people aged 65 and over. This pilot study was designed to test a methodology for examining links between fuel poverty and the health of older people, taking a population approach and concentrating on morbidity, rather than winter deaths.[8] Using the London Borough of Newham (LBN), whose area fell entirely within that of the East London and the City Health Authority, the likely incidence of fuel poverty was mapped by overlapping risk indicators of older, low-income households and housing with poor energy efficiency. This was compared with the location of older people suffering cold-related illness in winter, indicated by excess winter respiratory morbidity. With limited resources, data was sought from existing and, where possible, routinely collected sources, at a small area level. The sample population comprised LBN residents aged ≥65 years, about 25 000 in number.

A small area index of Fuel Poverty Risk (FPR) was devised to characterize enumeration districts (EDs) which comprise 220 households, or 460 persons, on average. The risk factors used were as follows:

- low income: households receiving Council Tax Benefit (LBN data), this benefit being available to householders of all tenures;
- age: households including pensioners (1991 Census*);
- poor housing: extent of homes with energy efficiency ratings below the 1991 national average;
- under-occupation (where small households occupy relatively large homes for their needs): from combined Census variables: households of one or two persons only and households with ≥5 rooms.

All determinants were indicated as a percentage of either total households or total dwellings, according to 1991 Census data. FPR was calculated as the product of these factors (unweighted), divided by 100 000 to give a manageable measure.

Local authorities do not have complete detailed databases of domestic energy-efficiency ratings for all tenures, although the Home Energy Conservation Act 1995 requires that they should aim to do so. Dwelling energy ratings were therefore estimated by approximating Newham house types to case study examples from the English House Condition Survey (EHCS),[9] where buildings are classified according to age, form and ownership and assigned typical average Standard Assessment Procedure (SAP) ratings.† The Newham study drew on census data for tenure by ED, with a mapped combination of building ages (from LBN planning department data) and a drive-round street survey of building sizes and types. House types identified by these characteristics were then assigned typical energy ratings equivalent to the EHCS types. On a scale of 0–100, where zero is least efficient, the 1991 national average SAP rating of 35 was taken as the upper threshold for poor energy efficiency.

Although greater numbers of deaths throughout the year are attributed to cardiovascular than to respiratory disease, winter has the greatest proportional effect on respiratory mortality.[10] Both GP consultations and emergency hospital admissions for respiratory disease are strongly associated with external temperature falls.[11,12] Admission data show that older patients take up most bed days during winter months, particularly for chronic respiratory conditions.[12] Respiratory disease is also one condition to show a correlation between admissions and disease prevalence at electoral ward level.[13] The cold-related health indicator was therefore determined as all respiratory diagnoses (ICD-9 codes 460–519; ICD-10 codes J00–J99) for hospital episodes, for patients ≥65 years. Only emergency episodes were counted, being most likely to reflect seasonal temperature effects. East London and City Health Authority provided Hospital Episode Statistics (HES) data for 1993–1997. Episodes were assigned to ED level only, to meet confidentiality and patient anonymity requirements.

An Excess Winter Morbidity Ratio (EWMbR) was calculated similarly to the conventional Excess Winter Mortality Index (where a year is taken as August to July):

$$\frac{\text{Number of emergency winter respiratory episode (Dec – Mar)}}{\begin{array}{c}\text{Average number for other two seasons}\\ \text{(Aug – Nov; Apr – July), called summer}\end{array}}$$

Because of the low incidence of respiratory episodes in single EDs over all seasons (annual average 2.6, for the ≥65 age group), EDs were aggregated before calculating EWMbR. (Without this aggregation, our statistical method lacks validity. We discuss this again later). The 450 EDs were ranked by FPR, secondly by CTB receipt, and then clustered into 25 groups of 18 (average population ≥65 years: 1004). EWMbR was examined against FPR, its component factors (listed above) and the following additional variables: lack of central heating, Townsend deprivation score, pre-1945 dwellings, most frequent

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*The Census defines pensioners as males aged 65 and over and females 60 and over.

†SAP is the government's preferred rating method for energy efficiency.

SAP rating of dwellings, population ≥65 and lone pensioners without central heating.

No ethical approval was necessary, because data was supplied as non-patient identifiable and was deliberately anonymized.

Statistical methods

Our presented analysis, using GLIM 4,[14] did not consider EWMbR directly. In a similar way to Wilkinson *et al.*,[15] we employed a Poisson, log linear model for morbidity counts in the 25 ED groups, with a two-level winter/summer factor ('season') and FPR as a covariate. (The winter/summer counts were fixed by fitting the season factor, and the variance was weighted to allow for the differing numbers of months.) The interaction between season and FPR measures the difference in the FPR effect on morbidity between winter and summer. For the 25 groups, we found little statistical difference in treating FPR as a two-level factor, which we called FFPR (the levels corresponding to high FPR and non-high FPR). For the factor FFPR, the interaction with season gives an estimated log odds ratio for EWMbR for high/non-high FPR.

Results

The overall EWMbR for respiratory disease, over 1993–1996, was 1.12 for all ages in Newham, indicating 12% more episodes in winter than in the other two seasons. This was greater than for cardiovascular diagnoses (1.05 for IHD and stroke, combined) or for 'all cause' (0.96, indicating no excess). For the total population ≥65 years, the respiratory EWMbR was also highest, at 1.36. FPR was found to be a predictor of the difference between winter and (averaged) summer respiratory morbidity counts for the older population. For the 25 groups, FPR was a contributory factor beyond the threshold FPR = 5000. In particular, high FPR showed a significant relationship with high winter counts for 1993 and 1996, although not for 1994 and 1995. (The high/low FPR factor is in fact based on just one of the 25 aggregated groups; hence this is influential in the statistical sense. However, as an aggregation of morbidity in 18 EDs, we feel justified in treating this influential group as important and non-discrepant.)

Using a Poisson regression, FPR significantly explains the difference in winter/summer counts for 1993 ($p = 0.01$) and 1996 ($p = 0.02$). Having allowed for FPR, no other variables in our set contribute to the winter/summer difference in the 25 groups. (Note that this does not necessarily imply that all FPR components are individually significant. This needs testing at the individual ED level, raising new methodological issues, as discussed later.) Using the simplified model with the two-level factor FFPR replacing FPR, the interaction between season and FFPR interaction is slightly less significant ($p = 0.02$ for 1993 and $p = 0.08$ for 1996) but gives a more convenient explanation in terms of odds ratios.

Table 1 can be used to find the estimated (natural) logarithms of EWMbR when comparing values of FPR, for 1993 and 1996. (It also shows p-values for a likelihood ratio-based test of the hypothesis that the interaction between season and FPR is zero.)

For example, for 1993 using the factor FFPR, the estimated log(EWMbR) for high FPR is 0.53 greater than log(EWMbR) for non-high FPR. Taking exponentials, the estimated EWMbR for high FPR is 1.7 times that for non-high FPR. From Table 1, a 95% confidence interval (95% CI) of 1.1–2.7 can be calculated from the standard error of the estimate for FFPR, namely 0.23. Alternatively, for 1993 but using FPR as a variate, the estimated increase in log(EWMbR) for a 1000 increase in FPR is $0.000092 \times 1000 = 0.092$, implying that the estimated EWMbR is 1.10 times higher for a 1000 increase in FPR. Using the standard error, an approximate 95% CI for this multiplier is 1.03–1.16.

Again from Table 1, utilizing factor FFPR for 1996, the estimated log(EWMbR) for high FPR is 0.47 greater than log(EWMbR) for non-high FPR. Hence, the estimated EWMbR for high FPR is 1.6 times that for non-high FPR. The corresponding 95% CI is 0.9–2.8. Alternatively, for 1996, using FPR as a variate, the estimated increase in log(EWMbR) for a 1000 increase in FPR is $0.000097 \times 1000 = 0.097$, implying the estimated EWMbR is 1.10 times higher for a 1000 increase in FPR, with 95% CI = 1.02–1.19.

Table 1 includes the 1994 and 1995 effects, although these estimates of log(EWMbR) are clearly not significantly different from zero. Hence the corresponding EWMbR should be taken to be unity. Thus, although for 1994 the estimated EWMbR is 1.01 times higher for a 1000 increase in FPR, its CI is 0.94–1.09, which includes the null effect value of 1.0. Similarly, for 1995, the estimated EWMbR is 1.04 with 95% CI = 0.97–1.12, again including the null effect. Table 1 also shows corresponding estimates for high FFPR, but these values are doubly unreliable as, for 1994 and 1995, the FFPR factor effects give a much less good fit than FPR.

Table 1 Interaction between Fuel Poverty Risk Index (FPR) and season for 25 groups of enumeration districts (EDs)

	FPR as variate	*p*-value	FPR as two-level factor (FFPR)	*p*-value
1993	$0.000092 \times$ FPR (SE $= 0.000034 \times$ FPR)	0.01	0.53 (SE = 0.23)	0.02
1994	$0.000013 \times$ FPR (SE $= 0.000036 \times$ FPR)	0.72*	−0.21 (SE = 0.22)	0.34*
1995	$0.000042 \times$ FPR (SE $= 0.000035 \times$ FPR)	0.23*	0.09 (SE = 0.21)	0.65*
1996	$0.000097 \times$ FPR (SE $= 0.000040 \times$ FPR)	0.02	0.47 (SE = 0.27)	0.08

*Not significant.

Figures 1 and 2 show the result of fitting regression lines for summer and winter morbidity, for 1993 and 1996, as a function of FPR (using actual morbidity counts for the winter 4 months and averaged counts for two non-winter 4-month periods). The strong winter effect is apparent. For the summer months, the fitted line slope for 1996 is not significantly different from zero; for 1993, there is some evidence of a non-zero slope ($p = 0.07$). It could be expected that FPR factors might also influence summer morbidity where, for example poorly insulated housing insufficiently mitigates extreme summer temperatures.

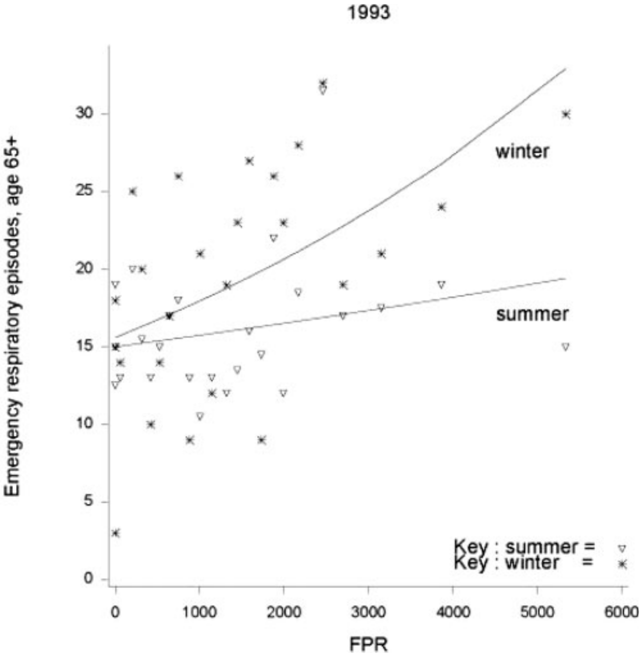

Figure 1 Relationship between Fuel Poverty Risk Index (FPR) and ratio of winter/summer morbidity (1993).

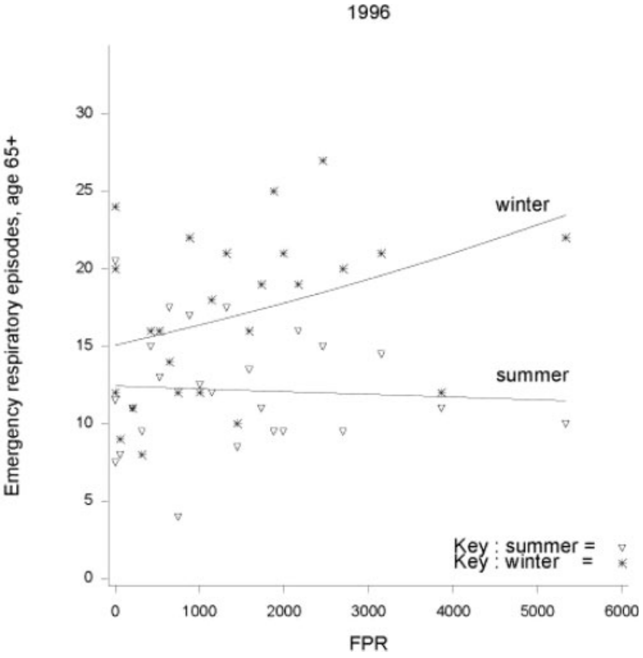

Figure 2 Relationship between Fuel Poverty Risk Index (FPR) and ratio of winter/summer morbidity (1996).

Discussion

Newham was the most deprived local authority in England in 1993,[16] which could suggest potentially insufficient contrast of socio-economic conditions across the borough to expect demonstrably significant differences in EWMbR. In cases where FPR is significant, other factors had no effect on EWMbR in the 25 groups, including energy ratings alone, lack of central heating or deprivation. Although deprivation may be considered a confounding factor for seasonal morbidity, the lack of any relationship found with EWMbR is probably because the Townsend score includes no indicators specifically related to hard-to-heat housing. This finding strengthens the conclusion that, rather than general poverty effects, buildings likely to produce cold indoor temperatures are key to winter ill-health when combined with poor ability to afford heating. (Others have also found a lack of association between socio-economic factors and excess winter mortality, possibly because social housing, which accommodates low-income households, is often more energy efficient than dwellings in other tenures.[1,5]) Relatively small numbers of lone pensioners lacked central heating, which may be why no association was evident between excess winter morbidity in older people and dwellings without central heating, in contrast to indications of other work.[5]

As described previously, related studies have conventionally used mortality data,[1,4,5] sometimes focussing on cardiovascular mortality.[1] There is no broad conflict between their results and ours, but the proposition here is a measurable health indicator based on morbidity. This could register the extent of cold effects on health more clearly than mortality data, on a wider population, and over a shorter time frame. This study also suggests a small area index for fuel poverty risk that includes a specific element of energy-inefficient housing, as distinct from other deprivation indices or proxies. The methodology was intended to combine data from sources gathered routinely, but the pilot identified difficulties attached to some data retrieval i.e.

- energy ratings information required an estimation method, available data being limited;
- software used for postcode to ED conversion is only accurate within certain limits, which produced some anomalies in the income-related data; a more accurate alternative is expensive and not routinely used by local authorities or the health services at present;
- census data, collected decennially, are not necessarily contemporaneous with income and health data; but the older population was assumed to be relatively stable.

Hospital activity data can depend on local admission policies and available bed spaces (the 'provider effect'),[17] but this may be less of an issue within a single health authority. This study was limited to a relatively small sample. Although total respiratory episode counts would still theoretically reflect seasonal effects, data could be skewed by frequent episodes for the same individual, because of low expected numbers for the total population. Even so, costs to the NHS would occur if episodes are attributable to one person or many.

Fuel poverty is officially defined by the proportion of household income needed for specified energy services and a standardized level of comfort. Characterizing areas by fuel poverty risk avoided difficulties in obtaining individuals' income and heating-expenditure details. Nevertheless, epidemiological studies are subject to the ecological fallacy, when assuming that relationships observed between areas apply equally to individuals.[18] Bearing this in mind, we analysed winter/summer counts at different levels of ED aggregation. The interaction between season and FPR was statistically significant in all cases for 1993 and 1996, with the additional interaction between season and all other variables not being significant. We have noted that our results do not necessarily imply that all component variables of FPR are important contributors to this explanatory measure. We intend to report on this elsewhere. Complications arise, since the explanatory variables are averaged over each group of aggregated EDs. Thus we intend to determine the importance of the various FPR components by analysing the data at individual ED level. However, this approach requires a different form of distributional assumption for morbidity counts, as counts for the 450 individual EDs are over-dispersed and not well fitted by a Poisson assumption.

Demonstrating links between housing and health is notoriously difficult, due to layers of socio-economic, environmental and individual health determinants, which inevitably operate as confounding factors. However, making seasonal comparisons across one population may eliminate some confounding by behavioural variables (e.g. smoking or diet). The data shows that high FPR does not necessarily lead to high EWMbR, and there may be another, unknown, factor operating, since the association does not appear in all years studied. Additional future exploration of the data will include examining weather data for individual years and daily temperature variables for any effect on seasonal morbidity. It will also involve investigating additional diagnoses for EWMbR calculations and distinction of age groups and gender within the older population sample.

At this stage, results appear to augment the limited evidence base of links between cold homes and health, thus strengthening the public health argument for increased joint activity on energy efficiency improvements by health and housing agencies. Follow-up research would require studies on individuals to confirm health improvements from specific interventions. Meanwhile, the proposed methodology could potentially help identify high-risk areas for prioritizing housing improvements designed to provide affordable warmth. If further refined and validated, it could provide baseline information for health impact assessment of such improvements where they are carried out on a sufficiently large scale. Cost-benefit analysis of efficiency measures is currently calculated predominantly against environmental targets of reduced energy use that can distort investment priorities in favour of the fuel rich, who can afford extravagant energy use and therefore offer greater potential in terms of savings. The methodology offers the beginnings of a basis for predicting potential associated NHS savings to be factored into such analysis, which could help justify further health-driven investment for addressing health inequalities.

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