Fuel poverty and the health of older people: the role of local climate

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ABSTRACT

Background Fuel poverty is a risk factor for ill-health, particularly among older people. We hypothesized that both the risk of fuel poverty and the strength of its detrimental effects on health would be increased in areas of colder and wetter climate.

Methods Individual data on respiratory health, hypertension, depressive symptoms and self-rated health were derived from the 2008/09 wave of the English Longitudinal Study of Ageing. Climate data for 89 English counties and unitary authorities were obtained from the UK Met Office. Multilevel regression models \( n = 7160 \) were used to test (i) the association between local climate and fuel poverty risk, and (ii) the association between local climate and the effect of fuel poverty on health (adjusted for age, gender, height, smoking status and household income).

Results Individual risk of fuel poverty varied across counties. However, this variation was not explained by differences in climate. Fuel poverty was significantly related to worse health for two of the outcomes (respiratory health and depressive symptoms). However, there was no significant effect of climate on fuel poverty’s association with these outcomes.

Conclusions Although there is regional variation in England in both the risk of fuel poverty and its effects on health, this variation is not explained by differences in rainfall and winter temperatures.

Keywords geography, social determinants

Introduction

Fuel poverty is the inability to affordably heat one’s home to a comfortable standard. The WHO defines this as having to spend more than 10% of household income on fuel to achieve temperatures of at least 21°C in living areas, and 18°C in all other areas.1 Fuel poverty is primarily caused by low income, but can be exacerbated by other factors including high fuel prices and energy-inefficient housing. It is particularly prevalent among older people,2 as they tend to have lower incomes. They also tend to spend more time indoors.3 The potential adverse consequences of fuel poverty for this vulnerable group are a significant public health concern.

Fuel poverty may affect health through three main mechanisms. First, the consequences of insufficient heating, such as condensation, mould and damp (CMD) and indoor cold, may have direct health consequences. Secondly, increasing spending on fuel may inhibit spending on other necessities, such as food.4 Finally, the stress caused by being unable to afford heating bills or by visible mould and damp may itself be harmful.

Previous work has shown that problems associated with fuel poverty (CMD and indoor cold) are associated with worse cardiovascular health,5 more respiratory infections and symptoms,6–8 increased anxiety and depression,5,9 and worse self-rated health (SRH).5,9 Increased risk of fuel poverty has also been shown to be associated with increased emergency respiratory admissions.10
The aim of the present study was to investigate the association between climate and fuel poverty as it relates to the health of older people. Existing work suggests that fuel poverty may be more common in rural than in urban areas. However, no previous work has specifically examined the association between local climate and fuel poverty risk.

Living in an area with a colder and wetter climate likely means a stronger need to artificially heat one’s home, and also greater energy requirements to maintain a comfortable temperature. We therefore hypothesized that older people living in areas of worse climate (with greater rainfall and colder winter temperatures) would be at greater risk of fuel poverty.

As well as increasing the risk of fuel poverty, worse climate might also alter its consequences for health. First, for people in colder areas, the same fuel expenditure will ‘buy’ a smaller gain in home temperature. If there is a common upper limit on the amount households are willing to spend on fuel, regardless of where they live (e.g. 20% of income), those in areas of worse climate will tend to have colder homes. Lower home temperatures combined with generally wetter weather would also serve to increase dampness and mould growth. We therefore further hypothesized that fuel poverty should have stronger effect on health in areas of worse climate.

We investigated these hypotheses using an area-stratified random sample of older people in England. We examined four health outcomes, corresponding to the domains of health found by previous work to be associated with either fuel poverty itself or the consequences of fuel poverty for housing conditions (see above). The four outcomes were respiratory health, blood pressure (BP), depressive symptoms and SRH (as an indicator of underlying general health).

Methods

Data

Data source and sample
Individual-level data were drawn from the English Longitudinal Study of Ageing (ELSA); a large biennial panel study of people aged 50 plus living in England. For this study, we used respondents to the fourth wave of ELSA data collection, conducted in 2008/09. This wave included both an interview and a visit from a nurse to collect objective health measurements.

A total of 8643 people participated in both the core interview and the nurse visit. After excluding those with missing data on any of the analysis variables, our final sample consisted of 7160 respondents nested within 89 counties and unitary authorities (henceforth referred to as counties).

The original ELSA survey was based on a stratified (by postcode sector) random sample, and was designed to be representative of the population over 50 in England. To compensate for sample ageing and attrition, refresher samples were added to the panel in Waves 3 and 4. Compared with ONS mid-year estimates for the population over 50 in England in 2008, our final analysis sample was closely representative in terms of gender and geographic distribution (by Government Office Region).

Health outcomes

As a measure of respiratory health, we used objectively measured peak expiratory flow (PEF). PEF was measured by a nurse using a portable Vitalograph Escort spirometer. Respondents were asked to stand, take a deep breath and blow into the spirometer as hard as they could. Respondents who were unable to stand performed the test seated. Three attempts were recorded. We used the maximum valid measure from these attempts.

A nurse used an Omron BP cuff to take BP measurements from the respondent’s right arm while they were seated. Three measurements were taken, with BP values derived from the mean of the second two measurements. We defined respondents as being ‘hypertensive’ if their systolic BP equalled or exceeded 140 mmHg or their diastolic BP equalled or exceeded 90 mmHg.

We defined respondents as ‘depressed’ if they reported more than three symptoms on the Centre for Epidemiological Studies Depression scale (CESD), reduced version. SRH was derived from a single item recording whether respondents reported their health as ‘excellent’, ‘very good’, ‘good’, ‘fair’ or ‘poor’. We created a binary variable indicating whether respondents reported their general health as ‘bad’ or ‘very bad’

Predictors and covariates

We derived a measure of fuel poverty from respondents’ reported weekly fuel spending (including on electricity, gas, solid fuel and all other fuels) and their reported total net weekly household income. We defined respondents as being fuel poor if their total fuel spend exceeded 10% of their total household income.

We derived geographical climate information from the UK Met Office 5 km gridded data (UKCP09 monthly averages) for 3 years prior to ELSA Wave 4 data collection (2004–06). From these data, we derived two measures of climate at the county level: (i) minimum winter temperature (December–March, including December 2003) and
We reversed the sign of the minimum winter temperature values, then converted both measures to \( z \)-scores and added them together to create a combined continuous measure of ‘worse climate’ at the county level.

We also included measures of respondent age (in continuous years), gender, height (in continuous centimetres), smoking status (a binary measure indicating whether the respondent reported ever having smoked cigarettes regularly) and total net household income per week (in continuous hundreds of pounds).

**Statistical analysis**

We used a two-level (individuals nested within counties) multilevel logistic regression to predict the individual odds of being in fuel poverty from county-level climate. These models were adjusted for individual age to account for differences in county age composition. The effect of age was fixed across counties.

To test the association between county-level climate and the effect of fuel poverty on each health outcome, we first used a two-level multilevel regression to model the association between fuel poverty and the outcome; allowing this association to vary randomly between counties. We then fitted a second model which added the county-level climate variable and a cross-level interaction between this and fuel poverty. Each of these models was adjusted for individual age, gender, height, smoking status, income and climate, to account for their potential independent effects on both health and fuel poverty risk. These models were also adjusted for net household income in order to isolate the specific effect of fuel poverty from the more general effects of low income. This procedure was followed for all four outcomes. For the binary outcomes (hypertension, depression and poor SRH), multilevel logistic regressions were used. For the continuous outcome (PEF), hierarchical linear models were used.

**Results**

Table 1 describes the sample in terms of the individual-level variables used in the analysis. By our definition, 16.75% of the sample were in fuel poverty. This is similar to official figures for 2008 which show 19.60% of households including a member 50 or over as being fuel poor.14

In terms of county-level climate, the county with the ‘worst’ climate was Cumbria (minimum winter temperature: \(-0.71^\circ C\); mean monthly rainfall: 124.92 mm). The county with the ‘best’ climate was Cornwall (minimum winter temperature: \(4.39^\circ C\); mean monthly rainfall: 68.45 mm). The median minimum winter temperature across all counties was \(1.24^\circ C\) (SD = 0.87); the mean monthly rainfall was 63 mm (SD = 15.49).

After accounting for differences in age composition between counties, 6.63% of the variance in fuel poverty was attributable to differences between counties as opposed to individuals. However, contrary to our prediction, adding county-level climate to the model did not explain a substantial proportion of this variance. There was no association between county-level climate and the individual odds of being fuel poor (OR = 1.03; SE = 0.03).

Table 2 shows that there was a consistent significant association between fuel poverty and two of the four health outcomes. Independent of age, gender, height, smoking status, income and climate, being fuel poor predicted significantly reduced PEF, and an increased likelihood of being depressed. There was no association between fuel poverty and either hypertension or SRH.

Adding county-level climate explained some proportion of the variation between counties in the strength of fuel poverty’s association with the outcome. However, it did not improve the fit of any of the models as measured by AIC. Further, contrary to our predictions, in none of the models was the interaction between climate and fuel poverty statistically significant.

**Sensitivity analyses**

We conducted several sensitivity analyses to test the robustness of the results to alternative analytical approaches. First, we repeated the analyses using separate measures of average monthly rainfall or minimum winter temperature. Consistent with the original analyses, there was no association between either factor and fuel poverty risk. We also found no
Table 2  Separate associations (β coefficients or odds ratios, and 95% confidence intervals) between fuel poverty and four health outcomes, with and without an interaction with county level climate; derived from separate multilevel models, individuals (n = 7160) nested within counties (n = 89)\(^a\)

<table>
<thead>
<tr>
<th></th>
<th>PEF (β: l/min)</th>
<th>Hypertension (OR)</th>
<th>Depression (OR)</th>
<th>Poor SR health (OR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
<td>Model 3</td>
<td>Model 4</td>
</tr>
<tr>
<td>Fuel poverty</td>
<td>–9.22*</td>
<td>–8.97*</td>
<td>0.99 (0.86, 1.14)</td>
<td>1.00 (0.87, 1.15)</td>
</tr>
<tr>
<td></td>
<td>(–16.83, −1.61)</td>
<td>(–16.43, −1.52)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate</td>
<td>–1.25 (–5.13, 2.63)</td>
<td>–1.02 (0.97, 1.06)</td>
<td>–1.03 (0.98, 1.09)</td>
<td>–1.06* (1.00, 1.12)</td>
</tr>
<tr>
<td>(Fuel poverty) × (climate)</td>
<td>–2.57 (–7.15, 2.02)</td>
<td>–0.94 (0.86, 1.02)</td>
<td>–0.95 (0.87, 1.05)</td>
<td>–1.02*** (1.01, 1.03)</td>
</tr>
<tr>
<td>Age</td>
<td>–4.91***</td>
<td>–4.90***</td>
<td>1.03***</td>
<td>1.03***</td>
</tr>
<tr>
<td></td>
<td>(–5.19, −4.62)</td>
<td>(–5.19, −4.62)</td>
<td>(1.03, 1.04)</td>
<td>(1.03, 1.04)</td>
</tr>
<tr>
<td>Male gender</td>
<td>107.68***</td>
<td>107.63***</td>
<td>1.31***</td>
<td>1.31***</td>
</tr>
<tr>
<td></td>
<td>(100.67, 114.68)</td>
<td>(100.64, 114.64)</td>
<td>(1.14, 1.50)</td>
<td>(1.14, 1.50)</td>
</tr>
<tr>
<td>Height</td>
<td>3.46***</td>
<td>3.46***</td>
<td>0.99*</td>
<td>0.99*</td>
</tr>
<tr>
<td></td>
<td>(3.08, 3.83)</td>
<td>(3.09, 3.84)</td>
<td>(0.98, 1.00)</td>
<td>(0.98, 1.00)</td>
</tr>
<tr>
<td>Smoking</td>
<td>–69.15***</td>
<td>–69.08***</td>
<td>1.56***</td>
<td>1.56***</td>
</tr>
<tr>
<td></td>
<td>(–76.48, –61.81)</td>
<td>(–76.41, –61.74)</td>
<td>(1.14, 1.50)</td>
<td>(1.14, 1.50)</td>
</tr>
<tr>
<td>Net weekly hhd income (£100s)</td>
<td>0.63***</td>
<td>0.63***</td>
<td>1.00</td>
<td>1.00 (0.99, 1.01)</td>
</tr>
<tr>
<td></td>
<td>(3.14, 9.40)</td>
<td>(3.14, 9.41)</td>
<td>(1.00, 1.01)</td>
<td>(1.00, 1.01)</td>
</tr>
<tr>
<td>var(FP)</td>
<td>147.02</td>
<td>113.83</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>% change var(FP)</td>
<td>−22.28</td>
<td>−22.28</td>
<td>−38.88</td>
<td>−5.96</td>
</tr>
<tr>
<td>var(county)</td>
<td>500.06</td>
<td>496.26</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>var(individual)</td>
<td>11 228.26</td>
<td>11 230.55</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>ρ(%)</td>
<td>4.26</td>
<td>4.23</td>
<td>0.79</td>
<td>0.78</td>
</tr>
<tr>
<td>% change in var(county)</td>
<td>−0.76</td>
<td>−1.22</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>% change in var(individual)</td>
<td>−0.02</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>AIC</td>
<td>87 242.43</td>
<td>87 244.54</td>
<td>9291.06</td>
<td>9292.81</td>
</tr>
</tbody>
</table>

\(^a\)Bold text indicates statistical significance, asterisks indicate level of significance (*P < 0.05; **P < 0.01; ***P < 0.001); var(FP): variance between counties in the effect of fuel poverty on the outcome; var(county/individual): variance in the outcome at the county/individual level; ρ(%) : county level variance as a percentage of the total outcome variance; AIC, Aikake's information criterion of model fit.
significant interactions between either factor and fuel poverty in their effects on any of the health outcomes.

Secondly, we repeated the analyses replacing the continuous measure of poor climate with a binary variable, indicating the top 25% of worst climate scores. Consistent with the original analyses, we found no association between this binary indicator and fuel poverty risk. We also found no significant interactions between this indicator and fuel poverty in their associations with PEF, hypertension or depression. However, for SRH, we found a small significant negative interaction between fuel poverty and living in the coldest and wettest counties ($\beta = -0.35, P < 0.05$). This indicates that the apparently negative (although non-significant) effect of fuel poverty on the risk of poor SRH may be stronger in the counties with the worst climate.

Thirdly, we repeated the analyses including a measure of the time of year the health measurement was carried out (during winter or at another time). This did not alter the primary results reported above.

Discussion

Main findings of the study

Contrary to our first hypothesis, this study showed no association between county-level climate (in terms of rainfall and winter temperature) and individual fuel poverty risk among people 50+ living in England (where fuel poverty was defined as spending more than 10% of total household income on fuel). Although we found evidence of variation in fuel poverty risk between counties, this variation was not explained by differences in climate.

In the present sample, we found that, independent of age, gender, height, smoking status and total income, being in fuel poverty was associated with an increased likelihood of suffering from significant depressive symptoms and was negatively associated with a measure of respiratory health. There was no association between fuel poverty and hypertension, or between fuel poverty and poor SRH. Contrary to our second hypothesis, the effects of fuel poverty on these health outcomes were not increased in areas of worse climate.

What is already known on this topic

Previous research has shown that fuel poverty and associated problems of indoor cold and CMD are associated with worse cardiovascular, respiratory and mental health outcomes. Previous work has also shown that people living in rural areas are particularly at risk of fuel poverty. However, existing work has not directly examined the potential effect of subnational climatic differences on the risk of fuel poverty, or on the effect how such differences might alter the extent of fuel poverty’s effects on health.

What this study adds

This study extends the existing literature by suggesting that climatic variation in England does not play a significant role in explaining regional differences in fuel poverty risk among older people, or in explaining regional differences in fuel poverty’s effects on the health of this group. This suggests that differences in temperature and rainfall may not affect indoor conditions substantially enough to increase the risk of fuel poverty, or to worsen its effect on health. In terms of social policy in England, these results suggest that fuel poverty interventions which aim to take into account regional differences might be more effectively directed towards local factors other than climate, such as housing quality and energy prices.

Limitations of the study

With respect to testing the overall hypothesized role of climate in increasing both the risk of fuel poverty and its effects on health, the primary limitation of the present study is that it was confined to people living in England. England has a relatively low level of climatic variation when compared with the UK as a whole, or with other countries such as the USA. Our findings of no significant effect of climatic differences may therefore not be generalizable to national contexts with higher levels of climatic variation, where local climate may have a bigger impact on fuel expenditure and indoor conditions.

A second limitation is that the nature of the study did not allow us to directly demonstrate a causal effect of fuel poverty on health. There are a number of material and psychosocial exposures which may be associated with fuel poverty which may have independent effects on health. However, the present study does demonstrate that any effect of fuel poverty on the health of older people in England is unlikely to be substantially modified by local climate.

The final limitation of the study is that we were unable to test the effect of a number of factors which may be important for regional variation, both in fuel poverty risk and in the effects of fuel poverty on health. Importantly, we were unable to examine the effects of housing quality or rural versus urban location. Both factors may play an important role in explaining regional variation in fuel poverty risk. However, it is unlikely that they would obscure any association between climate and fuel poverty. Previous research has demonstrated the existence of an ‘inverse housing law’
in the UK, such that housing quality is worse in areas of worse climate. More rural areas of England also tend to experience worse climate. These factors would therefore tend to magnify rather than obscure any association between climate and fuel poverty.

Additional climatic factors not accounted for in the present study may also play an important role. Notably, wind has a strong effect on perceptions of temperature, and may therefore have an impact on heating behaviour and consequent risk of poverty. This effect is likely to be strongly tied to the permeability of housing with respect to wind, and therefore to housing quality. Future work on fuel poverty which examined the interaction between housing quality and detailed measures of climate would therefore be valuable.

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References