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Original articles

Health service accessibility and deaths from asthma in 401 local authority districts in England and Wales, 1988–92

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Abstract
Background **– The possible contribution of health service accessibility to asthma mortality has not previously been studied in the UK.**
Methods **– Using regression analysis, the relationship between geographical isolation from large acute hospital services and mortality from asthma for 401 local authority districts in England and Wales was examined for the period 1988–92.**
Results **– Asthma mortality was found to be strongly associated with the proportion of district households where the head was of social class 4 or 5 (adjusted relative risk 1.61, 95% confidence interval (CI) 1.12 to 2.33), and the proportion of households without access to a car (adjusted relative risk 1.59, 95% CI 0.97 to 2.62). After controlling for these factors, there was a tendency for mortality to rise with increasing distance from hospital, with a relative risk of 1.01 for an increase in distance of one kilometre (95% CI 1.00 to 1.02).**
Conclusions **– The findings suggest that problems of accessibility of care may mean that the control of asthma amongst sufferers living in districts most remote from major health service units might be less than optimal, and this could result in a number of potentially avoidable deaths.**
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Keywords: asthma, mortality, health service accessibility.

Whilst deaths from asthma are rare, there has been concern in recent years about apparent increases in the levels of mortality attributable to the disease.[1] It is particularly disappointing that mortality has not fallen despite improvements in the standards of treatment available for the condition.[2] There has been much debate as to how much the rise in the number of deaths is attributable to a higher prevalence of asthma, the adverse effects of some forms of treatment, an increase in the severity of the disease, or changes in diagnostic practices.[2] However, the possible effect of health service accessibility on asthma mortality has received little attention.

Most asthma deaths are at least potentially avoidable,[3] and it has been concluded that up to 86% of deaths may be preventable given more timely and appropriate intervention.[4] Consequently, the detection and appropriate management of symptoms is particularly important and may involve emergency attention in general practice or a hospital casualty department. Inappropriate management of the condition is a common theme in studies of asthma deaths.[1 4–8]

In the county of Norfolk, UK, a confidential enquiry has examined the circumstances associated with deaths from asthma and found that they were often associated with a poor understanding of the condition and an unwillingness to comply with medical advice and therapy amongst sufferers, the failure of general practitioners to provide their patients with appropriate education, and delayed referral to a specialist chest physician in severe cases.[5] In Norfolk nearly 90% of deaths occurred outside hospital[9] and similar figures have been reported elsewhere.[4]

A number of studies have shown that the use of health facilities for the management of various conditions tends to be higher amongst populations who live close to them.[10–14] There are indications that social and geographical isolation may be factors in the inappropriate management of asthma. Taytard *et al* investigated the use of medical facilities by asthmatic subjects in two French rural settings[10] and found that, in the case of a severe asthma attack, respondents living in more densely populated areas nearer to health facilities were significantly more likely to contact a physician than those in a more rural environment, especially those living in isolated dwellings.

The research presented here examines whether, after controlling for other factors, asthma mortality in England and Wales is associated with remoteness from health services.

Methods

Information on the number of deaths from asthma (ICD revision 9 code 493) amongst members of the population aged between five and 55 years was collected from published statistics[15] for 401 local authority districts in England and Wales for the period 1988–92,

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Table 1 Source and distribution of the independent variables used in the regression models

Description	*Source*	*Coded as*	*Minimum*	*Maximum*
Percentage of households without access to a car in 1991	1991 Census[1]	Continuous	11	61
Percentage of households with head of household in social class 4 or 5 in 1991	1991 Census[1]	Continuous	10	34
Percentage of households in bedsits in 1991	1991 Census[1]	Continuous	0	5
Weighted population density in 1991 (per km^2)	Arc/Info GIS[2]	Continuous	127	661
Average distance to the nearest acute hospital with over 200 beds in 1991 (km)	Arc/Info GIS[2]	Continuous and 1 = 0–5, 2 = >5–10, 3 = >10–15, 4 = >15–25, 5 = >25	0	42

[1]Information obtained for each district from 1991 UK census of population statistics.
[2]Variable calculated for each district using the Arc/Info Geographical Information System software package.

the most recent for which information was available.

The district was chosen as a convenient geographical unit. These are big enough to yield a sufficient number of deaths from asthma in any one district, and data relating to the 1991 UK census[16] is readily available at this scale. The City of London and Isles of Scilly districts were excluded from the study because their small populations make the numbers of deaths observed unstable.

ANALYSIS OF DATA

The effects of five possible influences on asthma mortality were examined (table 1). The measure of health service accessibility employed was the accessibility of the nearest large hospital offering acute services to the residents of each district.

The indicator was calculated using the Arc/Info Geographical Information System (GIS) computer software package.[17] The location of every hospital in England and Wales which had over 200 beds and offered acute services in 1991 was determined from its postcode.[18] A highly detailed measure of the spatial distribution of the population was determined from the estimated number of people in England and Wales living near every 200 metre Ordnance Survey grid reference point in 1991.[19] The straight line distance to the nearest hospital, not necessarily in the same district, was then calculated for each resident. From this the mean distance for all residents was calculated for each district.

As a general indicator of rurality, weighted population densities were calculated. The variable was set to denote the mean population density, in terms of persons per square kilometre, for the residents of each district.

For each district two indicators of the socioeconomic status of the resident population were calculated from the 1991 census – the percentage of households where the head is in social class 4 or 5, and the percentage of households without access to a car. The proportion of dwellings in each district which were bedsits was used as an indicator of social isolation.

The relationship between asthma mortality and the factors outlined above was examined by fitting multilevel regression models (also known as hierarchical linear models)[20] using the Mln package for multilevel modelling.[21] Multilevel modelling is similar to traditional regression analysis except that it allows the effects of differing geographical hierarchies to be controlled for in a single model. An introduction to the theory and use of multilevel models with health related data is given by Langford and Bentham[22] and Duncan *et al.*[23] Here we fitted models using a two level nested design of districts within standard regions. This meant that the parameter estimates and measures of significance that we obtained for our measures of health service accessibility at a district level were independent of any regional influences on mortality. We achieved this by fitting a random parameter structure for regions in the model which estimated variance between regions independent of between district effects. This was done because there are unexplained regional variations in asthma mortality rates[24] which may be caused by historical or cultural influences outside the scope of the present study. The use of a multilevel model means that any measured effects of health service accessibility at the district level are not confounded by regional influences.

Because deaths from asthma are relatively rare, Poisson regression models[25] were used where the response variable for each district was the number of deaths from asthma, and the natural logarithm of the expected number of deaths, calculated based on the age and sex distribution of each district population, was fitted as an offset. This allowed the relative risk of asthma mortality to be modelled as a Poisson distribution.[21]

Variables were fitted into the regression model centred around their mean. All the variables were fitted as continuous (table 1). So that any trend associated with the measure of hospital accessibility was clear, this was also fitted as a categorical variable with categories corresponding to 5 km and 10 km mean distance intervals. These intervals were chosen to be geographically regular, whilst encompassing a roughly equal number of districts in each. All variables were tested for multicollinearity and interactions between them were examined. The results of the models are presented as relative risks, confidence intervals, and probabilities.

Results

Table 2 shows the adjusted relative risks for each of the explanatory variables based on the regression analysis including all variables. For social class, car ownership, bedsits, and density, the figures given are the relative risks over the

Table 2 Adjusted relative risk of asthma mortality based on regression analysis including all explanatory variables

Explanatory variables	*Relative risk*	*95% CI*	*p value*
Percentage of households with head of household in social class 4 or 5 in 1991	1.61	(1.12 to 2.33)	<0.01
Percentage of households without access to a car in 1991	1.59	(0.97 to 2.62)	0.08
Mean distance to the nearest acute hospital with over 200 beds in 1991:			
6–10 km	1.05	(0.94 to 1.18)	0.44
11–15 km	1.08	(0.96 to 1.22)	0.22
16–25 km	1.11	(0.99 to 1.25)	0.08
>25 km	1.27	(1.05 to 1.54)	0.02
Percentage of households in bedsits in 1991	0.95	(0.74 to 1.20)	0.62
Weighted population density in 1991	1.17	(0.61 to 2.24)	0.61

Distance from hospital was fitted as a single categorical variable with five levels; the values for relative risk are relative to the lowest (0–5 km) distance.

Table 3 Adjusted relative risk of asthma mortality based on regression analysis including only statistically significant explanatory variables

Explanatory variable	*Relative risk*	*95% CI*	*p value*
Percentage of households with head of household in social class 4 or 5 in 1991	1.59	(1.19 to 2.24)	<0.01
Percentage of households without access to a car in 1991	1.68	(1.29 to 2.20)	<0.01
Mean distance to the nearest acute hospital with over 200 beds in 1991:			
6–10 km	1.05	(0.93 to 1.18)	0.41
11–15 km	1.07	(0.94 to 1.23)	0.24
16–25 km	1.09	(0.95 to 1.22)	0.13
>25 km	1.24	(1.01 to 1.52)	0.03

Distance from hospital was fitted as a single categorical variable with five levels; the values for relative risk are relative to the lowest (0–5 km) distance.

range of values for each variable in the 401 districts.

There is evidence of a positive association between asthma mortality and both the percentage of households where the head was of a low social class and the percentage of households without access to a car. The relative risk estimates of each of the four categories of hospital accessibility shown in table 2 indicate the situation in districts in each distance category relative to those in the first (0–5 km mean distance). A trend is apparent suggesting that, after controlling for other influences, districts where the population lived further from hospital exhibited higher levels of asthma mortality. The highest relative risk of mortality was amongst those living in districts with a mean distance of over 25 km from hospital, and this was significantly increased compared with mortality in the most accessible districts. When modelled as a continuous variable, the indicator of hospital accessibility also showed a statistically significant association with asthma mortality with a relative risk of 1.01 for an increase in distance of 1 km (95% CI 1.00 to 1.02, $p=0.04$). Figure 1 shows the relationship between relative risk and distance, adjusted for the factors modelled in table 2.

The indicator of weighted population density was not a statistically significant predictor of mortality, either when modelled alongside hospital accessibility or without it (relative risk 1.00, $p>0.5$). Furthermore, the proportion of bedsits in a district was not found to affect mortality significantly.

Table 3 shows the model produced when the two non-significant explanatory variables were removed. The statistical significance of the socioeconomic measures increased and the trend with hospital accessibility remained strong, indicating the robustness of the association and suggesting that the results in table 2 were not due to confounding.

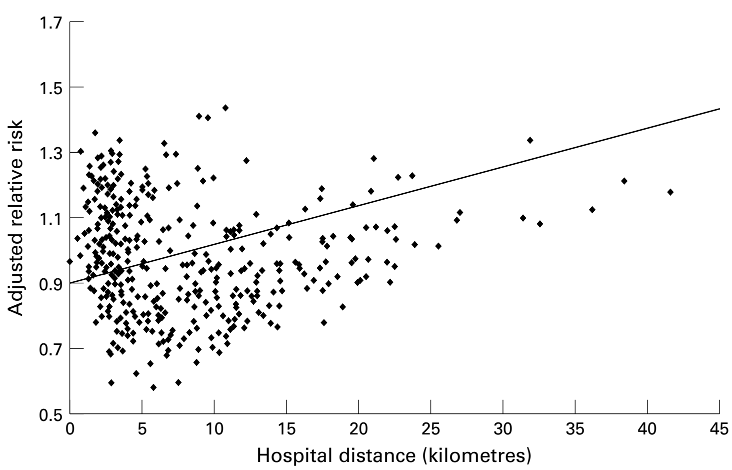

Figure 1 Relationship between relative risk of asthma mortality (adjusted for all the variables shown in table 2) and distance to the nearest major acute hospital for 401 local authority districts.

Discussion

The results suggest that asthma mortality is higher in more socioeconomically deprived communities. However, after controlling for social factors, there was a clear trend of increasing mortality with increasing mean distance from hospital. The trend may be due to a direct effect of health service accessibility, or may be because of some other factor associated with rurality not measured here.

Our measure of hospital accessibility is an indicator of the typical distance asthma sufferers may have to travel to receive emergency treatment in the event of a serious exacerbation of their condition. However, used in isolation it may suffer from association with other aspects of the rural environment. Evidence suggests that people in isolated rural environments may rely more on lay treatment and use health services less than urban populations.[26] Consequently, a more general indicator of rurality

– weighted population density – was also examined. However, the accessibility indicator showed the stronger association with mortality, suggesting that the relationship was not simply due to confounding with rurality.

In rural areas with a highly dispersed population our indicator of accessibility may be unrepresentative of the distance to hospital for some residents. However, the small geographical size of most districts minimises this bias, and the measure is a good indicator of the general remoteness of care.

The accuracy of asthma mortality data has been questioned,[27] particularly with respect to difficulties in identifying cause of death amongst older sufferers.[28] Only deaths amongst those aged 55 years or under were analysed here because it is likely that the accuracy of cause of death certification is higher for younger individuals.[29] Furthermore, younger asthmatic subjects are less likely to suffer severe secondary complications associated with their condition, suggesting that mortality is potentially more preventable in this age group. As recommended by McColl and Gulliford,[30] deaths in children under the age of five years were also excluded because the cause of death may be more difficult to determine in these individuals. However, where complications associated with the condition have arisen, the coding of cause on the death certificate can be ambiguous.[28] There is potential for diagnostic confusion of asthma deaths with chronic bronchitis, emphysema and obstructive airways syndrome, especially in urban areas.[24] Nevertheless, limiting the age group studied here should minimise problems of data accuracy.

In undertaking this analysis we have attempted to control for socioeconomic factors that may influence the prevalence and severity of asthma. There is evidence that the severity of the disease may be higher in the more socioeconomically disadvantaged,[31] they may be less likely to seek help in the case of medical problems,[32] and when they do so the quality of service they receive can be poorer than that for the general population.[33] Furthermore, the indicator of car ownership serves as more than a simple measure of socioeconomic circumstance as the effects of isolation from care, particularly in the most rural districts of England and Wales, may be amplified by a lack of private transport.

We have also examined the relationship between mortality and the percentage of households in each district which are bedsits. Socially isolated members of the population frequently tend to be concentrated in this part of the rented sector.[34 35] Bedsits are typically concentrated in urban areas but, whilst these individuals live geographically close to care, their social isolation means that they may have difficulty in seeking help and controlling conditions like asthma.

It has not been possible to control for possible variations in asthma prevalence or severity between districts. This information would be particularly difficult to obtain. It might have been possible to use details from hospital activity registers as a surrogate, although the completeness of these data sources has been questioned.[27] In any case, such indicators might themselves be associated with health service accessibility. The results may be biased if asthma is more prevalent or severe in more rural districts, but there is no evidence for this. Moreover, several studies have found a higher prevalence of atopy and allergic disorders associated with urbanisation[36] and a number have reported trends of higher asthma prevalence in urban areas.[37–40]

By using mortality data aggregated to the scale of local authority districts, we have not been able to examine more complex associations between asthma management and individual patient and health care provider relationships. However, our findings show that where access to large hospitals is more difficult there is an associated increase in asthma mortality, and this factor may explain a proportion of otherwise avoidable deaths from asthma.

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