Asthma is a common condition that causes significant morbidity but is usually responsive to treatment. Although there have been improvements in available therapies, asthma has been one of the few 'avoidable' causes of deaths that has not experienced major declines in death rates over the last few decades. Recently, we examined the relationship between geographical isolation from large acute hospitals and mortality from asthma in local authority districts in England and Wales. After controlling for socioeconomic factors we found there was a tendency for mortality to rise with increasing distance to hospital, suggesting that inaccessibility of hospital services may be a risk factor for asthma mortality.

Here we examine whether the findings could be replicated in a more detailed, local study. The study concentrates on the East Anglian region, which is one of the most rural areas of England, comprising the three counties of Cambridgeshire, Norfolk and Suffolk. There is evidence that the prevalence of asthma in the region is generally higher than that observed elsewhere in the country. In East Anglia, a confidential enquiry has been established into the circumstances surrounding asthma deaths. This has shown that a recurrent issue was a poor understanding of the condition amongst sufferers, causing delays in seeking care when required. Another study in Norfolk found an inverse relationship between hospital admission rates and asthma mortality. It was suggested that this may be because of difficulties in access to care.

The present study examines the relationship between asthma mortality and access to health services within populations of electoral wards in East Anglia, allowing the effects of accessibility to be examined in more detail than previously. As well as hospital services, we have been able to consider access to primary care, which has been shown to be an important factor in asthma management. We have also measured accessibility in terms of travel times to facilities, rather than straight line distances, and we have been able to calculate a more sensitive indicator of rurality.

Methods

Information on asthma deaths was taken from the Regional Deaths System, a database constructed from certificates of all deaths within East Anglia. Records were retrieved in which
death had occurred between January 1985 and December 1995, and asthma was mentioned in part one of the death certificate as one of the diseases directly leading to death or one of the diseases leading to the direct cause. The time period was chosen so as to allow for a large enough sample size. For each death, details of their sex, age, and postcode were obtained. The electoral ward of residence was determined from the postcode.\textsuperscript{11}

The Townsend Index of Deprivation Calculated from 1991 census\textsuperscript{a} Continuous –8.7464 7.896

Percentage of households in bedsits, 1991 1991 census\textsuperscript{a} Continuous 0 8.59

Estimated mean travel time to the nearest main or branch GP surgery (mins) Arc/Info GIS\textsuperscript{b} Continuous, and 3 20.8
1 = 0–4, 2 = >4–6,
3 = >6–9, 4 = >9

Estimated mean travel time to the nearest acute hospital with over 200 beds, 1991 (km) Arc/Info GIS\textsuperscript{b} Continuous, and 4.4 54.7
1 = 0–10, 2 = >10–20,
3 = >20–30, 4 = >30

Urban/rural ward indicator Arc/Info GIS\textsuperscript{b} 0 = Rural ward
1 = Urban ward

\textsuperscript{a} Information obtained for each ward from 1991 UK census of population statistics.
\textsuperscript{b} Variable calculated for each ward using the Arc/Info Geographical Information System software package.

Results

Amongst people of all ages, 768 asthma deaths meeting the criteria for study were recorded in East Anglia over the time period. Asthma was coded as the primary underlying cause of death in 365 of these cases. The measures of hospital and surgery accessibility were found to be highly correlated (\( r = 0.44, P < 0.001 \)). This means that it is difficult to determine their individual influences when included in the same model. Hence their effects on levels of mortality were examined separately.

For hospital accessibility, Model 1 in Table 2 shows the adjusted relative risks (RR) for each of the explanatory variables based on the regression analysis including all variables. For continuous variables, the figures given are the RR over the range of values in the 536 wards. Distance from hospital was fitted as a single categorical variable with four levels. The values for RR are relative to the lowest (0–10 minutes) travel time.

There is evidence of significant positive associations between asthma mortality and both the Townsend ward deprivation score and percentage of households which are bedsits. There are also indications of lower asthma mortality rates in urban than in rural wards, but this difference is not statistically significant.

Controlling for these other influences, there are indications of an effect of accessibility. The RR estimates of each of the categories of hospital accessibility shown in Model 1 indicate the situation in wards in each estimated mean travel time category relative to those in the first (0–10 minutes). A trend is apparent suggesting that wards where the population has a lengthier
journey to hospital exhibit higher levels of asthma mortality. The highest RR of mortality is amongst wards with the longest estimated travel time. This is significantly elevated ($P = 0.03$) compared to mortality in the most accessible wards. Modelling accessibility as a continuous variable, there was an RR of 1.06 for each 10-minute increase in estimated travel time, although this was not statistically significant ($P = 0.10$).

It is possible that the inclusion of the indicator of urban and rural wards might represent overadjustment, as the measure of rurality is itself associated with health service accessibility. Table 2, Model 2, shows the result obtained after removal of the variable. A statistically significant association with bedsit tenure is still apparent, and the effect of hospital accessibility is strengthened.

Model 3 shows the best-fit model after stepwise removal of all non-significant explanatory variables. The measure of household bedsit tenure remained significant, and the trend with hospital accessibility strengthened slightly. The statistical significance of the continuous measure of hospital accessibility also became stronger (RR for each 10-minute increase in estimated travel time = 1.07, $[P = 0.04]$).

For general practitioner surgery accessibility, Table 3 shows the adjusted RR for each of the explanatory variables based on the regression analysis including all variables. As before, the measure of bedsits, and the Townsend deprivation index were significantly positively associated with mortality, and there was a non-significant tendency for mortality to be lower in urban areas. Distance from surgery was fitted as a categorical variable with four levels. The values for RR are relative to the lowest (0–4 minute) travel time. However, there was no consistent trend for mortality to increase with estimated travel time to surgeries. The indicator was not statistically significant when included as a continuous variable (RR for each 10-minute increase in estimated travel time = 1.20, $[P = 0.2]$).

It is possible that the use of asthma mortality across all age groups may introduce bias due to misdiagnosis amongst older groups, where death from chronic obstructive pulmonary disease may sometimes be mislabelled as being due to asthma. To test for this, a second set of models was fitted where only deaths amongst those aged under 65 years were included. There were 259 deaths within this sub-sample, of which asthma was coded as the primary underlying cause of death in 158 cases.

Table 4, Model 1, shows the adjusted RR for mortality in the under 65-year-old age group based on the regression analysis including all variables. There is a strong statistically significant association between RR and the Townsend ward deprivation score. The increased strength of this indicator for this sample probably reflects an elevated importance of socioeconomic circumstance amongst the younger population, coupled with a reduction in noise in the results due to the probable elimination of some misdiagnosed deaths amongst older people.
As with the wider sample, a clear trend of increasing RR with increasing travel time to hospital is apparent. The RR are of a similar magnitude to those observed for all age groups although, due to the considerable reduction in sample size, the confidence intervals are wider than previously obtained. When modelled as a continuous variable, there was an RR of 1.09 for each 10-minute increase in estimated travel time. This was not statistically significant ($P = 0.19$).

The trend with hospital accessibility persisted when both the measure of rurality (Model 2) and the non-significant variables (Model 3) were removed. As with the findings for all ages, there was no consistent trend for mortality to increase with estimated travel time to GP surgeries (Table 5). However, there is evidence of generally higher RR within wards with poorer access to surgeries.

Discussion

There was a consistent tendency for asthma mortality to increase with travel time to hospital. This association was apparent even after controlling for socioeconomic indicators, showing it was not the result of confounding by the other factors that were considered. The trend also remained after deaths amongst the over 65-year-old age group were removed from the analysis. This suggests that the findings are not strongly biased by confounding due to misdiagnosis of asthma. The results of this detailed study in East Anglia therefore support the conclusions of our earlier study of larger geographical areas, that inaccessibility of hospital services may increase the risk of asthma mortality.

In this population-based study, it is not possible to determine the mechanisms by which hospital accessibility might influence mortality. It could be that the residents of wards remote from hospitals will take longer to reach the facilities in the event of a severe acute attack. Alternatively, the prospect of a lengthy trip may make them reluctant to undertake the journey at an early stage of the onset of symptoms. The mechanism might be more subtle; there is some evidence from elsewhere that doctors located further from hospitals could be more reluctant to refer their patients for specialist treatment. Another possibility is that the characteristics of rural communities mean that residents are reluctant to seek professional help for health problems, and are more likely to rely on lay care.

No strong association was apparent between the measure of general practitioner surgery accessibility and asthma mortality. This is perhaps surprising given that previous work has suggested an influence of accessibility on consultation rates. It may be that higher levels of presentation amongst residents living in areas with good access to these services represent unnecessary consultations. It could be that good access to hospital services is more important than access to surgeries in preventing asthma mortality. Alternatively, the lack of association may be due to the insensitivity of our study design; we were only able to measure the mean travel time to the nearest surgery, rather than the one with which residents were necessarily registered.

Although the mechanisms are as yet unclear and deserve further research, these results are consistent with our previous findings, and suggest that the provision of good access to acute hospital services may be one factor in reducing the burden of avoidable deaths from asthma.

Acknowledgements

We thank the Rackham Trust for their financial support for this research.

References


Table 5 GP accessibility: Adjusted relative risk (RR) of asthma mortality amongst the 0–64 year old age group

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>RR</th>
<th>95% CI</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Townsend deprivation index</td>
<td>5.46</td>
<td>(2.33–12.75)</td>
<td>0.05</td>
</tr>
<tr>
<td>% households in beds</td>
<td>1.09</td>
<td>(0.40–2.99)</td>
<td>0.86</td>
</tr>
<tr>
<td>Urban wards</td>
<td>0.91</td>
<td>(0.64–1.30)</td>
<td>0.62</td>
</tr>
<tr>
<td>Travel time to GP surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4–6 mins</td>
<td>1.08</td>
<td>(0.76–1.52)</td>
<td>0.67</td>
</tr>
<tr>
<td>6–9 mins</td>
<td>1.25</td>
<td>(0.83–1.88)</td>
<td>0.29</td>
</tr>
<tr>
<td>9+ mins</td>
<td>1.18</td>
<td>(0.73–1.93)</td>
<td>0.50</td>
</tr>
</tbody>
</table>

*Note: The values in the table are adjusted for other variables in the model.*


