The relationship between distance to hospital and patient mortality in emergencies: an observational study

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Objectives: Reconfiguration of emergency services could lead to patients with life-threatening conditions travelling longer distances to hospital. Concerns have been raised that this could increase the risk of death. We aimed to determine whether distance to hospital was associated with mortality in patients with life-threatening emergencies.

Methods: We undertook an observational cohort study of 10,315 cases transported with a potentially life-threatening condition (excluding cardiac arrests) by four English ambulance services to associated acute hospitals, to determine whether distance to hospital was associated with mortality, after adjustment for age, sex, clinical category and illness severity.

Results: Straight-line ambulance journey distances ranged from 0 to 58 km with a median of 5 km, and 644 patients died (6.2%). Increased distance was associated with increased risk of death (odds ratio 1.02 per kilometre; 95% CI 1.01 to 1.03; p < 0.001). This association was not changed by adjustment for confounding by age, sex, clinical category or illness severity. Patients with respiratory emergencies showed the greatest association between distance and mortality.

Conclusion: Increased journey distance to hospital appears to be associated with increased risk of mortality. Our data suggest that a 10-km increase in straight-line distance is associated with around a 1% absolute increase in mortality.

It has recently been suggested that reconfiguration of emergency care to concentrate services in a limited number of specialist centres could save thousands of lives each year in the UK, and that opposing the closure of local services could counterintuitively cost lives. In opposition to this view, concerns have been raised that reconfiguration could lead to acutely ill patients having to be transported greater distances to hospital with an associated risk of increased mortality. Few published studies have addressed this issue, so there is a risk that policy-making may be driven by anecdote or supposition.

We have recently completed a study to assess the effect on mortality among patients with life-threatening emergencies of implementing response time standards in four ambulance services. We have used these data to determine whether longer journey distances to hospital were associated with an increased risk of mortality.

METHODS

Call identification
Ambulance services use emergency medical dispatch (EMD) systems to prioritise 999 calls. Two systems were used during this study: the Advanced Medical Priority Dispatch System (AMPDS) and the Criteria Based Dispatch (CBD) system. Each provides structured protocols that allow trained emergency medical dispatchers to categorise 999 calls depending on urgency, and assigns each call a priority code based on condition and urgency. The Department of Health (DH) has identified a set of EMD codes for each system that correspond to conditions that are potentially life-threatening and to which the highest priority (category A) ambulance response should be made. We selected for inclusion in the study a subgroup of category A calls identified using the DH codes, in which the patient was reported as unconscious or not breathing or with acute chest pain. We termed these A* calls. Exclusion criteria were A* calls where patients were found dead at the scene, or were discharged at the scene and not conveyed to hospital, or were treated in hospitals other than those in our study areas; calls where no vehicle attended the scene; and out-of-hospital cardiac arrests (the last category was excluded because survival from out-of-hospital cardiac arrest has clearly been shown to depend upon the time from call to treatment that can be provided by ambulance staff, rather than time or distance from scene to hospital).

Data collection
Consecutive, life-threatening category A ambulance calls were sampled annually from 1997 to 2001 from four ambulance services: the Royal Berkshire, Derbyshire, Essex and West Midlands. These services were representative of the types of environment typically encountered in England and included urban, mixed urban and rural, and very rural areas. In 1999, the Derbyshire, Nottinghamshire and Leicestershire ambulance services merged to become East Midlands Ambulance Service NHS Trust. Two services used CBD, one used AMPDS, and one used CBD at the beginning of the study and changed to AMPDS halfway through.

From all category A calls, we sampled approximately 1000 consecutive A* calls from each service in each year, using the same sampling period for each service for all years. The ambulance service dispatch system provided patient information (name, sex, age), grid reference for the incident, and dispatch category codes. This information was then used to identify the paper ambulance patient report forms (PRFs). From the PRFs, further information was obtained about the patient (name, date of birth and address), incident description, the patient condition on arrival of the crew (including vital signs), details of treatment given, disposal of the patient (left at

Abbreviations: AMPDS, Advanced Medical Priority Dispatch System; CBD, Criteria Based Dispatch; DH, Department of Health; ED, emergency department; EMD, emergency medical dispatch; GCS, Glasgow Coma Score; NHS, National Health Service; PRF, patient report form; REMS, Rapid Emergency Medicine Score
the scene or transported to hospital) and outcome at this point (alive or deceased).

From the grid references of the incident and hospital, we calculated the straight-line ambulance journey distance from scene to hospital. These straight-line distances were preferred to journey times to hospital because journey times depend on the accuracy and consistency with which times of leaving the scene and arrival at hospital are recorded, and they can also be affected by ‘reverse causation’. This occurs when the patient condition is a cause of the journey time rather than vice versa, such as when ambulances drive as fast as possible to hospital for critically ill patients but more slowly and with less risk for patients not critically ill.

If the patient was taken to hospital, the emergency department (ED) notes were identified and information recorded on time of arrival and discharge from the ED, patient condition including vital signs, cardiac rhythm (for cardiac patients), preliminary diagnosis, condition on leaving the ED and disposal. If admitted, details of the length of stay, final diagnosis and disposition were recorded. For any patient who died, details were recorded of the date, time, place and cause of death. If the patient died before reaching hospital and was taken directly to the mortuary, the cause of death was obtained by accessing death certificates from the coroner or the National Health Service (NHS) Central Registry.

Details of patients taken to hospital, for whom no records could be found, were also sent to the NHS Central Registry. For those identified as dead, the date, place and cause of death were obtained and used to identify those who had died as a result of the incident for which the call was made and those who had survived.

Ethics approval was obtained, covering 27 hospitals that each of the ambulance services.

### Table 1
Relationship between ambulance journey distance and survival to discharge

<table>
<thead>
<tr>
<th>Distance category (km)</th>
<th>Outcome</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Survived (%)</td>
<td>Died (%)</td>
</tr>
<tr>
<td>0–10</td>
<td>7725 (94.2)</td>
<td>475 (5.8)</td>
</tr>
<tr>
<td>11–20</td>
<td>1479 (92.3)</td>
<td>124 (7.7)</td>
</tr>
<tr>
<td>21+</td>
<td>467 (91.2)</td>
<td>45 (8.8)</td>
</tr>
<tr>
<td>Total</td>
<td>9671 (93.8)</td>
<td>644 (6.2)</td>
</tr>
</tbody>
</table>

### Analysis

We planned to test for an association between journey distance to hospital and mortality. Such an association could be confounded by illness severity. Patients living further from hospital may have a higher threshold for calling for help and may therefore be more ill and at higher risk of death. There is currently no widely validated system for risk-adjusting emergency medical cases, but the Rapid Emergency Medicine Score (REMS) has been validated in a local setting and shown to predict mortality in our cohort. This score uses six variables (age, Glasgow Coma Score (GCS), oxygen saturation, pulse, blood pressure and respiratory rate) to give each patient a score between 0 (lowest predicted mortality) and 20 (highest). We therefore planned to examine whether patients with a longer journey distance had higher REMS scores and determine whether any association between distance and mortality was confounded by illness severity by testing the association in a multivariate analysis, with REMS score included as a covariate. Because full REMS scores were only available for a small number of patients, we also tried adjusting for partial scores based only on age and GCS, which were available for 80.8% of patients. We also tried adjusting for sex, categorical age, and clinical category coded as chest pain (any cause), respiratory disease or symptoms, and injury, poisoning, asphyxiation or haemorrhage, or other and unknown. By including “other and unknown” as a category all cases were included in this analysis. All analyses were undertaken using SPSS V.11.0 (SPSS Inc, Chicago, Illinois, USA).

### RESULTS

#### Numbers

During the 5-year period, A calls resulted in ambulance attendance for 11 794 patients who met the study inclusion criteria and who were followed up to discharge or traced through the NHS Central Register. Of these, we excluded 1479 from this analysis because distance to hospital could not be calculated. This resulted in a study sample of 10 315 (58.3% male, with a median age of 61 years).

#### Analyses

Ambulance journey distances ranged from 0 to 58 km, with a median of 5 km. Overall, 644 patients died (6.2%). Table 1 shows how mortality varied with straight-line distances, categorised as short (<10 km), medium (10–20 km) or long (>20 km). Longer distances were associated with higher mortality (p<0.002, χ² test for trend). Logistic regression showed that mortality increased with each additional kilometre of distance travelled, with an odds ratio (OR) of 1.02 per kilometre (95% CI 1.01 to 1.03; p<0.001). Some association was observed in all four clinical categories, but it was particularly striking for patients with respiratory problems (fig 1).

A full REMS score could be calculated for 3882 patients (37.6%). The mean REMS score was 6.79 (95% CI 6.67 to 6.91) for those with a short journey distance, 7.22 (6.92 to 7.51) for those with a medium journey distance and 7.33 (6.78 to 7.88) for those with a long journey distance. The association between journey distance and mortality remained significant after inclusion of REMS score in the logistic regression to adjust for potential confounding by disease severity (OR = 1.03; 95% CI 1.01 to 1.05; p = 0.006).

Missing oxygen saturation information was the main reason why a full REMS score could not be calculated, so we repeated the analysis using only the age and GCS components of REMS. We have previously shown that age, GCS and oxygen saturation are the only components of the REMS score that are independent predictors of mortality in our cohort. We were able to include 8335 (80.8%) cases and found that the
discussion

Increased journey distance to hospital seems to be associated with increased risk of mortality, even after potential confounding by illness severity is taken into account. Our data suggest that each additional kilometre is associated with a 2% relative increase in mortality. This equates to an approximate 1% absolute increase in mortality associated with each 10-km increase in straight-line distance. Our results show a sharp increase in mortality in patients with respiratory problems, but less change in patients with chest pain. This is clinically plausible. This means that, other things being equal, closing local EDs could result in an increase in mortality for a small number of patients with life-threatening emergencies, who have to travel further as a result.

Other evidence

Our results concur with a number of studies from around the world that have shown increased mortality in rural compared with urban trauma. However, much of this can be explained by the increased severity of road traffic crashes and increased ambulance response times in rural areas. Furthermore, results may not be generalisable from trauma to other emergency medical conditions nor from one emergency system to another. Only a few studies have examined hospital accessibility and outcomes in the UK. Studies of road traffic crashes in Yorkshire,47 all serious trauma in Scotland,48 and ruptured abdominal aortic aneurysms in West Sussex49 all failed to find any relationship between time to hospital and mortality. However, in line with our findings, two studies of the relationship between accessibility and mortality in asthma patients have found a 10% increase in the relative risk of death for each 10-km increase in distance,9 and a 7% increase for each 10-minute increase in journey time.10

Limitations

A number of potential limitations of our study should be considered when interpreting these results. First, this is an observational study, and inferring causality from our observed associations is fraught with difficulties, most notably by confounding. Although we attempted to adjust for confounding by illness severity and case mix, it is possible that at least some of the observed association may be explained by residual confounding. Second, we deliberately selected ambulance service calls that ing. Second, we deliberately selected ambulance service calls that compromised, for a reduced risk in other groups such as those with severe respiratory problems, but less change in patients with chest pain. This is clinically plausible. This means that, other things being equal, closing local EDs could result in an increase in mortality for a small number of patients with life-threatening emergencies, who have to travel further as a result.

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The emergency medical system and future research

There is good evidence for some groups of emergency patients that care provided in specialist centres improves outcomes.1 Examples include primary angioplasty for acute myocardial infarction,11 and care for major trauma patients with multiple injuries.12 In these cases we can be reasonably confident that with appropriate pre-hospital care and at distances typical in

References


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