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# Are pre-hospital deaths from accidental injury preventable?

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**Abstract**

***Objective*—To determine what proportion of pre-hospital deaths from accidental injury—deaths at the scene of the accident and those that occur before the person has reached hospital—are preventable.**

***Design*—Retrospective study of all deaths from accidental injury that occurred between 1 January 1987 and 31 December 1990 and were reported to the coroner.**

***Setting*—North Staffordshire.**

***Main outcome measures*—Injury severity score, probability of survival (probit analysis), and airway obstruction.**

***Results*—There were 152 pre-hospital deaths from accidental injury (110 males and 42 females). In the same period there were 257 deaths in hospital from accidental injury (136 males and 121 females). The average age at death was 41·9 years for those who died before reaching hospital, and their average injury severity score was 29·3. In contrast, those who died in hospital were older and equally likely to be males or females. Important neurological injury occurred in 113 pre-hospital deaths, and evidence of airway obstruction in 59. Eighty six pre-hospital deaths were due to road traffic accidents, and 37 of these were occupants in cars. On the basis of the injury severity score and age, death was found to have been inevitable or highly likely in 92 cases. In the remaining 60 cases death had not been inevitable and airway obstruction was present in up to 51 patients with injuries that they might have survived.**

***Conclusion*—Death was potentially preventable in at least 39% of those who died from accidental injury before they reached hospital. Training in first aid should be available more widely, and particularly to motorists as many pre-hospital deaths that could be prevented are due to road accidents.**

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## Introduction

In 1988 a retrospective study of 1000 deaths from injury in England and Wales showed that many of the deaths in hospital might have been prevented.[1] The authors expressed concern that in up to 20-30% of fatal cases a delay in diagnosis or treatment or an error in both was an important significant factor in the deaths. In response to this study and the recommendations of the Royal College of Surgeons' working party on the management of patients with major injuries[2] the Department of Health funded a pilot trauma centre in Stoke on Trent.[3] The study by Anderson *et al*,[1] however, was incomplete. Of the 1000 people who died of injury, 486 did so at the scene of the accident or were dead on arrival at hospital. No further information on these deaths was given, and the authors seem to have assumed that these deaths (about half the population studied) were not preventable.

This assumption is not without precedent. In 1977 Yates investigated airway patency in people in fatal accidents.[4] Airway patency may be compromised by the aspiration of blood or gastric contents when the gag reflex is lost during coma. This life threatening complication can often be prevented by early basic life support. Yates reviewed all deaths reported to the coroner over five years and studied in detail the findings of the necropsy on people who died in an accident. By correlating the severity of the injury with airway obstruction he concluded that airway obstruction contributed to the death of those who died in hospital but not of those who died before reaching hospital. This seems to suggest a limited scope for increasing the survival rate for those who die before reaching hospital.

Yates used the injury severity score to assess injury.[5] This had been developed by Baker *et al* during a study of 2128 victims of road traffic accidents in Baltimore, United States, from 1968 to 1969, which included those who died before reaching hospital.[5] In 1975 Bull used the injury severity score to reanalyse the data on 1333 victims of road traffic accidents treated as inpatients at Birmingham Accident Hospital in 1961.[6] He used probit analysis[7] to linearise the mortality data in separate age groups and showed a good correlation between the injury severity score and the probability of survival when this North American method was applied to a British population. Yates used Bull's findings to correct the injury severity score for age.[4] "Bull's probits" have been used by several other authors to identify preventable deaths from injury.[8-10]

In the United States Trunkey identified a trimodal distribution of deaths from injury.[11] The first peak occurred immediately after the injury: over half of all deaths due to trauma occurred within seconds or minutes of injury, owing to overwhelming injury to the brain, heart, or great vessels; death was inevitable and unavoidable. The second peak occurred in the first few hours after injury in about a third of cases; brain injuries and haemorrhage were the principal causes.

Trunkey emphasised that in patients who die of potentially treatable head injuries the usual cause of death is airway obstruction or aspiration, causing acute hypoxia. Early protection of the airway, including endotracheal intubation, could reduce the number of these deaths. Most victims who exsanguinate, however, do so because of internal bleeding, which can be treated only if they are taken quickly to hospital.

Large numbers of the public can be trained in basic first aid with good effect.[12] When paramedics are available the physiological state of the injured patient can be improved,[13] although the effect on long term survival is inconclusive. A doctor at the scene may be of additional benefit, but data on this too are inconclusive,[8] although the presence of a nurse, doctor, and helicopter reduces pre-hospital mortality.[14] The people best placed to give immediate care to the airway of an accident victim, however, are those who witnessed (or caused) the accident or those who first discovered it.

We investigated pre-hospital deaths from injury—that is, deaths at the scene of the accident and those that occur before the person has reached hospital—in Britain and explored how many of these deaths would have been preventable, avoidable, or simply inevitable.

## Method

We studied retrospectively the records of necropsies and the coroner's reports on all deaths from injury reported to the coroner for north Staffordshire between 1 January 1987 and 31 December 1990. We examined the full record of each inquest, including details of the accident and the events related to the discovery of the body; the pathologist's report was also studied.

The north Staffordshire conurbation includes Stoke on Trent, Newcastle under Lyme, and Leek; its population is about 500 000. All violent deaths (accidents, injuries, assaults, and hangings) in north Staffordshire are reported to a single coroner's office serving the area. When an injury leading to death occurs outside north Staffordshire the case is dealt with by the coroner for that district.

We identified all pre-hospital deaths. For each death we obtained a copy of the pathologist's report of the necropsy and identified airway patency, injuries sustained, age and sex of the person, and mechanism of injury. We also recorded the presence or absence of important neurological injury.

TABLE I—*Distribution by age of all pre-hospital and hospital deaths from injury recorded by coroner for north Staffordshire between 1 January 1987 and 31 December 1990. Figures are numbers (percentages) of deaths*

| Age at death (years) | Pre-hospital deaths (n=152) | Hospital deaths (n=257) |
|---|---|---|
| 0- | 4 (2·6) | 9 (3·5) |
| 10- | 22 (14·5) | 20 (7·8) |
| 20- | 30 (19·7) | 15 (5·9) |
| 30- | 23 (15·1) | 10 (3·9) |
| 40- | 17 (11·2) | 11 (4·3) |
| 50- | 13 (8·6) | 9 (3·5) |
| 60- | 17 (11·2) | 18 (7·0) |
| 70- | 19 (12·5) | 53 (20·6) |
| 80- | 6 (3·9) | 79 (30·7) |
| 90-99 | 1 (0·6) | 33 (12·8) |

TABLE II—*Mechanism of injury in all pre-hospital and hospital deaths from injury recorded by coroner for north Staffordshire between 1 January 1987 and 31 December 1990. Figures are numbers (percentages) of deaths*

| Mechanism of injury | Pre-hospital deaths (n=152) | Hospital deaths (n=257) |
|---|---|---|
| Road traffic accident | 86 (56·6) | 71 (27·6) |
| Fall | 23 (15·1) | 174 (67·7) |
| Gunshot | 12 (7·9) | |
| Industrial accident | 10 (6·6) | 3 (1·2) |
| Burns | 8 (5·3) | 5 (1·9) |
| Stabbing | 5 (3·3) | 2 (0·8) |
| Other | 8 (5·3) | 2 (0·8) |

TABLE III—*Types of road users who died after road traffic accidents before reaching hospital*

| Road user | No of deaths (n=86) |
|---|---|
| Pedestrian | 22 |
| Occupant of car | 37 |
| Motorcyclist | 22 |
| Bicyclist | 5 |

We used the abbreviated injury scale[15] and injury severity scores to calculate survival rates. The abbreviated injury scale is a simple numerical method for ranking and comparing injuries by severity, developed in the 1960s from an aid to investigating road traffic accidents in the United States. The scale was originally developed for assessing non-penetrating injuries but was expanded to include penetrating injuries, resulting from incidents other than road traffic accidents. The abbreviated injury scale is an anatomically based scoring system derived from consensus that classifies individual injuries by body region on a six point ordinal scale of severity from 1 (minor) to 6 (currently untreatable)[15] but does not assess the effect of multiple injuries.

In 1974 Baker described the injury severity score,[5] which gave a much better fit between overall severity of injury and probability of survival. The injury severity score is the sum of the squares of the highest score on the abbreviated injury scale in each of three body regions. Most deaths have an injury severity score of $>15$ (a score of 16 represents 10% mortality). Survival with injuries with a score of 51-74 is highly unlikely and with a score of 75 (the maximum) impossible. Bull found that the injury severity score at which half the patients died fell from a mean of 39·7 (SD 2·9) for those aged 15-44 to 29·4 (2·5) for those aged 45-64 and to 20·2 (1·6) for those aged $>65$.[6]

We gave each injury an abbreviated injury scale score according to the criteria in the *AIS 90 Handbook*.[15] We calculated the injury severity score from the abbreviated injury scale and, using Bull's probits, identified the cases in which the injury severity score indicated a greater than 50% chance of survival.

Yates identified airway obstruction when the pathologist indicated in the report that a substantial amount of blood, vomit, or other material was present in the upper respiratory tract.[4] This method was applied in our study. Owing to gravity, contamination of the upper airways can occur after death, although this is not usual. Contamination of the bronchi seen at necropsy was taken to indicate that aspiration had occurred as a complication of the injury.[17]

## Results

Between 1 January 1987 and 31 December 1990, 497 violent deaths were reported to the coroner for north Staffordshire. Of these, 58 occurred after fracture of the neck of the femur in patients over 65. All 58 deaths occurred in hospital, and none was the direct consequence of the fracture. These deaths were therefore excluded from this study but are being investigated separately. Thirty deaths were due to suicide by hanging; as these deaths were due to asphyxiation rather than injury they were also excluded from the study.

Of the remaining 409 deaths, 152 were pre-hospital deaths and 257 were hospital deaths. In all, 110 (72·4% of the pre-hospital deaths were in males and 42 (27·6%) in females, a ratio of almost 3:1; 136 (52·9%) of the hospital deaths were in males and 121 (47·1%) in females. The age range was similar in males and females but distributed differently (table I).

The people who died before reaching hospital were younger than those who died in hospital: the average age at death was 41·9 years in the pre-hospital deaths (109 (72%) people under 60) and 65·9 years in the hospital deaths (74 (29%) people under 60).

Table II shows the mechanism of injury in pre-hospital and hospital deaths. Most of the pre-hospital deaths were due to road traffic accidents, and occupants of cars were most vulnerable (table III).

Table IV compares the distribution of injury severity scores for the pre-hospital deaths from injury with that for the hospital deaths from injury at North Staffordshire Hospital from 1 April 1990 to 31 March 1992. When the people with untreatable injuries (an injury severity score of 75) were excluded those who died before reaching hospital were not more severely injured.

Important neurological injury was found in 113 of the 152 pre-hospital deaths, with no neurological injury in the rest. At necropsy the pathologist noted some degree of airway obstruction in 89 pre-hospital deaths; 71 of these (over three quarters of all deaths

TABLE IV—*Distribution of injury severity scores in all pre-hospital and hospital deaths recorded by coroner for north Staffordshire between 1 January 1987 and 31 December 1990. Figures are numbers (percentages) of deaths*

| Injury severity score | Pre-hospital deaths (n=152) | Hospital deaths (n=257) |
|---|---|---|
| 0- | 14 (9·2) | 42 (16·3) |
| 16- | 10 (6·6) | 44 (17·1) |
| 21- | 40 (26·3) | 84 (32·7) |
| 31- | 27 (17·8) | 38 (14·8) |
| 41- | 26 (17·1) | 42 (16·3) |
| 51- | 5 (3·2) | 2 (0·8) |
| 61- | 1 (0·7) | |
| 71- | | |
| 75 | 29 (19·1) | 5 (1·9) |

with airway problems at necropsy) were associated with important neurological injury. The lungs had not been examined histologically to identify contamination of the bronchioles. The presence of contamination is highly likely to indicate aspiration before death. Nevertheless, the observation of airway obstruction is important, particularly when the pathologist refers to it specifically in the report.

Serious, potentially life threatening injury has an injury severity score of $\geq 16$. Fourteen people who died before reaching hospital had an injury severity score of $<16$, indicating a degree of severity of primary injury unlikely to cause death. These people may have died after additional adverse factors or secondary complications, but in seven deaths airway obstruction was noted at necropsy. In 10 of these 14 deaths the records suggested that an appreciable delay occurred before either the body was discovered or the emergency services were summoned. In four cases, although the accident was witnessed, no skilled resuscitation was available, and in two cases a high concentration of alcohol was found in the blood and airway problems were likely to have occurred. In view of the low injury severity score an explanation for death in the rest of this group might be airway obstruction by the tongue, but this was not detected at necropsy.

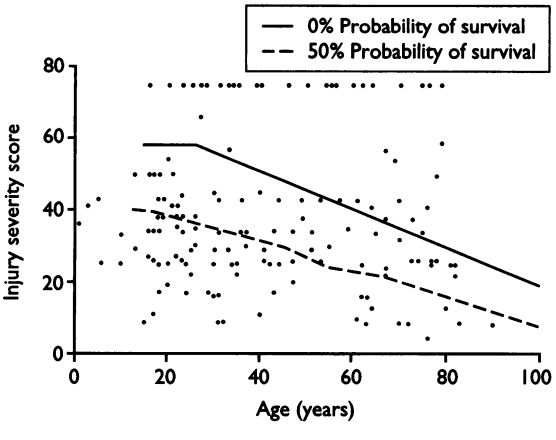
Figure 1 shows the relation between injury severity score, age, and probability of survival according to Bull.[6] In 46 cases the injury severity score and age of the patient suggest that, although injury was severe, death was not inevitable and the probability of survival was probably greater than 50%. In 35 of these there was partial airway obstruction; in 16 a delay occurred before the body was discovered; in 30 the accident was witnessed but neither resuscitation nor first aid was attempted by anyone at the scene; and in two there was evidence of excessive ingestion of alcohol.

An injury severity score of 75 identifies injuries that will cause death. In all, 29 cases had a score of 75. In these cases death was inevitable and could not have been prevented by improvements in pre-hospital care.

In conclusion, at least 60 patients who died before reaching hospital had injuries that they might have survived. At least 42 of these had airway obstruction at necropsy, and four had ingested a large amount of alcohol shortly before death. Another five probably had airway obstruction as their injuries alone did not account for their death. Up to 85% of those who died before reaching hospital and had injuries that they could have survived may have died with airway obstruction.

## Discussion

We have shown that many people who die of accidental injury before they reach hospital need not have died. Bull's probit analysis was carried out about 20 years ago on data that are now 30 years old. The probability of surviving injury has increased in Britain in the intervening years, and this study is likely to have underestimated the potential for survival in people who die before reaching hospital. Young men in road traffic accidents account for the largest proportion of pre-hospital deaths; this may indicate that they drive more recklessly or that they use the roads more. Road safety campaigns should be targeted at young male drivers. The mortality for a given injury severity score increases with age[10 11 16] and is reflected in the hospital deaths. The higher pre-hospital mortality in young people may also reflect a wider exposure to high risk, including assaults and industrial accidents.




*Relation between injury severity score, age, and probability of survival in 152 pre-hospital deaths and 257 hospital deaths recorded by coroner for north Staffordshire between 1 January 1987 and 31 December 1990. Probabilities of survival were calculated with Bull's probit analysis[6]*

**Clinical implications**

- Pre-hospital deaths from injury are not always inevitable
- A third of people whose deaths are not inevitable have airway obstruction
- Training in first aid should be more widely taught
- As car occupants account for most pre-hospital deaths from injury knowledge of first aid should be tested before a driving licence is issued

The strong association of head injury with airway obstruction clearly indicates coma complicated by aspiration in many cases. While contamination of the airways may have been a coincidental finding in some cases, the combination of head injury, relatively low injury severity scores, and airway obstruction cannot be ignored.

All the pre-hospital deaths in this study occurred before medical or paramedical help arrived. There was no suggestion that the emergency services were slow to respond, although in some cases a delay occurred before they were called. If death could have been prevented it would have to have been through the actions of the public. The high incidence of airway obstruction in preventable deaths emphasises the need for training in first aid for everyone, especially motorists. Knowledge of basic airway protection and the recovery position could be tested easily and quickly before a driving licence is issued, and every car should have a basic first aid kit. Training in basic first aid should be compulsory in schools.

The treatment of patients with major injuries is complex and rarely given priority in health care. Major accidental injury is the commonest cause of death in people under 40 and results in the loss of far more active years of life than even cancer or heart disease. Furthermore, it is preventable.

The number of road traffic accidents is falling, and heavy industry is declining. In Britain gunshot wounds and stabbings are rare and are unlikely ever to exceed the numbers of deaths from other causes. The size of the problem that accidental injury presents to any area of the country is clearly identifiable, and therefore costings can be made. Furthermore, we have shown that the pool of potential patients, even after further improvements in pre-hospital care, is manageable. In the north Staffordshire trauma system[3] 350 patients are treated each year in hospitals because of severe, life threatening injuries. The hospitals may be able to treat a further 20 or so each year, but, even if all the potential survivors lived there would never be more than 400 patients a year in our system. Unlike much spending in health care, in which investment simply leads to more candidates for treatment, investment in the care of patients with trauma can be targeted at a group of a known size; if such investment is coupled with accident prevention the group will diminish.

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# Postmortem examinations: general practitioners' knowledge, behaviour, and attitudes

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Postmortem examinations help to educate doctors and may reassure the relatives of the person who has died.[1] They provide information that may alter the future clinical management and outcome of a condition[2]; help ensure and indicate the quality of death certification, on which mortality statistics are based; and may provide some indication of the quality of a patient's care. About a fifth of deaths are followed by a postmortem examination; three quarters of these are requested by coroners for legal, not medical, reasons.[3] General practitioners issue over a quarter of death certificates (S Denley and A Berlin, unpublished data, 1992), but rarely request postmortem examinations; exact figures are difficult to obtain. We assessed the knowledge, attitudes, and behaviour of general practitioners with respect to postmortem examinations and reports.

## Methods and results

All general practitioners in the areas covered by Newcastle and Sunderland Family Health Services Authorities, in north east England, were sent a questionnaire about their patients' deaths. We asked, among other questions, whether the doctor had requested a postmortem examination or report and for her or his opinions on the value and availability of postmortem examinations. A covering letter and prepaid envelope were enclosed. A reminder and a second copy of the questionnaire were sent after two weeks, and after a further two weeks the remaining nonrespondents in Newcastle were followed up by a telephone call to their practice managers. Telephone follow up was not done in Sunderland because in Newcastle it resulted in only two additional responses.

Two hundred and thirty of the 305 questionnaires sent out were returned, of which 227 (74%) could be analysed as they were complete (126/161 (78%) from Newcastle and 101 (144 (70%) from Sunderland). As the findings from both cities showed no significant differences we combined the data.

The table shows the main findings of the survey. A sixth of general practitioners did not know that they could request a postmortem examination for clinical reasons without contacting a coroner, and half had never done so while in general practice. A sixth of general practitioners had requested a postmortem examination in the past year, although most had requested a postmortem report at some time.

*Findings of survey on knowledge, behaviour, and attitudes of 227 general practitioners in Newcastle upon Tyne and Sunderland with respect to postmortem examinations*

| | No |
|---|---|
| *Knowledge* | |
| Did not know could request non-coroner's postmortem examination | 38 |
| *Behaviour* | |
| Had requested non-coroner's postmortem examination: | |
| In past year | 36 |
| In past 10 years | 41 |
| Had never requested a postmortem examination while in general practice | 107 |
| Had ever requested postmortem report | 170 |
| *Attitude* | |
| Agreed that: | |
| Information from postmortem examination is of little clinical value in general practice | 4 |
| A higher number of postmortem examinations is important for effective audit of deaths in general practice | 96 |
| It would be useful to receive all postmortem reports routinely | 217 |
| "It is the moral right of the deceased person's [general practitioner] to know the findings of a postmortem examination"* | 200 |
| Coroners should be obliged to supply a copy of a postmortem report to the general practitioner | 211 |
| It is reasonable for coroners to charge general practitioners for postmortem reports | 6 |
| Hospital pathologists should routinely send a copy of a postmortem report to the general practitioner | 211 |

*Non-coroners' postmortem examinations are carried out at request of doctors for medical interest.

Information gained from postmortem examinations was perceived as useful: almost all general practitioners reported that they would value receiving copies of all postmortem reports and that coroners and hospital pathologists should supply reports routinely, although most did not think that coroners should charge for postmortem reports. Almost half of general practitioners thought that more postmortem examinations should be requested to improve audit of deaths.

## Comment

The report *Autopsy and Audit* stated that requests from general practitioners for postmortem examinations should be encouraged.[3] Though most general practitioners regard postmortem examinations as valuable, however, few request them and some are not even aware that they can do so. This may be because arranging one from the community is difficult: one general practitioner commented that it required several telephone calls and a visit to the pathologist. Furthermore, whether sufficient facilities exist to cope with an increase in requests is unclear.

Our most notable finding was the overwhelming