Health Technology Assessment 1998; Vol. 2: No. 17

The costs and benefits of paramedic skills in pre-hospital trauma care

Jon Nicholl
Sue Hughes
Simon Dixon
Janette Turner
David Yates

Health Technology Assessment
NHS R&D HTA Programme

How to obtain copies of this and other HTA Programme reports.
An electronic version of this publication, in Adobe Acrobat format, is available for downloading free of charge for personal use from the HTA website (http://www.hta.ac.uk). A fully searchable CD-ROM is also available (see below).

Printed copies of HTA monographs cost £20 each (post and packing free in the UK) to both public **and** private sector purchasers from our Despatch Agents.

Non-UK purchasers will have to pay a small fee for post and packing. For European countries the cost is £2 per monograph and for the rest of the world £3 per monograph.

You can order HTA monographs from our Despatch Agents:

– fax (with **credit card** or **official purchase order**)
– post (with **credit card** or **official purchase order** or **cheque**)
– phone during office hours (**credit card** only).

Additionally the HTA website allows you **either** to pay securely by credit card **or** to print out your order and then post or fax it.

Contact details are as follows:

HTA Despatch
c/o Direct Mail Works Ltd
4 Oakwood Business Centre
Downley, HAVANT PO9 2NP, UK

Email: orders@hta.ac.uk
Tel: 02392 492 000
Fax: 02392 478 555
Fax from outside the UK: +44 2392 478 555

NHS libraries can subscribe free of charge. Public libraries can subscribe at a very reduced cost of £100 for each volume (normally comprising 30–40 titles). The commercial subscription rate is £300 per volume. Please see our website for details. Subscriptions can only be purchased for the current or forthcoming volume.

Payment methods

Paying by cheque
If you pay by cheque, the cheque must be in **pounds sterling**, made payable to *Direct Mail Works Ltd* and drawn on a bank with a UK address.

Paying by credit card
The following cards are accepted by phone, fax, post or via the website ordering pages: Delta, Eurocard, Mastercard, Solo, Switch and Visa. We advise against sending credit card details in a plain email.

Paying by official purchase order
You can post or fax these, but they must be from public bodies (i.e. NHS or universities) within the UK. We cannot at present accept purchase orders from commercial companies or from outside the UK.

How do I get a copy of *HTA on CD*?

Please use the form on the HTA website (www.hta.ac.uk/htacd.htm). Or contact Direct Mail Works (see contact details above) by email, post, fax or phone. *HTA on CD* is currently free of charge worldwide.

The website also provides information about the HTA Programme and lists the membership of the various committees.

The costs and benefits of paramedic skills in pre-hospital trauma care

Jon Nicholl[1]
Sue Hughes[1]
Simon Dixon[2]
Janette Turner[1]
David Yates[3]

[1] Medical Care Research Unit, University of Sheffield, Sheffield, UK
[2] Sheffield Health Economics Group, ScHARR, University of Sheffield, Sheffield, UK
[3] University of Manchester, Hope Hospital, Manchester, UK

With contributions from:
Study design: Helen Snooks, John Brazier
Data collection: Tricia Myers, Kate Cleary, Kate Harrington
Avoidable death assessment: Chris Carney, Tom Clarke, Matthew Cooke, Howard Sherriff, and Tom Judge

Published November 1998

This report should be referenced as follows:

Nicholl J, Hughes S, Dixon S, Turner J, Yates D. The costs and benefits of paramedic skills in pre-hospital trauma care. *Health Technol Assessment* 1998; **2**(17).

Health Technology Assessment is indexed in *Index Medicus*/MEDLINE and *Excerpta Medica*/ EMBASE. Copies of the Executive Summaries are available from the NCCHTA web site (see overleaf).

NHS R&D HTA Programme

The overall aim of the NHS R&D Health Technology Assessment (HTA) programme is to ensure that high-quality research information on the costs, effectiveness and broader impact of health technologies is produced in the most efficient way for those who use, manage and work in the NHS. Research is undertaken in those areas where the evidence will lead to the greatest benefits to patients, either through improved patient outcomes or the most efficient use of NHS resources.

The Standing Group on Health Technology advises on national priorities for health technology assessment. Six advisory panels assist the Standing Group in identifying and prioritising projects. These priorities are then considered by the HTA Commissioning Board supported by the National Coordinating Centre for HTA (NCCHTA).

This report is one of a series covering acute care, diagnostics and imaging, methodology, pharmaceuticals, population screening, and primary and community care. It was identified as a priority by the Acute Sector Panel and funded as project number 93/23/18.

The views expressed in this publication are those of the authors and not necessarily those of the Standing Group, the Commissioning Board, the Panel members or the Department of Health. The editors wish to emphasise that funding and publication of this research by the NHS should not be taken as implicit support for the recommendations for policy contained herein. In particular, policy options in the area of screening will, in England, be considered by the National Screening Committee. This Committee, chaired by the Chief Medical Officer, will take into account the views expressed here, further available evidence and other relevant considerations.

Reviews in *Health Technology Assessment* are termed 'systematic' when the account of the search, appraisal and synthesis methods (to minimise biases and random errors) would, in theory, permit the replication of the review by others.

Series Editors: Andrew Stevens, Ruairidh Milne and Ken Stein
Editorial Assistant: Melanie Corris

The editors have tried to ensure the accuracy of this report but cannot accept responsibility for any errors or omissions. They would like to thank the referees for their constructive comments on the draft document.

ISSN 1366-5278

Published by Core Research, Alton, on behalf of the NCCHTA.
Printed on acid-free paper in the UK by The Basingstoke Press, Basingstoke.

Copies of this report can be obtained from:

The National Coordinating Centre for Health Technology Assessment,
Mailpoint 728, Boldrewood,
University of Southampton,
Southampton, SO16 7PX, UK.
Fax: +44 (0) 23 8059 5639 Email: hta@soton.ac.uk
http://www.hta.nhsweb.nhs.uk

Contents

List of abbreviations

A&E	accident and emergency
AIS	Abbreviated Injury Scale
ALS	advanced life support
BLS	basic life support
CI	confidence interval
CPR	cardiopulmonary resuscitation
DSH	deliberate self-harm
EMT	emergency medical technician
ET	endotracheal (intubation)
GP	general practitioner
GP BASICS	General Practitioner British Association of Immediate Care
HDA/U	high dependency area/unit
ISS	Injury Severity Score
ICU	intensive care unit
MTOS	Major Trauma Outcomes Study
OR	odds ratio*
PAS	patient administration system
PHTLS	pre-hospital trauma life support
PRF	patient report form
RR	relative risk*
RTA	road traffic accident
RTS	Revised Trauma Score
SD	standard deviation*
SE	standard error*
SF-36	Short Form 36-item questionnaire
TRISS	Trauma Score – Injury Severity Score
T-RTS	Triage Revised Trauma Score
TS	Trauma Score

* Used only in tables

Executive summary

Introduction

It is Department of Health policy that all emergency ambulance crews should include a paramedic trained in advanced life support. In addition to the training in basic life support (BLS) that all ambulance crew receive, training in the UK usually consists of 8 weeks of instruction and practice in endotracheal intubation, cannulation, and the administration of intravenous fluids and a limited range of drugs. This study assessed the effectiveness of the additional paramedic training in the management of serious trauma.

Methods

Main non-randomised cohort

Cohorts of patients attended only by ambulance service crews with BLS training (emergency medical technician [EMT] cases), or by crews with at least one paramedic were sampled over a period spanning 21 months from July 1994 to March 1996 from three ambulance service areas. Patients with serious trauma who died or stayed in hospital for 3 or more nights, and who were not attended by a doctor on scene, were eligible for inclusion.

Randomised cases

An attempt was made to randomise the dispatch of EMT or paramedic crews to '999' trauma calls. A total of 185 calls were randomised, but only 16 of these patients met the inclusion criteria for serious trauma (n = 8 paramedic cases, n = 8 EMT cases). These cases were added to the main cohort to give n = 1440 paramedic cases and n = 605 technician cases followed up in the main study.

Data collection

Characteristics of the incidents, the patients and their injuries, and the crews attending were taken from ambulance service dispatch records and patient report forms, from hospital accident and emergency (A&E), inpatient, and administrative records, and from coroners' records. Death was assessed from hospital and coroners' records at 6 months post-incident, and a random sample of n = 428 survivors were sent a follow-up questionnaire at 6 months post-incident, asking about use of healthcare services and including the Short Form 36-item questionnaire (SF-36).

Avoidable deaths

A stratified random sample of 244 deaths occurring within 3 days of the incident was examined by a panel of five experts in pre-hospital care to assess the role of pre-hospital care in any avoidable deaths.

Results

Processes

For all patients in the main cohort, mean length of stay was 15.2 nights, and 5.9% were admitted to intensive care. There were no significant differences between patients attended by paramedics or EMTs before or after adjustment for casemix.

Paramedic crews spent 2 minutes longer on scene than technician crews even after adjustment for casemix ($p < 0.01$). The difference was due to cases in which paramedics had cannulated or intubated the patient who had mean on-scene times 12 minutes longer than patients with no paramedic interventions.

Mortality

There was a total of 114 deaths from trauma related causes within 6 months of the incident; 86 in 1440 patients ever attended by paramedics (6.0%) and 28 in 605 patients only attended by EMTs (4.6%). Adjustment for casemix increased this difference, as did analysis by type of crew first on scene. Adjusted for casemix, the ratio of the odds of death in patients first attended by paramedics to the odds of death in patients first attended by EMTs was 2.02 (95% confidence interval (CI): 1.05, 3.89). This corresponds to an increase in risk of death from 4.5% to 8.7% (95% CI: 4.7%, 15.5%). This increased risk was similar for deaths before arrival at A&E, in A&E, or after admission. A small part of the difference was explained by the extra time on scene spent by paramedics.

The increased risk of death was only observed in patients with 'bleeding injuries' (penetrating injuries, injuries to abdomen or thorax, major

or multiple limb fractures; estimated relative risk 4.6, 95% CI: 1.1, 20.0), and there was no increased risk in patients with head injuries or other trauma.

Avoidable deaths

Excluding 65 cases recorded as found dead on scene, and blinded to the type of crew attending, the panel assessed that 17/120 (14.2%) deaths in patients attended by paramedics were possibly avoidable, and 4/59 (6.8%) in patients attended by EMTs.

For deaths judged to be probably avoidable, the proportions were 8/120 (6.7%) for paramedic attended patients and 0/59 for EMT patients ($p = 0.02$). The difference remained when cases possibly dead before the ambulance arrived at the scene were excluded.

The overall rate of cases judged probably avoidable was just 1.4% of all deaths within 3 days of the incident.

Morbidity

Outcomes in survivors showed the opposite effects. Survivors attended by paramedic crews had fewer days off from their usual activities, and had better scores on all SF-36 health dimensions. These differences were significant for comparisons by type of crew first on scene adjusted for casemix for five of the eight dimensions. The differences were large enough to be clinically important, and could not be explained by the excess mortality in the paramedic cases (a survivor effect).

Costs

The total cost of treatment was estimated to be just £22 (1%) more expensive for patients who were attended by a paramedic crew than a technician crew, and this difference is not at all statistically significant ($p = 0.82$).

Conclusion

There was no evidence from this study to support the view that a substantial proportion of pre-hospital deaths are avoidable, as suggested by previous studies.

The authors conclude that the protocols used by paramedics increase the mortality from serious trauma involving bleeding injuries, but may also lead to better outcomes for survivors. The observed increase in mortality may be due to factors such as delays on scene and inappropriate pre-hospital fluid infusion.

Recommendations for further research

An associated Health Technology Assessment study examining two paramedic fluid resuscitation protocols in blunt trauma is currently underway. If this comparison project finds poorer outcomes in blunt trauma resulting from fluid resuscitation, then it will still be necessary to go on to resolve whether this is due to the types of patients, the timing of resuscitation, the type of fluids used or the amount of fluid infused (or a combination of these factors). However, other studies comparing different training and protocol packages are also needed, specifically these should include:

- A comparison of the effectiveness of different pre-hospital time protocols in untrapped patients with bleeding injuries (e.g. an open protocol versus a limit of 10 minutes on scene).
- A comparison of training programmes, using similar protocols, to examine whether the skills developed in the longer degree-type courses beginning to be offered to paramedics make a difference to the way in which protocols are implemented and their effectiveness.

Chapter 1
Introduction

Department of Health policy requires all emergency ambulances to include a crew member trained in advanced life support (ALS). The decision to aim for the placement of a paramedic on every emergency ambulance was made on the assumption that the provision of ALS skills on scene would improve patient outcome. However, there has been much debate around this issue, both for trauma and cardiac arrests.

For cardiac arrests, recent UK research has suggested that paramedic-attended patients may be more likely to arrive at hospital with vital signs, but that there is no difference in survival to discharge.[1,2] Nevertheless, there is wide agreement about the importance of the earliest possible attendance by ambulance personnel trained in the use of a defibrillator. Consequently, ambulance service policy is now concentrated on improving response times to the scene.

There is less agreement about appropriate pre-hospital care for trauma patients. The extended skills used by paramedics over and above the basic life support (BLS) offered by non-paramedic technicians in the on-scene treatment of trauma patients are principally endotracheal (ET) intubation and intravenous fluid infusion. Paramedics also have access to a limited range of drugs, but these are infrequently used in trauma care. The debate centres around the issue of using the skills appropriately and in a way that will benefit the patient without delays on scene which may be to the patient's detriment.

It is agreed that 'the goals of pre-hospital care of the critically injured patient should be to reduce the time from injury to definitive surgical care and yet provide resuscitation that will increase the chances of the patient arriving at the hospital alive and in a reasonable condition',[3] but the appropriate balance between swift transfer to hospital and on-scene stabilisation is hotly debated.

The controversy in pre-hospital care ranges from protagonists of 'scoop and run' to those who believe the most appropriate treatment is in-field stabilisation, also referred to as 'treat in the street'. Advocates of the first school of thought recommend minimal medical attention at the scene, with speed of delivery to definitive care in hospital being the most important prognostic factor.[4,5] Others believe that pre-hospital ALS should be initiated at the earliest possible moment and that the time taken for a limited number of field interventions necessary to stabilise a patient before transport to an accident and emergency (A&E) department is offset by benefits gained by early treatment.[6,7]

There is general agreement about the need for a minimum period of time on scene to assess the patient and provide basic care, and most commentators believe that there is a case to be made both for rapid assessment and transport, and for stabilisation and treatment on scene, and that the issue is not one of general policy but of choosing the right approach in individual incidents. It is also agreed that an airway must be made secure as a first priority and that if ET intubation is needed then this should be carried out on scene without delay.[8] However, reported on-scene times in the US vary from a mean of 10.7 minutes in Denver[7] to 24.9 minutes in Washington.[9] In the UK, recently reported times spent on scene by paramedics in trauma cases were at the upper end of this range at 24.8 minutes in London and 20.6 minutes in Cornwall.[10] Studies in the US have also reported wide variations in times required to perform ALS techniques on scene ranging from no added time[11] to unacceptable delays.[12]

The controversy is usually focused on fluid resuscitation by intravenous infusion. Studies of the benefits of pre-hospital intravenous infusion show conflicting results, and the question of appropriate infusion protocols to be used by paramedics with ALS skills is the subject of on-going research.

However, whilst pre-hospital fluid infusion may be an important focus of the debate what is at issue are the more general questions of ALS training and the role of paramedics. In the UK ALS training of paramedics usually consists of a 4-week training period and a 4-week clinical placement, whilst in the USA it is frequently part of a 3-year professional training. Indeed at the extreme, ALS is regularly provided by doctors at the scene in some countries, and through the existence of hospital flying squads and the General Practitioner British Association of Immediate Care (GP BASICS) organisation is sometimes provided in the UK. Longer training may enable not only the techniques of discriminatory understanding of the patients, conditions, and circumstances when these techniques are appropriate. Thus a recent review conducted in the USA which examined the costs and benefits of ALS concluded that for trauma care 'recent studies are in substantial agreement that ALS intervention does significantly improve ... patient outcome, although there is significant disagreement regarding the value of pre-hospital fluid resuscitation'.[13] Unfortunately, none of the studies included in the review were from the UK, and there are fundamental problems in generalising the results to the UK not only because of potentially important differences in paramedic training, but also because of crucial differences in almost all the other critical factors such as casemix, response times, other pre-hospital support services, transfer times to A&E, A&E services and organisation, and other available hospital services.

The importance of pre-hospital care in outcomes of trauma is difficult to weigh up. However, of the 14,500 trauma deaths in the UK each year it has been estimated that between 50% and 75% die before arrival at hospital.[14,15] Even allowing for the fact that many of these deaths will by unsalvageable in any system, pre-hospital care could be as influential on the outcomes of trauma as hospital care.

This study set out to examine the critical issues – looking at the comparative effectiveness of paramedics and technicians in the care of serious trauma by examining scene times, lengths of stay in hospital, mortality rates, avoidable deaths, quality of life in survivors, and considering the costs of a paramedic emergency ambulance service.

Chapter 2

Methods

Overview

Cohorts of trauma patients attended only by ambulance service technicians with BLS training (Emergency Medical Technician, EMT cases), or by at least one paramedic with ALS training (paramedic cases), were sampled over a period spanning 21 months from three ambulance service areas.

Subject to some minor exceptions outlined below, all such patients who died or stayed in hospital 3 or more nights, and who were not attended on scene by a doctor, were eligible for inclusion. Random samples of these cases were chosen in order to include for follow-up approximately 2000 patients, as indicated in the protocol.

Characteristics of the incidents, the patients and their injuries, and the crews attending were recorded. Processes of care, mortality, morbidity, and costs have been assessed, and compared between EMT and paramedic cases. In pragmatic analyses, the cases have also been classified by whether an EMT or paramedic crew was first on-scene. In these analyses, incidents first attended by EMTs but later backed-up by paramedics have been treated as EMT cases.

Two additional studies were carried out. Firstly, during the 6 months of prospective data collection in area 3, an attempt was made to randomise the dispatch of EMT or paramedic crews to '999' trauma calls. Secondly, a sample of 244 deaths occurring on-scene, in transit, or in hospital up to 3 days post-incident, were reviewed by an expert panel to determine whether any deaths may have been preventable by optimal pre-hospital care.

The methods are outlined in more detail below.

Areas included in the study

Three ambulance service areas were included in the study. They were chosen to represent all the types of environment typically encountered in England, and included metropolitan, urban, suburban, and rural areas (*Table 1*).

TABLE 1 Ambulance Service areas included in the study

Study period	Catchment population (millions)	Persons/k (m^2)	No. of stations	A&E ambulances
Area 1				
July 94–Aug 95	2.7	2505	35	81
Area 2				
Oct 95–Mar 96	1.4	250	14	32
Area 3				
Sept 94–Feb 96	2.1	636	29	99

Approval for the study

Approval for the study was obtained from 34 ethics committees in all, covering the 42 hospitals that trauma patients could be taken to by the three ambulance services.

Following approval by the ethics committee letters were sent to all the Medical Directors of the hospitals involved and permission obtained to access the medical records of patients we wished to follow up.

The A&E Consultants from all 42 hospitals were also contacted, firstly by letter, and then by a personal visit of the researcher in that area to explain the nature of the study and request access to their records. Similarly, the senior officers and information technology managers in the three ambulance services were contacted to obtain their cooperation and to gain insight into the best methods of accessing their computerised activity data.

Once permission for the study to proceed had been granted from ethics committees, A&E Consultants and Medical Directors, medical records managers in each of the 42 hospitals were visited and permission sought to use the patient administration system (PAS) to follow up patients from A&E through to hospital admission. Access to the actual medical records was also negotiated at this time. The majority of hospitals did provide access to PAS. This proved an invaluable aid in tracing patients through the system and identifying the cases that satisfied our inclusion criteria. However, in a small number of hospitals in two of the areas, this access was not granted, and in these cases the researchers had to rely on computer generated lists of patients admitted. In hospitals in the third area, no access to PAS was granted and this proved a particular difficulty to the researcher in this area.

Data collection

Inclusion/exclusion criteria

The evaluation has been targeted on the more severe cases of trauma that may benefit from the extended skills offered by paramedic trained ambulance personnel. The inclusion criteria used were similar to those used in the Major Trauma Outcome Study (MTOS).[16] Data were collected on all trauma patients, irrespective of age, and included hangings, drownings and asphyxiations, who had been transported from the scene to hospital or mortuary by ambulance. In order to do this the following inclusion/exclusion criteria were employed.

Inclusion criteria

- All trauma admissions whose length of stay was 3 nights or more, unless it was written in the notes that admission was extended for social reasons or non-trauma care, e.g. psychiatric, geriatric, general medical or palliative care.
- All trauma patients who were admitted either to an intensive care unit (ICU) or to a high dependency area (HDA) which was distinctly identified as a separate unit on the hospital's administrative database.
- All patients who died before arrival at hospital or in hospital, but did not die before the ambulance arrived at the scene, when an injury of traumatic origin was stated as a cause of death.
- All trauma patients transferred to another hospital for further emergency care whose total length of stay was 3 nights or more, or who were admitted to ICU/HDA, or died from their injuries, when an injury of traumatic origin was stated as a cause of death.
- All trauma patients not included above, but known to have been admitted or re-admitted for treatment of their original trauma injuries, where the dates of their re-admission stay include a date that was more than 2 days from the date of the incident.
- All trauma patients who died within 6 months of the incident, irrespective of the above criteria, and whose death certificate listed a cause of death as the trauma sustained.

Exclusion criteria

- Poisonings.
- Patients transported to hospital by helicopter.
- Any patient attended on scene by a doctor who attempted resuscitation or treatment of any kind.
- Patients dead at the scene before the ambulance arrived.
- Patients, (all ages), with superficial skin injuries, including simple penetrating injuries.
- Patients with superficial burns including partial thickness burns < 10%.
- Any patient, over 65 years, whose trauma diagnosis on admission was an isolated fracture neck of femur or single pubic rami fracture, resulting from a fall of less than 1 m, whether or not they died.
- Patients, (all ages), whose trauma diagnosis on admission was an isolated simple facial injury, including simple eye injuries.
- Patients, (all ages), whose trauma diagnosis on admission was a simple spinal strain (i.e. acute cervical, thoracic or lumbar sprain with no fracture or dislocation)
- Patients involved in 'major incidents' as defined by each respective ambulance service.

Case identification

The starting point for case identification was the ambulance service computerised activity data, which were screened to exclude all medical emergencies, maternity cases, stopped calls, inter-hospital transfers and hoax calls. In two of the areas, pilot studies on a typical month's activity revealed approximately 3000 trauma cases transported to A&E departments, of which 1 in 10 were severe enough to warrant hospitalisation for more than 3 days, our major inclusion criteria. We only required 50 cases per month from each area over the time frame of the study (18 months), and so a sample of calls were followed up. In the third area, the number of trauma cases per month, approximately 700, was expected to yield 50 cases per month without sampling.

All cases sampled from ambulance records were followed up through A&E registers, and PAS or computer generated lists to identify those cases which satisfied our inclusion criteria. This was a thorough process in areas 1 and 3 which resulted in only a very small proportion of sampled cases remaining untraceable: 0.5% overall. However, in area 2, with poor access to PAS, we could not be so confident of our success in tracing the cases through to hospital admission. Patients meeting the inclusion criteria were entered into the study.

Sampling strategy

Area 1

No prospective data collection was possible in area 1 because of an absence of sufficient technician only crews at the start of the study. For each month, information was supplied from the ambulance services computerised activity data on all '999' trauma calls about incidents attended by technicians and paramedics. These incidents were followed up through A&E and hospital admission to identify those meeting the inclusion criteria commencing with the most recent months since only patients from recent incidents could be sent 6-month post-incident questionnaires. Initially the sample for follow-up was all EMT cases plus a random 1 in 10 sample of paramedic cases. After the first five most-recent months, it was discovered that a full 18-month retrospective data collection period would not be possible because prior to mid-July 1994, EMT and paramedic cases were not distinguished in the ambulance service records. We therefore decided to follow-up a simple random sample of 1000 paramedic cases in each of the other 8 months available, together with all EMT cases as before.

Area 2

There was no need to sample in area 2, as all identified trauma incidents were followed up during the 6-month prospective phase October 1995 to March 1996.

Area 3

From the ambulance computerised activity data, 600 cases were chosen at random in each of the 18 months of the study period, September 1994 to February 1996. It was not possible to know the status of the crews prior to taking this sample, as it had been in area 1. However, the EMT: paramedic ratio was known to be approximately 2:5 overall, and this was considered acceptable since the sample sizes had been calculated assuming a ratio of 1:2. Sample numbers and inclusions are described in chapter 3.

Consideration was given to randomising the dispatch of EMT or paramedic crews to trauma calls in the three area. In area 1 this was not possible, due to there being very few EMT crews at the start of the study, and in area 2 the ambulance control operating procedures did not allow randomisation to take place. However, during the 6-month prospective phase in area 3, September 1995 to February 1996, an attempt was made to randomise technician or paramedic crews to attend trauma incidents. A protocol for randomisation of dispatch of either a paramedic crew or technician-only crew to suitable trauma calls was agreed with the ambulance control personnel. A copy of this protocol is shown in *Figure 1*. Calls were to be randomised when there were two crews, one paramedic and one technician, equally available to attend the incident, and there were no known restrictions such as the patient being trapped. The dispatchers had boxes provided which contained sealed, numbered envelopes in which there were randomly ordered dispatching instructions. Crews were dispatched according to these instructions when the conditions for randomisation were met.

Unfortunately, control room staff remained undecided about the ethics of randomising calls

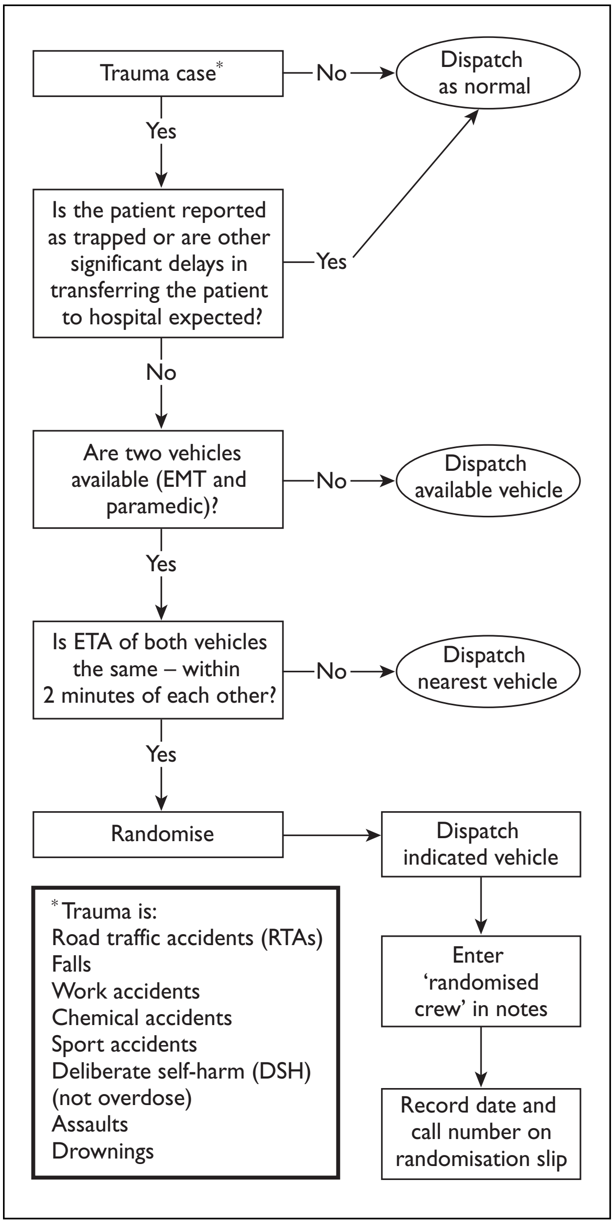

FIGURE 1 *Protocol for randomising trauma cases (999 calls only)[13] – single vehicle response*

despite repeated reassurances from the researchers and their own management. Consequently, compliance with the protocol was poor. Equally, as had been predicted in the original protocol, at the time of dispatch, and hence of randomisation, the dispatchers could not know whether the patients would meet the inclusion criteria. As a result, few randomised calls were for trauma serious enough to warrant inclusion in the study. It was decided, therefore, that randomised calls would be followed up if the patient stayed at least overnight in hospital (instead of 3 or more nights) and a follow-up questionnaire would be sent at 1 month instead of 6 months in view of their less serious injuries. Only 185 calls were randomised over the 6 months, and only 30 of these met even the less restrictive inclusion criteria (see chapter 3).

Information recorded

Pre-hospital

Pre-hospital information was abstracted from the ambulance service patient report form (PRF) when it was traced, and from computerised ambulance activity data. The latter provided details of times of call, dispatch, arrival on scene, left scene and arrived at A&E; together with grid references for incident location, crew type, crew names, date and nature of incident and destination hospital. The Triage Revised Trauma Score[17] (T-RTS) on scene was abstracted from the PRF when recorded, and condition of patient and details of interventions carried out. The T-RTS is a measure of physiological derangement calculated from the sum of values between 0 and 4 assigned to each of the Glasgow Coma Scale score, systolic blood pressure, and respiratory rate. It ranges from 0, indicating no vital signs, to 12, indicating normal responses.

Copies of the PRF were attached to the data record sheet. Where PRFs were not found then any information on the pre-hospital condition of the patient and interventions carried out by ambulance crews included in the A&E record were recorded on the data record sheet.

The availability of PRFs varied with area and crew status (*Table 2*) and were only reliably found in area 1. This meant that we had limited information on the patient's physiological state in the pre-hospital phase as given by the T-RTS in both area 3 (83% with no PRF) and area 2 (61% with no PRF). Added to this, the impossibility of determining the T-RTS if any of the three component parts, blood pressure, respiratory rate and Glasgow Coma Scale score were missing meant that very few complete pre-hospital T-RTS scores being available: only 25% overall.

In hospital

Every effort was made to trace each case sampled from ambulance service records to a matched A&E and inpatient record. Matching criteria used were name of patient (where this had been identified in the ambulance records), date and time of incident and type of incident. Where the researchers had access to manual A&E registers and PAS, very few cases remained unmatched, and we are confident that all possible inclusions including deaths have been identified. However, when reliant on computerised A&E registers and computer generated lists, direct matching to all cases was more difficult, and we were reliant on the completeness of the hospital computerised lists and correctness of the coding data used to generate the list. Sample cases left unmatched to hospital admissions were assumed to have been minor injuries that were not admitted, unless the researchers had other information from ambulance records that indicated a more serious incident. These cases were followed up further wherever possible, to exclude the possibility that they might have died or been transferred urgently. Hospital information was obtained from A&E records, inpatient notes and hospital PAS systems. Information was recorded in four sections – A&E events, inpatient stay and re-admissions, injury descriptions, and death details.

TABLE 2 *Availability of PRFs*

	Area 1			Area 2			Area 3			Total	
	Total cases	With PRF (n)	(%)	Total cases	With PRF (n)	(%)	Total cases	With PRF (n)	(%)	n	% with PRF
Paramedic	751	683	90.9	151	57	37.7	543	128	23.6	882	60.5
Technician	361	326	90.3	23	11	47.8	230	8	3.5	331	55.2
Total	1112	1009	90.7	174	68	39.1	773	136	17.6	1213	58.9

A&E events

Information recorded included the patient's time in A&E, time first seen and grade of staff, details of any referrals to other specialties including time seen and grade of staff, the first recorded T-RTS, and state on leaving A&E. For patients transferred to other hospitals within 6 hours, the time of departure, hospital transferred to, reason for transfer, and time of arrival at the second hospital were recorded.

In-patient stay and re-admissions

Details were recorded of the hospital, specialty, type of ward, acute or long-stay, and length of stay for each admission event. When patients were transferred either between hospitals or between specialties within the same hospital, each episode was treated as a separate event. This included any rehabilitation admissions. Where patients were subsequently transferred to hospitals outside the study regions, the patient's consultant in the receiving hospital was contacted for details of final discharge date, state on discharge (alive or dead) and for some specialties – notably spinal injuries and burns – a final diagnosis to complete injury descriptions. Any re-admissions to hospital for reasons directly attributable to the original injury were also recorded, detailing dates of re-admission, hospital, specialty and length of stay.

Injury descriptions

A full description of all injuries sustained and their Abbreviated Injury Scale (AIS) codes[18] were made using A&E records, in-patient notes and post-mortem reports. AIS codes indicate threat to life and range from 1 indicating a minor injury, to 6, indicating a non-survivable injury. Injury mechanism was classified as blunt or penetrating.

The injury descriptions were coded using the AIS90 dictionary[18] and Injury Severity Scores (ISS) calculated.[19] ISS scores are calculated by summing the squares of the AIS scores of the most severe injuries in up to three body regions. ISS scores range from 1 to 75 indicating the most severe injuries. All injuries were coded by one researcher in area 1 (PM), one researcher in area 2 (KH), and one researcher in area 3 (KC). In addition, a fourth researcher (SH) was involved in AIS coding for cases included in the avoidable death study, but did not code any inclusions to the main study. All the researchers attended a 3-day training course organised by the MTOS coordinator of the North West Injury Research Centre in Manchester.

In addition, all the researchers attended several 1-day injury coding training sessions in Sheffield to practise and discuss difficulties. These training sessions were designed to ensure, as far as possible, consistency in scoring between the researchers. An assessment of inter-rater agreement was made during the study. The researchers independently scored 40 identical sets of notes. The mean ISS scores of the three researchers were similar (Researcher 1 = 29.3, Researcher 2 = 27.0 and Researcher 3 = 29.6). Furthermore, the proportion of all pairs of scores which were in exact agreement was 60% and this compares favourably with the 28% reported in a similar exercise involving doctors and trauma researchers in Yorkshire.[20] In 20 cases (50%) there was complete agreement between all three researchers, and in eight cases (20%) no pairs of scores agreed. It is likely that our success in improving on scoring consistency comes from using jointly trained trauma audit clerks holding regular discussions throughout the study period.

Death details

For all patients who died, the date, time and place of death were recorded together with the causes of death.

After discharge

Samples of survivors were sent a postal questionnaire 6 months after injury to assess morbidity, and their use of health and social service since their accident. Information was requested about re-admissions to hospital, outpatient and general practitioner (GP) consultations, and use of other paramedical staff (e.g. district nurses, physiotherapists, social workers). Patients were also asked about the amount of help they had needed from family and voluntary organisations and of the number of days work lost.

Coroners' records

For trauma deaths, the coroners' records were examined and details of time and cause of death and injuries sustained abstracted together with any other details of pre-hospital or hospital care not already found in their respective records.

Training and experience profile of crews

Information about the length of service and skills acquired for all emergency ambulance crews was abstracted from ambulance service personnel and training records. Information recorded included an identity number for each crew member, their age, sex, ambulance station, whether paramedic or EMT status, date of first employment, date of qualification as a technician and where applicable date of qualification as a paramedic. In area 2, the date of their last requalifying training as either technician or paramedic was also recorded, but this was not available in either of the other areas. It was not possible to get accurate information on previous length of service, if any, in other ambulance services. The length of service recorded is, therefore, that of service with their present employer.

Outcomes assessment

Mortality

Sampled trauma cases from ambulance activity data were followed up and matched to A&E registers, resuscitation room registers, mortuary lists, PAS and computer generated admission lists, and all deaths recorded.

All deaths up to 6 months post-incident were included as deaths. There were no deaths within 6 months which were clearly unrelated to the original trauma incident. Cases where the patient died more that 6 months post-incident were included in the study as survivors. It is possible that some patients may have died within 6 months without our knowledge, if they were discharged from hospital and moved out of the area, and their subsequent deaths recorded by coroners elsewhere.

Morbidity assessment

Morbidity in survivors was assessed by postal questionnaire at 6 months post-incident.

Questionnaire

Past trauma studies have used several different measures of disability and general morbidity. The Short Form 36-item Questionnaire (SF-36) was chosen, as it is a proven and reliable instrument for measuring general health status whilst covering a broad range of disabilities, including physical, mental, and social functioning.[21] The 36 questions were extended to 39 in order to differentiate lower orders of physical functioning in the older population,[22] and analysis was also performed taking these extra questions into account.

Trauma patients are a diverse group, and therefore the instrument must be able to measure a wide range of disability within each dimension. Some traditional measures of disability, such as the Barthel, have focused on more severe forms of disability and have been insensitive to change. The SF-36 covers a wide range of health concepts, generating scores for eight dimensions – physical function, social function, physical role, emotional role, mental health index, energy and vitality, pain index, and general health perceptions. An important advantage of the SF-36 is its brevity, taking just 5–10 minutes to complete.

The dimensions were scored according to the developer's recommendations, modified for the UK version.[23] Each dimension is scored from 0 to 100 with 100 indicating no disability or evidence of limitations.

As well as the SF-36 questionnaire, questions were included on the patient's use of health and social services post-incident. These questions asked about re-admission to hospital, numbers of outpatient visits, GP visits, district nurse, social worker visits, etc. It also asked whether they needed extra help with daily activities from friends and family and how many days off work, school or usual activities they had taken.

Selection of patients for follow-up

During the 6-month prospective phase in area 2 (October 1995 to March 1996) and area 3 (September 1995 to February 1996), all identified survivors included in the study were sent a postal follow-up questionnaire, and in area 1 survivors from a 5-month period (April–August 1995) were sent the follow-up questionnaire, unless: (a) they were under 16 years old, or (b) their GP or their medical record indicated that a questionnaire would be inappropriate.

General health status and disability in children under 16 years cannot be assessed using the SF-36 questionnaire.

Patients selected for questionnaire were sent a letter asking whether they would be willing to take part in the study, unless they were known to still be a hospital in-patient or for the elderly to have been discharged for continuing care.

Where possible, the questionnaire was completed by the patient themselves at home. If the patient was too ill or too disabled to complete the questionnaire themselves the patient's relative or carer was asked to complete the questionnaire on their behalf and this was recorded as completed by proxy. The response rate to the postal questionnaire was 67% (*Table 3*).

TABLE 3 Response to follow-up

Response	Numbers of patients
Total sent out	412
Fully completed by patient	201
Completed by proxy	37
Partially completed	39
Refused	1
No reply	118
Returned 'not known at this address'	7
Other	9
Response rate (completed or partially completed)	67%

Avoidable deaths

The methods used in the avoidable death study are discussed separately in chapter 7.

Economic evaluation

The methods used in the economic evaluation are discussed separately in chapter 8.

Statistical methods

Comparisons between crew types

All the main analyses have compared processes and outcomes for patients included in the study who were attended by ambulances crewed by paramedics or technicians.

The cases included are principally injured survivors admitted for ≥ 3 days, and deaths from trauma not recorded as having occurred before the ambulance arrived or after 6 months post-incident. All cases attended by doctors at the scene have been excluded.

Explanatory analyses

All crews have two members, and many incidents are attended by more than one ambulance. Consequently there are often several ambulance personnel at the scene. Each ambulance person at the scene can also be classified by their length of service or experience as a technician and as a paramedic (which will be 0 for technicians, of course).

For the purposes of the explanatory analyses presented here, we have therefore categorised all cases by:

- 'ALS service' – which is the longest time since ALS training amongst all the ambulance personnel attending the scene.
- 'BLS service' – which is the longest period of employment with the current employer less any ALS time, of all ambulance personnel at the scene.
- In addition, if ALS service is zero the case is also categorised as a technician or EMT case, otherwise as a paramedic case.

Pragmatic analyses

In a pragmatic study concerned with policy as well as effectiveness, analysis should be by the therapeutic decision – sometimes known as intention-to-treat. In this case, that is whether the decision was to dispatch a paramedic crew or a technician crew. Unfortunately, the intention is not recorded and when several crews arrive at the scene, it is not always clear whether later crews were dispatched as a back-up or were dispatched first but simply arrived later. Nevertheless, it is likely that where a paramedic crew arrived first, the decision was to send a paramedic crew or the nearest available crew, and similarly with technician crews.

Accordingly, we have also carried out pragmatic analyses in which cases have been categorised as paramedic or technician according to the status of the crew arriving first on scene. For these analyses, approximately 7% of cases attended at some time by paramedics, and hence classified as paramedic cases for the explanatory analyses, were attended first by technician crews and have been reclassified.

Comparisons of processes

Comparisons of how technicians and paramedics managed the cases included in the study have been made. As well as looking at treatments provided by ambulance personnel, the times spent on-scene and the ratio of time on scene to transfer time to hospital have also been compared. These comparisons have been made both for the cases randomised who were admitted overnight, and for the more seriously injured cases who were admitted for ≥ 3 nights sampled in the main cohorts. The comparisons have been made after adjusting for any imbalance between the groups in the nature and severity of casualty injuries, the types and circumstances of the incident, and characteristics of the casualties and the ambulance crews.

The full list of characteristics taken into account is:

Patient: age
sex
Incident: area
type of incident (RTAs, falls, assault, fire, DSH, other)
place of incident (RTAs, home, work, street, other)
trapped or not
time of day (day = 0700–1859; or night)
total direct distance (calculated from the sum of the straight line distances from ambulance location to scene, and scene to hospital).
Injuries: ISS
AIS for head injuries
mechanism (blunt or penetrating).
Crews: type of crew (paramedic or technician)
length of service as technician (see above)
length of service as paramedic (see above).

The outcome for the patient – death or survival – was not taken into account when comparing processes, since this may be an outcome of those processes rather than a cause of them.

Simple linear regression models were fitted using standard least-squares methods, and preliminary statistical tests were made assuming that scene-times and ratios were normally distributed. Important results which have helped lead to the conclusions about the role and effectiveness of paramedic care have also been tested using permutation tests.

Comparisons of mortality

Trauma deaths have been compared for a combined cohort of randomised and non-randomised cases, since there were few cases and no deaths in the randomised group and they could not be analysed separately. Only the randomised cases meeting the non-randomised case inclusion criteria have been entered into these analyses.

For these comparisons, the same factors have been taken into account as for the process comparisons, and in addition, the role of the total travel time and total direct distances has been considered. The total travel time was the sum of the time from mobilisation to arrival on scene for the first vehicle arriving on scene, plus the time from leaving scene to arrival at A&E for the vehicle carrying the patient. The total direct distance and the total travel time can be considered as measures of the 'remoteness' of the incident.

In conventional analysis of trauma care, expected outcomes are calculated using the revised trauma score (RTS)[17] as well as age, ISS, and other characteristics. The RTS is a weighted combination of coded values for the Glasgow Coma Scale, respiratory rate and systolic blood pressure. The three elements (age, ISS and RTS) are usually combined in a linear logistic regression model known as Trauma Score – Injury Severity Score (TRISS).[24]

There are several difficulties with this method.[25] For the purposes of this study, one of the most worrying is that the model was developed for assessing hospital care, and not pre-hospital care. However, the main problems lie with the RTS. Firstly, whilst the ISS and age are to all intents and purposes free from changes with time, the RTS is not. Secondly, its value not only depends on when it is measured, but it also changes with management and treatment. Indeed, the RTS is as much a measure of outcome as input. Thirdly, unlike age and ISS, it is crucially dependent on the component indices (Glasgow Coma Scale, respiratory rate and systolic blood pressure) being measured and recorded by the emergency service teams. Even in the best settings this is rarely always done, and omission may be selective rather than random.

In a study of pre-hospital care, it seems appropriate that only the T-RTS, which is designed for use in pre-hospital triage, measured on arrival of the ambulance services on scene should be used, as values of T-RTS or RTS recorded on arrival in A&E may in part reflect the pre-hospital care already given. Unfortunately, in this study, only one-quarter of patients had a T-RTS recorded on scene. Although the proportions with missing values were very similar in the two groups (74.5% in paramedic attended cases and 75.4% in technician attended cases), the possibility of systematic biases remains, especially since scoring the T-RTS is part of the national paramedic training syllabus but is not part of the national EMT syllabus. Furthermore the small difference in missing values represents an extra six patients in the technician group with missing data. If the T-RTS was not recorded because the technicians found these patients were lifeless at the scene (i.e. they in fact had an T-RTS of 0), then there would be proportionally more T-RTS = 0 patients in the technician cases than in the paramedic cases, rather than fewer as found in the recorded data.

The only solution to this problem is to leave out the trauma scores (TS) altogether, as has been suggested.[26] We have therefore relied on the unchanging and objective measures with little or no missing data (AIS, ISS and age) as well as mechanism of injury details (type of incident, trapped patients, penetrating injuries, etc.) to enable any adjustments to be made.

The analyses have used logistic regression models to adjust the observed fatality rates for any imbalances in the potential prognostic factors. Critical estimates have been tested using permutation tests,[27] and confidence intervals (CIs) bootstrapped.

Chapter 3

Study numbers and casemix

Introduction

A total of 2076 cases was followed up in the main study cohorts, 1112 cases in area 1, 790 in area 3 and 174 in area 2. The total numbers of trauma calls to area 1 in each month of the study, together with the numbers sampled and the final inclusion numbers are shown in *Table 4*. Similarly, the numbers for area 3 over the study period are shown in *Table 5*. All trauma calls in area 2 were followed up.

In area 1, 15.6% of all calls were attended by EMT crews, but due to the sampling strategy of following up all the technician cases and only a sample of paramedic cases, the final proportion included in the study was 32.5%.

Preliminary studies in area 2 had indicated that approximately 20% of calls were attended by technician crews but the proportion in the final sample (13.2%; 151 paramedic: 23 technician cases) was distorted by the fact that not all cases could be followed up to assess whether they met the inclusion criteria.

In area 3, the type of crew was not known at the time of sampling and cases were sampled across the board for follow-up. As a result, in 47 of the cases followed up, the crew type could not be ascertained and these cases have been excluded from all further analyses. Amongst the remaining 743 cases in area 3, 28.7% were attended by technician crews.

The total number of calls followed up in area 1 was 17,391 and in area 3 10,800. The resultant ratios of calls followed up to cases identified as meeting the inclusion criteria for area 1 and area 3, respectively, indicate that only 6.7% of all trauma calls to large predominantly urban ambulance services are serious trauma meeting our inclusion criteria. With a typical workload of 3000 trauma calls per month this, would mean about 200 trauma in-patients per month whose length of stay is 3 days or more.

Randomised calls

Calls were randomised in area 3 during the 6-month period September 1995 to February 1996.

***TABLE 4** Sampling and study numbers in area 1*

	All trauma incidents				Cases satisfying inclusion criteria		
		Technician	Paramedic		Total	Technician	Paramedic
Month	**Total**	**All**	**All**	**Sample taken**			
7–31 July 1994	2073	479	1594	1000	91	28	63
August 1994	3515	874	2641	1000	103	39	64
September 1994	3100	608	2492	1000	96	34	62
October 1994	2997	581	2416	1000	98	35	63
November 1994	3197	490	2707	1000	112	25	87
December 1994	3670	565	3105	1000	101	31	70
January 1995	2936	341	2595	1000	110	23	87
February 1995	2928	362	2566	1000	92	23	69
March 1995	3126	492	2634	1000	99	36	63
April 1995	3275	375	2900	290	37	18	19
May 1995	3616	376	3240	324	40	18	22
June 1995	3339	495	2844	284	41	19	22
July 1995	3408	439	2969	297	46	13	33
August 1995	3254	437	2817	282	46	19	27
Total	**44,434**	**6914**	**37,520**	**10,477**	**1112**	**361**	**751**

TABLE 5 Sampling and study numbers in area 3

Month	All trauma incidents		Cases followed up[a]			
	Total	Sampled calls	Total	Technician	Paramedic	Crew not known
September 1994	2474	600	55	12	37	6
October 1994	2735	600	50	16	31	3
November 1994	2532	600	42	13	28	1
December 1994	2985	600	43	13	28	2
January 1995	2773	600	53	16	36	1
February 1995	2356	600	40	10	26	4
March 1995	2784	600	41	13	26	2
April 1995	3016	600	53	13	36	4
May 1995	2906	600	36	6	27	3
June 1995	2966	600	45	14	31	0
July 1995	3077	600	42	4	36	2
August 1995	3029	600	39	13	26	0
September 1995	2709	600	46	11	31	2
October 1995	2806	600	43	15	23	4
November 1995	2868	600	53	6	32	2
December 1995	3175	600	40	15	19	1
January 1996	2111	600	36	11	24	1
February 1996	2551	600	63	12	33	9
Total	**50,853**	**10,800**	**790**	**213**	**530**	**47**

[a] *These are cases followed up in the main cohorts. A further 30 cases randomised to paramedic or EMT dispatch were also followed up (see* Table 6*)*

TABLE 6 Randomised dispatch in area 3

Month	Total calls randomised	Length of stay					
		Total inclusions		Technician		Paramedic	
		≥ 3 days	1 or 2 days	≥ 3 days	1 or 2 days	≥ 3 days	1 or 2 days
September 1995	20	1	1	1	1	–	–
October 1995	13	–	1	–	–	–	1
November 1995	67	5	8	2	6	3	2
December 1995	26	4	1	2	–	2	1
January 1996	18	–	–	–	–	–	–
February 1996	41	6	3	3	2	3	1
Total	**185**	**16**	**14**	**8**	**9**	**8**	**5**

The total numbers randomised each month and those subsequently identified as meeting the inclusion criteria are shown in *Table 6*. The inclusion criteria were modified for the randomised cases to capture as much useful data as possible and cases were included if they had been admitted to hospital at least overnight. Cases satisfying the original inclusion criteria of at least 3 days hospital stay are shown separately. Only 30 (16.2%) of the 185 randomised calls met the modified inclusion criteria and only 16 (8.6%) met the main cohort inclusion criteria; it can be seen that to achieve the proposed target of 225 randomised inclusions would have required approximately 2970 calls to have been randomised. This would have meant 500 dispatches a month meeting the requirements for randomisation.

In the analyses of processes (chapter 4), the 30 randomised call patients have been included giving a total of 2059 cases. However, in the analyses of outcomes, randomised cases staying for less than 3 nights (n = 14) have been excluded, leaving a total of 2045 cases. The study numbers are summarised in *Table 7*.

TABLE 7 *Study numbers[a]*

	Paramedics	Technicians	All known	Not known
Main cohorts				
Area 1	751	361	1112	0
Area 2	151	23	174	0
Area 3	530	213	743	47
Randomised cases				
Area 3 randomised cases meeting inclusion criteria	8	8	16	0
All				
Study cases meeting inclusion criteria	1440	605	2045	47
Area 3 randomised cases no meeting inclusion criteria	5	9	2059	0

[a] 94 patients attended by paramedic crews were first attended by EMT crews. In the intention-to-treat analyses therefore there are 699 EMT cases and 1346 paramedic cases

Casemix by area

Types of crew

Of the 2045 cases, 605 (29.6%) were attended only by BLS trained crews (technician cases), and 1440 (70.4%) by at least one ALS trained paramedic (paramedic cases). These proportions were similar in areas 1 and 3, but there was a significantly higher proportion in area 2. Only 96 of the paramedic cases were also attended by technician crews; 94 after the technician crew and two before the later arrival of a technician crew.

A training skills and experience profile of all emergency ambulance personnel active during the period of the study was drawn up for each of the services. There were 601 crew members identified in area 1, 152 in area 2, and 458 in area 3 – 1211 in all. The proportion of emergency crew active during the period of study that were paramedics varied from 42% (area 3) to 46% (area 2) to 52% (area 1).

Bearing in mind that only 6.7% of trauma calls meet our MTOS-type inclusion criteria, and that more than one crew attends the scene in about 10% of these types of incident, it was calculated that each emergency ambulance person sees on average just 14 MTOS-type patients per year. This is roughly one per month with serious injuries.

Paramedics and technicians were further subdivided by length of service – paramedics were classified as experienced if they had more than 3 years experience as a paramedic at the time of the study. Similarly, EMTs were classified as experienced if they had more than 10 years experience as a technician. The proportion of experienced paramedics within the total paramedics in each service varied from 27% (area 1) to 39% (area 3) to 43% (area 2), whereas the proportion of experienced technicians within the total technicians in each service varied from 50% (area 1) to 60% (area 2) to 67% (area 3) (*Table 8*). These differences were also reflected in the mean ages of the emergency ambulance personnel in the three areas, with area 1 (mean age 36.5) having significantly younger, as well as less experienced, personnel than area 3 (mean age 41.1) or area 2 (mean age = 42.4).

These differences between the staff profiles of the three areas were clearly reflected in the cases included in the study (*Table 9*). In terms of the most experienced crew member attending the scene, a higher proportion of area 2 cases were paramedic attended incidents (86.8%), and more of these

TABLE 8 *Experience of personnel by ambulance service (n = 1201, missing = 10)*

Experience	Area 1		Area 2		Area 3	
	n	%	n	%	n	%
Paramedics						
≥ 3 years experience	84	27	30	43	75	39
< 3 years experience	226	73	40	57	119	61
Technicians						
≥ 10 years experience	140	50	49	60	175	67
< 10 years experience	142	50	33	40	88	33
Total						
Experienced	224	38	79	52	250	55
Inexperienced	368	62	73	48	207	45

TABLE 9 *Crew experience status by ambulance service*

Characteristic		Values	Area 1		Area 2		Area 3[a]		All	
			n	%	n	%	n	%	n	%
***Experience*[b]**										
Paramedic cases										
	ALS < 3 years	BLS < 10 years	221	32.8	131	7.3	148	29.6	382	30.6
		BLS ≥ 10 years	191	28.3	233	0.7	931	8.6	307	24.6
	ALS ≥ 3 years	BLS <10 years	52	7.7	7	9.3	71	14.2	130	10.4
		BLS ≥ 10 years	210	31.2	324	2.7	188	37.6	430	34.4
	Not known		77		76		38		191	
Technician cases		BLS < 10 years	120	35.0	6	40.0	31	14.2	157	27.2
		BLS ≥ 10 years	223	65.0	9	60.0	188	85.8	420	72.8
	Not known		18		8		2		28	
Status	Paramedic		751	67.5	151	86.8	538	66.7	1440	70.4
	Technician		361	32.5	23	13.2	221	27.4	605	29.6
	Not known		–		–		47		47	

[a] *Including n = 16 randomised cases who stayed at least 3 nights in hospital*
[b] *This is the experience of the most experienced ambulance crew attending the scene*

TABLE 10 *Incident characteristics by ambulance service area*

Characteristic	Values		Area 1		Area 2		Area 3		All	
			n	%	n	%	n	%	n	%
Incident										
Type		RTA	337	30.3	48	27.6	263	34.7	648	31.7
		Falls	573	51.5	98	54.0	369	48.6	1036	50.7
		Fire	18	1.6	2	1.1	20	2.6	40	2.0
		DSH	11	1.0	0	0.0	14	1.8	25	1.2
		Assault	93	8.4	11	6.3	40	5.3	144	7.0
		Other	80	7.2	19	10.9	53	7.0	152	7.4
Place	RTA		337		48		263		648	
	Other	Home	406	57.0	63	50.4	227	53.4	696	55.2
		Street	112	15.7	19	15.2	47	11.1	178	14.1
		Work	94	13.2	11	8.8	46	10.8	151	12.0
		Other	100	14.0	32	25.6	105	24.7	237	18.8
		Not known	63		1		71		135	
Trapped	Yes		18	1.6	8	4.6	21	2.8	47	2.3
	No		1094	98.4	166	95.4	738	97.2	1998	97.7
Time of day	Day (7–7)		703	63.2	119	68.4	573	71.1	1363	66.7
	Night		406	36.5	55	31.6	233	28.9	679	33.3
	Not known		3						3	

had experience. There was little difference between areas 1 and 3, except for the fact that area 3 had relatively few cases included in the study attended by inexperienced paramedics with long BLS service.

Patients and incidents

There were few differences between areas in the type of patient or incidents attended (*Tables 10* and *11*). Just over half the cases attended were male, with an even distribution of ages, and there were no substantive differences between the areas. The ISS distribution was heavily weighted towards the lower end, and only 10.7% of these patients, who died or stayed more than 3 nights, had ISS ≥ 15, which is conventionally designated as major trauma. Only a quarter of the patients in the study (25.6%) had a head injury, and a further nine patients without a head

TABLE 11 *Characteristics of patients and their injuries by area*

Characteristic	Values	Area 1		Area 2		Area 3		All	
		n	%	n	%	n	%	n	%
Patients									
Age	0–14	161	14.6	15	8.6	91	12.0	267	13.1
	15–34	274	24.9	53	30.5	208	27.5	535	26.3
	35–54	219	19.9	41	23.6	163	21.5	423	20.8
	55–74	242	22.0	32	18.4	159	21.0	433	21.3
	75+	204	18.5	33	19.0	136	18.0	373	18.4
	Not known	12		0		2			
Sex	Male	618	55.6	103	59.2	440	58.0	1161	56.8
	Female	494	44.4	71	40.8	319	42.0	884	43.2
Injuries									
ISS	0–8	519	46.7	97	55.7	451	54.4	1067	52.2
	9–15	472	42.4	64	36.8	224	29.5	760	37.2
	16–24	53	4.8	6	3.4	39	5.1	98	4.8
	25–40	52	4.7	5	2.9	36	4.7	93	4.5
	41–75	16	1.4	2	1.1	9	1.2	27	1.3
Head injury AIS	None	793	71.3	144	82.8	585	77.1	1522	74.4
	1	98	8.8	9	5.2	37	4.9	144	7.0
	2	101	9.1	10	5.7	77	10.1	188	9.2
	3	62	5.6	7	4.0	25	3.3	94	4.6
	4	25	2.2	3	1.7	17	2.2	45	2.2
	5	33	3.0	1	0.6	18	2.4	52	2.5
On-scene T-RTS	0	8	1.8	0	–	8	15.7	16	3.1
	1–11	50	11.3	4	16.0	5	9.8	59	11.4
	12	384	86.9	21	84.0	38	74.5	443	85.5
	Missing	670		149		708			
Injury mechanism	Blunt	1071	96.3	170	97.7	706	93.0	1947	95.2
	Penetrating	41	3.7	4	2.3	53	7.0	98	4.8

injury had a neck injury. This broad description was also similar in all three areas, as was the small proportion of cases with penetrating injuries.

A minority of cases (24.6%) had a T-RTS score recorded on scene, and this varied from 39.7% in area 1 to just 6.3% in area 3, principally reflecting the availability of PRFs. Because of this large amount of missing data, the T-RTS has not been used in comparisons between groups.

The types of incident and whether the patient was recorded as trapped or not, place of occurrence, and time of day of occurrence were all broadly similar in the three ambulance service areas (*Table 10*).

Casemix by crew status

The types of incidents, and the patients and their injuries attended by the two cohorts included in the main study were remarkably similar (*Tables 12* and *13* and *Figures 2–4*). The only exception to this were the small proportions of EMT cases recorded

TABLE 12 *Characteristics of incidents by crew status*

Characteristics	Values		Paramedic cases		Technician cases	
			n	%	n	%
Incident						
Type	RTA		465	32.3	183	30.2
	Falls		720	50.0	316	52.2
	Fire		27	1.9	13	2.1
	DSH		16	1.1	9	1.5
	Assault		105	7.3	39	6.4
	Other		107	7.4	45	7.4
Place	RTA		465		183	
	Other	Home	490	55.1	206	55.2
		Street	131	14.7	47	12.6
		Work	98	11.0	53	14.2
		Other	170	19.1	67	18.0
		Not known	86		49	
Trapped	Yes		42	2.9	5	0.8
	No		1398	97.1	600	99.2
Time of day	Day (7–7)		943	65.6	420	69.5
	Night		495	34.4	184	30.5
	Not known		2		1	

as trapped or as a difficult extrication case. There were 47 such cases in total (36 in RTAs), and of these only five were attended by technicians.

Equally in the 25% of cases in which a T-RTS score was recorded on scene, there were 16 who were recorded as without vital signs (T-RTS = 0), and only two of these were in the technician group. However, this difference is not significant ($\chi^2 = 3.2$, df = 2, $p = 0.2$), and is probably due to technicians not recording the T-RTS in these types of patient rather than any difference in casemix.

TABLE 13 *Characteristics of patients and their injuries by crew status*

Characteristics	Values	Paramedic cases n	Paramedic cases %	Technician cases n	Technician cases %
Patients					
Age	0–14	185	12.9	82	13.6
	15–34	394	27.6	141	23.5
	35–54	300	21.0	123	20.5
	55–74	295	20.6	138	23.0
	75+	256	17.9	117	19.5
	Not known	10		4	
Sex	Male	826	57.4	335	55.4
	Female	614	42.6	270	44.6
Injuries					
ISS	0–8	751	52.2	316	52.2
	9–15	526	36.5	234	38.7
	16–24	78	5.4	20	3.3
	25–40	66	4.6	27	4.5
	41–75	19	1.3	8	1.3
Head AIS	None	1072	74.4	450	74.4
	1	97	6.7	47	7.8
	2	135	9.4	53	8.8
	3	68	4.7	26	4.3
	4	36	2.5	9	1.5
	5	32	2.3	20	3.3
On-scene T-RTS	0	14	3.8	2	1.3
	1–11	44	12.0	15	9.9
	12	309	84.2	134	88.7
	Missing	1073		454	
Injury mechanism	Blunt	1368	95.0	579	95.7
	Penetrating	72	5.0	26	4.3

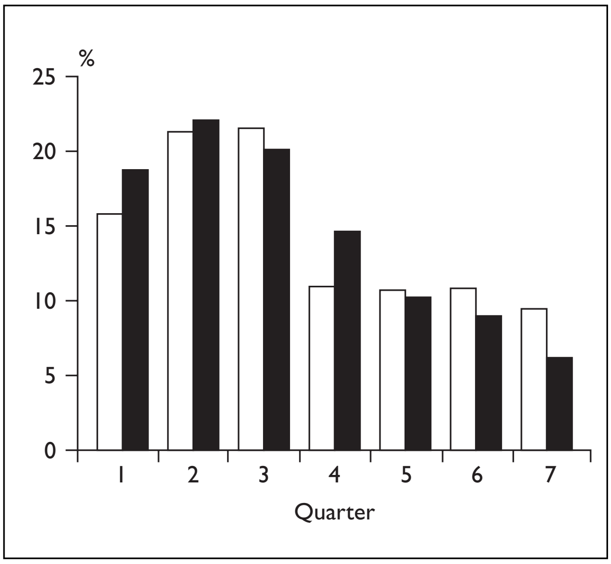

FIGURE 2 *Number of cases by quarter and type of crew (□, paramedic; ■, EMT)*

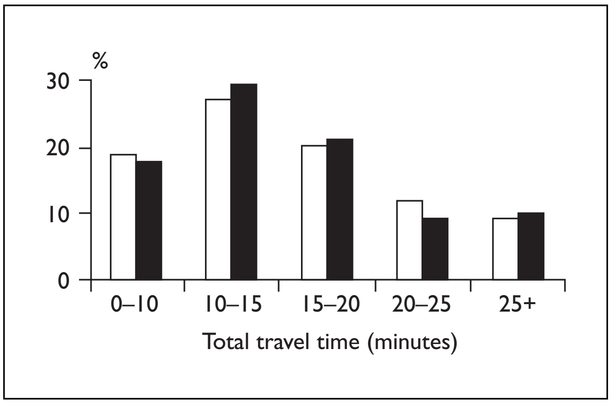

FIGURE 3 *Distribution of cases by total travel time and type of crew (□, paramedic; ■, EMT)*

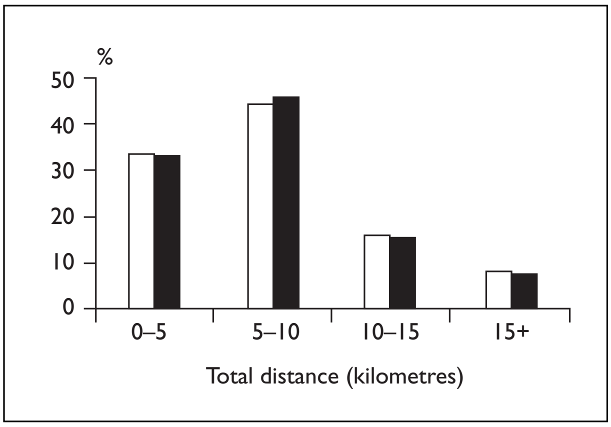

FIGURE 4 *Distribution of cases by total distance and type of crew (□, paramedic; ■, EMT)*

Chapter 4

Processes of care

Pre-hospital processes of care

During the course of the study period, the number of emergency ambulances dispatched with at least one paramedic on board increased in all three areas. Paramedics are able to treat some patients using methods unavailable to technician only crews, e.g. by cannulation and the infusion of intravenous fluids or drugs, or by intubation in comatose patients to assist the maintenance of a clear airway. However, these processes of care can also extend the length of time spent on scene. These changes and the consequences for time on scene and care in hospital are examined below.

Treatments given on scene

Table 14 describes the treatments available to both technicians and paramedics which are known to have been administered in the pre-hospital phase. These were those actually reported on the PRF where found, or as stated in the A&E record as having been done before arrival at hospital. It is not known to what extent the treatments recorded on PRFs are complete, nor whether incidents with PRFs are typical of all incidents.

The most common treatments/observations were pulse monitoring (85% of patients), assessment of pupils (62%), pulse oximeter (62%), and blood pressure monitoring (45%). Oxygen was given in 26% of cases and a cervical collar applied in 21%. Fractures were splinted in 18% of cases and entonox given for pain relief in 13%. In general, paramedics reported administering these treatments to a greater proportion of patients than technicians, although this observation should be treated with some caution, since the difference may be a consequence of non-reporting of treatments actually given by technicians particularly when reporting on the PRF was by open comment rather than ticking pre-determined boxes.

Table 15 describes those treatments that are solely administered by paramedics. Cannulation was attempted in 293 (34%) out of a total of 868 paramedic attended cases with a PRF and successful cannulation achieved in 274 of these 293 cases (94%). The ISS scores and pre-hospital Glasgow

TABLE 14 *Pre-hospital treatments/observations common to both paramedics and technician crews*

Treatment given	Paramedic			Technician			All crews	
	Total	n	%	Total	n	%	n	%
Wound care	885	91	10.3	332	23	6.9	114	9.4
Fracture splintage	894	167	18.7	341	51	15.0	218	17.7
Pulse monitor	878	744	84.7	331	283	85.5	1027	84.9
Cardiac monitor	881	98	11.1	331	11	3.3	109	9.0
Oxygen	885	243	27.5	334	71	21.3	314	25.8
Spinal immobiliser	884	72	8.1	333	25	7.5	97	8.0
Ventilation	881	17	1.9	331	1	0.3	18	1.5
Defibrillation	881	3	0.3	331	0	–	3	0.2
Cardiopulmonary resuscitation (CPR)	881	11	1.2	333	1	0.3	12	1.0
Limb traction	883	6	0.7	331	1	0.3	7	0.6
Burns dressing	881	2	0.2	331	1	0.3	3	0.2
Nebuliser	881	3	0.3	331	2	0.6	5	0.4
Pulse oximeter	878	533	60.7	328	209	63.7	742	61.5
Pupils check	880	562	63.9	330	182	55.2	744	61.5
Cervical collar	910	208	22.9	350	62	17.7	270	21.4
Entonox	881	113	12.8	332	45	13.6	158	13.0
Blood pressure monitor	860	397	46.2	327	134	41.0	531	44.7
Other	884	109	12.3	331	9	2.7	118	9.7

TABLE 15 Pre-hospital interventions only available to paramedics

Intervention	Number of cases	%
Cannulation		
Attempted	293	33.8
Successful	274	31.6
Fluids	160	18.4
Intubation		
Attempted	16	1.8
Successful	10	0.7
Given drugs	87	10.0
All patients with PRF	868	100.0

Coma Scale scores for those patients with attempted cannulation were higher and lower, respectively, than in the study as a whole, indicating more seriously injured patients.

Intravenous fluids were given in 160 out of 274 cases successfully cannulated (58%). Those just cannulated with no fluids given were often given a saline flush only, but in 42 cases drugs were given intravenously. For those given fluids 68% had ≤ 500 ml.

Intubation was attempted in only 16 out of 868 cases (1.8%), and successfully achieved in just 10 of these 16 patients (63%). Paramedics are not allowed to paralyse patients or use other means to achieve an airway, and this may explain the low rates of attempted and successful intubation.

Drugs were given to 87 patients (10%). Adrenaline was given to eight patients, including five who also received atropine (presumably for patients already in cardio-respiratory arrest). Nubain (nalbuphine hydrochloride) was given to 72 patients, six of whom also received other drugs; and seven further patients received other drugs, such as Hepsal (heparin sodium in saline) or tramadol.

In total, 288 patients received an intervention that could only be administered by a paramedic, one third of those attended by paramedics for whom a PRF was recovered.

Time on scene

Time spent on scene with patients is thought to be a critical factor in patient outcome in trauma. The basic trauma life support and pre-hospital trauma life support (PHTLS) courses recommend that this time should usually be kept to a minimum, and preferably within 10 minutes.[28] In some cases, this is impossible for physical reasons – where the patient is trapped or there is some other reason for difficult extrication. Equally, the on-scene time is difficult to ascribe to a particular ambulance crew when one crew is the first to arrive on the scene, but another crew transfers the patient from the scene to hospital. For comparing scene times, these two small groups of patients (n = 47 recorded as trapped and n = 33 conveyed by a different vehicle) were therefore excluded.

Explanatory analyses

For patients in the non-randomised cohorts, those ever attended by paramedics spent nearly 2 minutes longer attended on scene than those only attended by technicians (*Table 16*). For the randomised cases, this difference was 5.5 minutes.

The estimated effect of paramedic attendance was largely unaffected by adjusting the estimates to take account of any differences between patients, their injuries, and the circumstances of the incidents.

After considering all the factors listed in chapter 2, the scene times were found to be dependent to some extent on ISS and head injury AIS, the type and place of the incident, the age of the patient, and the ambulance service area. Together these factors explained about 10% of the variance in the

TABLE 16 Time on scene (minutes) by type of crew ever attending[a]

	Missing cases (n)	Non-randomised cases		Randomised cases[b]	
		Paramedic mean (SE)	Technician mean (SE)	Paramedic mean (SE)	Technician mean (SE)
On-scene time	52	15.2 (0.25)	13.5 (0.30)	14.1 (2.6)	8.6 (1.0)
Transfer time to hospital	67	9.7 (0.15)	9.8 (0.24)	10.8 (2.8)	9.4 (2.4)
Ratio scene/transfer	73	2.3 (0.07)	2.0 (0.09)	2.1 (0.54)	1.0 (0.12)

[a] Excluding cases trapped, or first attended and transferred by different vehicles
[b] All randomised cases staying ≥ 1 night in hospital (n = 30) are included here

on-scene times in the main cohort, and 24% in the randomised group. The same set of factors was used to adjust transfer times to hospital and the ratio of scene time to transfer time.

After adjustment for both randomised and non-randomised cases, there were significantly longer scene times associated with attendance on scene by paramedics (*Table 17*). This was not explained by longer transfer times to hospital; the ratio of on-scene to transfer times were also significantly larger in patients ever attended by paramedics, and remained similar after adjustment.

Pragmatic analyses

The differences between EMT and paramedic scene times are partly because some cases first attended by technicians were later attended by paramedic crews who may have been called in as a back-up. These cases had longer than average scene times.

Analysis of both non-randomised and randomised groups by type of crew first attending (equivalent to 'intention to treat' for the randomised cases) reduced the unadjusted differences in mean on-scene times to 1.3 minutes and 2.1 minutes respectively (*Table 18*). When these differences were adjusted for casemix , there was no reliable evidence in the randomised group (n = 27 patients with all measures) that there were longer scene times for patients first attended by paramedic crews (*Table 19*). However, the estimates were similar to those in the non-randomised group, with no statistical evidence of any difference between randomised and non-randomised groups. Pooling the results for randomised and non-randomised cohorts, after adjustment for casemix differences, the estimated effect of first attendance by paramedics was to increase the scene time by 2.0 minutes (+16%), and to increase the ratio of scene to transfer times by 0.35 (+18%).

TABLE 17 *Effect of attendance at any time by paramedics on pre-hospital times*

Time	Cases	Model	% variance explained by adjustment[a]	Estimated effect of paramedics on mean		*p*-value[b]
				Min	(SE)	
On-scene time	Non-randomised cohort	Crude		+1.8	(0.46)	< 0.01
		Adjusted	10.3%	+2.0	(0.44)	< 0.01
	Randomised cohort	Crude				
		Adjusted		+5.5	(2.4)	0.04
			24.1%	+7.2	(3.1)	0.04
Transfer time	Non-randomised cohort	Crude		–0.2	(0.29)	NS
		Adjusted	13.4%	–0.3	(0.28)	NS
	Randomised cohort	Crude		+1.4	(2.5)	NS
		Adjusted	39.8%	+2.6	(3.0)	NS
Ratio transfer/ on-scene	Non-randomised cohort	Crude		+0.3	(0.13)	0.02
		Adjusted	9.2%	+0.36	(0.13)	< 0.01
	Randomised cohort	Crude		+1.1	(0.47)	0.03
		Adjusted	29.0%	+1.2	(0.61)	0.07

[a] *Adjusted for ISS, head injury AIS, type and place of incident, age and ambulance service area*
[b] *NS = p > 0.1*

TABLE 18 *Time on scene by type of crew first attending*[a]

	Missing cases (n)	Non-randomised cases		Randomised cases[b]	
		Paramedic mean (SE)	Technician mean (SE)	Paramedic mean (SE)	Technician mean (SE)
On-scene time	52	15.1 (0.26)	13.8 (0.29)	12.2 (1.9)	10.1 (1.7)
Transfer time to hospital	67	9.8 (0.16)	9.6 (0.23)	11.3 (3.0)	9.2 (0.86)
Ratio scene/transfer	73	2.2 (0.07)	2.0 (0.08)	1.8 (0.47)	1.3 (0.29)

[a] *Excluding cases trapped, or first attended but transferred by different vehicles*
[b] *All randomised cases staying ≥ 1 night in hospital (n = 30) are included here*

TABLE 19 Effect of first attendance by paramedics on pre-hospital times

Time	Cases	Model	% variance explained by adjustment[a]	Estimated effect (min) Min (SE)	p-value[b]
On-scene time	Non-randomised cohort	Crude		+1.6 (0.44)	< 0.01
		Adjusted	10.3%	+1.9 (0.43)	< 0.01
	Randomised cohort	Crude		+2.1 (2.7)	NS
		Adjusted	24.1%	+3.4 (3.6)	NS
Transfer time	Non-randomised cohort	Crude		+0.1 (0.28)	NS
		Adjusted	13.4%	–0.2 (0.27)	NS
	Randomised cohort	Crude		+2.1 (0.13)	NS
		Adjusted	39.8%	+4.3 (2.9)	NS
Ratio transfer/ on-scene	Non-randomised cohort	Crude		+0.2 (0.13)	0.08
		Adjusted	9.2%	+0.3 (0.12)	< 0.01
	Randomised cohort	Crude		+0.48 (0.52)	NS
		Adjusted	29.0%	+0.41 (0.69)	NS

[a] Adjusted for ISS, head injury AIS, type and place of incident, age and ambulance service area
[b] NS = p > 0.1

Time spent on scene by paramedics

The time spent on scene by paramedics was longer than taken by technicians only for those patients in whom ALS interventions were carried out or attempted to be carried out. For untrapped patients who were attended by a paramedic crew but had no paramedic interventions (intubation, cannulation, intravenous fluids or drugs), the mean time on scene was 13.4 minutes compared to 13.5 minutes for EMT cases. In contrast, untrapped paramedic patients who had at least one intervention had a mean time on scene of 25.4 minutes (*Table 20*), a difference of 12.0 minutes compared with those who had no intervention. The differences between on-scene times for paramedic cases with and without interventions were similar in all three areas (12.9, 8.1, 9.3 minutes) and were similar for all types of incident (*Table 21*). The differences were not explained by a joint association between time on scene and both interventions and death on scene. Excluding cases dead on arrival at A&E, the difference in time on scene between intervention and non-intervention cases was still 12.1 minutes.

TABLE 20 Time spent on scene by paramedics

Intervention	Time (minutes) n[a]	Mean (SD)	95% CI for difference
Attempted cannulation			
Yes	234	25.5 (9.2)	10.7, 13.3
No	568	13.5 (7.2)	
Not known	541	12.4 (7.2)	
Intravenous fluids			
Yes	123	26.8 (9.4)	9.9, 13.3
No	678	15.2 (8.4)	
Not known	542	12.4 (7.2)	
Attempted intubation			
Yes	13	22.1 (8.2)	0.1, 10.3
No	786	16.9 (9.5)	
Not known	544	12.4 (7.2)	
Any paramedic intervention			
Yes	242	25.4 (9.2)	10.8, 13.2
No	560	13.4 (7.1)	
Not known	541	12.4 (7.2)	

[a] Excluding incidents where more than one ambulance arrived or the patient was recorded as trapped

Adjusting the observed 12-minute difference between incidents with and without ALS interventions for area, ISS, head AIS, type and place of incident and mechanism of injury produced no change. The adjusted difference was also 12.0 minutes (standard error 0.71).

Thus these data suggest that paramedic interventions are associated with an effective doubling of the on-scene time. This finding confirms exactly results reported from Nottinghamshire that for all patients, trauma and medical, on-scene times were 11.5 minutes for EMTs, 12 minutes for paramedics not intervening, and 23 minutes for paramedics intervening.[29]

There are two possible explanations of this association other than the interventions increasing the time spent on scene. Firstly, it could be an artefact caused by some incidents which will inevitably

TABLE 21 *Mean time on scene (minutes) by type of incident and type of crew*

Type of incident	Paramedic			Technician
	Interventions	No interventions	Not known interventions	
RTA	24.7	14.6	13.6	14.8
Falls	27.1	13.4	12.0	12.7
Fire	18.0	12.1	10.2	14.4
DSH	23.6	7.2	13.4	10.8
Assault	24.8	9.4	12.8	12.1
Other	25.0	12.6	11.5	15.6

TABLE 22 *Odds of admission to ICU/HDU in paramedic attended patients relative to EMT attended patients*

Comparison	Relative odds	95% CI
Patients ever attended by paramedics		
Unadjusted	1.19	0.77, 1.82
Casemix adjusted	1.08	0.64, 1.85
Patients first attended by paramedics		
Unadjusted	1.42	0.93, 2.17
Casemix adjusted	1.38	0.82, 2.33

TABLE 23 *Length of stay*

Comparison	Paramedics Length of stay (days)				EMTs Length of stay (days)				Unadjusted difference in mean		Adjusted[a] difference in mean *p*-value	
	n[b]	Median	Mean	SD	n[b]	Median	Mean	SD	Mean	SE	Mean	SE
Ever attended by	1340	8.0	15.2	24.2	572	8.0	15.0	28.0	+0.18	1.28	+0.40	1.21
First attended by	1248	8.0	15.3	24.8	664	8.0	14.9	26.5	+0.42	1.23	+0.75	1.17

[a] *Adjusted for ISS, age, head AIS, trapped, type of incident, and area using analysis of variance for log length of stay*
[b] *Cases with unknown length of stay, and all deaths have been excluded*

lead to long scene times not being recorded as trapped or difficult extrication, and of course in these circumstances paramedics will be more likely to be concerned to cannulate and infuse as necessary. This seems unlikely both because the increase in scene times was seen to be similar for all types of incident (*Table 21*) and because median times, which are not sensitive to the highest values, were also 12.6 minutes longer in the intervention group. The second possibility is that there is some characteristic of the patient or their injuries which leads both to long scene times and to the need for ALS interventions. However, this is clearly not overall injury severity, for which adjustment made no difference, nor is it the presence or severity of a head injury. It seems most likely, therefore, that it is the carrying out of the interventions which leads to longer scene times.

Admission to intensive care

Amongst 1994 patients who met the main study inclusion criteria, and who were alive on leaving the A&E department there were 117 admissions to intensive care or an HDA (5.9%). The differences in the observed proportions admitted to ICU/HDU between patients ever attended by paramedic crews and EMT crews (6.2 versus 5.2%) or first attended by paramedic crew and EMT crews (6.5 versus 4.7%) were similar to differences in mortality rates (see chapter 5).

However, unlike mortality differences these crude differences diminished after adjustment for casemix (*Table 22*), and there was no reliable statistical evidence of any differences between the groups in rates of admission to ICU.

Length of stay

Excluding patients who died, the median length of stay of all patients in the cohorts in the main study was 8 nights, and this was the same both for patients ever attended by paramedics, patients only attended by EMTs, patients first attended by paramedics, and patients first attended by EMTs (*Table 23*). There were small and statistically insignificant differences in the mean length of stay, and adjustment for age, injury severity, type of incident and area made no difference to this finding. This finding has been reported before.[30]

Chapter 5

Outcomes – mortality

Crude mortality rates

During the study, there was a total of 114 deaths within 6 months of the original incident, 86 in 1440 patients attended by paramedics (6.0%) and 28 in 605 patients attended by technicians (4.6%). These death rates were lower than had been anticipated amongst patients staying for more than 3 nights in hospital. In a study of 466 patients attended by paramedics in London, who met similar inclusion criteria, there were 77 deaths (16.5%).[31] The difference is largely due to a less seriously injured casemix in this study. For example, 80% of cases had ISS scores < 16, compared to 68% in the London study. The reasons why more patients with lower ISS scores were staying ≥ 3 nights in this study remain unclear. However, since all three ambulance service areas had similar ISS distributions (*Table 10*) and comparatively similar mortality rates (area 1 = 5.0%, area 2 = 3.4%, area 3 = 6.9%), the exception seems to be London.

Just over one-quarter of the deaths (30/114) were due to head injuries, slightly fewer (n = 35) than were due to causes possibly related to exsanguination (hypovolaemic shock, recurrent haemorrhage, multiple fractures, injuries to abdomen and/or thorax) (*Table 24*).

***TABLE 24** Primary cause of death*

Cause	n	%
Head injury (excluding neck)	30	26.5
Injuries to thorax/abdomen	15	13.3
Multiple fractures	13	11.5
Hypovolaemic shock/ recurrent haemorrhage	7	6.2
Other injuries (excluding burns)	8	7.1
Other trauma (including burns, drowning, etc.)	13	11.5
Other conditions secondary to trauma:		
Respiratory	17	15.0
Other	10	8.8
All known	113	100.0
Not known	1	
All	114	

***TABLE 25** Mortality by characteristics of incident*

Characteristic	Values	Mortality n	Mortality %	p-value[a]	Adjusted p-value[b]
Area	1	1112	5.0	0.09	0.01
	2	174	3.4		
	3	759	6.9		
Incident					
Type	RTA	648	9.7		
	Falls	1036	2.4	< 0.001	0.01
	Fire	40	17.5		
	DSH	25	24.0		
	Assault	144	5.6		
	Other	152	3.3		
Place	RTA	648	9.7		
	Other:				
	Home	696	5.2	< 0.001	0.43
	Street	178	3.9		
	Work	151	2.0		
	Other	237	1.3		
	Not known	117	0.9		
Trapped	Yes	47	23.4	< 0.001	–
	No	1998	5.2		
Time of day	Day (7–7)	1363	5.4	> 0.5	> 0.5
	Night	679	6.0		
	Not known	3	0.0		

[a] *Based on 2031 cases: excluding unknown crew status; cases randomised with length of stay < 3; and cases not known age (n = 14)*
[b] *Adjusted for ISS, head injury AIS, age, mechanism of injury and whether trapped or not*

Mortality was found to be related to most of the characteristics of the incident (*Table 25* and *Figures 5* and 6), and the patients and their injuries (*Table 26*), which were considered earlier in relation to processes. The exceptions were experience of crews (*Table 27*), mechanism of injury, time of day, and sex of patient. Although mechanism of injury (blunt or penetrating) was not related to overall mortality, there was a large difference between patients who were trapped and others. The strongest relationships were with measures of injury severity, of course. However, different types of incident were also found to have different mortality rates with particularly high rates in fires and DSH, and low rates in falls.

Two surprising relationships to mortality were with the total travel time to and from the scene

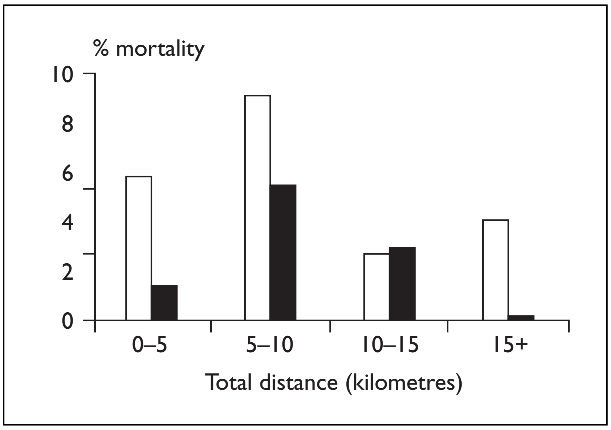

FIGURE 5 *Mortality by total distance and type of crew (□, paramedic; ■, EMT)*

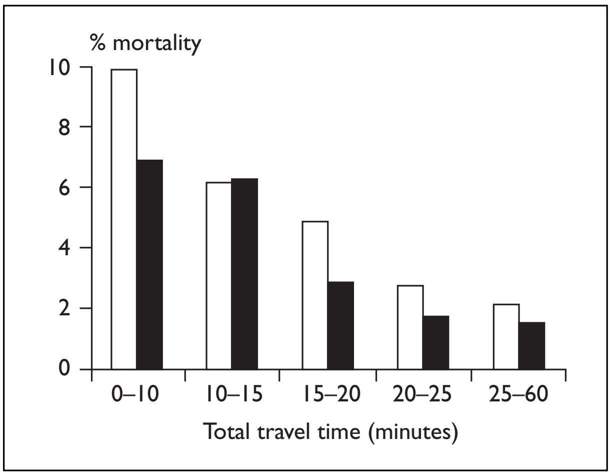

FIGURE 6 *Mortality by total travel time and type of crew (□, paramedic; ■, EMT)*

to hospital (*Figure 6*), and with areas (*Table 25*). A strong inverse relationship between time and mortality was observed. Cases which were < 10 minutes total travel time had an observed mortality of 9.0% compared with only 2.0% for incidents with > 25 minutes travel time. Differences between areas were smaller but weakly significant ($\chi_2^2 = 4.7$, $p = 0.09$) with observed mortality rates of between 6.9 and 3.4%, and these differences were not explained by differences in total travel times. However, in area 2 (mortality 3.4%) doctors were frequently called to the scene and any deaths in these cases were excluded from the study. In areas 1 and 3 where doctors were very rarely called out there was no significant difference in mortality (area 1 = 5.0%; area 2 = 6.9%; $\chi^2_1 = 2.7$, $p = 0.10$).

Adjusted mortality

After adjusting mortality for injury severity (ISS and head AIS), age of patient, mechanism of

TABLE 26 *Mortality by characteristics of patients and their injuries*

Characteristic	Values	Mortality n	Mortality %	*p*-value	Adjusted *p*-value[a]
Patients					
Age	0–14	267	3.4		
	15–34	535	5.8		
	35–54	423	4.0	0.005	–
	55–74	433	4.4		
	75+	373	9.7		
	Not known	14	14.3		
Injuries					
Sex	Male	1161	6.2	0.14	> 0.5
	Female	884	4.8		
ISS	0–8	1067	1.3		
	9–15	760	1.3		
	16–24	98	11.2	< 0.001	–
	25–40	93	58.1		
	41–75	27	92.6		
Head AIS	None	1522	2.6		
	1	144	5.6		
	2	188	0.0	< 0.001	–
	3	94	16.0		
	4	45	37.8		
	5	52	54.8		
On-scene T-RTS	0	16	100.0		
	1–11	59	15.3	< 0.001	< 0.001
	12	443	1.8		
	Missing	1527	5.3		
Injury mechanism	Blunt	1947	5.6	> 0.5	–
	Penetrating	98	5.1		

[a] *Adjusted for ISS, head injury AIS, age, mechanism of injury, and whether trapped or not*

injury, and whether trapped or not, some of the observed associations disappeared (*Tables 25–27*), but associations with the type of injury remained, as did a weak association with total travel time.

However, when the type of incident was added into the model, the association of mortality with total travel time reduced still further and was no longer statistically significant at a conventional level ($\chi^2_1 = 3.4$, $p = 0.07$). It thus seems that the strong inverse relationship between mortality and travel time was largely the result of differences in casemix.

Differences between crews

Explanatory analysis

The observed death rate amongst patients ever attended by paramedics was 6.0% compared with

TABLE 27 *Mortality by characteristics of most experienced ambulance crew attending the scene*

Characteristic	Values	Mortality n	Mortality %	p-value	Adjusted p-value[a]
Experience					
ALS service	None (technician case):	605	4.6		
	< 3 years	692	6.5	> 0.5	0.15
	≥ 3 years	580	6.4		
	Not known	168	2.4		
BLS service	< 10 years	715	5.7	> 0.5	> 0.5
	≥ 10 years	1194	5.9		
	Not known	136	1.5		
Training	ALS – Paramedic	1440	6.0	0.18	0.12
	BLS – Technician	605	4.6		

[a] Adjusted for ISS, head injury AIS, age, mechanism of injury, and whether trapped or not

TABLE 28 *Effect of different casemix adjustment models on the estimated odds of death when attended by paramedics at any time*

Adjusted for	Estimated odds ratio (OR)	95% CI
Unadjusted	1.34	0.86, 2.11
ISS	1.54	0.83, 2.87
+ age	1.70	0.89, 3.24
+ mechanism	1.70	0.86, 3.25
+ trapped	1.58	0.83, 3.02
+ head injury AIS	1.63	0.84, 3.17
+ type of incident	1.74	0.89, 3.41
+ area	1.86	0.93, 3.72

4.6% for patients only attended by technicians. The similarity in the types of patients and incidents attended shown earlier, means that even after adjusting for injury severity (ISS and head AIS), injury mechanism (blunt or penetrating), age of patients, and circumstances (type of incident, and whether trapped or not) the difference between crew types remained. Indeed, the adjusted odds of dying when attended by a paramedic relative to a technician, though still not statistically significant, increased (adjusted odds ratio = 1.74, 95% CI = 0.89, 3.41).

These odds translate into an increase in the mortality rate from 4.6% with technician attended patients needing ≥ 3 days stay to 7.7% with paramedic attended patients.

The reliability of this estimate has been examined by estimating the odds ratio after adjusting for casemix using several different models (*Table 28*). In all cases the casemix adjusted estimates were larger than the crude (unadjusted) estimate and were of a similar size to one another indicating an increased odds ratio of about 1.5–1.75. However, these estimates were not statistically significant, and if in fact there was no effect from paramedic care there was about a 10% chance of getting these sorts of estimated differences simply as a chance effect.

It was also examined whether the estimated difference between crew types was the same in the ambulance service areas studied. In area 2, where there was only two deaths in 23 technician cases, there was too little information to make a reliable estimate and only areas 1 and 3 were compared.

The crude mortality in paramedics and technician cases in areas 1 and 3 showed opposite effects. In area 1, the crude relative risk of death in paramedic attended cases compared with technician attended patients was 3.1, but in area 3, it was 0.78. However, this difference was explained by a difference between areas in the mix of cases attended by paramedics and technicians, indicating that there may have been some targeting of paramedics to particular incidents. Consequently the expected relative risks were also different (1.6 versus 0.67). Thus after taking the casemix into account there was no evidence of any difference between the areas in the excess of deaths in patients attended by paramedics ($\chi^2_1 = 2.2$, $p = 0.13$).

There is some weak evidence, then, that patients attended by paramedics who stay in hospital for ≥ 3 days have a higher mortality rate than those attended by technicians. This observation is not explained by differences in casemix. Indeed, adjusting for small differences between the cohorts in known or discovered prognostic factors increased the estimated effect. However, it could be a chance finding.

If it is an artificial effect, then we are confident that it is not caused by differences in casemix, but must be caused by differences in the way data are recorded or collected. We have deliberately avoided adjusting the estimates using information such as the T-RTS which may be recorded differentially by paramedics and technicians. Using hospital or coroners' information on age and anatomical injury severity to adjust the mortality rates slightly increases the evidence of an excess of paramedic deaths. We have also adjusted for the information known to the control room at the time of dispatch.

But including type of incident or remoteness, for example, again leaves the estimates unaffected. A second possibility is that the data generation or collection methods have resulted in us finding more deaths in the paramedic attended cases. In incidents attended by technicians which are assessed by the technicians on arrival at the scene as being critical, it would be possible, for example, that they then call in doctors (which results in the case being excluded) or paramedics (which results in it being classified as a paramedic case).

Pragmatic analysis

The possibility that some deaths attended by technicians are being re-categorised as paramedic deaths because paramedic crews are requested as back-up can be examined by comparing mortality by type of crew first attending the scene. The evidence is quite clear that this is not an explanation of the observed excess of paramedic deaths.

Classified in this way, there were 84 deaths in 1346 deaths first attended by paramedics (6.2%), and 30 deaths in 699 patients first attended by technicians (4.3%). This is an observed relative risk of 1.45 associated with first attendance by paramedics ($\chi^2_1 = 3.8$, $p = 0.05$), compared with 1.29 for patients ever attended by paramedic crews.

When the observed risk was adjusted for casemix, in all models there was a weakly significant excess risk in patients attended by paramedics (*Table 29*). In the full model, the estimated odds ratio was 2.02, corresponding to an increase in the risk of death from 4.5% with first attendance by EMT to 8.7% (95% CI: 4.7%, 15.5%) with first attendance by paramedic.

With cases classified by type of crew first attending, after adjustment for casemix there was a difference between areas 1 and 3 ($\chi^2_1 = 4.0$, $p = 0.05$), with a highly significant increased risk for paramedics in area 1 (relative risk = 2.17), but only a small excess risk in area 3 (relative risk = 1.13) (*Table 30*).

In area 1, 40% of the records had a T-RTS recorded on scene, and in this area the estimated risk associated with first attendance by paramedics changed from 2.17 to 1.80 when the casemix adjustment included the T-RTS.

Time of death

A third possibility for the excess deaths in paramedic attended patients is that paramedics were attempting to resuscitate patients who would otherwise have been excluded as dead on arrival of the ambulance at the scene if attended by a technician. Again, this seems unlikely to be the case because technicians are more likely than paramedics to simply 'load' such patients into the ambulances and 'go' to the nearest A&E department. This would automatically have qualified them for inclusion in the study – even if they were in fact dead before the ambulance arrived. Furthermore, if more attempted resuscitation by paramedics was the explanation for the excess deaths then we would expect to see the excess risk of death only for deaths before arrival at A&E. However, the unadjusted (crude) relative risk of dying before arrival at A&E, in A&E, or after admission, when first attended by paramedics compared with technicians was to all intents and purposes constant (1.45, 1.56, 1.42) (*Table 31*). There is, therefore, no evidence that this could explain the excess paramedic mortality we have found.

A related possibility is that the exclusion of cases attended by a doctor at the scene has disproportionately (selectively) excluded patients attended by technician crews who died. This seems to be unlikely because it is just those incidents to which doctors might be called which may be targeted to paramedics. Indeed it seems more likely that there is a disproportionate exclusion of critical incidents from the paramedic group rather than from the technician group for this reason. Furthermore there is no BASICS scheme in either area 1 or area

TABLE 29 *Effect of different casemix adjustment models on the estimated odds of death when paramedics were first on scene*

Adjusted for	Estimated OR	95% CI
Unadjusted	1.52	0.99, 2.33
ISS	1.86	1.03, 3.35
+ age	2.05	1.10, 3.85
+ mechanism	2.05	1.09, 3.88
+ trapped	1.91	1.03, 3.54
+ head injury AIS	1.94	1.03, 3.63
+ type of incident	1.97	1.04, 3.74
+ area	2.02	1.05, 3.89

TABLE 30 *Ratio of observed to expected deaths by area and type of crew first attending*

	Standardised mortality ratio	
	Area 1	Area 2
Crew first attending		
Paramedics	1.02	1.29
Technicians	0.47	1.14
Casemix adjusted relative risk (RR) with paramedics	2.17	1.13

TABLE 31 *Mortality rates by time of death and type of crew first attending*

Time of death	Paramedic (%)	EMT (%)	RR
Before arrival at A&E	14/1346 (1.0)	5/699 (0.7)	1.45
Before hospital admission	24/1332 (1.8)	8/694 (1.2)	1.56
After admission	46/1308 (3.5)	17/686 (2.5)	1.42

3, and doctors were rarely called out. In these areas when hospital flying squads were called out, it was typically to RTAs involving entrapment. However, for untrapped patients in areas 1 and 3, in whom there is little or no possibility of bias by exclusion of doctor attended cases, the crude relative risk of death in patients first attended by paramedics rather than EMTs was 1.42.

Time spent on scene

Paramedics spend on average 2 minutes longer on scene than EMTs (chapter 4). The question arises as to whether it is this extra time on scene, which translates into a delay to definitive care, which is the cause of the higher mortality in the paramedic cohort.

There was a strong and significant positive association between time on scene and mortality even after adjusting for injury severity and other factors (odds of death increased by +4% for each extra minute on scene), and this explained a small proportion of the increased odds of death with paramedics. Adjusting the odds of death associated with first attendance on scene by paramedics for time on scene reduced the casemix adjusted odds ratio from 2.02 (see *Table 28*) to 1.83 (95% CI: 0.89, 2.19).

Sub-groups

In order to begin to investigate why there may be an increased mortality in the paramedic groups, it would be helpful to pin down the sub-groups in which the relative risk is raised and those in which it is not.

However, although widely practised, this cannot usefully be done in terms of the processes of care. We cannot determine, for example, whether there was higher mortality in those cannulated than in others, because this and other such processes of care are responses to likely outcomes as well as contributors to those outcomes. Paramedics cannulate and infuse patients because they perceive them to be at risk of death. No amount of risk factor adjustment can be relied upon to deal with the potential selection biases. For example, the unadjusted odds ratio of death in the paramedic group receiving any intervention compared to the group receiving no intervention was 4.41, and after adjustment for ISS, head AIS, mechanism, whether trapped, and type of incident the estimated odds were still 2.42 (95% CI: 1.19, 5.01). However, nothing can be concluded from this because of the selection effects. These results mirror those reported recently by Sampalis,[32] who used this approach to show, apparently, that pre-hospital fluid infusion more than doubled the risk of death. However, his results are uninterpretable.

On the other hand, objective characteristics such as the type of incident, the presence of head injuries and the age of the patient are not subject to selection effects and sub-group comparisons can usefully be made in these cases. It will be seen that the excess risk occurs in most types of incident and in patients of all ages (*Table 32*). However, it appears to be exclusive to patients with non-major injuries which are not to the head. Patients with major injuries (ISS > 15) or with head injuries have the same risk of dying whether attended by paramedics or technicians. But patients with ISS scores < 15 not involving any head injury have about twice the risk of death when attended by paramedics as they do when attended by technicians.

TABLE 32 *Death rates by characteristics of incidents, patients, and their injuries and type of crew first attending*

Characteristic	Value	Paramedics	Technicians	Relative risk
ISS	< 15	20/1194	4/633	2.65
	> 15	64/152	26/66	1.07
Head injury AIS	None	32/1001	8/521	2.08
	1, 2	5/213	3/119	0.93
	3+	47/132	19/59	1.11
Type of incident	RTA	46/437	17/211	1.31
	Falls	18/669	7/367	1.41
	Fire	3/24	4/16	0.50
	DSH	6/16	0/9	–
	Assault	7/100	1/44	3.08
	Other	4/100	1/52	2.08
Age	0–54	42/823	15/402	1.37
	55–74	13/272	6/161	1.28
	75+	28/242	8/131	1.89

Examining the causes of death, it seems that the excess risk is confined to those patients with injuries in which blood loss may have been an important problem. Deaths resulting from exsanguination (hypovolaemic shock/recurrent haemorrhage), or other causes which may have resulted in exsanguination (multiple fractures; injuries to thorax and abdomen) were much more common in paramedic attended patients (n = 30/1440) than in technician attended patients (n = 5/605) (*Table 33*). The estimated (crude) relative risk of death from these causes in all patients attended by paramedics compared to technicians was 2.52 (95% CI: 0.98, 6.61), whilst death rates from other causes were nearly identical (relative risk for other causes 1.02; 95% CI: 0.62, 1.68).

To explore this further, the patients without a head injury were subdivided according to whether or not they had 'bleeding injuries'. These were defined as penetrating injuries, or injuries to abdomen or thorax, or major (AIS 3+) or multiple (2 or more AIS 2) limb fractures. The extraordinary result is that for non-bleeding injuries the risks of death when attended by paramedics or technicians were similar in all groups, whilst for bleeding injuries there were 18 deaths in 604 patients first attended by paramedics, and only two in 304 patients first attended by technician (relative risk = 4.60, 95% CI: 1.07, 20.0) (*Table 34*). This difference could not reasonably be expected to have occurred by chance ($p < 0.02$ permutation test).

Furthermore, both the deaths in the technician group actually occurred in patients who were subsequently attended by paramedics. Thus explanatory analysis by type of crew ever attending yields risks of 20/649 in paramedic patients and 0/264 in technician patients. The relative risk is not computationally well-defined, but 'Bayesian' estimates of the risks are (20 + 1)/(649 + 2) and (0 + 1)/(264 + 2), and one estimate of the relative risk is therefore 8.58.

TABLE 33 *Primary cause of death by type of crew ever attending*

Cause	Paramedics (n = 1440)	Technicians (n = 605)	RR
Head injury (excluding neck)	20	10	0.85
Injuries to thorax/abdomen	12	3	1.68
Multiple fractures	12	1	5.04
Hypovolaemic shock/ recurrent haemorrhage	6	1	2.52
Other injuries (excluding burns)	6	2	1.26
Other trauma (including burns, drowning, etc.)	9	4	0.95
Other conditions secondary to trauma:			
Respiratory	15	6	1.05
Other	5	1	2.10
All known	85	28	
Not known	1	0	
All	86	28	1.29

TABLE 34 *Death rates by type of injuries and type of crew ever attending*

Type of injuries	Paramedics	Technicians	RR	95% CI
Head injury:				
AIS 3+	47/132	19/59	1.11	0.58, 2.14
AIS 1, 2	5/213	3/119	0.93	0.22, 3.96
No head injury:				
Bleeding injuries[a]	18/604	2/309[b]	4.60	1.07, 20.0
Other injuries	14/397	6/212	1.25	0.47, 3.30

[a] *Bleeding injuries are penetrating injuries, or injuries to thorax or abdomen, or major (AIS 3+) or multiple (two or more AIS 2) limb fractures*

[b] *Both the deaths in the first attender EMT group were later attended by paramedics*

Chapter 6
Morbidity

Introduction

Patients identified during 6 months of prospective data collection who were over 16 and whose GPs agreed, were sent a 6-month follow-up questionnaire asking about their health and use of health services. A total of 273 questionnaires were sent out to patients first attended on-scene by paramedics who met the main study inclusion criteria, of which 177 (65%) were returned in a usable form, and 139 were sent to patients first attended by EMTs of which 100 (72%) were usable returns. As well as asking about use of health services the questionnaire asked about restrictions on work and usual activities and general health perceptions using the SF-36.

Restrictions on usual activities

Almost all respondents who answered the question reported some days of restriction on their work or usual activities (217/228). The median duration of restriction reported was 115 days, and 14% of respondents reported still being restricted at 6 months (12% for patients attended by paramedics and 19% for EMTs). The patients attended by paramedics also reported, on average, 19 fewer days of restricted activity (*Table 35*). After adjusting for casemix (ISS, head AIS, age, trapped, type of incidents, mechanism and area) this difference was estimated to be 14 days but was still marginally significant ($F_{1,207} = 4.2$, $p = 0.04$).

TABLE 35 *Differences in mean days off usual activities for patients attended by paramedics or EMTs*

	Unadjusted difference[a]	**Adjusted difference[b]**	***p*-value**
	Mean (SE)	**Mean (SE)**	
Attended scene	19.4 (9.3)	14.4 (9.5)	0.04
First on-scene	17.7 (8.9)	9.1 (9.2)	> 0.1

[a] *Mean days off for technician patients minus mean for paramedic patients*
[b] *Adjusted for: area, ISS, head injury AIS, mechanism of injury, type of incident, trapped, age and sex*

Analysed by first attender on scene the differences were smaller and not significant after casemix adjustment ($F_{1,207} = 2.3$, $p > 0.1$).

General health perceptions

For all eight dimensions of the SF-36 except general health perceptions, and for the extended physical functioning dimension, mean scores on the SF-36 were better (larger) for patients ever attended by paramedics (*Figure 7*). The differences for physical functioning (6.7), social functioning (9.2), and for physical and emotional effects on role (9.4 and 11.2) would conventionally be considered to be clinically significant. After adjustment for casemix the differences were larger and were marginally significant ($p < 0.1$) for these four dimensions (*Table 36*).

When comparisons were made between patients first attended by paramedics and those first attended by EMTs the differences between dimensions were found to be greater still (*Figure 8*). Again, adjustment usually increased the differences and the difference in energy and vitality also became marginally significant (*Table 37*).

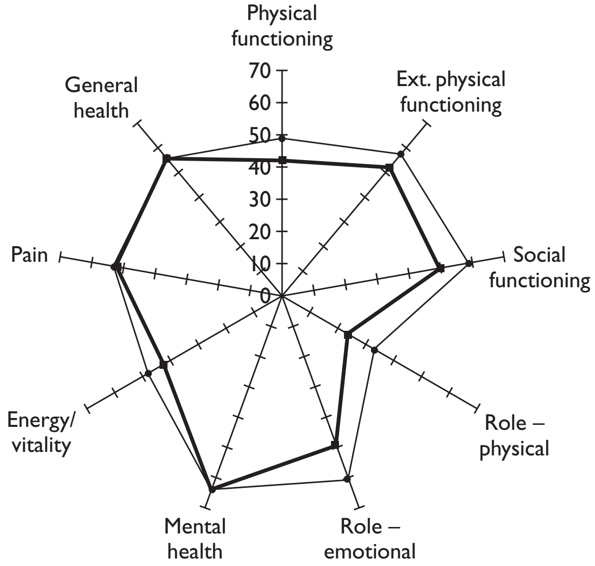

FIGURE 7 *Mean SF-36 scores by type of crew ever attending (–●–, paramedic; –■–, EMT)*

TABLE 36 Differences between mean SF-36 scores for patients attended by paramedics or EMTs

Dimension	Unadjusted difference[a] Mean (SE)	Adjusted difference[b] Mean (SE)	p-value[c]
Physical functioning	6.7 (4.2)	6.8 (4.1)	0.09
Extended physical functioning	5.5 (4.0)	6.5 (4.0)	0.08
Social functioning	9.2 (4.4)	10.5 (4.7)	0.02
Role physical	9.4 (5.7)	13.4 (6.2)	0.03
Role emotional	11.2 (6.4)	12.8 (7.0)	0.06
Mental Health Index	0.4 (3.1)	1.2 (3.4)	0.70
Energy/vitality	5.5 (3.2)	5.4 (3.4)	0.10
Pain	0.8 (3.6)	0.1 (3.9)	0.97
General health perceptions	0.1 (3.5)	2.5 (3.6)	0.46

[a] Mean score for patients attended by paramedics – mean score for patients attended by EMTs
[b] Adjusted for: area, ISS, head injury AIS, mechanism of injury, type of incident, trapped, age and sex
[c] Permutation p-value for difference in means

TABLE 37 Differences between mean SF-36 scores for patients first attended on-scene by paramedics or EMTs

Dimension	Unadjusted difference[a] Mean (SE)	Adjusted difference[b] Mean (SE)	p-value[c]
Physical functioning	8.0 (4.0)	9.1 (4.1)	0.02
Extended physical functioning	7.1 (3.9)	8.7 (3.9)	0.01
Social functioning	10.7 (4.3)	13.5 (4.6)	0.005
Role physical	9.5 (5.5)	13.6 (6.2)	0.03
Role emotional	14.4 (6.1)	17.2 (6.8)	0.01
Mental Health Index	2.8 (3.0)	3.8 (3.3)	0.20
Energy/vitality	6.3 (3.1)	6.4 (3.4)	0.04
Pain	2.6 (3.5)	2.4 (3.9)	0.55
General health perceptions	0.4 (3.4)	3.4 (3.6)	0.30

[a] Mean score for patients attended by paramedics – mean score for patients attended by EMTs
[b] Adjusted for: area, ISS, head injury AIS, mechanism of injury, type of incident, trapped, age and sex
[c] Permutation p-value for difference in means

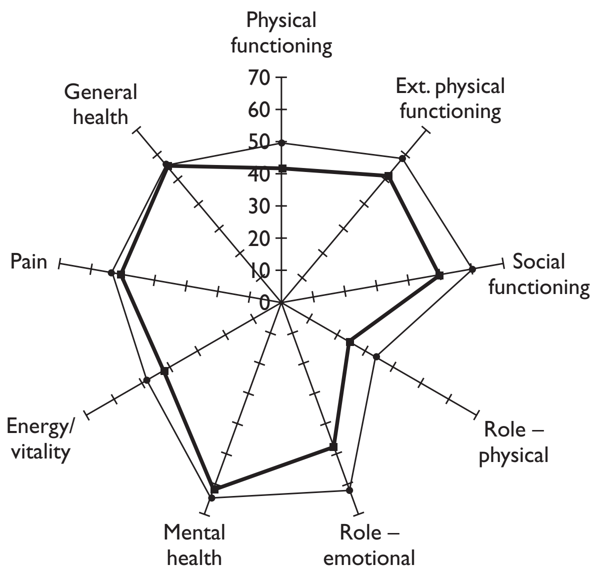

FIGURE 8 *Mean SF-36 scores by type of crew first attending (–●–, paramedic; –■–, EMT)*

The benefit from attendance by paramedics was similar in survivors with different types of injuries (*Table 38* and *Figure 9*).

Discussion

These data suggest that there may be better residual health in patients to whom paramedics were dispatched than to patients to whom EMTs were dispatched. The results are difficult to interpret both because of the lack of a simple pattern (e.g. social functioning, and emotional roles appeared to be substantially affected but Mental Health Index scores were not), and because of the response rate (67%). Some doubts might also arise because if there is a greater mortality in one group than another then better health might be expected amongst survivors in the group with the higher mortality. However, this is probably not a concern here because there were few deaths in both groups, and also because even if a few lower scores are 'trimmed' from the EMT group (as if they had in fact died) the scores still remain better in the paramedic group.

TABLE 38 *Differences between mean SF-36 dimension scores for patients attended by paramedics and EMTs by type of injuries*

Dimension	Difference in mean (SE) scores		
	Head injury	No head injury	
		Bleeding[a] injuries	Other injuries
Physical functioning	8.1 (9.8)	6.7 (5.8)	8.8 (8.0)
Extended physical functioning	4.5 (9.5)	5.9 (5.4)	11.9 (8.4)
Social functioning	7.0 (10.5)	10.9 (6.1)	7.1 (8.7)
Role – physical	3.0 (13.5)	1.8 (7.8)	30.0 (11.3)
Role – emotional	5.0 (15.3)	10.4 (8.8)	16.3 (12.2)
Mental Health Index	–2.9 (7.3)	–3.9 (4.2)	11.0 (6.2)
Energy/vitality	6.2 (7.6)	5.0 (4.4)	3.0 (6.5)
Pain	9.9 (8.5)	–4.8 (4.9)	5.6 (7.0)
General health perceptions	0.2 (8.1)	–0.3 (4.8)	0.1 (7.1)

[a] Bleeding injuries are penetrating injuries, or injuries to thorax or abdomen, or major (AIS 3+) or multiple (two or more AIS 2) limb fractures

If the mortality rate in the group first attended by paramedic (6.2%) had applied to the group first attended by EMT (4.3%) then a further 10 deaths would have been expected in the latter group. Since only one in nine of the first attender EMT group were both sent follow-up questionnaires in the prospective phase of the study and replied with SF-36 scores (n = 87), it follows that only one or two respondents might have died if the paramedic mortality rate had prevailed. Trimming the two worst scores from the EMT group makes no difference to the comparisons.

A second possible explanation for the difference in mortality and morbidity effects is that paramedic interventions and management represent a high risk strategy which 'kill or cure'. When successful they achieve earlier stabilisation and aid better recovery but because of the extra time taken and consequent delays, or the inappropriate use of skills, they can lead to deaths which can sometimes be avoided by the scoop-and-run approach adopted by EMTs.

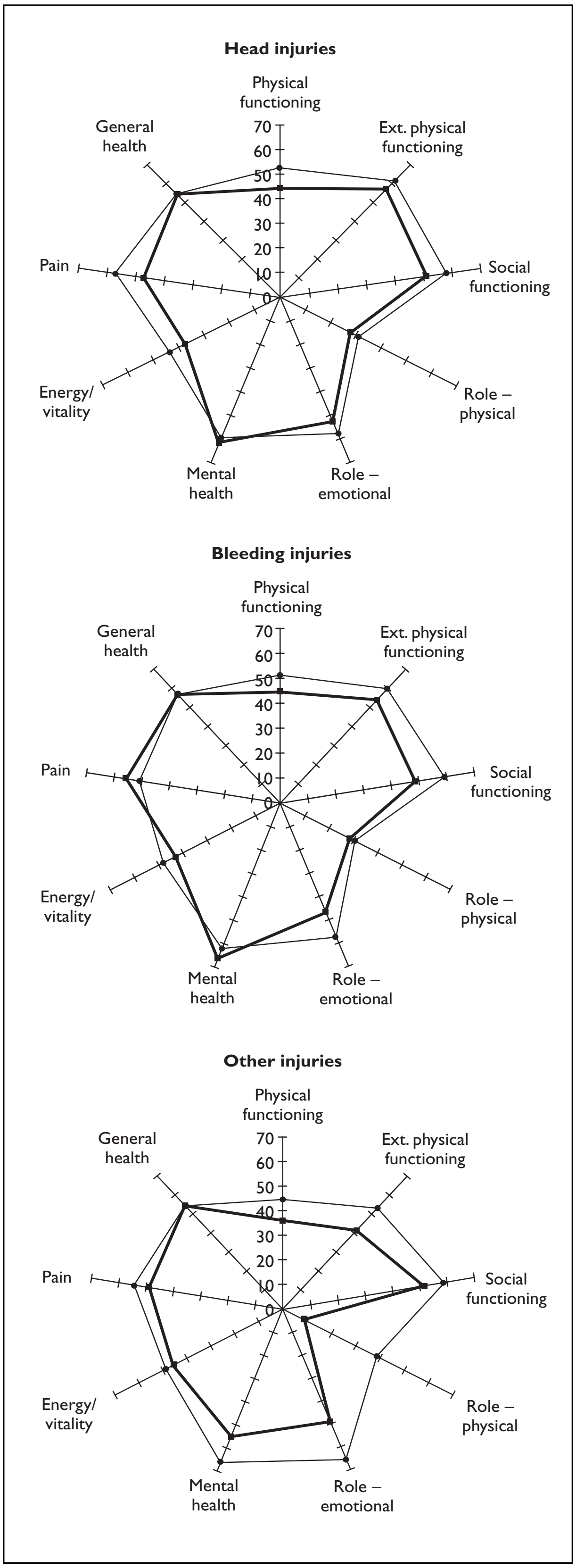

FIGURE 9 *Mean SF-36 dimension scores by type of injuries and type of crew attending (–●–, paramedic; –■–, EMT)*

Chapter 7
Avoidable deaths

Introduction

There is little published work on the extent of avoidable death from trauma in the pre-hospital phase of care. An assessment in Staffordshire over a 5-year period based on a probability of survival greater than 50%, which was estimated from Bull's probits,[34] allowing for ISS and age, reported a 39% rate of potentially preventable death in those who died from injury before they reached hospital.[35] However, in many of these cases there was a considerable delay before emergency services were alerted and there was no record of what proportion may have been dead before the ambulance arrived. The authors concluded that in the majority of their cases bystander intervention rather than ambulance service response, could have made a critical difference.

Another study, from Greece,[36] which also included deaths at the scene, and again used Bull's probits, found a rate of potentially preventable death of 29%. In this study the cases were also assessed by a clinician, and he concluded that 48% of these same deaths were potentially preventable. In contrast, in a study in England when an expert panel estimated the proportion of pre-hospital trauma deaths that may have been preventable, it was concluded that only 2% of those who were dead at the scene and 5% of those dead on arrival at hospital were potential survivors.[37]

In a fourth study, from Australia,[38] in which RTS were available, TRISS analysis was used to assess the 50% probability of survival. In this case, even though deaths at the scene were also included, the rate of potentially preventable death (defined as having a predicted probability of survival greater than a half) was found to be only 8%. This low rate probably reflects the recategorisation of deaths at scene with a fairly low ISS score but poor or no vital signs (i.e. low RTS score), into the probably not survivable category.

Furthermore, in studies which did not include deaths at scene, but concentrated on deaths on arrival at A&E or within 6 hours of admission to A&E,[39,40] the rate of potentially preventable death found was 14 and 11%, respectively.

This study has set out to clarify the debate and to assess the role of ALS in preventing trauma deaths. It has concentrated on deaths occurring up to 72 hours from admission to A&E, using a panel of experts to judge the probability of survival and the potential that death may have been prevented with optimal pre-hospital care.

Aims of the study

1. To determine what proportion of all deaths at the scene of the incident, deaths before admission to hospital and deaths within three days of admission from traumatic injury are preventable, with optimal pre-hospital care delivered by ambulance services.
2. To compare the proportion of preventable trauma deaths for paramedic attended incidents and technician only attended incidents.
3. To identify the main factors in pre-hospital care which may have contributed to these potentially avoidable deaths.

In order to examine the contribution of paramedics in preventing trauma deaths, patients whose death had occurred some time before the ambulance service arrived on scene or who had suffered injuries which inevitably would lead to death were excluded from the comparisons (study 1). However, in order to determine what proportion of all trauma deaths are preventable by optimal pre-hospital care, a consecutive series of 100 deaths, without any exclusions, were assessed to determine whether any of the deaths were, in fact, preventable (study 2).

Methods

Overview

The pre-hospital ambulance service care of samples of patients who died from accidental injury within 3 days of their accident, in the main two ambulance service areas, one of which is predominantly metropolitan and the other mixed urban and rural, has been examined in order to ascertain what proportion of these deaths might have been avoided. This proportion has been compared in paramedic attended and technician attended cases, and the number of these deaths that occurred before the ambulance services arrived, the extent of bystander intervention, and the contributory causes of death, have been described.

Avoidable death was assessed using the method developed in earlier work on avoidable hospital trauma deaths whereby an expert panel are asked to scrutinise case histories and judge whether the deaths were in any way avoidable and what factors may have prevented death.[25]

Sample frame

The sample frame for the deaths studied was taken from the cases who died or had an inquest during a 1-year period in the registers of all the coroners covering the two ambulance service areas. For one of the coroner's districts this 1-year period was from 1 September 1994 to 31 August 1995. For all other districts, the 1-year period ran from 1 January 1995 to 31 December 1995. Information on age, sex, mechanism of injury, cause of death and place of death was taken from the register.

The sample frame comprised all deaths from accidental injury including hangings, drownings, asphyxiations and hypothermia but excluding carbon monoxide and other poisonings (acute/ chronic alcohol poisoning, drug overdoses, etc.) and fracture of the neck of femur in patients over 65 years. Inquest deaths where the cause of death was unascertained, deaths from industrial disease, or from medical or surgical complications following treatment for non-trauma were all excluded, as were those with a verdict of natural causes. All incidents occurring out of the areas covered by the two ambulance services and those cases found to have been taken directly to a mortuary or not carried by these ambulance services, were also excluded.

All remaining deaths comprised the total sample frame, and the coroners' records were investigated further.

Inclusion criteria study I

In order to compare avoidable death rates in patients attended by paramedics and technicians, cases in which there was presumptive evidence that death was unavoidable by any action of the ambulance services were excluded. The exclusions were:

1. Deaths that had occurred at some time previous to discovery identified from the coroners' records by the statement 'Found Dead' on the inquest form.

2. Deaths that had occurred shortly before discovery, and were certified at the scene by a doctor, or where paramedics had pronounced life extinct followed by certification by a doctor at the scene or hospital mortuary. These cases were identified from the Sudden Death Form in the coroners' records where date, time and place of certification of death is reported. Only one of the ambulance service areas allowed their paramedics to pronounce life extinct and only in exceptional circumstances meeting these criteria:
   - The patient must be adult, i.e. over 16 years old.
   - The patient must have been in a collapsed condition, with no signs of life for at least 10 minutes and with no intervening bystander CPR.
   - The patient must have no palpable pulses, carotid or femoral.
   - There must be no signs of spontaneous respiration.
   - The patient's pupils must be fixed and dilated.
   - Asystole must be seen and recorded on the defibrillator.

3. Cases where the pathologist clearly stated that the injuries were such that death was inevitable, also identified from the post-mortem report.

4. Deaths that occurred more than 3 days after the incident were identified from the coroner's record and were also excluded from the panel sample frame because any errors in pre-hospital care were judged less likely to account for the deaths.

This left two groups of deaths: those that died shortly after the incident and before reaching hospital who were dead on arrival at A&E; and those who survived for up to 3 days in hospital. In all these cases, the injuries sustained were identified from the post-mortem reports and coded according to the AIS system[18] and an ISS[19] derived. Injuries which have an ISS score of 75 are usually unsurvivable (e.g. decapitation, avulsion of the heart, laceration of brain stem, etc.), and so

5. Cases identified with ISS = 75 were also excluded from analysis by the panel.

All the remaining cases formed the sample frame for consideration by the expert panel. The cases presented to the panel were randomly sampled from this frame on the basis of crew type and ISS score. Since there were, at the time of the study, far fewer technician-only attended incidents than paramedic-attended incidents, all the technician cases had case histories prepared for the panel to scrutinise, regardless of ISS score. The paramedic attended cases were grouped by ISS score. All those with scoreable injuries and an ISS score < 26 had case histories prepared together with a 1 in 3 sample (area 1) and a 1 in 2 sample (area 3) of those with an ISS score between 26 and 74. Cases such as hangings, drownings, and asphyxiations where ISS was not applicable were sampled 1 in 3. From this sampling procedure 179 cases, matching the inclusion criteria described, were presented to the panel.

Inclusion criteria study 2

Finally, 50 consecutive cases, where death had occurred within 3 days of the incident, were taken from sample frames compiled from one coroners register in each of the two ambulance service areas. Case histories for all these deaths were also prepared for scrutiny by the panel regardless of when or how the patient had died. This was done in order to present to the panel a selection of all trauma deaths in order to estimate the proportion of all trauma deaths which could be avoided by the actions of ambulance services, and in order to investigate whether the cases, excluded as unsurvivable in study 1 for the reasons above, were corroborated as such by the expert panel themselves. Of these 100 cases, 35 had already been included as part of the sample in study 1 and 65 extra cases were therefore assessed by the panel.

Data recorded

Case histories consisted of a summary of events from incident to death (gleaned from a combination of coroners' record, ambulance service PRF and the A&E department records); all injuries were documented and given an AIS code and overall ISS score; cause of death; ambulance response times and whether the type of crew attending was paramedic or technician only; physiological state pre- and post-hospital; all known interventions by the ambulance service pre-hospital and in the A&E department; and age and sex of patient.

Whilst preparing case histories for the panel other incidental information was collected, i.e. the mechanism of injury, whether blunt or penetrating; whether alcohol was a contributory factor; whether there had been any bystander intervention and if so what; and contributory causes to death such as airways obstruction, neurological damage, exsanguination, or multiple injuries.

The expert panel

Avoidable death was assessed by a panel of four experts comprised of Dr C Carney, Medical Director of Staffordshire Ambulance Service (now Chief Executive Bedfordshire and Hertfordshire Ambulance Service); Dr T Clarke, Consultant Anaesthetist; Dr M Cooke, Consultant/Senior Lecturer in A&E; and Mr H Sherriff, Consultant in A&E; all were chosen for their interest and knowledge of pre-hospital trauma care, and three are operational doctors in BASICS. All the panellists were drawn from regions unconnected to the study. All cases were reviewed by each expert independently. Death was classified as potentially avoidable when at least three out of four assessors agreed. Equivocal cases were assessed at periodic meetings attended by all reviewers and an independent chairman (JN).

In addition, Mr Tom Judge, visiting Atlantic Fellow in Public Policy and former board chair of the State of Maine Emergency Medical Services Regulatory Authority, acted as an observer and commentator on the factors discussed as contributors in the cases identified as avoidable.

The assessment process

In order to blind the assessors to the origin of each case no information about the year, type of crew attending, hospital, or region was provided.

The definition of avoidable death used was:

> One in which the cause of death could have been prevented and the outcome reversed if the patient had been managed (within the present state of clinical knowledge) with all the necessary skills and resources appropriate to the severity of the injury.

The panel were asked to scrutinise the case histories presented in a two-part process.

1) *Assessment of survivable injury*

The panel member was asked to judge if

> In the present state of medical knowledge, with immediate attention and all necessary skills and resources available, were the injuries survivable?

This required a yes or no answer. Patients judged to have unsurvivable injuries were classified as unavoidable deaths. For patients with survivable injuries, the panel member was then asked to judge

> Were these injuries survivable in this patient in these circumstances?

and

> In your opinion was the patient dead before the ambulance arrived?

Patients who because of their age, other co-morbidity, or other circumstances were judged to have been unable to survive their injuries, or who were dead already, were also classed as unavoidable deaths. The remaining cases are judged to have survivable injuries and their deaths were therefore potentially avoidable.

2) Assessment of avoidable death
Deaths considered to be potentially avoidable were further reviewed. Each expert was asked to identify the type of errors, if any, that may have occurred in pre-hospital care. Errors were classified into two types:

> Errors of commission – that is, actions taken which were inappropriate. This is primarily concerned with clinical skill and decision making.
>
> Errors of omission – should things have been done which were not done. This is concerned not only with skill but also resources. For example, the availability of necessary personnel, facilities and equipment.

To simplify this process, a score sheet was used on which the reviewer could indicate which aspects of care were unacceptable and the errors involved. The list of items used was derived from errors reported in previous studies. It is not considered to be exhaustive, but does provide a framework for the assessment of errors and an analysis of the range and type of errors found.

The list provided was:

AMBULANCE TIMES
- to scene/at scene/from scene

TREATMENT
- Airway/breathing
- Circulation/intravenous fluids
- Stabilisation/(splintage)
- Drugs
- Oxygen
- Cardiac care
- Destination
- Other/(specify)

An assessment was made of the level of pre-hospital care deemed necessary/appropriate for each case. The panel members were asked to assess avoidability by answering two further questions on a scale of 1–5 from 'Yes almost certainly' to 'No almost certainly not'.

1. Assuming optimal hospital care: if all the errors and omissions identified in pre-hospital care (as delivered by the ambulance service, and including unavailable services) had not occurred, could the cause of death have been prevented?
2. Assuming optimal hospital care, would this have altered the outcome for this patient?

and finally each panel member was asked to

> Summarise briefly what could have been done differently in pre-hospital care that may have prevented this death

Cases in which it was judged that outcome would have been affected were classed as avoidable deaths. The panel met 5 times over a period of 1 year. In the last meeting, all deaths which had been judged to be potentially avoidable were discussed to reach agreement on the most significant or common errors occurring in pre-hospital care and the contributory causes of death in these cases. The causes were itemised as 'airways obstruction', 'exsanguination', 'neurological injury', and 'other' and the panel were asked to rate these on a 5-point scale, from 1 = almost certainly made no contribution to death to 5 = almost certainly contributed to death.

Information for all the case histories and injury severity scoring was abstracted by a single research associate using ambulance records, A&E records and coroners' records/post-mortem reports. In each case, the panel were also asked to judge whether they considered the information available was adequate to assess whether the death was avoidable. Responses were scored from 1 (completely inadequate) to 4 (more than adequate), and 213 cases (87%) were scored 3 or 4, i.e. were judged to have adequate information by the panel. Only one of the 31 cases where the information was less than adequate was subsequently judged to be a potentially avoidable death.

Confidentiality

It is essential for this type of study that confidentiality of both patients and care providers is maintained. To achieve this, all information given on the case histories which could identify the patient, ambulance service or hospitals involved was removed. This included name, date of birth, hospital identification numbers, date and location of incident and type of ambulance crew, whether paramedic or technician. Any subsequent dates were removed and replaced with day numbers, day 0 being the date of the incident. Through this process, the assessors were blinded to when and where and by whom each patient was treated.

Even with these precautions, it is possible that individual assessors could have recognised some cases or, more harmfully, believed they recognised particular cases. Panel members were therefore asked not to discuss or show the cases to other colleagues for their 'expert' opinion. They were advised that the views of the whole panel itself should be sufficient.

Methods of analysis

The deaths included in the avoidable death study have been classified as **unavoidable**, due to having unsurvivable injuries in that particular patient and in those circumstances, or **potentially avoidable**, if the patients had survivable injuries as judged by the consensus opinion of the expert panel, or the panel remained equivocal (at least two out of four agreed). Potentially avoidable deaths were further sub-divided into **possibly not avoidable** or **probably avoidable** based on the individual assessments of the panel.

Amongst patients with injuries judged to be survivable, i.e. potentially avoidable, deaths were considered to be 'probably avoidable' if it was assessed that the outcome might have been altered if all errors and omissions in pre-hospital care had been avoided. This was judged to be the case if the average assessment of the panel was smaller than or equal to 3, graded on the scale 1 = almost certainly altered, 2 = probably altered, 3 = possibly, 4 = probably not, 5 = almost certainly not. Conversely deaths were considered 'possibly not avoidable' if it was assessed that the outcome was probably not altered, i.e. the average assessment of the panel was larger than 3.

If there was no consensus about whether the injuries were survivable the deaths have been included in the potentially avoidable group, and their avoidability judged by averaging the individual assessments of the members of the panel in the same way as for cases in which there was a consensus that the injuries were survivable.

Comparisons of the rates of potentially and probably avoidable deaths in all patients who died have been made between the paramedic attended and technician only attended cases.

Only one case was attended by both an EMT crew and later by a back-up paramedic crew, and if this case is transferred from the paramedic to the EMT category (as in the pragmatic analyses earlier), the differences outlined later are negligibly larger.

Reliability of panel assessments

The authors have assessed the inter-panelist reliability by comparing the assessment of survivability assigned to all the same cases by the four panellists. The possibility that the expert panel were changing their criteria for assessing avoidability as their experience changed during the course of the study was examined by analysing the results of 20 cases resubmitted to the panel, unknowingly, for a second scrutiny approximately 4 months after the initial assessment. For these 20 cases, the intra-panel reliability has been assessed by comparing the final conclusion of the whole panel on whether the death was possibly avoidable or probably avoidable on the two occasions. This is a measure of the extent to which the panel as a whole agrees with itself.

Inter-panel reliability could not be measured of course as due to the limitations of time and resources there was only one review panel.

Results of reliability assessment

Inter-panelist reliability

On the question of could this patient have survived their injuries in these circumstances (the basis for determining potentially avoidable death) the panel members agreed as follows:

> Four out of four agreed (yes or no) in 186 cases (76%).
> Three out of four agreed in 45 cases (19%).
> and there was a 2:2 split in 13 cases (5%).

Intra-panel reliability

In the 20 cases presented on two separate occasions to the panel, the panel agreed with itself for every case.

Results of study 1

Numbers of deaths

During the 1-year time frame, 1382 inquest deaths were recorded. Of these, 314 (23%) were deaths from overdose, 73 (5%) from fractured neck of femur in the elderly, 87 (6%) from carbon monoxide poisoning and 11 not carried by the local ambulance services. The remaining 897 deaths comprised the total sample frame of trauma deaths for this study.

In the Coroner's records, 264 cases (29% of the total sample frame) were identified as having been found dead and as such were deemed irretrievable (*Table 39*). A further 111 (12%) were identified from the coroner's record as either having been certified at the scene by a doctor or pronounced life extinct by paramedics at the scene with no indication that they were taken to A&E.

There were 44 (5%) cases where the patient was transported to hospital but their injuries scored ISS = 75 and their death was therefore deemed

TABLE 39 *Expert panel sample frame – study 1*

	Inquest deaths studied n = 897
Exclusions	
Found dead stated in coroner's record	264 (29.4%)
Certified dead at scene	111 (12.4%)
Post-mortem assessment – unsurvivable injuries	47 (5.2%)
Died in hospital > 3 days from incident	165 (18.4%)
Death inevitable ISS = 75	44 (4.9%)
Inclusions	
Died before reaching hospital (dead on arrival)	70 (7.8%)
Died in hospital within 3 days of incident	196 (21.9%)

TABLE 40 *Expert panel sample*

ISS score	Paramedic cases		Technician cases	Total panel cases
	All (n = 207)	Sample (n = 120)	All (n = 59)	
Null (i.e. hangings/ drownings, etc.)	21	6	5	11
≥ 25	64	64	16	80
26–75	122	50	38	88
Area 1	72	24		
Area 3	50	26		
Total presented to panel		120	59	179

inevitable. A further 47 (5%) cases went to hospital, but the post-mortem report or the Sudden Death Form reported death as occurring instantaneously, or reported that the injuries were such that death was inevitable.

All these deaths were collectively deemed unsalvageable and these 466 (52%) cases were therefore excluded from scrutiny by the expert panel in study 1. A further 165 (18%) deaths were found to have occurred more than 3 days after the incident and again these were not presented to the panel. It was felt that any errors in pre-hospital care were unlikely to account for these deaths.

The remaining 266 (30%) deaths were divided into those who died before reaching hospital, (dead on arrival; 70 cases) and those dying in hospital within 3 days, (196 cases) (*Table 39*). Deaths were classified as dead on arrival if there was no attempt at the A&E department to resuscitate at all. Any attempt at resuscitation, if only for a few minutes, was classified as a hospital death. These 266 cases formed the sample frame for the case histories prepared for scrutiny by the expert panel in study 1.

Expert panel sample

The ISS score for each of these 266 cases was computed and the crew type, paramedic or technician, ascertained. There were 59 technician attended cases and a case history prepared for each of these, regardless of ISS score. The remaining 207 paramedic attended cases fell into the ISS score bands shown in *Table 40*.

As a result of sampling of paramedic attended cases described in the method, 120 paramedic cases were prepared for scrutiny by the expert panel with ISS scores shown in *Table 40*. In total therefore 179 cases were presented to the panel for study 1.

There was no significant differences found in the age distributions between the expert panel sample frame (266 cases, mean age 44.1) and the sample of 179 cases presented to the panel (mean age 45.1).

Causes of injury in all deaths within 3 days of the incident and those more than 3 days post-incident are summarised in *Table 41*. As expected deaths from hangings, drownings and asphyxiations occur

TABLE 41 *Causes of injury*

Cause	All deaths within 3 days of incident n = 732	All deaths more than 3 days after n = 165	Expert panel cases n = 179
RTA	207 (28.2%)	60 (36.4%)	79 (44.1%)
Train	19 (2.6%)	0	0
Air	14 (1.9%)	0	1 (0.6%)
Fall	89 (12.2%)	73 (44.2%)	38 (21.2%)
Hangings	140 (19.1%)	1 (0.6%)	10 (5.6%)
Drowning/ asphyxiation, etc.	80 (10.9%)	1 (0.6%)	8 (4.5%)
Assault	65 (8.9%)	6 (3.6%)	25 (14.0%)
Industrial accident	19 (2.6%)	1 (0.6%)	8 (4.5%)
Burns	52 (7.1%)	10 (6.1%)	10 (5.6%)
Other	21 (2.9%)	2 (1.2%)	0
Not known	26 (3.6%)	11 (6.7%)	0

predominantly fairly shortly after the incident whereas deaths from falls often occur more often 3 days or more post-incident. Patients dying from falls belong generally to a much more elderly population than any of the other causes of death, and as expected there was a significant difference between the mean ages of those dying within 3 days of the incident and those dying more than 3 days after the incident. The difference in mean age between these two populations was 20 years (42.5 and 62.5 years).

Causes of injury in the 179 cases scrutinised by the expert panel are also summarised in *Table 41*. Of note is the much higher proportion of assaults assessed by the panel. This is as a result of the sampling procedure where all cases with ISS less than 26 were assessed and assaults were usually found to have an ISS under 26.

Penetrating injuries were found to account for 11% of these trauma deaths (*Table 42*) which is more than double the proportion of penetrating injury identified in the main study of all trauma incidents including both survivors and deaths (4.8%). Alcohol was found to be a contributory factor in almost a quarter of the trauma deaths (22%). There was some form of bystander intervention in just over one-third of all deaths. Where this intervention took place, approximately one half was carried out by the general public and a further quarter by trained first aiders. In 79% of cases, the intervention was limited to simple first aid, i.e. putting patient into recovery position, clearing airway, bandaging, talking/reassuring patient. In 45% of cases CPR was attempted.

TABLE 42 *Circumstances of deaths in the expert panel sample – study 1*

	179 panel cases study 1 n (%)
Mechanism of injury	
Blunt injury	159 (88.8)
Penetrating injury	20 (11.2)
Mechanism of death	
Airways obstruction	71 (39.7)
Exsanguination	55 (30.7)
Neurological deficit	107 (59.8)
Multiple injuries	81 (45.3)
Alcohol contributory factor	
Yes	40 (22.3)
No	139 (77.7)
Bystander interventions	
Yes	65 (37.3)
No	109 (62.7)
Not known	5
Bystander intervention (n = 65)	
Public	28 (43.1)
First aider	14 (21.5)
Nurse/paramedic	6 (9.2)
Medic	17 (26.2)
What done	
First aid	51 (78.5)
Nurse skills	8 (12.3)
Medic skills	2 (3.1)
Not known what done	4 (6.2)
CPR	29 (44.6)

Expert panel results (study 1; 179 cases)

Potentially avoidable deaths

There were 56 cases out of the 179 studied (31%) where the panel agreed that death had occurred before the ambulance arrived, 120 cases (67%) where they were still alive, and three cases where the panel could not decide or agree.

Of the 56 cases dead before the ambulance arrived, the panel agreed by consensus (four out of four, or three out of four) that 46 had sustained unsurvivable injuries in any circumstances. In the other 10 cases there was consensus agreement that the injuries were unsurvivable in that patient and those circumstances. In 39 of the 56 cases, some degree of airway obstruction contributed to death. Similarly, in 10 cases exsanguination and in 26 cases neurological injury contributed to death. There were 22 cases with multiple injuries.

In 34 out of the remaining 123 cases who may have been alive when the ambulance arrived, some degree of airway obstruction contributed to death. Similarly, in 45 cases exsanguination and in 80 cases neurological injury contributed to death. There were 59 cases with multiple injuries.

For these 123 cases who may have been alive when the ambulance arrived, the panel agreed by consensus (four out of four, or three out of four) that 43 had unsurvivable injuries in any circumstances, a further 59, by consensus majority, were unsurvivable in that patient and those circumstances, leaving 21 cases with survivable injuries where death was therefore deemed potentially avoidable. For these 21 cases the panel agreed unanimously in two cases, three out of four in eight cases and were equivocal in the other 11 cases. These results are summarised in *Table 43*, split by type of ambulance crew attending.

***TABLE 43** Potentially avoidable deaths by type of crew (study 1)*

	All cases n = 266	All cases in sample n = 179	Dead before ambulance on scene	Unavoidable		Potentially avoidable	Probably avoidable
				Not survivable in any circumstances	Not survivable in these circumstances		
Paramedic							
ISS = N/A	21	6	6	6	6	0	0
ISS < 25	50	47	19	13	19	9	5
ISS ≥ 25	136	67	10	34	25	8	3
Technician							
ISS = N/A	3	3	3	3	3	0	0
ISS < 25	14	13	6	9	16	1	0
ISS ≥ 25	42	43	13	24	19	3	0

Thirty-eight percent (8/21) of these potentially avoidable deaths had penetrating injuries (compared to 11% of the whole sample of 179 deaths reviewed) and 40% of all penetrating injury fatalities (8/20) were judged to have led to potentially avoidable death.

Overall, there were 17/120 (14.2%) deaths assessed as potentially avoidable attended by paramedics compared to 4/59 (6.8%) attended by technicians. This difference is not statistically significant ($\chi^2_1 = 2.08$, $p = 0.15$) suggesting that it could be a chance finding rather than a real difference.

Because deaths were more likely to be assessed as potentially avoidable at lower ISS scores, the observed difference could reflect the fact that 64/120 (53%) of paramedic attended cases had ISS (25 compared to 16/59 (27%) of technician attended cases (*Table 40*). However, there was a similar increased chance of death being assessed as potentially avoidable in paramedic attended cases in both ISS groups (*Table 44*).

Probably avoidable deaths

For the 21 cases that were considered potentially avoidable the panel independently assessed the likelihood that the cause of death could have been prevented (if the errors identified in pre-hospital care had not occurred). They also went on to assess the likelihood of this altering the outcome for the patients in terms of eventual death.

In eight of these 21 cases the panel judged that the death was probably avoidable (i.e. differences in management would probably have altered the outcome) (*Table 43*). Half of these probably avoidable deaths had penetrating injuries, so that 20% (4/20) of all penetrating injuries in the sample were judged to have led to probably avoidable death.

For these probably avoidable deaths, there were 8/120 (6.7%) in paramedic attended cases and 0/59 (0%) in technician attended cases. This difference is statistically significant ($p = 0.04$, Fisher's exact two-sided test) suggesting that this is not a chance finding and may represent a real difference. When the ISS scores or mechanism of injury are taken into account the numbers are becoming very small, of course (*Tables 45* and *46*). Nevertheless, the data suggest that death was much more likely to be judged avoidable if it followed a low ISS penetrating injury (4/14 = 29% probably avoidable) than if it followed another type of injury (4/165 = 2.4%), and most of the low ISS penetrating injury cases (11/14) were seen by paramedics.

It is not clear, of course, whether these cases involving low ISS penetrating injuries had probably avoidable deaths as a result of being attended by

***TABLE 44** Potentially avoidable deaths by ISS and crew type*

ISS score	Crew type		RR in paramedic cases
	Paramedic	Technician	
< 25	9/47 (19.1%)	1/14 (7.1%)	2.68
≥ 25	8/67 (11.9%)	3/42 (7.1%)	1.67

***TABLE 45** Probably avoidable deaths by ISS and crew type*

ISS score	Crew type		RR in paramedic cases
	Paramedic	Technician	
< 25	5/47 (10.6%)	0/14 (0%)	–
≥ 25	3/67 (4.5%)	0/42 (0%)	–

TABLE 46 Probably avoidable deaths by mechanism of injury and crew type

Mechanism of injury	Crew type		RR
	Paramedic	Technician	
Blunt	4/105 (3.8%)	0/54 (0%)	–
Penetrating	4/15 (26.7%)	0/5 (0%)	–

paramedics, or whether they were attended by paramedics because of the type of incident and it is these types of incident which are likely to give rise to deaths judged avoidable. It is possible that both explanations are true to some extent, and support for this comes from observing that although 4/14 deaths in these types of incident were judged avoidable, 0/3 deaths attended by EMTs were judged avoidable, and although 4/165 deaths in other incidents were judged avoidable, 0/53 were attended by EMTs.

It may be more appropriate to compare the proportions of deaths in paramedic and technician attended cases which were judged probably avoidable when deaths which were assessed to have occurred before the ambulance services arrived are excluded. The difficulty with this sort of analysis is the presumption that the time to arrival at the scene (the response time) was itself not affected by the crew type. Assuming that this is the case, there were 8/85 probably avoidable deaths in the paramedic sample versus 0/37 in the technician sample, a difference which remains significant ($p < 0.01$, Fisher's exact test).

Factors in pre-hospital care contributing to death and causes of death

The panel were also asked to report on what might have been done differently in pre-hospital care to prevent death in the 21 cases deemed potentially avoidable, and what were the main factors in pre-hospital care which, in their opinion, contributed to death.

Excessively long scene times were a recurring factor, where a 'scoop and run' approach was thought necessary for any chance of survival for these patients (*Table 47*). This is examined further

TABLE 47 Pre-hospital contributory factors in potentially avoidable death

Factor	21 potentially avoidable cases		8 probably avoidable cases	
	Paramedic n = 17	Technician n = 4	Paramedic n = 8	Technician n = 0
Delay on scene attempting cannulation and/or infusing intravenous fluids	7	0	4	–
Excessive scene time delayed surgical intervention	7	1	4	–
Excessive ratio 'on-scene' time to "to hospital" time i.e. > 4	9	1	4	–
Needed 'scoop and run', rapid transfer to definitive care	11	0	5	–
No oxygen or inadequate oxygen given pre-hospital (or not recorded as given)	3	1	1	–
Needed earlier definitive airway control (including failure to clear airway)	8	1	4	–
Tension pneumothorax not relieved	1	0	1	–
Needed cannulation and intravenous fluids en-route or whilst trapped	2	1	1	–
Inadequate amount of fluids given	3	0	1	–
Failure to fully assess hypovolaemia/or hypoxia – lack of observations on blood pressure, pulse, etc.	4	1	4	–
Failure to control bleeding	7	1	3	–
Medical assistance should have been requested	2	0	2	–
Delay in reaching specialist care e.g. neurosurgical unit	1	0	0	–
No pre-hospital care factors (predominantly hospital care errors that may have prevented the cause of death)	1	2	0	–

below. Failure to control bleeding and need for earlier or better airway control were also prominent factors. There was some evidence that crews were not making physiological observations and therefore not able to fully assess hypovolaemia or hypoxia in these patients.

The expert panel were also asked to review all 21 cases that had been identified by them as potentially avoidable and score the contributory causes of death.

Exsanguination was the most common contributory cause of death in the 21 potentially avoidable deaths, 15 out of 21 (71%) (*Table 48*). Airway obstruction was a major cause in eight cases (38%) and neurological injury in just four (19%). Causes of death other than these were one case of hypothermia and one case of pneumonia.

A similar pattern emerged in the eight probably avoidable deaths. In six out of eight cases (75%), exsanguination was a contributory cause of death, whereas airway obstruction, neurological injury and hypothermia accounted for just one each.

In almost half of the cases 10/21 (48%), exsanguination was the only major contributory factor, and 6/8 (75%) probably avoidable deaths were judged to have been due to exsanguination alone.

Time on scene

Time spent on scene, and time between leaving scene and arrival at A&E ('to hospital' time) were calculated for the 154 out of 179 panel cases where the patient was neither trapped nor had a difficult extrication. The results are summarised in *Table 49* comparing paramedic with technician attended cases. Paramedics were found to spend approximately double the length of time on scene in these cases of serious injury leading to death. In the main study in which the mean injury severity was much less and 95% of patients survived, a difference in 'on-scene' times was also demonstrated. This difference was only found for patients having paramedic interventions (see chapter 4).

The difference in scene times for the 154 deaths considered could not be explained by differences in transfer times to hospital which were similarly short in both groups. Consequently, the mean ratio of on-scene to transfer times was twice as large in the paramedic group as in the technician group ($p < 0.001$). Similarly, the mean ratio of on-scene to transfer times remained approximately twice as large for paramedic attended cases when the time of death ($p < 0.01$) or the mechanism of injury ($p < 0.01$) were taken into account.

Results of study 2 – 100 consecutive cases

Circumstances of deaths

In the 100 consecutive deaths assessed by the panel, 12% had penetrating injuries, alcohol was a factor in 22%, and 24% had some bystander interventions. In 12%, bystander CPR had been attempted (*Table 50*).

Panel results

There were 67 cases (67%) where the panel agreed that death had occurred before the ambulance arrived, and 33 cases where they were still alive.

Of the 67 cases dead before the ambulance arrived, the panel agreed by consensus (four out of four, or three out of four) that 59 had sustained unsurvivable injuries in any circumstances. In the other eight cases, there was consensus agreement that the injuries were unsurvivable in that patient and those circumstances. In 45 of the 67 cases some degree of airway obstruction contributed to death. Similarly, in 15 cases exsanguination and in 25 cases neuro-

TABLE 48 *Contributory causes of death*

Contributory cause of death	21 potentially avoidable cases		8 probably avoidable cases	
	Paramedic n = 17	Technician n = 4	Paramedic n = 8	Technician n = 0
Exsanguination	13	2	6	–
Airways obstruction	6	2	1	–
Neurological injury	2	2	1	–
Other	1 (Hypothermia)	1 (Pneumonia)	1 (Hypothermia)	–

***TABLE 49** Scene times by crew type, excluding trapped or difficult extrication cases*

Contributory cause of death	Paramedic attended	Technician attended
Number of cases – all	104	50
Death on arrival	18	12
Hospital deaths	86	38
Penetrating injuries	15	5
Blunt injuries	89	45
Mean on-scene time – all	20.4	11.0
Mean 'to hospital' time – all	6.7	7.7
Mean ratio 'on-scene' to 'to hospital' times – all	4.0	1.9
Death on arrival	5.4	1.8
Hospital deaths	3.8	2.0
Penetrating injury	4.4	2.0
Blunt injuries	4.0	1.9

***TABLE 50** Circumstances of deaths in the consecutive death sample – Study 2*

	100 consecutive cases study 2 n (%)
Mechanism of injury	
Blunt injury	86 (86)
Penetrating injury	12 (12)
Both	2 (2)
Mechanism of death	
Airways obstruction	50 (50)
Exsanguination	27 (27)
Neurological deficit	43 (43)
Multiple injuries	43 (43)
Alcohol contributory factor	
Yes	22 (22)
No	78 (78)
Bystander interventions	
Yes	24 (24)
No	75 (76)
Not known	1
Bystander intervention (n = 24)	
Public	13 (54.2)
First aider	6 (25.0)
Nurse/paramedic	2 (8.3)
Medic	3 (12.5)
What done	
First aid	20 (83.3)
Nurse skills	3 (12.5)
Medic skills	1 (4.2)
Not known what done	
CPR	12 (50.0)

logical injury contributed to death. There were 25 cases with multiple injuries.

Sixty-five cases had not been presented to the panel as part of the 179 cases in study 1. These 65 cases were representative of those cases excluded from the expert panel sample frame, i.e. found dead, ISS = 75, the post-mortem report stated death instantaneous or unsurvivable injuries. The expert panel did not find any of these cases to have survivable injuries in the circumstances, and it is therefore reasonable to assume that none of the trauma deaths excluded from the study 1 sample would have been judged to have had survivable injuries.

For the seven cases that were considered potentially avoidable the panel members independently scored the likelihood that the death could have been prevented (if the errors identified in pre-hospital care had not occurred). They also went on to assess the likelihood of this altering the outcome for the patients in terms of eventual death. In four of these cases the panel judged that the death was also probably avoidable (i.e. the outcome could probably have been altered).

Table 51 summarises the avoidable deaths for the 100 consecutive cases. The proportion of cases with survivable injuries in optimal circumstances for all cases was almost identical (approximately 22%) for both paramedic and technician attended cases. There were no probably avoidable deaths in cases with very severe injuries (ISS ≥ 25). None of the pre-hospital deaths were judged potentially avoidable, compared to 16% of the hospital deaths within 3 days of incident. All four probably avoidable deaths identified in these 100 consecutive cases had an ISS < 25, died in hospital and were attended by paramedic crews.

Estimation of rate of avoidable death with optimal pre-hospital care

Excluding deaths from overdose and carbon monoxide poisoning, and fractured neck of femur in the elderly, 897 deaths were identified in the coroners registers in 1 year in the areas studied. Of these, 631 had presumptive evidence that death could not have been prevented. Of the remaining 266, 179 were randomly sampled for detailed review by an expert panel. The panel judged that 21 had potentially avoidable deaths, and of these eight had probably avoidable deaths with optimal pre-hospital care. Taking into account the sampling

***TABLE 51** Avoidable deaths in 100 consecutive cases by type of crew*

	Paramedic attended	Technician attended	Not attended by ambulance	All cases
	n (%)	n (%)		n (%)
All cases assessed	70	18	12	100
Survivable in optimal circumstances	16 (22.9)	4 (22.2)	0	20 (20.0)
Potentially avoidable	5 (7.1)	2 (11.1)	0	7 (7.0)
Probably avoidable	4 (4.5)	0 (0.0)	0	4 (4.0)
	(13 = ISS 75)	(1 = ISS 75)		
ISS ≥ 25 cases	45	10	4	59
Survivable in optimal circumstances	8 (17.7)	2 (20.0)	0	10 (16.9)
Potentially avoidable	1 (2.2)	1 (10.0)	0	2 (3.4)
Probably avoidable	0	0	0	0
Pre-hospital deaths	36	9	11	56
Survivable in optimal circumstances	2 (5.5)	1 (11.1)	0	3 (5.4)
Potentially avoidable	0	0	0	0
Probably avoidable	0	0	0	0
Hospital deaths (< 3 days)	34	9	1	44
Survivable in optimal circumstances	14 (41.2)	3 (33.3)	0	17 (38.6)
Potentially avoidable	5 (14.7)	2 (22.2)	0	7 (15.9)
Probably avoidable	4 (11.8)	0	0	4 (9.1)

scheme these results suggest that 12.2% of the 266 cases had potentially avoidable death and 3.6% had probably avoidable deaths. The panel assessment of 65 of the 631 cases with presumptive evidence that death could not have been prevented found no deaths that might have been avoided, confirming the presumption. Assuming then that there were no avoidable deaths in this group, it is estimated that overall 4.7% of trauma deaths are potentially avoidable, and just 1.4% probably avoidable (95% CI: 0.4%, 2.5%).

Discussion

Rate of avoidable death

We sought to determine just how many deaths from trauma were potentially and probably avoidable in the pre-hospital phase, and what factors in pre-hospital care could be identified as sources of possible prevention for these deaths. We used an expert panel to assess both a sample of 179 cases in which there was presumptive evidence that the outcome might have been affected by pre-hospital care, and 100 consecutive unselected cases. Previous studies described in the Introduction, using a variety of methods, have found rates of potentially avoidable death anywhere between 4% and 48%.

Our panel judged that in 179 selected deaths without presumptive evidence that death was unavoidable, there were 21 potentially avoidable deaths, and in eight of these cases death was judged probably avoidable. In a further 65 cases with presumptive evidence of unavoidable death, no cases were judged potentially or probably avoidable. After adjusting for the sampling scheme, it is estimated, therefore, that just 1.4% of trauma deaths could have been prevented by optimal pre-hospital care.

Three riders need to be attached to this estimate before generalisation. Firstly, we have only examined two ambulance service areas, and although these areas are typical of metropolitan, urban, and rural areas of England, the balance in other parts of the country might be different. Secondly, we have excluded poisonings and deaths from fractured femur in the elderly. Thirdly, only deaths occurring up to 3 days have been judged. Plainly, if all deaths had been judged some additional small number of cases might have been found in which death was judged to have been related to pre-hospital care. More importantly, however, a different cut-off such as 6 hours from arrival in A&E might have led to quite different estimates. Despite these cautions, and although comparisons with other studies are difficult, an avoidable death rate of 1–2% compares very favourably with other reports.

Factors contributing to death

There was a recurring theme in the factors in pre-hospital care identified by the panel as contributing to death in the 21 potentially avoidable cases.

Assessments of unnecessarily long scene times, time spent on scene attempting cannulation and/or infusion of intravenous fluids, and delay to definitive airway care or surgical intervention were all reflected in the relatively long scene times for all the deaths studied (mean = 17.4 minutes) compared with the mean scene times found in the cohort study mainly of survivors (14.6 minutes). Other major factors were failure to control bleeding and to take observations in order to fully assess the patients state with regard to potential problems such as hypovolaemia/hypoxia.

Analysis of type of injury and the mechanism of injury revealed a disproportionately large percentage of penetrating injury compared to that found generally for trauma. Between 11% and 14% for both the sample cases and the consecutive cases, compared with 4.8% found in the main cohort study. When the probably avoidable deaths only are considered then the percentage of penetrating injury increases to 20–29%. Penetrating injuries are therefore 2–3 times more prevalent in trauma deaths than in the general population of trauma injury alone, and moreover are possibly up to 6 times more prevalent in the probably avoidable trauma deaths.

Airway obstruction was a contributory cause of death in 50% of cases, neurological deficit in 43% and exsanguination in 27%. However, exsanguination was the most prevalent contributory cause of death in the 21 cases identified by the panel as potentially avoidable, and the eight probably avoidable cases. Thus the most common cause of avoidable death is injuries where the patient has exsanguinated. Those found potentially and probably avoidable were cases where there had been unnecessary delay in reaching definitive care to control this bleeding and in some cases failure to assess the extent and seriousness of injuries. There are implications for training of emergency ambulance crew with emphasis on a rapid and appropriate assessment of the patient, pressure control of bleeding, rapid transfer to definitive surgical care, and for patients with penetrating abdominal injuries omission of attempted fluid infusion.[41]

Comparison of paramedic and technician cases

The panel judged that 21 of the 179 deaths studied had injuries that they could have survived taking all known factors, including age, ISS score and type of injury, into account (17/120 attended by paramedics versus 4/59 attended by EMTs). Eight of these 21 potentially avoidable deaths were judged to be probably avoidable in terms of identifiable improvements in pre-hospital care (8/120 attended by paramedics versus 0/59 attended by EMTs). This is 4.5% of the 179 cases scrutinised.

The identification and analysis of avoidable deaths are subject to numerous well-documented problems.[42,43] One principal difficulty is that we really want to compare avoidable death rates as a proportion of all patients (i.e. deaths and survivors) since it is possible that both more avoidable deaths and more unexpected survivors could result from the same intervention. Thus, for example, the interventions of paramedics could be ‘high risk’ leading to both unexpected survivors and to avoidable deaths. However, the main analysis comparing cohorts of patients attended by paramedics and technicians found a slightly higher mortality rate in the paramedic group, suggesting that the small number of additional avoidable deaths was not being outweighed by more survivors.

A second difficulty with the avoidable death methodology is the ascription of causes. Whilst errors of omission and commission can be judged to have occurred, it remains a matter of opinion, albeit ‘expert’, that these might have altered the outcome. Furthermore, the process of judging avoidability involves assessing errors of management. Thus, for example, we can’t determine whether the scene times, were the cause of avoidable deaths, or whether the deaths were judged to be avoidable because of the large scene to transfer time ratios.

On-scene times were identified as a particular problem in the paramedic attended cases. For all cases reviewed the mean of the ratio of on-scene time to ‘to hospital time’ for n = 120 paramedic attended cases was four compared to two for technician attended cases. Of course, these comparisons may be confounded by the types of incident attended, and there is clearly a dilemma when confronted with a patient in an immediately critical condition as to whether time should be spent at the scene trying to stabilise the patient or to transfer the patient immediately to hospital. Nevertheless, bearing these factors in mind, as well as the type of injury, and the time to hospital, the panel judged that in 9/17 potentially avoidable paramedic attended deaths there was an excessive scene time in relation to the journey time to hospital. Furthermore, there was a greater ratio of ‘on-scene’ to ‘to hospital’ time on average for paramedic attended deaths than technician attended deaths for all types of patients. The subjective judgements of the panel together with these objective measures do suggest that delays at the scene particularly when hospital facilities were close by were an important factor contributing to potentially avoidable deaths in paramedic attended cases.

A third difficulty with the process of comparing avoidability is that whilst blinding of the panel to the type of crew is possible for judging survivable injuries (i.e. potentially avoidable deaths), inevitably judgements about whether these were probably avoidable, which depend on assessing errors of management, cannot be blinded. Only paramedics can intubate, insert cannulae and infuse fluids. Thus at this stage of the assessment the panellists could accurately infer whether they were assessing a paramedic or technician attended death. However, we believe that the panel were free from prejudgements about the value of paramedic interventions. The fact that a substantial excess of survivable injury deaths were also found in the paramedic group, which was judged blind to the type of crew, appears to confirm this.

Conclusion

There was no evidence from our study to support the view that a substantial proportion of pre-hospital deaths are avoidable as suggested by previous studies. Only 1.4% were probably avoidable. However, there was no evidence from our study of deaths to suggest that the current use of paramedic skills was preventing possible avoidable death. The most common cause of avoidable death was exsanguination, and the most frequently cited avoidable factor was delay on scene. These results suggest that our paramedics may need different training courses based around different protocols in order to be able to make better judgements about when skills should be used, on whom, and in which circumstances.

Courses such as the pre-hospital trauma life support course have been introduced for ambulance services by the Royal College of Surgeons of England and the National Association of Emergency Technicians. These courses aim to help ambulance staff resolve issues surrounding assessment, resuscitation, triage and transport in critically injured patients. Skills from these courses might have reduced scene times, improved decision making, and enabled the whole emergency care system to operate more effectively in reducing the small number of avoidable deaths even further.

Chapter 8

Economic evaluation of the impact of the paramedics in the treatment of patients with trauma

Clarification of the study question

Economic evaluation aims to inform future decision making with regard to two, or more, alternative courses of action. Identifying the two courses of action, and hence the basic study question, is fundamental to the conduct of the evaluation. This economic evaluation, therefore, does not aim to answer the question of whether paramedics are cost-effective because only those components of paramedic training relating to the management of serious trauma have been studied.

Consequently, a lack of effectiveness would not result in the phasing out of all paramedics, as some of their advanced skills might still be required for cardiac cases and other cases not investigated here. Furthermore, even in the event of a negative result, some of the skills investigated in this study will still be required in some cases, e.g. the use of intravenous fluids for trapped trauma patients. Changes in practice following a negative result, therefore, would not allow the full costs of paramedic training and salaries to be recovered.

One possible scenario following a negative result is that all front-line ambulances continue to have fully trained and paid paramedics on board, but administer treatments to trauma patients according to different protocols. Under such circumstances, the incremental costs of training and employing paramedics would not change from those at present.

The stance taken in this evaluation is that the alternative course of action under investigation (i.e. that which would occur in the event of a negative result), is that there would be some reduction in training and salary costs. This would be consistent with either a reduced level of skills being taught to future cohorts of paramedics, or the full range of skills being taught to a reduced number of paramedics. In light of the uncertainty around the changes in practice following from a negative result, sensitivity analysis has been undertaken to estimate cost differences under other scenarios, including that of no changes in training and salaries.

The study has therefore investigated the cost and health consequences of the current pattern of pre-hospital treatment of patients with trauma, compared with treatment patterns consistent with a reduced aggregate level of paramedic skills. For brevity, these two options have been termed 'paramedic treatment' and 'technician treatment'.

Costs

The costs of paramedic treatment compared to technician treatment include the additional costs of training and re-certification, the additional salary costs, and the additional costs of pre-hospital treatment. However, cost consequences may extend beyond these, for example, if the patients that reach hospital are less severely ill due to paramedic treatment, then treatment costs during and after hospitalisation may be reduced. In order to capture this and other possible impacts, the cost study has collected resource use data at all stages of treatment.

Data were collected and analysed for NHS and indirect costs. However, only NHS costs were valued because the valuation of indirect costs (i.e. production losses) is highly contentious. Consequently, the cost estimates in this section, do not include production losses and as such reflect an NHS perspective. All costs are in 1996/7 prices.

Methods

The cost items that were studied and the sources of the resource use and unit cost data are outlined in *Table 52*. The incremental costs of ALS training and their service costs, such as increased salaries and changes in on-scene time, were derived for each individual service. The incremental costs of ALS training were estimated using a bottom-up approach. Furthermore, in order to estimate the incremental costs of trauma-related ALS training each service was asked to estimate the proportion of training that could be classified as either 'basic' (e.g. physiology and anatomy), 'trauma', 'medical' or 'mixed'. The incremental costs of training, and the incremental salary costs to the service, could

TABLE 52 *Measurement and valuation of resources used*

Resource	Measure	Source of data	Valuation
1. Ambulance service (ALS training) – instructors – equipment, facilities, consumables – time off work for training – associated costs of skills maintenance	Resources per student	Ambulance Services	Local unit costs
2. Ambulance service (service costs) – staff – consumables – support requested on scene – time on scene	Number Number and type Number and type Minutes	PRFs and other Ambulance Service records	Local cost data (except consumables which were national averages)
3. Inpatient departments – ward stay (including re-admissions) – ICU stay (including re-admissions)	Length of stay (by spec) Length of stay	Patient records	Regional average unit costs
4. Ambulatory care – out-patients – GP contacts – nurse visits	Number	Patient questionnaire	National and regional average unit costs

then be adjusted in line with the estimates of training devoted to trauma skills.

The service costs were estimated using the following top-down methodology. The total costs of emergency services for each service were collected, together with information on their staffing complements, and the staff mix required to meet the 'paramedic policy'. These total costs were then adjusted to take into account the additional costs attributable to paramedic training, re-certification and salaries (both adjusted to represent only the trauma related part of the additional skills). The total costs were then adjusted in proportion to the change in average call-out time attributable to paramedic training; this implies that, say, a 5% increase in call-out time produces a 5% increase in the emergency services budget. This produced two total costs; one representing a paramedic service with full trauma training, and the other a paramedic service with reduced trauma training.

Activity data were then used to estimate a cost per call-out, and finally the mean length of a call-out for ALS and BLS call-outs were used to produce a cost per minute. The difference in cost per minute, is therefore, made up of two separate effects; firstly, a unit cost effect reflecting the additional costs of a call-out due to increased training and salaries, secondly, a time effect, reflecting differences in length of call-out time.

A top-down methodology was used in preference to a more detailed bottom-up methodology in order to ensure that full data was available for each individual service. This was not thought possible with more complex data requirements. Furthermore, the differences between a more detailed bottom-up methodology and that produced here would be reflected in the unit cost differences for the two services. Yet it was expected that any significant cost differences between 'paramedic' and 'technician' treatment would be attributable to the time-effect. Previous estimates of the incremental costs of paramedics[42] produce a unit cost effect of a 2% increase in cost per call-out and a time effect of 28%.

Individual patient costs were estimated for all cases using the following formula:

Cost of
patient *i* = length of call out for patient *i multiplied* by cost per minute of ambulance
plus
consumables and drugs used by patient *i*
plus
length of hospital stay of patient *i multiplied* by cost per patient day
plus
length of hospital stay for re-admissions by patient *i multiplied* by cost per patient day
plus
number of outpatient attendances by patient *i multiplied* by cost per attendance
plus
number of GP attendances by patient *i multiplied* by cost per attendance
plus

number of community visits by health and social services for patient *i multiplied* by cost per visit.

Attendance costs included all vehicles attending each incident. This is important as it possible that ALS and BLS crews require different levels of back-up. Simply estimating the cost of an attendance, as opposed to the cost of incidents, may therefore produced distorted cost estimates.

Hospital unit costs were averages based on a survey of hospitals in the three regions studied undertaken for this study. Costs of primary care and social services were taken from estimates complied by the Personal and Social Services Research Unit at the University of Kent.[44]

Analysis of variance was undertaken in order to estimate the independent effect of the crew type on resource use and costs. The model used was the same as used in the majority of the preceding analysis of mortality and morbidity. Crew type was defined as whether any attending crew was an ALS crew or not. Analyses were undertaken for both definitions. Log transformation of resource use and costs was undertaken in order to produce more normally distributed data.

Results

Ambulance service costs for the three services are shown in *Table 53*. The negative time cost effect in area 2 shows that paramedics crews spent less time on the scene than technician crews, and on average, this dominated the unit cost effect.

Resource use across the three services for each major cost component are shown in *Table 54*. The

TABLE 53 *Ambulance service unit costs*

Ambulance Service	Unit cost effect of paramedic training	Time cost effect of paramedic training*	Total effect of paramedic training	Average cost of ALS call out	Average cost of BLS call out	Unit cost of ALS crew	Unit cost of BLS crew
				(£)	(£)	(£/min)	(£/min)
Area 1	+0.8%	+6.1%	+6.8%	63.67	59.33	1.97	1.95
Area 2	+0.4%	–1.0%	–0.6%	97.19	97.77	2.91	2.90
Area 3	+0.4%	+6.2%	+6.6%	82.39	76.96	2.45	2.44

* *The time cost effect is equivalent to the change in total call out time within each of the three services*

TABLE 54 *Differences in resource use on patients attended on-scene by paramedics or EMTs*

	Paramedic crews[a]				EMT crews[a]				*p*-value[b]
	n	Mean	Median	SD	n	Mean	Median	SD	
Ambulance time, including supporting vehicles (min)	1404	35.7	31.4	23.5	594	31.5	29.0	13.4	< 0.01
Number of treatments given[c]	892	1.3	0.0	1.6	351	0.5	0.0	1.0	< 0.01
ICU days	1439	0.4	0.0	3.0	605	0.5	0.0	3.4	0.70
Inpatient days (first admission)	1339	14.9	7.0	24.6	570	16.0	8.0	34.4	0.81
Inpatient days (re-admissions)	1432	0.6	0.0	4.0	601	0.6	0.0	3.4	0.62
Outpatient attendances	180	9.9	5.0	12.0	83	10.1	5.0	20.7	0.36
GP contacts (clinic and domiciliary visits)	180	2.3	1.0	3.8	83	2.6	1.0	3.6	0.79
Other community contacts	180	4.3	0.0	14.7	83	4.9	0.0	19.4	0.56

[a] *Unadjusted figures*
[b] *Adjusted using analysis of variance for: area, ISS, head injury AIS, mechanism of injury, type of incident, trapped and age*
[c] *Only those treatments with a non-negligible cost are included here*

statistical significance of the differences between the two groups were tested through analysis of variance.

Costs were then calculated to produce a cost for each patient, and differences estimated through analysis of variance. The results of these analyses are shown in *Tables 55–59*. Overall, the explanatory effects of the models were intuitively correct and many were statistically significant, although the overall fit of the model was low.

TABLE 55 *Differences in mean ambulance costs by patient and incident characteristics*

	n[a]	Deviation from mean cost	*p*-value
Mean cost £68.03			
Characteristics			
Area			< 0.001
Area 1	1080	–13%	
Area 2	168	+34%	
Area 3	750	+15%	
ISS			< 0.001
1–8	1046	–6%	
9–15	739	+1%	
16–24	95	+20%	
25–40	91	+35%	
41–71	27	+28%	
Head AIS			< 0.001
None	1492	+2%	
1	141	+2%	
2	182	–1%	
3	87	–7%	
4	45	–32%	
5	51	–20%	
Age			0.002
0–14	259	–9%	
15–34	524	+6%	
35–54	413	+1%	
55–74	423	–2%	
75 and over	365	–2%	
Not known	14	+6%	
Incident type			< 0.001
RTA	632	+4%	
Fall	1015	+2%	
Fire	40	–13%	
DSH	25	–6%	
Assault	141	–17%	
Other	145	–4%	
Injury mechanism			0.811
Blunt	1905	0%	
Penetrating	93	0%	
Trapped			< 0.001
Trapped	47	105%	
Not trapped	1951	–2%	
Crew type			0.002
Paramedic	1404	+2%	
Technician	594	–4%	

Multiple R^2 = 25.4%
[a] *Excluding any with not known pre-hospital times*

TABLE 56 *Differences in mean pre-hospital treatment costs by patient and incident characteristics*

	n[a]	Deviation from mean cost	*p*-value
Mean cost £2.25			
Characteristics			
Area			< 0.001
Area 1	1013	–11%	
Area 2	69	+21%	
Area 3	157	+105%	
ISS			< 0.001
1–8	563	–10%	
9–15	520	–3%	
16–24	69	+46%	
25–40	69	+77%	
41–71	18	+62%	
Head AIS			< 0.001
None	883	–9%	
1	96	+55%	
2	120	+25%	
3	72	+28%	
4	29	–10%	
5	39	–10%	
Age			0.011
0–14	175	–20%	
15–34	333	+8%	
35–54	247	–2%	
55–74	270	–2%	
75 and over	203	11%	
Not known	11	–1%	
Incident type			< 0.001
RTA	412	+22%	
Fall	595	–11%	
Fire	21	–2%	
DSH	14	+11%	
Assault	107	–16%	
Other	90	+12%	
Injury mechanism			< 0.001
Blunt	1175	–3%	
Penetrating	64	+84%	
Trapped			0.004
Trapped	38	+55%	
Not trapped	1201	–1%	
Crew type			0.088
Paramedic	888	+3%	
Technician	351	–7%	

Multiple R^2 = 25.1%
[a] *Excluding patients with missing PRFs*

The model of costs which defines a paramedic attendance as an incident where at least one of the attending vehicles was a paramedic staffed ambulance shows ambulance costs are around £4 (6%) greater for paramedic attendances than technician attendances ($p = 0.002$). There is some evidence that pre-hospital treatment costs are also greater for paramedics ($p = 0.088$); however, the difference is small and the data used to estimate these costs unreliable because of missing PRFs. All other cost components do not differ significantly between the two groups. The mean total cost of treatment

***TABLE 57** Differences in mean hospital costs (including re-admissions) by patient and incident characteristics*

	n[a]	Deviation from mean cost	*p*-value
Mean cost £2165			
Characteristics			
Area			0.044
Area 1	1097	–1%	
Area 2	173	–14%	
Area 3	628	+6%	
ISS			< 0.001
1–8	974	–6%	
9–15	723	+23%	
16–24	92	+118%	
25–40	85	–77%	
41–71	24	–95%	
Head AIS			< 0.001
None	1408	–1%	
1	134	+5%	
2	176	–11%	
3	91	–27%	
4	39	–10%	
5	50	+249%	
Age			< 0.001
0–14	247	+1%	
15–34	493	–24%	
35–54	395	–13%	
55–74	402	+16%	
75 and over	348	+46%	
Not known	13	–28%	
Incident type			0.02
RTA	604	+9%	
Fall	964	–3%	
Fire	32	+9%	
DSH	19	–21%	
Assault	136	–15%	
Other	143	–3%	
Injury mechanism			0.136
Blunt	1808	+1%	
Penetrating	90	–16%	
Trapped			0.417
Trapped	42	+15%	
Not trapped	1856	0%	
Crew type			0.809
Paramedic	1332	0%	
Technician	566	+1%	

Multiple R^2 = 17.3%
[a] Excluding patients with missing data on all inpatient stays

***TABLE 58** Differences in mean ambulatory care costs by patient and incident characteristics*

	n[a]	Deviation from mean cost	*p*-value
Mean cost £368.71			
Characteristics			
Area			0.968
Area 1	77	+3%	
Area 2	66	–13%	
Area 3	129	+5%	
ISS			0.11
1–8	163	–11%	
9–15	93	+12%	
16–24	11	+42%	
25–40	5	+139%	
41–71	0		
Head AIS			0.764
None	228	+6%	
1	15	–8%	
2	22	–24%	
3	2	–56%	
4	4	–78%	
5	1	+11%	
Age			< 0.001
0–14	0		
15–34	67	+27%	
35–54	70	+48%	
55–74	81	+31%	
75 and over	54	–70%	
Not known	0		
Incident type			0.264
RTA	78	+26%	
Fall	160	–16%	
Fire	3	–38%	
DSH	0		
Assault	10	–8%	
Other	21	+70%	
Injury mechanism			0.909
Blunt	263	0%	
Penetrating	9	+5%	
Trapped			0.69
Trapped	11	+22%	
Not trapped	261	–1%	
Crew type			0.531
Paramedic	185	+5%	
Technician	87	–10%	

Multiple R^2 = 17.2%
[a] Includes only patients responding to follow-up postal questionnaire

is £22 more expensive for patients who were attended by a paramedic crewed ambulance, but this difference is not statistically significant ($p = 0.814$).

***TABLE 59** Differences in mean total cost by patient and incident characteristics*

	n	Deviation from mean cost	*p*-value
Mean cost £2231			
Characteristics			
Area			0.326
Area 1	1080	–2%	
Area 2	171	–14%	
Area 3	750	+6%	
ISS			< 0.001
1–8	1048	–7%	
9–15	740	+23%	
16–24	95	+116%	
25–40	91	–59%	
41–71	27	–92%	
Head AIS			< 0.001
None	1494	0%	
1	141	+6%	
2	183	–15%	
3	87	–20%	
4	45	–28%	
5	51	+206%	
Age			< 0.001
0–14	259	+4%	
15–34	525	–24%	
35–54	414	–13%	
55–74	424	+15%	
75 and over	365	+43%	
Not known	14	–29%	
Incident type			0.003
RTA	633	+9%	
Fall	1016	–3%	
Fire	40	+21%	
DSH	25	–22%	
Assault	142	–17%	
Other	145	–3%	
Injury mechanism			0.202
Blunt	1907	+1%	
Penetrating	94	–14%	
Trapped			0.248
Trapped	47	+17%	
Not trapped	1954	0%	
Followed-up status			0.002
Not followed-up	1598	–4%	
Followed-up	403	+19%	
Crew type			0.814
Paramedic	1407	0%	
Technician	594	–1%	
Multiple R^2 = 16.4%			

Discussion

Sensitivity analysis

The main areas of uncertainty with regard to the estimation of the costs are:

- the reduction in paramedic training and salary costs associated with the policy alternative, as discussed earlier in this chapter
- the imprecision of the top-down methodology for producing ambulance unit costs
- the impact of missing data.

The reduction in paramedic training and salary costs for each service associated with the alternative policy, were calculated using estimates of the proportion of paramedic training which is solely attributable to trauma skills. Within area 1, for example, it was estimated that 20% of paramedic training could be classified as relating to trauma. This estimate was then used to scale down the incremental training and salary costs associated with the policy alternative by 20%. This method is crude, however, it is the best available. Uncertainty, therefore arises around the accuracy of the estimate of the proportion of paramedic training which is solely attributable to trauma skills, which ranges between 20% and 30% for the three services. There is also uncertainty around the use of this figure as a method of scaling down the incremental costs to a level that reflects a sensible policy alternative. As mentioned earlier, the method of scaling used in this study produces cost estimates that are consistent with either:

- A reduced level of skills being taught to future complements of paramedics. Using area 1 as an example, this would produce a 20% reduction in the incremental costs of training and employing a paramedic;

or

- A reduced complement of paramedics. In the case of area 1, this would imply a 20% reduction in the number of technicians trained to paramedic grade.

In order to estimate the uncertainties around the size of the scaling factor and the appropriateness of using it, costs were re-estimated using a 0% reduction in training and salary costs, and a 100% reduction in training and salary costs. The figures for the central estimates used in this study and the two other possible scenarios are shown in *Table 60*. The changes in assumptions produce a range of costs for the alternative policy of less than £3 in the three services. This is not thought to have a significant impact on the results of this study.

***TABLE 60** Cost per ambulance call-out under different assumptions of changes in paramedic training and salary costs*

		Proportion of total paramedic and salary costs attributable to trauma skills[a]			
Service	**Policy**	**0%**	**20%**	**30%**	**100%**
Area 1	Paramedic	63.67	63.67		63.67
	Alternative	59.79	59.33		57.47
Area 2	Paramedic	97.19		97.19	97.19
	Alternative	98.14		97.77	96.93
Area 3	Paramedic	82.39	82.39		82.39
	Alternative	77.29	76.96		75.68

[a] Area 1 and area 3 both estimated that 20% of paramedic training was attributable to teaching trauma skills, while area 2 estimated it to be 30%

The top-down methodology for producing ambulance service unit costs has several weaknesses. Firstly, top-down methods are in general more crude than bottom-up costing methods. So, for example, the size of capital costs within the unit costs is unknown, as it is hidden within the aggregate cost total supplied by the Ambulance Services. However, it was not thought possible to produce detailed bottom-up costings for each of the three services. Furthermore, it was expected that the main component of any cost difference between the paramedic policy and the alternative policy would lie in the time effect, and as such, any imprecision in unit costs would be relatively unimportant.

Missing data is only thought to have a significant impact on the costs produced for pre-hospital treatments. This is due to the high rate of missing PRFs and also the variable quality of completion for those forms that were retrieved. It is thought that these problems will affect the validity of cost estimates and cost differences. However, as such costs make up only a small proportion of total treatment costs, it is unlikely that these problems will impact on the overall results of the cost study and economic evaluation.

It is also worthwhile comparing the cost figures produced by this study to those of a recent study by Martin Knapp and colleagues which present the only other published estimates of ambulance attendances for different crews in the UK. Knapp *et al.*[45] (1997) use a bottom-up methodology to produce a cost for a paramedic attendance of £213.32 and the cost of an EMT attendance of £162.94. The difference of these estimates from those shown in *Table 53* are primarily due to the different services under investigation. In particular, the different magnitude of costs between this study and Knapp's study is due to the marked differences in costs between ambulance services. National Health Service Executive figures for 1995/6 show cost per journey ranges from £63.61 for Greater Manchester Ambulance Service, through to £202.12 for the Isle of Wight Ambulance Service. The much larger difference between paramedic and EMT costs found in the Knapp study is primarily due to the much greater increase in call-out time found in their study. They found an increase in call-out time of around 11 minutes, whereas this study identified an increase of around 2 minutes. This is likely to reflect differences in practice between the three services studied here, and those studied by Knapp. Some of the differences in costs between the two studies are also attributable to the different methodologies and study questions.

The analyses presented in *Tables 55–59* show that relationships between patient and incident characteristics are present, with the chosen factors explaining between 16 and 25% of the variation in costs. Furthermore, the sign and size of the relationships between the explanatory variables and costs meet expectations. For example, costs are lower than average for minor and major injuries, and higher for moderate, survivable injuries. Crew type is a statistically significant factor in explaining ambulance costs, and there is further weak evidence of a relationship with pre-hospital treatment costs. Taken together, this indicates that the analyses was successful in identifying significant relationships within the data.

Another point of interest is that production losses, i.e. time off work for the survivors were lower for the patients treated by paramedics, and the difference of 30 days was statistically significant at conventional levels ($p = 0.05$). The precise value of this benefit is not estimated. Furthermore, in order that the full welfare effects are considered, these benefits need to be offset by the lifetime production losses associated with the increased mortality of patients treated by paramedics. This is not undertaken here.

In summary, the costs presented here are insensitive to changes in assumptions and problems caused by missing data.

Economic evaluation

The analysis of mortality data identified an increased risk of death associated with an incident being attended by a paramedic crew. The analysis of morbidity data, however, identified improved health outcomes for survivors treated by a paramedic crew. This potential trade-off needs to be investigated further before it is possible to determine whether the mortality costs outweigh the morbidity benefits. Without knowing whether paramedic attendance is preferable to EMT attendance, we cannot say which policy is superior in terms of overall outcomes. Without knowing which alternative is superior, we are unable to assess the relative efficiency of the alternatives in definitive terms. Instead, we can only present the costs and outcomes in disaggregated form; a so called 'cost-consequences analysis' (*Table 61*).

TABLE 61 *Costs and consequences of first attendance by paramedics in the treatment of trauma patients*

First attender	Morbidity									
	Cost per patient (£)	Mortality	Physical functioning	Social functioning	Role – physical	Role – emotional	Mental health	Energy/ vitality	Pain	General health perceptions
Paramedics	2231	6.2%	49.7	60.2	33.8	61.9	64.3	48.5	53.8	56.0
EMTs	2209	4.3%	41.7	49.6	24.3	47.5	61.6	42.3	51.2	55.6
Adjusted difference	+22	OR[a] = 2.02	+9.1	+13.5	+13.6	+17.2	+3.8	+6.4	+2.4	+3.4

[a] *OR of death in paramedic attended patients compared with EMT attended patients*

Chapter 9

Discussion, conclusions and recommendations

It has been found that patients seriously injured in accidents who are attended by ALS trained paramedics have a higher risk of death than patients attended by EMTs. This mortality increase was estimated to be between 29% (unadjusted) and 86% (adjusted for casemix and taking into account the first responder), the latter reaching statistical significance.

On the other hand, it was found that all eight dimensions of health outcome on the SF-36 questionnaire were better in survivors attended by paramedics than EMTs, and these improvements were both statistically and clinically significant for five out of eight of the dimensions.

Previous literature

The mortality results are in sharp contrast to an American literature review[13] which concluded that recent evidence was in agreement on the benefits of ALS training in pre-hospital care to prevent trauma mortality. Questions arise therefore about how reliable and generalisable our findings are, and these issues are discussed below. With regard to the literature, a search of MEDLINE from 1976 to 1997, the references cited in the systematic review,[13] and the references cited in all the articles followed up initially, revealed just eight studies in addition to the current study which have compared death rates from traumatic injuries for patients receiving ALS or BLS pre-hospital care (*Table 62*). One study, using an ecological design found lower death rates in American counties using ALS crews than in counties using BLS crews,[46] and a second using a case control approach found no difference in the estimated odds ratio of death between crew types (odds ratio for ALS crews = 1.1; 95% CI = 0.6–1.8 after adjustment for mechanism of injury).[47] There were therefore just six previous studies identified which directly compared mortality rates in cohorts of trauma patients attended by ALS or BLS crews. Two of these studies used historical cohorts of BLS attended patients as controls,[48,49] one of which found significantly better outcomes in the more recent ALS cohort.[47] However, this study can be reanalysed to examine trends over 32 years. This shows that, in fact, there was no change associated with the introduction of an ALS-based emergency medical service in the generally improving trend.

One of the remaining four studies comparing contemporary cohorts of ALS and BLS managed trauma patients does not give any direct data.[50] The study report suggests that in a model of death as a function of initial TS, change in TS between scene and hospital (ΔTS), time on scene, and crew status, there was no association between death and crew status. However, the results suggest that this was because crew status was associated with ΔTS which was in turn associated with outcome. Unfortunately, the data, estimates and interaction terms are not shown.

The remaining three studies all report outcomes n contemporary trauma cohorts.[29,51,52] The results, summarised in *Table 62,* show a crude relative risk of death in all three ALS cohorts of between 16% and 41% higher than in the BLS cohorts.

Cayten[51] studied more seriously injured cohorts than the others and only included patients with an ISS > 10. He found a crude relative risk of 1.16, which after adjustment for potential confounding factors reduced to 0.98. Our study also found no difference in risk for more seriously injured patients (see *Table 32*). Potter's study[29] found a crude relative risk of +41%, but excluding the nine deaths from unsurvivable injuries the increased RR was +68%. Unfortunately, there was no multiple factor risk adjustment for all deaths, only for deaths during hospital stay for critically injured patients. Despite his evidence that ALS care was associated with higher risk of death, Potter claims that there may have been benefits from ALS care because 'the most significant finding was that 54% of ALS deaths occurred more than 24 hours after injury compared with 27% of BLS fatalities'. However, excluding the nine cases with unsurvivable (ISS = 75) injuries (BLS 7; ALS 2), who are likely to have early deaths, the proportions are 57 versus 35%. Furthermore, 60% of the ALS critically injured had head/neck injuries and 25% thoracic injuries compared to 40% of the BLS critically injured with head/neck injuries and 47% with thoracic injuries. Head injuries may be late deaths, and thoracic injuries early deaths.

Rainer's study from Scotland[52] found a crude relative risk associated with ALS care of 1.31, but again failed to adjust for risk factors. Though the ISS distributions were similar in the two cohorts

TABLE 62 *Literature on mortality rates associated with paramedic care*

Authors/place	Type of patients	Comparison groups	Type of study	Outcome measures	Findings
Messick *et al.*, 1986–88[46] North Carolina	Trauma deaths	24 BLS counties vs. 76 ALS counties based on n = 12,417 deaths	Ecological	Per capita county trauma death rates	Adjusted for density and demographics there was a significant ($p < 0.01$) difference between ALS and BLS counties (results do not show size of effect or direction, but from discussion presumably in favour of ALS counties)
Sampalis *et al.*, 1987–88[47] Montreal	Moderate to severe trauma, excluding deaths before arrival at hospital	Patients given ALS treatment or not (by doctors)	Case-control	Death at ≥ 6 days	ALS at the scene was not associated with survival. (OR = 1.08. 95% CI = 0.64–1.83 after adjustment for ISS and mechanism of injury)
Aprahamian *et al.*, 1970–81[48] Milwaukee	Major open intra-abdominal trauma	n = 64 EMT attended patients (first 8 years) vs. n = 48 paramedic attended patients	Historical controls	Deaths in hospital	BLS = 22/64 (34.4%) vs. ALS = 14/48 (29.2%) RR of death for paramedics = 0.85 (95% CI = 0.45, 1.95)
Fortner *et al.*, 1932–81[49] Aurora Bridge, Seattle	Multiply injured patients who jumped from the Aurora Bridge	n = 71 ALS (1970–81) n = 36 BLS (1950–69)	Historically controlled cohorts	Death before discharge	BLS = 4/36 (11%) vs. ALS = 22/72 (31%) Trend BLS 1950–59 6% 1960–69 16% ALS 1970–79 28% 1980–81 36%
Jacobs *et al.*, 1981[50] Boston	Severely injured trauma patients	n = 80 ALS vs. n = 98 BLS	Contemporary cohorts	Change in TS. Death adjusted for TS +ΔTS	Shows that ΔTS affects outcome and that ΔTS is affected by crew status. But the model of outcome as a function of ΔTS, ΔTS, crew status, scene time) failed to find a relationship to crew status
Cayten *et al.*, 1987–89[51] New York City	Trauma, aged ≥ 13, Length of stay ≥ 48 hours, ISS ≥ 10	n = 434 ALS n = 347 BLS	Contemporary cohorts	Death before discharge	BLS = 51/347 = 14.7% ALS = 74/434 = 17.1% OR = 1.19 RR = 1.16 Adjusted for age, RTS, ISS, mechanism RR = 0.98
Potter, 1984[30] Sydney (ALS) Brisbane (BLS)	Trauma: death or admission > 24 h	n = 472 ALS n = 589 BLS	Contemporary cohorts	Death, length of stay, Glasgow Outcome Score	Crude: ALS 37/469 (7.9%) BLS 33/589 (5.6%) OR = 1.44 RR = 1.41 Excluding unsurvivable (ISS = 75) injuries ALS 35/467 (7.5%) BLS 26/582 (4.5%) OR = 1.73 RR = 1.68 After adjustment, No difference in length of stay, ICU stay, Glasgow Outcome Score. More respiratory failure (19% vs. 5%) in BLS patients
Rainer, 1993–95[52] South East Scotland	MTOS criteria excluding trapped	n = 247 ALS n = 843 BLS	Contemporary cohorts	Death in hospital	ALS 10/247 = (4.0%) BLS 26/843 = (3.1%) Crude OR = 1.33 RR = 1.31
Nicholl, *et al.*, 1994–96 (current) England	MTOS criteria excluding doctor on scene	n = 1440 ALS n = 605 BLS	Contemporary cohorts	Death before 6 months post-incident	ALS = 86/1440 (6.0%) BLS = 28/605 (4.6%) Crude OR = 1.31 RR = 1.29 Adjusted RR = 1.67

they compared, the paramedics had probably been targeted at **potentially** more serious incidents (assaults; RTAs; falls > 2 m; etc.), and the effect that adjustment would have on the estimated relative risk is difficult to determine.

This study in England with a crude relative risk of +29%, or +45% when the incidents are classified by the type of crew first on scene, clearly fits consistently and coherently with these other studies from America,[51] Scotland,[52] and Australia.[29] Exceptionally, however, we found that this risk did not disappear after adjustment for the major risk factors. Indeed adjustment tended to increase the estimated relative risk. However, the increased risk associated with ALS care was only apparent for patients with non-major trauma without head injury, and was particularly pronounced in patients with bleeding injuries (relative risk 4.60, 1.07, 20.0).

A meta-analysis of the results of the four studies using contemporary cohorts yields a significantly increased crude relative risk of 1.26 ($p = 0.03$) (*Figure 10*).

Reliability

At the request of the HTA commissioning group we attempted to carry out a partially randomised study. The intention was to randomise trauma calls during a 6-month prospective data collection phase in two of the ambulance services. In the event one service could not agree to any randomisation protocol, and the dispatchers remained very reluctant in the second.

Eventually 185 calls were randomised, but only 16 calls met the principal study inclusion criteria requiring patients to be admitted for ≥ 3 nights. A further 14 patients were admitted for one or two nights. The reasons for the failure of the randomisation were well laid out in the original protocol and were related to:

- The conviction amongst the media, public, and ambulance service staff that paramedic interventions are beneficial in serious trauma.
- The rapidly decreasing number of EMT-only crews, which was shutting the window on the opportunity to instigate the randomisation protocol which required both an ALS and an EMT crew to be equally ready to respond.
- The fact that there were no priority dispatch systems in place at the time to target serious trauma, which meant that > 90% of all randomised dispatches were to minor trauma.

Without a randomised trial, there will always be some doubts about our findings. These doubts would not be resolved by larger numbers because we have found significant differences, although we were surprised by the small number of deaths in our cohorts. The doubts arise because of the possibility of selection biases and unknown confounding, or biases caused by selective inaccuracies in the data, and these doubts remain the same whatever the size of the study. Nevertheless, we are confident that the finding of an increased mortality with paramedic attendance represents a real effect of paramedic attendance, because:

- It is not explained by any differences in casemix in terms of well-established prognostic factors in trauma. Indeed casemix adjustment increased the estimated risk.
- If there are any other important prognostic factors not taken into account (such as co-morbidities) these were certainly not known or guessable at the time of dispatch of

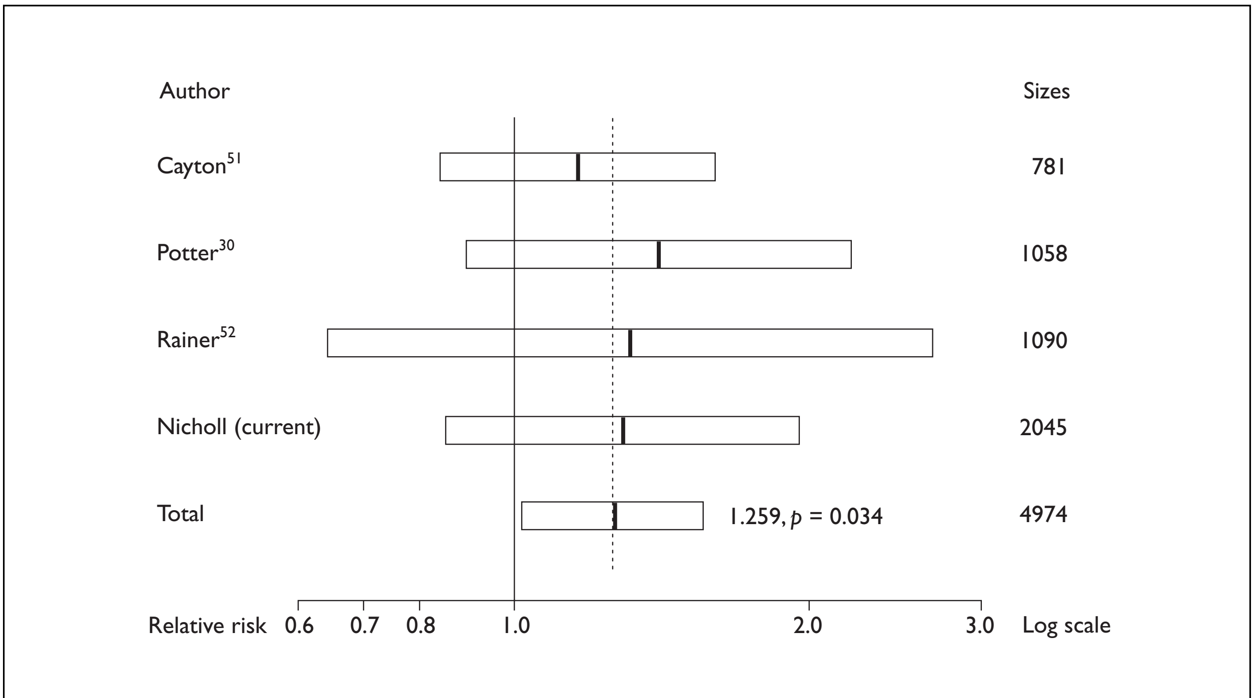

FIGURE 10 *Meta-analysis of unadjusted relative risks of death from trauma in paramedic patients compared with technician patients*

paramedic or EMT crews. There could not have been any selection by these unknown factors, and indeed there was little selection by known factors.
- The crude estimated relative risk, 1.29, is consistent with results from the only other studies comparing contemporary cohorts from Australia and America, and almost exactly matches that found in a contemporary study from Scotland (1.31) which used similar inclusion criteria.
- A panel of four trauma care experts, blinded to whether incidents were attended by paramedics or EMTs, found approximately twice the rate of potentially avoidable death in deaths attended by paramedics (17/120) than in the deaths attended by EMTs (4/59), and all the eight deaths judged probably avoidable were in the paramedic group.

Lastly, all the data used to determine characteristics of the incidents, the patients and their injuries were derived retrospectively from routinely completed notes and forms. We have not checked or validated the accuracy of the information on injuries in patient notes, or on incident locations and types in ambulance service records and so on. We have relied on their accuracy – which is routinely assumed in traumas registry studies. This means that inaccuracies, which are certain to be present, will have contributed some noise, or random variation, to the results. However, there is little chance that any such inaccuracies have introduced any bias, since there is no reason to suppose that routine data sources are more or less likely to contain inaccuracies if an EMT or paramedic attended the incident. This would only be likely if we had used information directly from the PRFs completed by the paramedics or EMTs such as the T-RTS. However, we have avoided using any information which was not also available from the dispatch records. Information about interventions carried out at the scene and on the T-RTS which might have been recorded with different accuracy by EMTs and paramedics has not been used in the evaluation.

With regard to the morbidity outcomes, reliability is less easy to judge. Firstly, the responses were obtained only in a sample of respondents to a mailed survey which did not have a high response rate (67%). Secondly, the relative improvements in patients attended by paramedics were limited to some dimensions and did not appear to any significant extent with regard to general health perceptions. Nevertheless, the paramedic patients did report less time off work and their other usual activities, and this was consistent with their replies indicating better physical and social functioning.

Generalisability

It is also difficult to determine to what extent these results are generalisable to other areas. However, cohorts were collected from three ambulance service areas covering a wide diversity of environments. The estimated effects regarding on-scene times were identical in the three areas, mortality effects were in the same direction (although not of the same size), and SF-36 scores also showed similar results.

The results within the context of the time period studied are probably generalisable to the whole of England.

Interpretation

Although the recent review of the benefits of pre-hospital ALS care by paramedics referred to earlier concluded that there was evidence of benefit,[13] doubts about the value of ALS care have often been raised.[5,12,53] Usually these have been expressed in relation to increased scene times leading to delays in reaching definitive care,[54–56] or damaging effects of pre-hospital fluid replacement,[57,58] particularly in penetrating trauma[41] or if small volumes of inappropriate fluid are used.[59]

Although our study has confirmed that there are increased scene times in patients attended by paramedics, these are on average only 2 minutes longer. In relation to total pre-hospital times which usually exceed 30 minutes this average difference can have had little impact, and if the therapies being provided during this time were effective then they could not explain any deleterious effects. However, the average delay of 2 minutes is made up of a delay of 12 minutes in patients receiving ALS care and no delay in other patients. This difference is not explained by characteristics of the patients, their injuries, or the incidents. Many of the patients receiving ALS interventions have very serious injuries and in this group of patients 12 minutes could have an impact on the risk of death, especially in penetrating trauma.

It is only in penetrating trauma that adverse effects of fluid replacement therapy have been established,[41] and in which potentially serious consequences of even short delays to definitive care have been reported.[60,61] However, in this study only 98 (4.8%) of cases had penetrating trauma and only five of these died. Thus although this is likely to be a contributory factor, and was explicitly identified as a problem by the avoidable death expert panel, it cannot explain the increase in mortality that we have found. Instead, the data suggest that the problem occurs in a wider group of patients with bleeding injuries which could lead to hypovolaemia. It was found that:

- Injuries involving blood loss were 2.5 times more likely to be the primary cause of deaths in patients attended by paramedics than in patients attended by EMTs (see *Table 33*).
- Patients with bleeding injuries attended by paramedics were estimated to be between 4 and 8 times more likely to die than similar patients attended by technicians (see *Table 34*).
- The avoidable death panel identified exsanguination as the commonest contributing cause in potentially avoidable deaths (15/21), and was the only contributory cause identified in six out of eight probably avoidable deaths, all of whom were attended by paramedics (see *Table 48*).

It is postulated that this is due to several factors. Increased scene time and delays to definitive care, and inappropriate fluid resuscitation may play an important part even in blunt trauma. In Smith's review of 52 consecutive cases all of them required more time for intravenous initiation than the transport time to hospital.[12] More recent research has shown, however, that ALS techniques including intravenous infusion, can be performed without adding significantly to time spent on scene. Cayten, for example, reported no differences in times spent on scene between ALS and BLS attended trauma cases in New York.[51] Models which have been developed by Lewis in 1986[62] and Wears in 1990[63] also give a mixed picture. Lewis suggested that in all but the most rural systems where pre-hospital times exceed 30–45 minutes (depending on the bleeding rate) intravenous infusions are of no benefit. Even then the paramedic must infuse the patient at a rate which in practice most personnel would be reluctant to do because of the danger of fluid overload. Wears developed a similar model which he claims to be closer to the clinical reality and his result is more favourable to establishing intravenous infusion at scene. He suggests that a survival advantage is produced in patients with high bleeding rates if the average time from injury to hospital is more than 30 minutes. The conclusions of this research seem to be that intravenous infusions should only be carried out in situations where proportionally little or no time is added to the pre-hospital phase of care. Some authors have studied the practicality of cannulating patients and giving fluids in the ambulance en route to hospital. It has been shown that intravenous lines can be started in the moving ambulance with similar success rates to those achieved on scene, and concluded that except in cases of entrapment the intravenous line should always be placed en route.[64]

Cannulation and fluid replacement take time, may increase bleeding, and fluids are sometimes given in clearly sub-therapeutic quantities.[62] It is possible therefore that pre-hospital fluid infusions are sometimes beneficial and sometimes harmful. This could in part explain the apparent contradiction between increased mortality and better outcomes in survivors. It is postulated that indiscriminate use of pre-hospital fluid replacement therapy even in blunt trauma would be a 'kill or cure' strategy, and that current use by paramedics may not have been sufficiently discriminating for the problems to be avoided and the benefits achieved. One possible reason for this is the comparatively short training course which paramedics in the UK usually undergo. Another possibility is that paramedics cannot maintain their skills and judgement in implementing trauma protocols since on average they only see one serious trauma patient per month (chapter 3).

Conclusions

There was no evidence from our study to support the view that a substantial proportion of pre-hospital deaths are avoidable as suggested by previous studies. Only 1.4% were probably avoidable. However, there was no evidence from our study of deaths to suggest that the current use of paramedic skills was preventing possible avoidable death either. Indeed the study of cohorts of serious trauma patients found evidence of an increased risk of death from serious trauma involving bleeding injuries in patients attended by paramedics, but better outcomes for survivors of serious trauma generally.

A panel of experts identified unnecessary delays at the scene and failures to control bleeding adequately and establish airways as the main problems. These factors are readily remediable, and the possibility remains that paramedic pre-hospital care could lead to substantial and worthwhile benefits to survivors without any increase in risk of death if the causes of the increased mortality can be identified.

Recommendations for further research

An associated Health Technology Assessment study examining two paramedic fluid resuscitation protocols in blunt trauma is currently underway. If this comparison project finds poorer outcomes in blunt trauma resulting from fluid resuscitation, then it will still be necessary to go on to resolve whether this is due to the types of patients, the timing of resuscitation, the type of fluids used or the amount of fluid infused (or a combination of these factors). However, other studies comparing different training and protocol packages are also needed, specifically these should include:

- A comparison of the effectiveness of different pre-hospital time protocols in untrapped patients with bleeding injuries (e.g. an open protocol versus a limit of 10 minutes on scene).
- A comparison of training programmes, using similar protocols, to examine whether the skills developed in the longer degree-type courses beginning to be offered to paramedics make a difference to the way in which protocols are implemented and their effectiveness.

Acknowledgement

This study was supported by the NHS R&D Executive Health Technology Assessment Programme. The authors would like to thank the officers and staff of the three ambulance services, particularly those who have helped to find us the information we needed, and the control room staff who helped with the randomisation.

The authors would like to thank the consultants and staff of the A&E departments, medical records departments, and hospitals in the three areas for their help and cooperation.

They would also like to thank their colleagues Joanne Higgins, Kathryn Saunders, and Creena Roberts, who helped with the data collection.

References

1. Nguyen-van-Tam JS, Dore AF, Bradley MP, Pearson JCG, *et al.* Effectiveness of ambulance paramedics versus ambulance technicians in managing out of hospital cardiac arrest. *Journal of Accident and Emergency Medicine* 1997;**14**:142–8.
2. Mann CJ, Guly H. Paramedic interventions increase the rate of return of spontaneous circulation in out of hospital cardiac arrests. *Journal of Accident and Emergency Medicine* 1997;**14**:149–50.
3. Evans RC, Evans RJ. Accident and emergency medicine I. *Postgraduate Medicine* 1992;**68**:714–34.
4. Ivatury RR, Nallathambi MN, Roberge RJ, Rohman M, Stahl W. Penetrating thoracic injuries: in-field stabilization vs prompt transport. *Journal of Trauma* 1987;**27**:1066–72.
5. Sampalis JS, Lavoie A, Williams JI, Mulder DS, Kalina M. Impact of on-site care, pre-hospital time, and level of in-hospital care on survival in severely injured patients. *Journal of Trauma* 1993;**34**:252–61.
6. Reines HD, Bartlett RL, Chudy NE, Kiragu KR, McKnew M. Is advanced life support appropriate for victims of motor vehicle accidents: the South Carolina highway trauma project. *Journal of Trauma* 1998;**28**:563–70.
7. Honigman B, Rohweder K, Moore E, Lowenstein SR, Pons PT. Prehospital advanced trauma life support for penetrating cardiac wounds. *Annals of Emergency Medicine* 1990;**19**:145–50.
8. Trunkey DD. Is ALS necessary for pre-hospital trauma care? *Journal of Trauma* 1984;**24**:86–7.
9. Hedges JR, Sacco WJ, Champion HR. An analysis of pre-hospital care of blunt trauma. *Journal of Trauma* 1982;**22**:989–93.
10. Snooks HA, Nicholl JP, Brazier JE, Lees-Mlanga S. The costs and benefits of helicopter emergency ambulance services in England and Wales. *Journal of Public Health Medicine* 1996;**18**:67–77.
11. Jacobs LM, Sinclair A, Beiser A, D'Agostino RB. Pre-hospital advanced life support: benefits in trauma. *Journal of Trauma* 1984;**24**:8–13.
12. Smith JP, Bodai BI, Hill AS, Frey CF. Pre-hospital stabilization of critically injured patients: a failed concept. *Journal of Trauma* 1985;**25**:65–70.
13. Bissell R. Eslinger D. Advanced life support literature review. The American Ambulance Association, National Study Center for Trauma and EMS. University of Maryland at Baltimore, USA, July 1995.
14. Wyatt J, Beard D, Gray A, Busuttil A, Robertson C. The time of death after trauma. *British Medical Journal* 1995;**310**:1502.
15. Wyatt J, McLeod L, Beard D, Busuttil A, *et al.* Timing of paediatric deaths after trauma. *British Medical Journal* 1997;**314**:868.
16. Yates DW, Woodford M, Hollis S. Preliminary analysis of the care of injured patients in 33 British hospitals: first report of the United Kingdom major trauma outcome study. *British Medical Journal* 1992;**305**:737–40.
17. Champion HR, Sacco WJ, Copes WS, Gann DS, Genarelli TA, Flannagan ME, *et al.* A revision of the trauma score. *Journal of Trauma* 1989;**209**:623–30.
18. Association for the advancement of automotive medicine. The abbreviated injury scale. 1990 revision. Des Plaines, USA.
19. Copes WS, Champion HR, Sacco WJ, Lawnick MM, Keast SI, Bain LW, *et al.* The injury severity score revisited. *Journal of Trauma* 1988;**28**:69–77.
20. Zoltie N, deDombal FT. The hit and miss of ISS and TRISS. *British Medical Journal* 1993;**307**:906–9.
21. Brazier JE, Harper R, Jones NMB, O'Cathain A, Thomas KJ, Usherwood T, Westlake L. Validating the SF-36 health survey questionnaire: new outcome measure for primary care. *British Medical Journal* 1992;**305**:160–4.
22. Hayes V, Morris J, Wolfe C, Morgan M. The SF-36 health survey questionnaire: is it suitable for use with older adults. *Age and Ageing* 1995;**24**:120–5.
23. Jenkinson C, Layte R, Wright L, Coulter A. The UK SF-36. An analysis and interpretation manual. Health Services Research Unit, University of Oxford, Oxford. March 1996.
24. Spence MT, Redmond AD, Edwards JD. Trauma audit – the use of TRISS. *Health Trends* 1988;**20**:94–7.
25. Nicholl JP, Turner J, Dixon S. The cost-effectiveness of the regional trauma system in the North West Midlands. Medical Care Research Unit, University of Sheffield, 1995.
26. Bull JP, Dickson GR. Injury scoring by TRISS and ISS/age. *Injury* 1991;**21**:127–31.
27. Good P. Permutation tests:a practical guide to resampling methods for testing hypotheses. Berlin: Springer-Verlag, 1993.
28. Werman HA, Nelson RN, Campbell JE, Fowler RL, Gandy P. Basic trauma life support. *Annals of Emergency Medicine* 1987;**16**:79–82.

29. Powar M, Nguyen-van-Tam J, Pearson J, Dore A. Hidden impact of paramedic interventions. *Journal of Accident and Emergency Medicine* 1996;**13**:383–5.

30. Potter D, Goldstein G, Fung SC, Selig M. A controlled trial of pre-hospital advanced life support in trauma. *Annals of Emergency Medicine* 1988;**17**:55–61.

31. Nicholl JP, Brazier JE, Snooks HA. Effects of London helicopter emergency medical service on survival after trauma. *British Medical Journal* 1995;**311**:217–22.

32. Sampalis JS, Tamin H, Denis R, Boukas S, Ruest S-A, Nikolis A, *et al.* Ineffectiveness of on-site intravenous lines: is pre-hospital time the culprit? *Journal of Trauma* 1997;**43**:608–17.

33. Fleiss JL. Statistical methods for rates and proportions, 2nd edition. New York: Wiley, 1981.

34. Bull JP. The injury severity score of road traffic casualties in relation to mortality, time of death, hospital treatment time and disability. *Accident Analysis and Prevention* 1975;**7**:249–55.

35. Hussain LM, Redmond AD. Are pre-hospital deaths from accidental injury preventable? *British Medical Journal* 1994;**308**:1077–80.

36. Papadopoulos IN, Bukis D, Karalas E, Katsaragakis S, Stergiopoulos SP, *et al.* Preventable prehospital atrauma deaths in a Hellenic urban health region: an audit of prehospital trauma care. *Journal of Trauma* 1996;**41**:864–9.

37. Limb D, McGowan A, Fairfield JE, Pigott TJD. Prehospital deaths in the Yorkshire Health Region. *Journal of Accident and Emergency Medicine* 1996;**13**:248–50.

38. Papadimitriou DG, Mathur MN, Hill DA. A survey of rural road fatalities. Australia and New Zealand *Journal of Surgery* 1994;**64**:479–83.

39. Gordon MWG, Luke C, Robertson CE, Busuttil. An audit of trauma deaths occurring in the accident and emergency department. *Archives of Emergency Medicine* 1989;**6**:107–15.

40. Underhill TJ, Finlayson BJ. A review of trauma deaths in an accident and emergency department. *Archives of Emergency Medicine* 1989;**6**:90–6.

41. Bickell WH, Wall MJ, Pepe PE, Martin RR, Ginger VF, Allen MK, Mattox KL. Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. *New England Journal of Medicine* 1994;**331**:17.

42. Wilson DS, McElligott J, Fielding LP. Identification of preventable trauma deaths: confounded inquiries? *Journal of Trauma* 1992;**32**:45–51.

43. Salmi LR, Williams JI, Guibert R, *et al.* Preventable deaths and the evaluation of trauma programmes: flawed concepts and methods. Proceedings of the 30th Annual Meeting of the American Association of Automotive Medicine, Arlington Heights, III, 1986.

44. Netten A, Dennet J. Unit costs of health and social care 1997. Canterbury: University of Kent, 1997.

45. Knapp M, Forsythe M, Wall B. Costs and effectiveness of paramedic pre-hospital management of major trauma. London School of Economics, London, 1997.

46. Messick WJ, Rutledge R, Meyer AA. The Association of Advanced Life Support Training and decreased capita trauma death rates: an analysis of 12417 trauma deaths. *Journal of Trauma* 1992;**33**:850–5.

47. Sampalis JS, Lavoie A, Williams I, Mulder S, Kalina M. Impact of on-site care, prehospital time, and level of in-hospital care on survival in severely injured patients. *Journal of Trauma* 1993;**34**:252–61.

48. Aprahamian C, Thompson BM, Towne JD, Darin JC. The effects of a paramedic system on mortality of major open intra-abdominal vascular trauma. *Journal of Trauma* 1983;**23**:687–90.

49. Fortner GS, Oreskovich MR, Copass MK, Corrico CJ. The effects of prehospital trauma care on survival from a 50-metre fall. *Journal of Trauma* 1983;**23**:976–81.

50. Jacobs LM, Sinclair A, Beiser A, D'Agostino RO. Prehospital advanced life support: benefits in trauma. *Journal of Trauma* 1984;**24**:8–13.

51. Cayten CG, Murphy JG, Stahl W. Basic life support versus advanced life support for injured patients with an injury severity score of 10 or more. *Journal of Trauma* 1993;**35**:460–6.

52. Rainer TH, Houlihan KPG, Robertson CE, Beard D, Henry JM, Gordon MWG. An evaluation of paramedic activities in prehospital trauma care. *Injury* 1998;**28**:623–17.

53. Gold CR. Pre-hospital advanced life support vs 'scoop and run' in the management of trauma. *Annals of Emergency Medicine* 1987;**16**:797.

54. McNicholl BP. The golden hour and prehospital trauma care. *Injury* 1994;**25**:251.

55. Anderson IWR, Black RJ, Ledingham IMcA, Little K, Robertson CE, Urquhart JD. Early emergency care study: the potential and benefits of advanced prehospital care. *British Medical Journal* 1987;**294**:228.

56. Petri RW, Dyer A, Lumpkin J. The effect of prehospital transport time on the mortality from traumatic injury. *Prehospital Disaster Medicine* 1995;**10**:24.

57. Kaweski SM, Sise MJ, Vigilio RW. The effect of prehospital fluids on survival in trauma patients. *Journal of Trauma* 1990;**30**:1215.

58. Kowalenko T, Stern S, Dronen S, Wang X. Improved outcome with hypotensive resuscitation of uncontrolled shock in a swine model. *Journal of Trauma* 1992;**33**:2349.

59. Scheirout G, Roberts I. Crystalloid vs colloids in fluid resuscitation. Cochrane Library, issue 1, 1998.

60. Honigman B, Rohweder K, Moore EE, Lowenstein SR, Pons PT. Prehospital advanced trauma life support for penetrating cardiac wounds. *Annals of Emergency Medicine* 1990;**19**:145.

61. Gervin A, Fischer R. The importance of prompt transport in salvage of patients with penetrating hear wounds. *Journal of Trauma* 1982;**22**(6):443–8.

62. Lewis FR. Pre-hospital intravenous fluid therapy: physiologic computer modelling. *Journal of Trauma* 1986;**26**:804–11.

63. Wears RL, Winton CN. Load and go versus stay and play: analysis of pre-hospital IV fluid therapy by computer simulation. *Annals of Emergency Medicine* 1990;**19**:163–8.

64. O'Gorman M, Trabulsy P, Pilcher DB. Zero-time pre-hospital IV. *Journal of Trauma* 1989;**29**:84–6.

Health Technology Assessment panel membership

This report was identified as a priority by the Acute Sector Panel.

continued

continued

Pharmaceutical Panel

Chair: Professor Tom Walley, University of Liverpool †

Professor Michael Rawlins, University of Newcastle-upon-Tyne*

Dr Colin Bradley, University of Birmingham

Professor Alasdair Breckenridge, RDRD, Northwest Regional Health Authority

Ms Christine Clark, Hope Hospital, Salford †

Mrs Julie Dent, Ealing, Hammersmith & Hounslow Health Authority, London

Mr Barrie Dowdeswell, Royal Victoria Infirmary, Newcastle-upon-Tyne

Dr Tim Elliott, Department of Health †

Dr Desmond Fitzgerald, Mere, Bucklow Hill, Cheshire

Dr Felicity Gabbay, Transcrip Ltd †

Dr Alistair Gray, Health Economics Research Unit, University of Oxford †

Professor Keith Gull, University of Manchester

Dr Keith Jones, Medicines Control Agency

Professor Trevor Jones, ABPI, London †

Ms Sally Knight, Lister Hospital, Stevenage †

Dr Andrew Mortimore, Southampton & SW Hants Health Authority †

Mr Nigel Offen, Essex Rivers Healthcare, Colchester †

Dr John Posnett, University of York

Mrs Marianne Rigge, The College of Health, London †

Mr Simon Robbins, Camden & Islington Health Authority, London †

Dr Frances Rotblat, Medicines Control Agency †

Mrs Katrina Simister, Liverpool Health Authority †

Dr Ross Taylor, University of Aberdeen †

Dr Tim van Zwanenberg, Northern Regional Health Authority

Dr Kent Woods, RDRD, Trent RO, Sheffield †

Population Screening Panel

Chair: Professor Sir John Grimley Evans, Radcliffe Infirmary, Oxford †

Dr Sheila Adam, Department of Health*

Ms Stella Burnside, Altnagelvin Hospitals Trust, Londonderry †

Dr Carol Dezateux, Institute of Child Health, London †

Dr Anne Dixon Brown, NHS Executive, Anglia & Oxford †

Professor Dian Donnai, St Mary's Hospital, Manchester †

Dr Tom Fahey, University of Bristol †

Mrs Gillian Fletcher, National Childbirth Trust †

Professor George Freeman, Charing Cross & Westminster Medical School, London

Dr Mike Gill, Brent & Harrow Health Authority †

Dr JA Muir Gray, RDRD, Anglia & Oxford RO †

Dr Anne Ludbrook, University of Aberdeen †

Professor Alexander Markham, St James's University Hospital, Leeds †

Professor Theresa Marteau, UMDS, London

Dr Ann McPherson, General Practitioner, Oxford †

Professor Catherine Peckham, Institute of Child Health, London

Dr Connie Smith, Parkside NHS Trust, London

Dr Sarah Stewart-Brown, University of Oxford †

Ms Polly Toynbee, Journalist †

Professor Nick Wald, University of London †

Professor Ciaran Woodman, Centre for Cancer Epidemiology, Manchester

Primary and Community Care Panel

Chair: Dr John Tripp, Royal Devon & Exeter Healthcare NHS Trust †

Professor Angela Coulter, King's Fund, London *

Professor Martin Roland, University of Manchester *

Dr Simon Allison, University of Nottingham

Mr Kevin Barton, East London & City Health Authority †

Professor John Bond, University of Newcastle-upon-Tyne †

Ms Judith Brodie, Age Concern, London †

Dr Nicky Cullum, University of York †

Professor Shah Ebrahim, Royal Free Hospital, London

Mr Andrew Farmer, Institute of Health Sciences, Oxford †

Ms Cathy Gritzner, The King's Fund †

Professor Andrew Haines, RDRD, North Thames Regional Health Authority

Dr Nicholas Hicks, Oxfordshire Health Authority †

Professor Richard Hobbs, University of Birmingham †

Professor Allen Hutchinson, University of Sheffield †

Mr Edward Jones, Rochdale FHSA

Professor Roger Jones, UMDS, London

Mr Lionel Joyce, Chief Executive, Newcastle City Health NHS Trust

Professor Martin Knapp, London School of Economics & Political Science

Dr Phillip Leech, Department of Health †

Professor Karen Luker, University of Liverpool

Professor David Mant, NHS Executive South & West †

Dr Fiona Moss, Thames Postgraduate Medical and Dental Education †

Professor Dianne Newham, King's College London

Professor Gillian Parker, University of Leicester †

Dr Robert Peveler, University of Southampton †

Dr Mary Renfrew, University of Oxford

Ms Hilary Scott, Tower Hamlets Healthcare NHS Trust, London †

* Previous Chair
† Current members

National Coordinating Centre for Health Technology Assessment, Advisory Group

Copies of this report can be obtained from:

The National Coordinating Centre for Health Technology Assessment,
Mailpoint 728, Boldrewood,
University of Southampton,
Southampton, SO16 7PX, UK.
Fax: +44 (0) 1703 595 639 Email: hta@soton.ac.uk
http://www.soton.ac.uk/~hta

ISSN 1366-5278