Transportation of emergency patients

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LEVEL OF EVIDENCE CONSIDERED IN TECHNICAL BRIEFS

Technical Briefs are rapidly produced assessments of the best available evidence for a topic of highly limited scope. They are less rigorous than systematic reviews. Best evidence is indicated by research designs which are least susceptible to bias according to the National Health and Medical Research Council’s (NHMRC) criteria (see Appendix 2). Where methodologically acceptable and applicable, appraised evidence is limited to systematic reviews, meta-analyses, evidence based clinical practice guidelines, health technology assessments and randomised controlled trials (RCTs). Where not available, poorer quality evidence may be considered.

CONFLICT OF INTEREST

None.
EXECUTIVE SUMMARY

**Aim**

This technical brief examined four questions:

1. In adults and children with a medical or trauma related emergency, does the presence of a medical doctor on emergency helicopter services improve health outcome when compared with transportation by emergency helicopter without a medical doctor?

2. In adults and children with a medical or trauma related emergency, does the presence of a medical doctor on a road ambulance service improve health outcome when compared with transportation by a road ambulance service without a medical doctor?

3. In adults and children with a medical or trauma related emergency, does the presence of a medical crew able to perform rapid sequence intubation and/or thoracostomy improve health outcome when compared with a medical crew unable to perform rapid sequence intubation and/or tube thoracostomy and/or thoracotomy?

4. In adults and children with a medical or trauma related emergency how does variation in the time from callout to arrival at a medical facility with definitive care influence health outcome?

There are two general strategies about pre-hospital transportation: “scoop and run” and “stay and treat”. Scoop and run consists of short times at the scene with the emphasis being to transport the patient to definitive care as quickly as possible. In contrast, stay and treat involves longer times at the scene in order to start the stabilisation process. The above questions were designed to help address the most appropriate transportation strategy.

**Data sources**

The literature was searched using the following bibliographic databases: Medline, Embase, Cinahl, Current Contents, Science Citation Index, and Social Science Citation Index. Review databases searched were the Cochrane Database of Systematic Reviews, the Database of Abstracts of Reviews of Effects, the NHS Economic Evaluation Database and the Health Technology Assessment Database. Relevant publications referenced in material obtained in the course of the project were also identified.

Searches were performed between 24 October and 7 November 2006, and were restricted to material in English published from 1980 onwards.

**Selection criteria**

The selection criteria varied by review question. Selection criteria for each question included:

- primary aim of the study was to evaluate the comparison of interest in each review question
- methods were clearly described
- studies had a relevant control group
- study population included trauma and/or medical emergencies
- minimum sample size of 50
- outcomes included death and days in hospital
- Non-English language articles and publications that had been superseded were excluded.

Criteria were also set for the intervention and comparator based on the review question of interest.
Data extraction

A single reviewer extracted data and appraised the selected studies. Summaries were presented in the form of evidence tables and full text.

Key results and conclusions

Key results were:

1. There was generally more support for the inclusion of doctors on helicopters in the seven studies appraised in this section. However, there were uncertainties due to study design issues (levels of evidence ranged between III-1 and III-3), lack of consideration about whether non-doctor groups can be trained to perform certain procedures that would improve patient outcome and whether there may be different clinical scenarios that would favour one crew mix over another.

2. Similar considerations applied in the studies examining the use of doctors on board road ambulances. There were four studies in this section with levels of evidence ranging between III-2 and III-3.

3. When considering the outcome in patients who were treated by crews able to perform rapid sequence intubation and/or thoracostomy with other crews who were not able to perform these procedures, the only studies identified that met the study eligibility criteria included doctors amongst those able to perform the procedures of interest. It was therefore not possible to form conclusions about the effectiveness of non-doctor crews able to perform the procedures of interest when compared with crews that included a doctor. There were five studies in this section with levels of evidence all being III-1 and III-3.

4. There was inconsistent data on the association between pre-hospital time and patient outcome. However, the general direction was to support improved outcome in association with shorter pre-hospital times. Two studies provided information to consider whether crew mix or rapid transport had a more significant bearing on outcome. The results were conflicting across these two studies. There were 21 studies in this section with levels of evidence ranging between III-1 and III-3.

5. Most of the studies included related to trauma rather than medical emergencies.

6. There was insufficient information to consider subgroups based on injury severity or age group.

While the balance of studies support improved outcome associated with doctors on board emergency transportation, the robustness of these studies and the areas of uncertainty that remain (see under research gaps) provide uncertainty about the best approach. The best study supported the use of doctors on board helicopters. The balance of studies supported improved outcome associated with shorter pre-hospital times. The studies identifying improved outcome frequently assessed the linear relationship between pre-hospital outcome and time, meaning that the focus was on any improvement in outcome rather than a set threshold of pre-hospital time to meet in order to achieve improved outcome.

Further research/reviews required

Some general areas of future research that would be helpful include:

1. Is there some form of interaction between pre-hospital time and pre-hospital crew that has impact on patient outcome? Linked to this is whether the same pre-hospital approach (time and crew) results in improved outcome in all emergency patients or whether the best approach is dependent on the clinical situation.

2. Given differences in procedures performed and clinical assessment processes adopted by doctors compared with non-doctor pre-hospital personnel, to what extent would enhanced procedure training for non-doctor groups be helpful?

3. There are cost differences between the “scoop and run” and “stay and treat” approaches, along with the crew mixes used that ideally should be examined in relation to cost effectiveness of different approaches. However, given current uncertainties in
effectiveness of the different strategies, incremental cost effectiveness can not be robustly examined at this time.
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ABBREVIATIONS

AIS  abbreviated injury scale
ALS  advanced life support
APACHE acute physiology and chronic health evaluation
ASCOT A severity characterisation of trauma
AUC  area under the curve
CI  confidence interval
CPR  cardiopulmonary resuscitation
DHB  District Health Board
ED  emergency department
GCS  Glasgow Coma Scale
HEMS  helicopter emergency medical service
ICU  intensive care unit
ISS  injury severity score
IV  intravenous
MECU  mobile emergency care unit
MI  myocardial infarction
MTOS  Major Trauma Outcome Study
NSW  New South Wales
OR  odds ratio
Ps  probability of survival
RTS  revised trauma score
TISS  Therapeutic Intervention Scoring System
TRISS Trauma and Injury Severity Score
TS  trauma score
UK  United Kingdom
USA  United States of America
BACKGROUND

This technical brief was requested by Paul Howard, DHB Funding and Performance Directorate, Ministry of Health, New Zealand Government.

International variation in approach to transporting emergency patients

Variations are seen in the approach to transportation of emergency patients internationally. Some use helicopters with doctors on board, others use helicopters that include nurses or paramedics. Some regions use road ambulance when others would use helicopters and some have used a combination of helicopters supported by ground services (Frankema et al. 2004). At longer distances, there is also variation between fixed wing and rotary wing aircraft. The most appropriate approaches are controversial, particularly in relation to:

1. Staffing of emergency helicopter services
2. Road versus air ambulance transportation.

There is also debate about time spent on the trauma scene (Feero et al. 1995; Sampalis et al. 1993), with Europe tending towards placing more importance on field stabilisation while the North American philosophy tends to be that field stabilisation only contributes to reducing mortality if on-scene time is not prolonged or if the patient would die without immediate intervention (Osterwalder 2002). In some regions, such as Europe and Quebec, field stabilisation is usually achieved by physicians whereas in others paramedics with access to voice control by physicians are used in the field (Sampalis et al. 1993).

The optimal staffing for helicopter transport is controversial (Bartolacci et al. 1998; Cameron 1999) (Cameron and Zalstein 1998; Gisvold 2002; Rhee et al. 1986). Proponents of the inclusion of a physician on helicopter transport suggest improved outcomes can be expected from improved assessment and better use of advanced life support (ALS) skills (Rhee et al. 1986). However, the major advantage from the use of helicopters may be a result of speed (Matsumoto et al. 2006). Under those circumstances, the use of a limited range of ALS skills would be more appropriate, thus obviating the need for physician skills. Some suggest ALS may be more beneficial in certain circumstances, such as blunt trauma (Cameron 1999).

A range of studies exist that compare road with air ambulance. These studies reflect ongoing controversy about the most appropriate use of these two forms of transport (Cameron and Zalstein 1998; Kerr et al. 1999; Nicholl et al. 1995; Thomas et al. 2002).

In the UK the first helicopter ambulance service started in 1987. Since that time air ambulance services operating in the UK have expanded and, interestingly, bear little resemblance to one another, further emphasising the uncertainty about the most appropriate transportation methods in different circumstances. A study set in London reported crew arrangements at the time. The service, which operated from Royal London Hospital, was crewed by two pilots, a registrar and a paramedic (Nicholl et al. 1995). In another study, set in Italy, the helicopter was crewed by an anaesthetist, registered nurse with ICU or pre-hospital emergency experience, a flight co-ordinator with the same skills as the registered nurse and the pilot (Sanson et al. 1999). A national air ambulance service implemented in Norway in 1988 also included anaesthetists on all helicopter services (Nielsen et al. 2002). A study set in Michigan used helicopters crewed by a pilot, flight nurse (with emergency of intensive care experience) and a physician (resident or fellow), (Rhee et al. 1986). Japan has recently started using helicopters with physicians on board to transport emergency patients (Matsumoto et al. 2006).

Some air ambulance services are developed to overcome issues of remoteness. For example, an emergency medical retrieval service was set up in the Argyll and Clyde Health Board, Scotland to support rural community hospitals in the area (Corfield et al. 2006). Transferring patients via helicopter resulted in highly significant differences in transfer times when compared with road/ferry combinations in the regions covered by this service.
Procedures performed by different groups of transport staff

Procedures performed by different groups vary by region. For example, paramedics in New South Wales intubate without paralysis or sedation. Therefore, only unconscious patients could be intubated. In other regions, paramedics can use paralysing agents and sedation (Garner et al. 1999; Murphy-Macabobby et al. 1992). In Quebec, emergency medical technicians are prohibited from performing any invasive procedures or administering medications. Physicians are dispatched to the trauma scene based on severity of the trauma. Only physicians can intubate, insert intravenous (IV) lines, and administer IV fluids and medications. Emergency technicians are restricted to basic life support procedures including extrication, wound dressing, head and spine immobilisation, oxygen administration, fracture splinting and cardiopulmonary resuscitation (CPR) (Sampalis et al. 1992).

Thoracostomy may be differentially performed by staff groups. There is some controversy concerning relative outcomes of thoracostomy pre-hospital versus in the emergency department setting. Spanjersberg et al. (2005) compared thoracostomies in these two settings and found no difference in complication rates between the two groups.

Intubation frequency and difficulty in the pre-hospital setting has been examined. A study set in the USA found there were 11,951 intubations from 1,544,791 patient care reports (0.77%), (Wang et al. 2005). In a study set in Germany, pre-hospital intubation was performed in 342 of 3669 (9.3%) patients treated by helicopter emergency medical service (HEMS), (Helm et al. 2006). The first attempt was successful in 87.4% of the 342 intubations.

Some studies have raised uncertainties about the use of IV fluids pre-hospital. For example, Sampalis et al. (1997) found that IV fluid replacement was associated with an increase in mortality risk and this association was exacerbated by increased pre-hospital times. A health technology assessment of the issue found no evidence that pre-hospital IV fluid resuscitation was beneficial and some evidence was identified that it may be harmful. However, they commented that this evidence was not conclusive (Dretzke et al. 2004).

Further differences in procedures performed are documented in the studies selected for appraisal in this review.

Dispatch strategies

Dispatch strategies vary internationally and within countries (Garner et al. 1999). In some countries (and studies) there is no consistency in approach between systems. For example, a study comparing a physician with a paramedic crew appeared to use the physician crew on a selective basis (Garner et al. 1999), making interpretation of the study results difficult.

Some have stated that helicopters have a role in transporting critically ill trauma patients over distances greater than 50 km or 30 minutes by road (Cameron and Zalstein 1998; Garner et al. 1999; Ministerial Taskforce on Trauma and Emergency Services 1999).

The following section provides examples of selected dispatch strategies to illustrate the variation in approaches.

The dispatch of CareFlight, a medically staffed helicopter service operating in New South Wales (NSW), is at the discretion of the NSW Ambulance Service. Dispatch is based on injury severity, entrapment, remote location or difficult hoist (needing a rescue hoist for extraction), (Bartolacci et al. 1998).

In Rotterdam, the following criteria are used for the primary deployment of a helicopter transported medical team for trauma patients (Frankema et al. 2004):
- place difficult to reach for ambulances
- in the professional opinion of the dispatcher, the helicopter service provides additional value
- motor vehicle crashes with estimated speed > 30 km/hr
Transportation of emergency patients

- frontal collisions outside the built up area of town
- fall from > 6 metres or third floor
- entrapment in vehicle
- death of other occupant
- ejected from vehicle
- explosions
- near drowning or diving accidents
- exposure to toxic chemicals
- inhalation trauma or severe burns
- penetrating injuries to head, neck or trunk
- pelvic, spinal or femur fracture
- comatose (Glasgow Coma Scale ≤ 8)
- systolic blood pressure < 95 mm Hg or pulse > 120 per min
- major estimated blood loss (> 1 litre)
- respiratory distress.

Some centres have a paramedic stationed in ambulance service control to help identify calls that would benefit from helicopter retrieval (Nicholl et al. 1995).

Golden hour

Trunkey classified deaths as immediate, early and late. Immediate deaths were defined as occurring instantaneously or within one hour of the time of injury. Such deaths resulted from severe injuries to the brain, major blood vessels, heart or spinal cord. Early deaths were defined as occurring between one hour and one week following injury. These deaths resulted from major haemorrhage, multiple brain injuries and severe brain damage. These injuries should not result in death if definitive care can be given within one hour (the golden hour) of the time of injury. Late deaths occur more than one week after injury and result from later complications or infections (Trunkey 1983). The data used to support this classification was largely based on wartime findings. There is debate whether the golden hour applies to civilian settings (Lerner and Moscati 2001).

Definitions related to transportation times

There are five phases in the transportation of emergency patients to the emergency department:

1. Activation.
2. Dispatch.
3. Travel.
5. Travel.

Activation, dispatch and travel to the scene represent the response time. The retrieval time encompasses all five phases (Ministerial Taskforce on Trauma and Emergency Services 1999).

Traumatic versus non-traumatic medical emergencies

The scope of this review included both traumatic and non-traumatic medical emergencies. The studies examining the staff mix on helicopters tended to focus on study populations resulting from trauma as opposed to medical emergencies. Trauma patients are thought to be good subjects as the predicted mortality can be estimated objectively and compared with the actual mortality (Osterwalder 2003). The
great majority of studies eligible for the comparison of outcomes by pre-hospital time were also conducted in trauma populations. Reasons for this are explained in more detail in the relevant results section.

**Study types**

 Judgment of skills required for specific trauma incidents

In some studies the judgment and skills shown by physicians were used to evaluate their role on helicopter transport (Dalton et al. 1992; Rhee et al. 1986). These studies can be expected to be somewhat subjective and the added value proposed for physicians may be dependent on who is doing the evaluation. In some cases the added value of the physician may be underestimated and in others it may be overestimated, depending on the study design. It is difficult to extrapolate the findings of these studies to precise estimates of improvement in health outcome. If a delay in transportation to the base hospital occurs as a result of the physician involvement, this may adversely affect outcome and such factors are unlikely to be considered in this type of study. Therefore, this type of study was omitted from this review, in favour of studies that included relevant health outcomes. A variant on the above study design was also identified. In this design, records were retrospectively reviewed and classified into groups indicating whether a physician was required (Nielsen et al. 2002; Snow et al. 1986). Similar considerations apply to those outlined above, so these studies were also excluded. Gries et al. (2006) examined the frequency of defined procedures and conditions that may require physicians to adequately manage emergency situations. In this study it was estimated that patients with life threatening conditions such as acute coronary syndrome, stroke, head trauma, and multiple trauma only occurred once every 0.4-14.5 months and CPR and intubation was carried out once every 0.5-1.5 months. The ranges represent time periods before encountering each specific outcome across both helicopter and ground transportation. Chest tubes were inserted every six months to six years. This was in the context of a service with 82,002 scene calls registered for ground crews during a 54 month period and 47,184 calls for air rescue services over 24 months.

Scientific methods used to compare the predicted mortality with actual mortality

A common method used in the studies selected for this review made use of a comparison between predicted and actual mortality. Most of these studies made use of the Trauma and Injury Severity Score (TRISS). Another, less frequently used comparison was with the ASCOT (A Severity Characterization of Trauma) model. Both these approaches are detailed below.

Study methods involving the TRISS approach evolved for two reasons: understanding the limitations of a retrospective evaluation of helicopter use in relation to patient outcome and the practical difficulties associated with conducting a randomised controlled trial. TRISS incorporates physiologic (trauma score), anatomic (injury severity score) and age (55 years as cut-off) independent variables into a logistic regression model. Predicted mortality can then be compared with actual mortality (Boyd et al. 1987).

The trauma score (TS) includes five components:

1. Systolic blood pressure.
2. Capillary refill.
3. Respiratory rate.
4. Respiratory expansion.
5. Glasgow Coma Scale (GCS).

Boyd et al. (1987) considered the trauma score had a sensitivity of 80% (meaning 20% of patients with severe injury will not be identified with this score) and specificity of 75% (meaning overestimation of severity will occur when physiologic changes are related to factors other than the consequences of hypovolaemia, cerebral oedema or hypoxia). The predictive value is greatly improved when combined with an injury severity score (ISS).

The ISS is based on the abbreviated injury scale (AIS). It was first proposed by Baker et al. (1974) as a method of using the AIS but adjusting for multiple injuries. The AIS is a list of several hundred injuries...
each with a score that can range from 1 (minor injuries) to 6 (nearly always fatal). The ISS takes values from 1-75. If the patient has any AIS 6 injury, the ISS score is automatically 75. Otherwise, the highest AIS severity score in each of six body regions is identified, and the squares of the largest three are added to obtain the ISS.

Age greater than 55 years was shown to be associated with significantly increased mortality given comparable levels of physiologic derangement and anatomic injury severity in the Major Trauma Outcome Study (MTOS), (Boyd et al. 1987).

The probability of survival can be estimated from:

\[ P_s = \frac{1}{1 + e^{-b}} \]

Where \( b = b_0 + b_1(TS) + b_2(ISS) + b_3(A) \).

\( b_0, b_1, b_2, b_3 \) are regression coefficients that were initially derived from the patients included in the MTOS. As improvements in trauma care result in decreased mortality, these MTOS coefficients can be expected to change. Different sets of coefficients are used for blunt and penetrating trauma.

A revised trauma score (RTS) evolved out of a critical analysis of patients whose outcome was not predicted by the TRISS methods. Three parameters were used: GCS, systolic blood pressure and respiratory rate. When using the RTS the coefficients are different from those originally proposed. The RTS classification rather than the TS classification was used in the MTOS results published in 1990 (Champion et al. 1990b). The MTOS norms were obtained for adults (15+ years) with either blunt injuries (n=15,754) or penetrating injuries (n=7,423).

Various statistics are calculated using the TRISS methodology. The Z statistic compares outcome in two population subsets (Flora 1978). It quantitates the difference in the actual number of deaths in the test subset with the predicted number of deaths. Z values can be affected by the injury severity match between the study and baseline patient sets. The M statistic is a measure of that match. Values for M range from zero to one. The closer the value is to one, the better is the match of injury severity. Z values associated with lower values of M (< 0.88) should be viewed with sceptism.

Younge et al. (1997) discussed the use of the W statistic in order to compare trauma survival rates between different institutions and reference databases hampered by different injury severity mixes. The W statistic estimates excess survivors per 100 patients that would be achieved if the study centre treated patients with the same distribution of injury severity as the reference database (e.g. MTOS). It represents the number of excess survivors per 100 patients attending a particular centre that would be achieved if that centre received patients with the same distribution of injury severity as the reference database. The standardising process places undue emphasis on patients with a good probability of survival. In lower strata of survival, which are based on smaller patient numbers in the reference database, the linear regression model over-predicts survival. Overall, the TRISS model tends to over-predict survival when using the MTOS database, meaning the performance of individual centres with a poor prognosis casemix will appear to be poor. This problem is reduced if the W statistic for each probability of survival interval at the study centre is compared with the W statistic for the equivalent interval in the reference database.

As a general comment, the analytic complexity of TRISS based studies is one aspect that lacks appeal to a wide readership. Stratification by severity marker is a method of overcoming this limitation but requires large patient numbers to achieve adequate study power. Other limitations include:

- unmeasured factors (e.g. pre-existing medical conditions, mixture of injury types, injury mechanism, time between injury and assessment of RTS) may account for differences between predicted and actual outcome
- distribution of probability of survival (Ps) may differ within comparative Ps intervals
- choosing different Ps intervals may alter the result.

The MTOS was a retrospective study of injury severity that initially aimed to develop national norms for trauma care that could be used for quality assurance. The study was co-ordinated through the
American College of Surgeons’ Committee on Trauma and data collection started in 1982. Over 140 hospitals from the USA, Canada, Australia and the UK submitted demographic, aetiologic, injury severity and outcome data. At the time of publishing results in 1990 more than 120,000 trauma patients had been treated at the participating hospitals, including 80,544 trauma patients from 139 USA and Canadian institutions for the period October 1982-1987. These 80,544 patients were the focus of a publication by Champion et al. (1990b). It should be noted that MTOS was not population based, participation was voluntary, participating centres may have tended to have increased trauma care expertise and may have been biased towards more severe trauma.

The ASCOT model was developed by Champion et al. (1990a). This approach combines emergency department admission values of GCS, systolic blood pressure, respiratory rate, patient age and AIS anatomic injury scores in a way that was designed to overcome ISS shortcomings. In his original description, Champion et al. suggested, based on Hosmer-Lemeshow statistics, that ASCOT reliably predicted patient outcome in penetrating injuries and “nearly so” for blunt injured patients. He commented that statistically reliable predictions were not achieved by TRISS in either patient group.

Other more recent studies have compared TRISS, ASCOT and other models (Frankema et al. 2005; Gabbe et al. 2005). Gabbe et al. (2005), estimated the sensitivity, specificity and the area under the curve (AUC) of receiver operating characteristic curves (which is a discriminating estimate of measure performance). The sensitivity, specificity and AUC of TRISS were 19%, 98% and 0.87 respectively. Likewise, the sensitivity, specificity and AUC of ASCOT were 75%, 58% and 0.78 respectively. In contrast in Frankema et al. (2005), the AUC for TRISS was 0.940 and for ASCOT was 0.956. Thus, on the basis of these two studies, it was not clear which of the two measures were better. What is clear is that neither is perfect, indicating potential problems with the estimation of excess unexpected deaths and excess unexpected survivors in the studies that use this approach in this review.

Other measures have been used to compare severity of injury at baseline in some of the included studies. One measure was the APACHE (Acute physiology and chronic health evaluation) II score. Some studies have been conducted evaluating the performance of APACHE II. One study estimated an AUC in receiver operating characteristic curves with mortality as the outcome of interest of 0.84 (95% CI 0.83-0.85), (Suistomaa et al. 2002). Another study estimated an AUC of 0.787 and also noted there were significant differences between observed and predicted mortality \( (p<0.001) \), (Moreno and Morais 1997). Vassar et al. (1999) compared TRISS, APACHE II and APACHE III. TRISS and APACHE were described as having poor performance characteristics. In relation to predicting mortality both had poor goodness of fit characteristics (Hosmer-Lemeshow testing). The AUC for APACHE II was 0.87 and for TRISS was 0.82. APACHE had better goodness of fit characteristics and the AUC was 0.89. Similar performance characteristics for APACHE II were found by Muckart et al. (1997). In this study, goodness of fit was poor compared with a new model the authors developed. The AUC for APACHE II was 0.78.

**Stratified/multivariate studies**

As previously mentioned, there are drawbacks to studies comparing predicted with actual mortality. One method that has been used to overcome some of these limitations is stratification by severity marker. However, this design requires large sample sizes. Multivariate analysis can help with this.

**Scope of evaluation**

The scope of the systematic review included two broad areas:

1. The usefulness of including medical doctors on emergency transportation.
2. Ideal times between receipt of call out and delivery to base hospital for emergency patients.

The second aspect of the scope was designed to assist with the process of determining the most appropriate form of transport (air or road ambulance) in different locations of New Zealand. The literature was restricted to 1980 onwards.
**Review Questions**

**Question 1**

In adults and children with a medical or trauma related emergency, does the presence of a medical doctor on emergency helicopter services improve health outcome when compared with transportation by emergency helicopter without a medical doctor? The health outcomes of interest are death in-transit and in-hospital and time to hospital discharge to the community.

Explanatory notes:
1. The cut off between childhood and adulthood was 16 years.
2. Neonates were excluded.
3. An inpatient stay in a local secondary hospital after discharge from the “definitive care” hospital was included in ‘length of stay’ where possible.

**Question 2**

In adults and children with a medical or trauma related emergency, does the presence of a medical doctor on a road ambulance service improve health outcome when compared with transportation by a road ambulance service without a medical doctor? The health outcomes of interest are death in-transit and in-hospital and time to hospital discharge to the community.

Explanatory notes:
1. The cut off between childhood and adulthood was 16 years.
2. Neonates were excluded.
3. An inpatient stay in a local secondary hospital after discharge from the “definitive care” hospital was included in ‘length of stay’ where possible.

**Question 3**

In adults and children with a medical or trauma related emergency, does the presence of a medical crew able to perform rapid sequence intubation and/or thoracostomy improve health outcome when compared with a medical crew unable to perform rapid sequence intubation and/or tube thoracostomy and/or thoracotomy? The health outcomes of interest are death in-transit and in-hospital and time to hospital discharge to the community.

Explanatory notes:
1. The cut off between childhood and adulthood was 16 years.
2. Neonates were excluded.
3. An inpatient stay in a local secondary hospital after discharge from the “definitive care” hospital was included in ‘length of stay’ where possible.

**Question 4**

In adults and children with a medical or trauma related emergency how does variation in the time from callout to arrival at a medical facility with definitive care influence health outcome? The health outcomes of interest are death in-transit and in-hospital and time to hospital discharge to the community.
Explanatory notes:

1. The cut off between childhood and adulthood was 16 years.
2. Neonates were excluded.
3. An inpatient stay in a local secondary hospital after discharge from the “definitive care” hospital was included in “length of stay” where possible.

**SELECTION CRITERIA**

**Question 1**

The selection criteria for question 1 are set out in Table 1.

**Table 1. Inclusion/exclusion criteria for the effectiveness of including medical doctors on emergency helicopter transportation**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inclusion criteria</strong></td>
<td></td>
</tr>
<tr>
<td>Aim</td>
<td>A primary aim of the study was to evaluate the effectiveness of including medical doctors on emergency helicopter transportation</td>
</tr>
<tr>
<td>Methods</td>
<td>The methods were clearly described</td>
</tr>
<tr>
<td>Publication type</td>
<td>Randomised controlled trials, cohort studies, case control studies, interrupted time series and systematic reviews of the above publication types</td>
</tr>
<tr>
<td>Population</td>
<td>Adults or children (excluding neonates) who present to the emergency department after helicopter transportation Medical emergencies or trauma related health emergencies will be included</td>
</tr>
<tr>
<td>Sample size</td>
<td>At least 50 human patients</td>
</tr>
<tr>
<td>Intervention/test</td>
<td>Inclusion of a medical doctor on the helicopter transporting the emergency patient</td>
</tr>
<tr>
<td>Comparator</td>
<td>The absence of a medical doctor for the helicopter transporting the emergency patient</td>
</tr>
<tr>
<td>Outcome</td>
<td>Death: in transit, death in hospital, days to hospital discharge</td>
</tr>
<tr>
<td><strong>Exclusion criteria</strong></td>
<td></td>
</tr>
<tr>
<td>Publication type</td>
<td>Non-systematic reviews, case series, letters, editorials, expert opinion articles, conference proceedings, comments and articles published in abstract form.</td>
</tr>
<tr>
<td>Population</td>
<td>Restriction to publication of incidents during transportation</td>
</tr>
<tr>
<td>Comparator</td>
<td>Expected outcome based on expert panel</td>
</tr>
<tr>
<td>Publication superseded</td>
<td>Publication superseded by a later publication with longer follow-up data and overlap in the patient population</td>
</tr>
<tr>
<td>Language</td>
<td>Non-English language articles will be excluded</td>
</tr>
</tbody>
</table>
**Question 2**

The selection criteria for question 2 are set out in Table 2.

**Table 2. Inclusion/exclusion criteria for the effectiveness of including medical doctors on road ambulances**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inclusion criteria</strong></td>
<td></td>
</tr>
<tr>
<td>Aim</td>
<td>A primary aim of the study was to evaluate the effectiveness of including medical doctors on road ambulances</td>
</tr>
<tr>
<td>Methods</td>
<td>The methods were clearly described</td>
</tr>
<tr>
<td>Publication type</td>
<td>Randomised controlled trials, pseudorandomised controlled trials, cohort studies, case control studies, interrupted time series and systematic reviews of the above publication types</td>
</tr>
<tr>
<td>Population</td>
<td>Adults or children (excluding neonates) who present to the emergency department after road ambulance transportation. Medical emergencies or trauma related health emergencies will be included</td>
</tr>
<tr>
<td>Sample size</td>
<td>At least 50 human patients</td>
</tr>
<tr>
<td>Intervention/test</td>
<td>Inclusion of a medical doctor on the road ambulance transporting the emergency patient</td>
</tr>
<tr>
<td>Comparator</td>
<td>The absence of a medical doctor on the road ambulance transporting the emergency patient</td>
</tr>
<tr>
<td>Outcome</td>
<td>Death: in transit, death in hospital, days to hospital discharge to community</td>
</tr>
<tr>
<td><strong>Exclusion criteria</strong></td>
<td></td>
</tr>
<tr>
<td>Publication type</td>
<td>Non-systematic reviews, case series, letters, editorials, expert opinion articles, conference proceedings, comments and articles published in abstract form.</td>
</tr>
<tr>
<td>Population</td>
<td>Restriction to publication of incidents during transportation</td>
</tr>
<tr>
<td>Comparator</td>
<td>Expected outcome based on expert panel</td>
</tr>
<tr>
<td>Publication superseded</td>
<td>Publication superseded by a later publication with longer follow-up data and overlap in the patient population</td>
</tr>
<tr>
<td>Language</td>
<td>Non-English language articles will be excluded</td>
</tr>
</tbody>
</table>
**Question 3**

The selection criteria for question 3 are set out in **Table 3**.

**Table 3. Inclusion/exclusion criteria for the effectiveness of including a crew able to perform rapid sequence intubation and/or thoracostomy on pre-hospital emergency transportation**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inclusion criteria</strong></td>
<td></td>
</tr>
<tr>
<td>Aim</td>
<td>A primary aim of the study was to evaluate the effectiveness of different crew configurations on health outcome</td>
</tr>
<tr>
<td>Methods</td>
<td>The methods were clearly described</td>
</tr>
<tr>
<td>Publication type</td>
<td>Randomised controlled trials, pseudorandomised controlled trials, cohort studies, case control studies, interrupted time series and systematic reviews of the above publication types</td>
</tr>
<tr>
<td>Population</td>
<td>Adults or children (excluding neonates) who present to the emergency department after emergency transportation</td>
</tr>
<tr>
<td></td>
<td>Medical emergencies or trauma related health emergencies will be included</td>
</tr>
<tr>
<td>Sample size</td>
<td>At least 50 human patients</td>
</tr>
<tr>
<td>Intervention/test</td>
<td>Inclusion of a crew able to perform rapid sequence intubation using muscle relaxants and/or tube thoracotomy and/or thoracotomy</td>
</tr>
<tr>
<td>Comparator</td>
<td>Inclusion of a crew unable to perform rapid sequence intubation and/or thoracostomy</td>
</tr>
<tr>
<td>Outcome</td>
<td>Death: in transit, death in hospital, days to hospital discharge to community</td>
</tr>
<tr>
<td><strong>Exclusion criteria</strong></td>
<td></td>
</tr>
<tr>
<td>Publication type</td>
<td>Non-systematic reviews, case series, letters, editorials, expert opinion articles, conference proceedings, comments and articles published in abstract form,</td>
</tr>
<tr>
<td>Population</td>
<td>Restriction to publication of incidents during transportation</td>
</tr>
<tr>
<td>Comparator</td>
<td>Expected outcome based on expert panel</td>
</tr>
<tr>
<td>Publication superseded</td>
<td>Publication superseded by a later publication with longer follow-up data and overlap in the patient population</td>
</tr>
<tr>
<td>Language</td>
<td>Non-English language articles will be excluded</td>
</tr>
</tbody>
</table>
**Question 4**

The selection criteria for question 4 are set out in Table 4.

**Table 4  Inclusion/exclusion criteria for the ideal time between call out and delivery of emergency patients to the emergency department**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inclusion criteria</strong></td>
<td></td>
</tr>
<tr>
<td>Aim</td>
<td>A primary aim of the study was to evaluate the effect of different transportation times (from call out to arrival at an emergency department) on health outcome</td>
</tr>
<tr>
<td>Methods</td>
<td>The methods were clearly described</td>
</tr>
<tr>
<td>Publication type</td>
<td>Study that includes a control group</td>
</tr>
<tr>
<td>Population</td>
<td>Adults or children (excluding neonates) who present to the emergency department after helicopter transportation Medical emergencies or trauma related health emergencies will be included</td>
</tr>
<tr>
<td>Sample size</td>
<td>At least 50 human patients</td>
</tr>
<tr>
<td>Comparison</td>
<td>Comparison of at least two different categories of time from call out to time of delivery of patients to the emergency department Comparison of different methods of transport that have different mean times of transport</td>
</tr>
<tr>
<td>Outcome</td>
<td>Death: in transit, death in hospital, days to hospital discharge</td>
</tr>
<tr>
<td><strong>Exclusion criteria</strong></td>
<td></td>
</tr>
<tr>
<td>Publication type</td>
<td>Non-systematic reviews, letters, editorials, expert opinion articles, conference proceedings, comments and articles published in abstract form</td>
</tr>
<tr>
<td>Publication superseded</td>
<td>Publication superseded by a later publication with longer follow-up data and overlap in the patient population</td>
</tr>
<tr>
<td>Language</td>
<td>Non-English language articles will be excluded</td>
</tr>
</tbody>
</table>

**MAIN SEARCH TERMS**

Details of the search strategies are presented in Appendix 1.

Medline Subject Headings (MeSH headings): air ambulances, aircraft, “personnel staffing and scheduling”, personnel selection, patient care team, physician’s role, exp physicians, allied health personnel, nurse’s role, nurses, manpower[as floated subheading], time facts, survival analysis, treatment outcome, patient discharge, length of stay, morbidity, mortality, “outcome assessment (health care)”, emergencies, exp emergency medical services, emergency service-hospital, transportation of patients, ambulances

Additional keywords: helicopter$, medivac, medivac, casivac, casevac, evac, aeromedic$, air ambulanc$, flight ambulanc$, medical practitioner$, medic$, adj qualif$, paramedic$, medic, medics, flight nurse$, doctor$, staff$, physician$, personnel, time adj3 delay$, ((pre-hospital or, pre-hospital) adj (time or care or treatment)), ((call-out or callout) and (arrival or admit$ or hospital or medical
facility or definitive care or emergency department or ED), scene time, “out of hospital time”, transport adj time$, transfer$ adj time$, survival, outcome, golden hour, golden minute$

**SEARCH SOURCES**

**Bibliographic databases**

- Medline
- Embase
- Cinahl
- Current Contents
- Science/Social Science Citation Index
- PubMed (last 90 days)

**Review databases**

- Cochrane Database of Systematic Reviews
- Database of Abstracts of Reviews of Effectiveness (DARE)
- NHS Economic Evaluation Database
- Health Technology Assessment Database

Articles published in English language only were considered.

The search was restricted to literature published from 1980 onwards. Searching was undertaken between 24 October and 7 November, 2006.

**APPRAISAL METHODOLOGY**

Summaries of appraisal results are shown in tabular form (known as Evidence Tables) which detail study design, study setting, sample, methods, results, and reported conclusions.

The evidence presented in the selected studies were assessed and classified according to the NHMRC’s revised hierarchy of evidence (Appendix 2).
RESULTS

Doctor versus no doctor on board helicopter

From the search strategy for question one (comparing helicopter transportation with and without medical doctor staffing) we identified, 1068 potentially relevant articles/abstracts of which 58 were retrieved. Of these retrieved articles, 51 were excluded. These excluded papers are presented in Appendix 3. Two additional articles were identified from reference lists. Both these studies were excluded: one was not relevant to the review question and the other used an incorrect comparator. Reasons for exclusion of studies before retrieval in full text are outlined in Table 5. Reasons for exclusion of studies retrieved in full text are detailed in Table 6.

Table 5 Reasons for exclusion of studies before retrieval in full text: doctor versus no doctor on board helicopter

<table>
<thead>
<tr>
<th>Reason for exclusion</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not relevant to review question aim</td>
<td>894</td>
</tr>
<tr>
<td>Methods were not clearly described</td>
<td>0</td>
</tr>
<tr>
<td>Wrong publication type</td>
<td>98</td>
</tr>
<tr>
<td>Incorrect population</td>
<td>1</td>
</tr>
<tr>
<td>Sample size less than 50</td>
<td>4</td>
</tr>
<tr>
<td>Incorrect comparator</td>
<td>7</td>
</tr>
<tr>
<td>Incorrect outcomes</td>
<td>3</td>
</tr>
<tr>
<td>Publication superseded</td>
<td>0</td>
</tr>
<tr>
<td>Non-English language</td>
<td>0</td>
</tr>
<tr>
<td>Neonatal study</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>1010</td>
</tr>
</tbody>
</table>

Table 6 Reasons for exclusion of studies retrieved in full text: doctor versus no doctor on board helicopter

<table>
<thead>
<tr>
<th>Reason for exclusion</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not relevant to review question aim</td>
<td>16</td>
</tr>
<tr>
<td>Methods were not clearly described</td>
<td>2</td>
</tr>
<tr>
<td>Wrong publication type</td>
<td>18</td>
</tr>
<tr>
<td>Incorrect population</td>
<td>1</td>
</tr>
<tr>
<td>Sample size less than 50</td>
<td>0</td>
</tr>
<tr>
<td>Incorrect intervention group</td>
<td>3</td>
</tr>
<tr>
<td>Incorrect comparator</td>
<td>6</td>
</tr>
<tr>
<td>Incorrect outcomes</td>
<td>3</td>
</tr>
<tr>
<td>Publication superseded</td>
<td>0</td>
</tr>
<tr>
<td>Non-English language</td>
<td>0</td>
</tr>
<tr>
<td>Neonatal study</td>
<td>0</td>
</tr>
<tr>
<td>Patient transfer</td>
<td>1</td>
</tr>
<tr>
<td>Article unable to be obtained</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
</tr>
</tbody>
</table>

Seven retrieved articles were appraised and are listed in the references and Appendix 7. Included papers are presented in the evidence table below. Included studies ranged from level III-1 to III-3 and above according to NHMRC’s hierarchy of evidence, including one pseudorandomised controlled trial, four cohort studies and two before and after studies. Evidence tables for the included studies are found at the end of this section (Table 7). Two of the seven studies were of marginal relevance given the high proportion of patients transferred from a hospital rather than the scene (Burney et al. 1992; Burney et al. 1995). These are presented separately from the remaining five studies.
Baxt et al. (1987) conducted a pseudorandomised controlled trial (Level III-1 evidence) comparing mortality in a group of consecutive patients with blunt trauma transported by helicopter with physician and nurse on board with another group with paramedic and nurse on board. There were 574 participants (316 in the physician group and 258 in the comparator group). Actual mortality was compared with predicted mortality using TRISS methodology. The trauma score scale rather than the revised trauma score scale was included in this calculation. Differences in procedures that the different groups could perform were noted and are detailed in Table 7. Actual mortality was not statistically significantly different from predicted mortality in the paramedic group while, in the physician group, actual mortality was significantly lower than predicted ($P<0.05$). There was a statistically significant difference in the $Z$ statistic between the two groups, supporting reduced mortality in the physician group compared with the paramedic group.

There were potential sources of confounding and bias that should be considered when interpreting this study. Key issues included:

- the study was not truly randomised so is susceptible to confounding. However, significant baseline differences were not observed for transport time, trauma score, ISS, GCS, predicted survival or patient age.
- the key difference between the groups related to the category of patients who survived but were expected to die. There were only 22 patients who were expected to die in the physician group (five survived) and 16 who were expected to die in the paramedic group (none survived).
- the TRISS methodology used in this review did not assess the degree of match in injury severity between the two groups, or adjust for different casemix in the study groups.
- the study did not use all-cause mortality as the outcome (the focus was on mortality due to trauma), resulting in the potential for misclassification of outcome.

Despite the limitations this was the strongest study considering the effectiveness of including doctors on board helicopters.

Garner (2004) noted that the non-doctor team in this study was “considerably more procedurally capable than most Australian paramedics” and observed that despite this, a better outcome was observed in the physician treatment group.

Hamman et al. (1991) conducted a before and after study (Level III-3 evidence) comparing mortality in a group of consecutive patients transported by helicopter crewed by physician and nurse (before phase) with another group crewed by paramedic and nurse or two nurses (after phase). There were 145 in the physician group and 114 in the non-physician group. Actual mortality was compared with predicted mortality using TRISS methodology. Differences in procedures that the different groups could perform were noted and are detailed in Table 7. Comparison of actual with predicted mortality showed a lower than predicted mortality in both groups. However, there was no overall difference in patient outcomes between the two groups.

Despite the above results, this study should be viewed cautiously, given a number of significant limitations:

- before and after design is a weak method as factors other than the factor of interest may contribute to the estimated measure of effect
- the study lacked power to detect a difference between the two groups as there were only 32 patients in total who were expected to die based on estimates of the probability of survival
- comparison of injury severity between the two groups is consistent with a poor match in severity between the groups ($M$ statistic 0.87)
- lack of documentation about the timing of deaths and timing of estimation of RTS added to difficulties interpreting the results.
Schmidt et al. 1992

Schmidt et al. (1992) reported on a registry based study (level III-2) that compared mortality in two centres with differing crew configurations on their emergency helicopter services. In the German centre a trauma surgeon was included on all flights, whereas in the USA centre the trauma surgeon was replaced with either a flight nurse or a paramedic. There were 221 participants in the setting with a surgeon and 186 in the setting without a surgeon. Actual mortality was compared with predicted mortality using TRISS methodology. Differences in procedures that the different groups could perform were noted and are detailed in Table 7. The Z statistic was calculated for the comparison between actual and predicted outcome at both centres. This statistic was consistent with improved survival compared with that predicted in the surgeon centre. This improvement was consistent with an additional 1.35 survivors per 100 patients when compared with the MTOS reference population. No such improvement was noted in the non-surgeon centre. However, there were reservations about the degree of match in injury severity between the actual data and the reference population in the non-surgeon setting. There were a lower proportion of deaths in the first six hours in the surgeon present setting.

There were limitations to this study:

- registry based study that resulted in the omission of 37 patients in the surgeon setting due to missing charts or data. This is likely to have resulted in selection bias, in that it seems likely the excluded patients were not representative of the general population, given no deaths occurred amongst these 37 patients.
- the measurement of RTS, a key component of the projected survival populations, occurred at different times in the two centres. This results in variation in the accuracy of the comparison with the reference population, and therefore in the Z statistic.
- there was variation in key time intervals relating to transport. In particular, there was a significantly shorter time between the incident and arrival at the scene in the surgeon setting. This may have resulted in improved prognosis in this setting.
- management was more aggressive in the setting with a surgeon and this increased aggressiveness may have produced the more favourable results, rather than the presence of a surgeon per se. The procedures adopted that reflected this increased aggressiveness could be performed by flight nurses and paramedics as well as surgeons.

Garner et al. 1999

Garner et al. (1999) reported on a retrospective study set in Australia (level III-2). They compared the outcome (mortality) between groups transported via helicopter with a physician on board versus patients transported with a paramedic on board. All patients were transported directly from the scene to the relevant hospital (hospitals varied by the crew mix on the helicopter). There were 67 patients in the physician group and 140 in the paramedic group. The patients were restricted to those with blunt trauma and an ISS score greater than 10. Actual mortality was compared with predicted mortality using TRISS methodology (MTOS as the reference population) and the adjusted W statistic was also used to directly compare the physician and paramedic groups. The degree of match on injury severity between the MTOS population and the physician and paramedic groups was poor, therefore the adjusted W statistic was appropriately presented. When comparing the physician group with the MTOS population it was estimated that 9.48 (95% CI 3.84-15.12) extra lives per 100 population were saved in the physician group. There was no significant difference in mortality between the MTOS population and the physician and paramedic groups was poor, therefore the adjusted W statistic was appropriately presented. Direct comparison between the paramedic and physician groups suggested 13.44 (95% CI 7.80-19.08) extra lives per 100 population were saved in the physician group. There were differences in the procedures performed between the two groups. These are detailed in Table 7. In general, the physician group treated patients more aggressively and also conducted a number of rapid sequence intubations and tube thoracostomies (the paramedic group did not).
The study had limitations:

- it was a retrospective study
- there were sources of selection bias – with differences in baseline measures between the two study groups (the physician group appeared to manage a more severely injured group) and seven patients who died were excluded from the paramedic group due to missing case sheets
- confounding was a potential problem between the two groups although use of the \( W \) statistic should have partially controlled confounding (based on injury severity)
- the degree of match in injury severity with the MTOS study was poor and there were variations in methods adopted in the MTOS study and this study (most notably related to the timing of RTS measurement) which limits the usefulness of the MTOS cohort as a reference population.

Cameron et al. 2005

A retrospective chart review was conducted in Australia (Cameron et al. 2005). This study used a before and after design (Level III-3 evidence) to compare outcome in a period where helicopters included emergency physicians with a subsequent period where the helicopter did not include an emergency physician (intensive care paramedics were used). Given the nature of the data recorded measures of injury severity were restricted to the RTS. Chart abstraction was primarily performed by one person but a 10% sample was validated by another abstractor. There was an excellent level of agreement between the two abstractors. There were 163 patients in the physician group and 211 in the paramedic group. Mortality was measured at 30 days. There were 10 deaths in total and no significant difference was detected between the study groups. There was also no significant difference in the length of stay, although the mean length of stay was only two days and one day respectively in the physician and paramedic groups.

There were significant limitations to this study:

- the effects of a retrospective design were apparent. As the authors documented, they were unable to extract data that would have provided a better indication of injury/illness severity.
- there was no control over potential confounders. Given baseline differences suggestive of a more severe casemix in the physician group this may have led to bias in the comparison.
- the outcome of the group discharged from ED was not obtained.
- the study power was low, particularly for mortality, so the lack of a significant difference in outcome was not surprising.

Studies that included predominantly transfer patients

Burney et al. 1992

Burney et al. (1992) reported on a retrospective cohort study (Level III-2 evidence) that compared outcome following the helicopter transportation of patients by physician/nurse with nurse/nurse. Both groups were studied concurrently during 1987-1988. There were 659 participants (418 in the P/N team and 241 in the N/N team). Most of the transports originated in an emergency department (ED), followed by inpatient units with only 5.5% being from the scene. There was no overall difference in mortality or number of hospital days. No statistically significant differences in these outcomes were observed on subgroup analysis (by clinical category or point of origin of the transport). However, the latter analyses had low study power.

This study had a number of limitations:

- measures of injury severity were not typical of those used in the studies conducted to investigate this review question
- lack of documentation about the procedures available to the two groups, dispatch criteria for the two groups, and number of receiving hospitals involved
- there was variation in baseline characteristics between the two groups in the following variables: age, clinical category and origin of patient

- there was no adequate method of controlling for confounding used (the stratified analyses resulted in loss of study power)

- low proportion of participants were transported from the scene, thus having little relevance to the New Zealand setting.

Details of this study are provided in Table 7.

Burney et al. 1995

Burney et al. (1995) followed their retrospective cohort study with a prospective cohort study (Level III-2 evidence). The same study comparisons were made and the same data collection tools were used (although severity measures were measured more frequently). There were 255 patients in the P/N group and 914 in the N/N group. As previously, the proportion of transports originating from the scene was low (7.6%). There were differences in criteria for the selection of who was to attend the patient particularly in the second year of the study when the physician group attended patients with more complicated injuries. Overall, there was no significant difference in mortality between the two groups (25% in physician group, 21% in nurse group, \( P=0.12 \)). There was also no difference in the group transported from the scene (mortality of 16% in both groups). Duration of hospital days was assessed separately across each study year. The nurse group was associated with a significantly shorter stay in the second year but this wasn’t surprising given the more complex cases attended by the physician group in that study period.

This study had similar limitations to that conducted by Burney et al. in 1992, except it had the advantage of a prospective approach. If the study was to have 80% power to detect a 5% difference in mortality at the 5% significance level a sample of 2,000 patients would have been required (there were 1,169 patients). The increased complexity of the patients transported by physicians in the second year makes it very difficult to interpret the results of this study.
Table 7  Evidence tables of studies comparing the outcome or patients transported by helicopter with and without a medical doctor on board

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
</table>
| (Baxt and Moody 1987) USA | Pseudo-randomised controlled trial Level III-1 | Study setting. Consecutive patients with blunt trauma over a 24 month period. All patients were transported to the University of California, San Diego, Medical Trauma Center where they were cared for until discharge. | Incl/excl criteria. Patients with blunt trauma Excluded patients who did not have any resuscitative procedures in the field | Number of actual deaths by the number predicted to die (based on Ps ≤ 0.05) Paramedic group: Predicted = 19.5 Actual = 19 Zstatistic 0.208 (P>0.05) | • Not truly randomised: dispatch depended on rotation of calls or which helicopter was closer to the scene at time of dispatch. • Central communication did not appear to be available for either staff group. • The level of experience of both staff groups was unclear. • TRISS methodology included the trauma score (TS) rather than the revised trauma score (RTS). In later years the RTS score was considered to be more accurate than the TS score. Subsequent developments in TRISS methodology made use of the W statistic which allows an assessment of the severity of injury mix. The W statistic, which deals with different case mixes across samples. |}
| Comparator: Helicopter staffed by flight nurse and paramedic (n=396) Procedures: oral/nasal endotracheal intubation Needles/intravenous catheters Placement of chest tubes "Cricothyroidotomy placement* Expanded medications* Follow-up interval Minimum of six months Analysis Predicted mortality estimated using the TRISS methodology, utilising the most recent coefficients available at the time. Analytic methods included use of two tailed Student t test, Mantel-Haenszel test and the Zstatistic of comparison between predicted and actual survival. | | | Distribution of patients by probability of survival Expected to die but lived: Paramedic: 0 Physician: 5 Expected to live but died: Paramedic: 5 Physician: 3 Expected to die and died: Paramedic: 14 Physician: 8 | **Transportation of emergency patients** |

*P<0.05.
Table 7   Evidence tables of studies comparing the outcome or patients transported by helicopter with and without a medical doctor on board (continued)

<table>
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<tr>
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<tbody>
<tr>
<td>Baxt and Moody 1987</td>
<td>Analyses comparing groups at baseline.</td>
<td>Median probability of survival:</td>
<td>Blinded chart analysis assessing adherence to written medical treatment protocols.</td>
<td>Patients who survived: Paramedic group 18 of 239 patients with inconsistencies from the recommended protocols. Physician group: 2 of 305 patients with inconsistencies from the recommended protocols.</td>
</tr>
<tr>
<td>USA</td>
<td></td>
<td>Paramedic crew: 0.95-1.0</td>
<td></td>
<td>1. Patients who survived: Paramedic group 18 of 239 patients with inconsistencies from the recommended protocols. Physician group: 2 of 305 patients with inconsistencies from the recommended protocols.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Physician crew: 0.95-1.0</td>
<td></td>
<td>2. Patients who died: Paramedic group: 9 of 19 patients with inconsistencies from the recommended protocols. Physician group: 0 of 11 patients with inconsistencies from the recommended protocols.</td>
</tr>
<tr>
<td></td>
<td>Median Glasgow Coma Score of severely brain injured patients (GCS≤8)</td>
<td>Paramedic crew (n=44, 17% of total): 4</td>
<td></td>
<td>Note inconsistencies included failure to conduct the indicated procedure or medical procedure not followed.</td>
</tr>
<tr>
<td></td>
<td>Mean Trauma Score:</td>
<td>Physician crew (n=54, 17% of total): 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paramedic group: 14.2</td>
<td>Physician group: 14.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean Injury severity score:</td>
<td>Paramedic group: 13.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paramedic group: 13.9</td>
<td>Physician group: 13.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean predicted survival</td>
<td>Paramedic group: 0.924</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paramedic group: 0.947</td>
<td>Physician group: 0.924</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean age</td>
<td>Paramedic group: 27.6 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paramedic group: 27.8 years</td>
<td>Physician group: 27.6 years</td>
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<tr>
<td></td>
<td>Transport times:</td>
<td></td>
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<tr>
<td></td>
<td>Mean response time:</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Paramedic group: 15.5 minutes</td>
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<td></td>
<td>Physician group: 14.9 minutes</td>
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<td></td>
<td>Mean scene time:</td>
<td></td>
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<tr>
<td></td>
<td>Paramedic group: 18.6 minutes</td>
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<tr>
<td></td>
<td>Physician group: 19.1 minutes</td>
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<tr>
<td></td>
<td>Mean delivery time:</td>
<td></td>
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<tr>
<td></td>
<td>Paramedic group: 16.9 minutes</td>
<td></td>
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<tr>
<td></td>
<td>Physician group: 16.1 minutes</td>
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</tbody>
</table>

**Limitations and Conclusions**

- Potential for confounding, although baseline analyses indicate little difference in transport time, trauma score, injury severity score, GCS, predicted survival and patient age between groups.
- Key results are based on a small number of patients who survived but were expected to die (5 of 22 in the physician group and 0 of 16 in the paramedic group).
- Unclear if RTI was available to the comparator group.

**Comments**

- All patients attended a single trauma centre.
- The TRISS methodology was applied to the two study groups using data that were collected at the same time between the two groups.
- Used appropriate methodology to estimate injury severity.
- Three patients were excluded in each group due to the lack of resuscitative measures in the field.

Reported conclusions (by authors).
A statistically significant reduction in the mortality of patients with blunt trauma treated by a medical helicopter emergency care service staffed by a nurse/physician combination could be demonstrated compared with that staffed by a nurse/paramedic combination.

* Difference in procedures available to the two staffing groups

**Transportation of emergency patients**
Table 7  Evidence tables of studies comparing the outcome or patients transported by helicopter with and without a medical doctor on board (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
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</thead>
<tbody>
<tr>
<td>Hamman et al. 1991, USA</td>
<td>Before and after design, Level III-3.</td>
<td>Study setting: All patients transported from accident scene to Humana Hospital University in a 10 month period in 1985 (with physician) and compared with a group transported during a 10 month period in 1987 (without physician). Participants: Total sample 259 Intervention (n=114). Stopped the presence of a medical doctor on emergency helicopter (two nurses or nurse + paramedic present). Comparator (n=145). Medical doctor (Faculty member or a second or third year resident physician) present on helicopter (before phase of the study). Nurse also on board. Physicians able to perform the following additional procedures: cricothyroidotomies and tube thoracostomies. Both intervention and comparator groups intubated, obtained IV access, performed advanced CPR, placed pneumatic antishock garment, performed needle thoracostomy and pericardiocentesis, immobilised the neck, splinted fractures and dressed open wounds.</td>
<td>Inclusion criteria: Consecutive adults during the two study periods. Excluded patients with an initial and subsequently unchanged RTS of 0 and burn victims. Data collection: Distance transported, Time at scene, Procedures performed: RTS, ISS. Outcome measures: Mortality, Follow-up interval, Not stated. Analysis: Mean comparisons used either t^2, Behrens-Fisher t^2, or the Welch d^2 test to determine similarity. Regression constants were derived from PTSD. The Z and M statistics were calculated.</td>
<td>Number of actual deaths by the number predicted to die (based on: Ps &lt; 0.50)</td>
<td>Physician present group: Predicted: 17 Actual: 12 % reduction: 30 Z statistic: -2.03 Physician absent group: Predicted: 15 Actual: 8 % reduction: 47 Z statistic: -3.11 Frequency of potentially life threatening injuries not addressed before arrival at ED</td>
</tr>
</tbody>
</table>

Transportation of emergency patients
Table 7  Evidence tables of studies comparing the outcome or patients transported by helicopter with and without a medical doctor on board (continued)

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<tbody>
<tr>
<td>(Hamman et al. 1991) USA continued</td>
<td>Analyses comparing groups at baseline.</td>
<td>Average age (years):  Physician present: 34  Physician absent: 30  P &lt;0.05  Distance transported (miles):  Physician present: 21  Physician absent: 23  Initial trauma score  Physician present: 7  Physician absent: 7  Number of organs injured:  Physician present: 2  Physician absent: 2  ISS  Physician present: 15  Physician absent: 15  Time at scene (minutes):  Physician present: 15  Physician absent: 15  Number of scene procedures (% per attendance):  Physician present: 221  Physician absent: 256  Number of in-flight procedures (% per attendance):  Physician present: 8  Physician absent: 4</td>
<td>Comments  • All patients attended a single trauma centre.  • Central communication was not documented for either group.  • TRISS methodology appropriately used RTIS score.  • TRISS analysis appropriately included estimation of the M statistic.  • Used appropriate methodology to estimate injury severity.  Reported conclusions (by authors):  It appears that experienced nurses and paramedics, operating with well-established protocols, can provide aggressive care that yields equal outcome results compared with those of a flight team that includes a physician.</td>
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</table>
Table 7  Evidence tables of studies comparing the outcome of patients transported by helicopter with and without a medical doctor on board (continued)

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<tbody>
<tr>
<td>(Hamman et al. 1991)</td>
<td></td>
<td>Number of emergency room procedures (% per attendance)</td>
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<tr>
<td>USA</td>
<td></td>
<td>Physician present: 26</td>
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<tr>
<td></td>
<td></td>
<td>Physician absent: 20</td>
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<tr>
<td>continued</td>
<td></td>
<td>Blunt versus penetrating injuries (%)</td>
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<tr>
<td></td>
<td></td>
<td>Physician present: 95.5</td>
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<td></td>
<td></td>
<td>Physician absent: 93.7</td>
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### Table 7  Evidence tables of studies comparing the outcome or patients transported by helicopter with and without a medical doctor on board (continued)

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</table>
| (Schmidt et al. 1992) USA and Germany | Registry based study  | Two settings: USA and Germany. The USA setting consisted of helicopters crewed by flight nurse and paramedic. (July 1988-June 1989). The German setting consisted of helicopters crewed by trauma surgeon and paramedic. (November 1988-October 1989).  | Incl/excl criteria:  All patients with multiple injuries transported to the two respective trauma centres during a one year period. Patients were transported directly to the trauma centre rather than via an intermediate facility. Excluded patients with incomplete or missing charts.  | Number of actual deaths by the number predicted to die (based on:  
Ps ≤ 0.50)  
Surgeon group  
Z-statistic: +2.459  
P<0.025  
M-statistic: 0.89  
W-statistic indicates 1.35 additional survivors from 100 patients analysed, compared with the MTO5 population.  | Retrospective, registry based study.  
Excluded 37 patients from the German setting due to incomplete or missing charts. This is a likely source of selection bias given there were no deaths in this group.  
Variation in timing of RTS estimation will result in variation in the predicted survival in the two groups. Therefore, concerns exist about the direct comparability of patient survival data between the two groups.  
Unclear if there were differences in the duration of follow-up between study groups.  
High potential for confounding.  
Significantly shorter time from incident to launch in the surgeon group potentially improving prognosis.  
Significantly longer scene time in the surgeon group.  |
|                  | Study setting |                           |         |         |                             |
|                  | Level III-2. |                           |         |         |                             |
|                  | Participants | Total 407                 |         |         |                             |
|                  | Intervention (n=221) | German setting (with surgeon) |         |         |                             |
|                  | Comparator (n=186) | USA setting (without surgeon) |         |         |                             |
|                  | Pre-hospital ALS included | IV fluids, ET intubation, tube thoracostomy, needle decompression.  
High use of IV anaesthesia in Germany. |         |         |                             |

**Outcome measures**
- Mortality
- Follow-up interval
- Not stated
Table 7  Evidence tables of studies comparing the outcome of patients transported by helicopter with and without a medical doctor on board (continued)

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<tr>
<td>(Schmidt et al. 1992) USA and Germany continued</td>
<td>Analyses comparing groups at baseline. Mean age (years)</td>
<td>Analyses of age, ISS and flight times calculated. Distributions of ISS constructed. Comparability of body regions injured compared using the AIS score. TRISS methods used (reference MTOS) to compare both centres. Probability of survival used to calculate the z-statistic. The M and W statistics were calculated for each institution.</td>
<td>Advanced pre-hospital care Et intubation Surgeon present: 37.1% Surgeon absent: 13.4% P&lt;0.001 Thoracic cavity decompression Surgeon present: 9.1% Surgeon absent: 0.5% P&lt;0.001 IV fluid infusion (mean ml) Surgeon present: 1800 Surgeon absent: 825 P&lt;0.05</td>
<td>Comments • All patients attended a single trauma centre in each country. • TRISS methodology appropriately used. • TRISS analysis appropriately included estimation of the M and W statistics. • Used appropriate methodology to estimate injury severity. • Medical control available by radio in USA. • Results may reflect more aggressive therapy in Germany rather than the specific crew configuration since key differences in the procedures used can be conducted by paramedics and flight nurses as well as doctors.</td>
<td>Reported conclusions (by authors). With on scene experience and judgement of a trauma surgeon, the German aeromedical system provided more aggressive pre-hospital resuscitation, particularly in the areas of airway and ventilation management.</td>
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Table 7  Evidence tables of studies comparing the outcome or patients transported by helicopter with and without a medical doctor on board (continued)

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<th>Limitations and Conclusions</th>
</tr>
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<tbody>
<tr>
<td>Garner et al. 1999</td>
<td>Australia</td>
<td>Retrospective cohort study</td>
<td>Level Ill-2.</td>
<td>Study setting: Helicopter transportation of patients from the scene over a 28 month period; Participants (n=207): Intervention (n=67), Physician staffed NRMA CareFlight helicopter Comparator (n=140), Paramedic staffed Westpac Hunter region helicopter. Analyses comparing groups at baseline: Median age (years): Physician group: 31 (13-70); Paramedic group: 33 (2-89)</td>
<td>Incl/excl criteria: Blunt trauma ISS ≥10: Transported directly from the incident scene: Incident occurred between January 1996 and April 1998. Data collection: Paramedic group retrospectively identified from the trauma registry at John Hunter Hospital, Newcastle. Physician group identified from the medical database of NRMA CareFlight/NSW Medical retrieval Service who were transported to Westmead or Nepean hospitals in Sydney. Pre-hospital case sheets were examined to allow the calculation of the RTS (first recorded data used). Other data collected included demographics, mechanism of injury, response, scene and transport times, entrainment at the scene, requirement for which extraction, fluids administered and procedures performed at the scene or in transit. Outcome measures: Mortality. Compared with TRISS methodology using coefficients derived from the MTO-S using the 1990 abbreviated injury scale. Comparison between observed and predicted mortality made at hospital discharge.</td>
<td>Number of actual deaths by the number predicted to die (based on: Ps 0.50) Physician group Z statistic: +2.72 P&lt;0.01 M statistic: 0.62 Adjusted W's statistic 9.48 (95% CI: 3.84-15.12) compared with the MTO-S population. Paramedic group Z statistic: -1.16 P=0.25 M statistic: 0.68 Adjusted W's statistic -2.37 (95% CI: -6.81 to 2.07) compared with the MTO-S population. Direct comparison between physician and paramedic group Adjusted W's statistic: 13.44 (95% CI: 7.80-19.08) suggesting an additional 13 survivors per 100 patients treated in the physician group compared with the paramedic group.</td>
</tr>
</tbody>
</table>
**Table 7** Evidence tables of studies comparing the outcome or patients transported by helicopter with and without a medical doctor on board (continued)

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<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Garner et al. 1999) Australia continued</td>
<td>Falls</td>
<td>Paramedic group: 10%</td>
<td>Follow-up interval</td>
<td>Procedures at scene</td>
<td>Comments</td>
</tr>
<tr>
<td></td>
<td>Physician group: 6%</td>
<td></td>
<td>Not stated</td>
<td>Median volume of fluid infused in patients who received &gt; 50mL</td>
<td>• TRISS methodology appropriately used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median time intervals (minutes)</td>
<td>Analysis</td>
<td>Physician group: 2500</td>
<td>RTS score.</td>
</tr>
<tr>
<td></td>
<td>Call to scene arrival</td>
<td></td>
<td>Categorical variables: χ² or Fisher's exact test, as appropriate</td>
<td>Paramedic group: 825</td>
<td>• TRISS analysis appropriately included</td>
</tr>
<tr>
<td></td>
<td>Physician group: 29</td>
<td></td>
<td>Continuous variables: Mann-Whitney U test.</td>
<td>P&lt;0.001</td>
<td>estimation of the M and W statistics.</td>
</tr>
<tr>
<td></td>
<td>Paramedic group: 26</td>
<td></td>
<td>Comparison between predicted and observed mortality using Z, W and M statistics. An adjusted W statistic was calculated by the method of Younge when the M statistic indicated a poor match with the MTOS cohort and to directly compare the paramedic and physician treated groups.</td>
<td>Median volume of fluid (mL) infused in patients with initial hypotension (systolic BP&lt;90mmHg)</td>
<td>• Used appropriate methodology to estimate injury severity.</td>
</tr>
<tr>
<td></td>
<td>Scene time (excluding trapped and winched patients)</td>
<td></td>
<td></td>
<td>Physician group: 5035</td>
<td>• Differences in procedures performed between study groups.</td>
</tr>
<tr>
<td></td>
<td>Physician group: 33</td>
<td></td>
<td></td>
<td>Paramedic group: 1475</td>
<td>Reported conclusions (by authors). Physicians perform a greater number of procedures at accident scenes without increasing scene time. This results in significantly lower mortality. Critical care physicians should be added to paramedic helicopter services for scene response to blunt trauma.</td>
</tr>
<tr>
<td></td>
<td>Paramedic group: 34</td>
<td></td>
<td></td>
<td>P&lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transport time to hospital</td>
<td></td>
<td></td>
<td>Number of patients intubated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physician group: 15</td>
<td></td>
<td></td>
<td>Physician group: 34/67 (1 cricothyroidotomy, muscle relaxant drugs used in 28 of the 34 intubations)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paramedic group: 12</td>
<td></td>
<td></td>
<td>Paramedic group: 14/140</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total pre-hospital time</td>
<td></td>
<td></td>
<td>P&lt;0.001</td>
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<tr>
<td></td>
<td>Physician group: 86</td>
<td></td>
<td></td>
<td>Proportion of patients with GCS&lt;9 intubated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paramedic group: 82</td>
<td></td>
<td></td>
<td>Physician group: 23/23</td>
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</tr>
<tr>
<td></td>
<td>Median RTS</td>
<td></td>
<td></td>
<td>Paramedic group: 14/36</td>
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<tr>
<td></td>
<td>Physician group: 6.90</td>
<td></td>
<td></td>
<td>P&lt;0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paramedic group: 7.55</td>
<td></td>
<td></td>
<td>Thoracic decompressions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Median GCS</td>
<td></td>
<td></td>
<td>Physician group: 8/67 (6 tube, 2 needle)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physician group: 13</td>
<td></td>
<td></td>
<td>Paramedic group: 2/140 (both needle)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paramedic group: 14</td>
<td></td>
<td></td>
<td>P&lt;0.01</td>
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<td></td>
<td>P=0.05</td>
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<tr>
<td></td>
<td>Median ISS</td>
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<tr>
<td></td>
<td>Physician group: 25</td>
<td></td>
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<tr>
<td></td>
<td>Paramedic group: 18</td>
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<tr>
<td></td>
<td>P=0.05</td>
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</table>

**Transportation of emergency patients**
Table 7  Evidence tables of studies comparing the outcome or patients transported by helicopter with and without a medical doctor on board (continued)

<table>
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<tr>
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<td>Cameron et al. 2005</td>
<td>Before and after study, Retrospective chart review Level III-3.</td>
<td>Studying setting: Canberra Base hospital. Until 2001 helicopters included emergency physicians. Since 2001 they have been staffed by intensive care paramedics. &lt;br&gt;Participants (n=374): Intervention (n=163) &lt;br&gt;Comparator (n=211) &lt;br&gt;Emergency physician on board</td>
<td>Inclusion criteria: Any primary tasking of the helicopter. Cases were identified by the “mode of arrival” field recorded on the ED information system &lt;br&gt;Data collection: The RTS was calculated using the initial clinical observations in the medical records and ambulance forms.</td>
<td>30 day mortality proportion, by study group (%) &lt;br&gt;Physician group: 2.8%  &lt;br&gt;Paramedic group: 2.9%  &lt;br&gt;P=0.8 &lt;br&gt;Mean hospital length of stay, by study group (days) &lt;br&gt;Physician group: 2  &lt;br&gt;Paramedic group: 1  &lt;br&gt;P=0.3</td>
<td>Limitations: &lt;br&gt;- Retrospective study &lt;br&gt;- The accuracy of coding the mode of arrival (used to identify relevant patients) was not documented. However, this is not likely to be a major source of bias. &lt;br&gt;- Unclear if the timing of the measurements used to assess RTS was the same in both groups. &lt;br&gt;- Measures of injury severity used were different from the normal approach. No use of the ISS so it was not possible to assess probability of survival with reference to a suitable population such as MTOSS. &lt;br&gt;- Observation study is susceptible to confounding. &lt;br&gt;- Central communication was not documented for either group. &lt;br&gt;- Baseline differences in patients admitted with higher proportion of the physician group being admitted. &lt;br&gt;- Very low number of deaths consistent with low study power (10 deaths in total). &lt;br&gt;- Authors suggested RTS was a poor predictor of need for admission and postulated that APACHE may have been a better measure. &lt;br&gt;- No follow-up of patients discharged directly from ED</td>
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<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
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<tbody>
<tr>
<td>(Cameron et al. 2005) Australia continued</td>
<td>Proportion discharged from ED  Physician group: 14.7% Paramedic group: 33.1%  P=0.0001</td>
<td>Proportion of trauma patients admitted  Physician group: 86.7% Paramedic group: 68.9%  P=0.002</td>
<td>Proportion of non-trauma patients admitted  Physician group: 83.7% Paramedic group: 64.4%  P=0.004</td>
<td>Proportion of trauma patients with maximum RTS  Physician group: 89.4% Paramedic group: 90.0</td>
<td>Comments  Two consecutive years for each group were examined in the chart review.  A second reviewer validated the chart extraction in 40 randomly selected charts (10.7% of the total). Excellent level of agreement achieved (Kappa 0.937).  All patients transported to the same base hospital.  Reported conclusions (by authors). The similarities in outcomes for admitted patients support the view that both groups have similar tasking criteria for high acuity patients and suggest that paramedics are as efficacious as physicians in delivering pre-hospital care in this group of patients. However, for lower acuity patients, there is a statistically significant higher rate of clinically unnecessary taskings by the ambulance group. Given the recent fatal aeromedical accidents in Queensland it would seem prudent to reduce clinically unnecessary retrievals through clinical coordination with appropriately qualified emergency physicians.</td>
</tr>
</tbody>
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Table 7  Evidence tables of studies comparing the outcome or patients transported by helicopter with and without a medical doctor on board (continued)

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</thead>
<tbody>
<tr>
<td>(Burney et al. 1992) USA</td>
<td>Retrospective cohort study</td>
<td>Aeromedical transfers between September 1, 1987 and August 31, 1988. Include transport from other EDs (n=40), the scene (n=36) and other inpatient units (n=218). Participants: Total = 659. Intervention (n=418). Physician and nurse team. Comparator (n=241). Two nurse team. Analyses comparing groups at baseline: APACHE-II score. Physician group: 8.0. Nurse group: 7.8. RTS1 score (Obtained at origin of transport). Physician group: 10.67. Nurse group: 10.847. RTS2 score (obtained after arrival at receiving hospital). Physician group: 10.877. Nurse group: 10.972. TISS1 score. Physician group: 17.0. Nurse group: 16.0. TISS2 score. Physician group: 14.9. Nurse group: 12.6. P=0.001.</td>
<td>Incl/excl criteria. Included all patients transferred during the study period. Excluded patients under 16 years and patients transferred to other hospitals. Data collection. Severity of illness measured using RTS, APACHE-II and the Therapeutic Intervention Scoring System (TISS). Two TISS scores were obtained: TISS1: Interventions carried out before the arrival of the flight team. TISS2: Interventions continued or initiated by the flight team. Outcome measures. Hospital mortality. ICU length of stay. Hospital length of stay. Follow-up interval. Not stated. Analysis. Patients stratified into three groups: cardiac, trauma and other. Origins of the transport and transfer times were included in the analysis. Data analysed using SYSTAT.</td>
<td>Proportion discharged alive (%) Physician group: 83 Nurse group: 79 P=0.2 Number of hospital days Physician group: 20.4 Nurse group: 20.3 P=0.946 Outcomes were not significantly different in any of the clinical subgroups or patient origin.</td>
<td>Limitations. • The origin of one patient was not accounted for. • Only 5.5% of transports originated at the scene. • Scant details provided about the analysis procedure in the methods section of the paper. • No details provided about the procedures conducted by each group. • Measures of injury severity used were different from the normal approach. No use of the ISS so it was not possible to assess probability of survival with reference to a suitable population such as MTOS. • Imperfect validity of APACHE, TISS and ISS may have implications regarding balance of groups at baseline. • Unclear whether there was any variation in criteria for the dispatch of the helicopters with different crews. • Observation study is susceptible to confounding. • Unclear how many receiving hospitals were included – if there was more than one it may have resulted in variation in quality of care at different hospitals, resulting in different outcomes.</td>
</tr>
</tbody>
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Table 7  Evidence tables of studies comparing the outcome of patients transported by helicopter with and without a medical doctor on board (continued)

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<tr>
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<tr>
<td>(Burney et al. 1992)</td>
<td>USA</td>
<td></td>
<td>Mean age (years)</td>
<td></td>
<td></td>
<td>Patient origin may be consistent with the nurse group transporting a more stable group of patients.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Physician group: 45.7</td>
<td></td>
<td></td>
<td>Also variation in clinical category group transported between the two groups.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nurse group: 50.9</td>
<td></td>
<td></td>
<td>Nurse group transported a significantly older group of patients - other severity indicators being equal this would suggest a group with a poorer prognosis.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male (%)</td>
<td></td>
<td></td>
<td>Stratified analysis by clinical subgroup and patient origin subgroup had low study power.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Physician group: 66</td>
<td></td>
<td></td>
<td>No subgroup analyses presented by different markers of injury severity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nurse group: 61</td>
<td></td>
<td></td>
<td>Comments</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Patient origin (%)</td>
<td></td>
<td></td>
<td>Overall sample size of 659 is large enough to identify a 10% difference in survival with a power of 0.80.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ED</td>
<td></td>
<td></td>
<td>Reported conclusions (by authors), No objective differences in outcome of patients were found between physician/nurse and nurse/nurse teams. Although small differences were found in types of flights taken by P/N and N/N teams, there were no differences in objective measures of severity between the two teams. We find no objective evidence to prefer one crew composition over another.</td>
</tr>
</tbody>
</table>

Clinical category
Cardiac
Physician group: 40
Nurse group: 36

Trauma
Physician group: 38
Nurse group: 30

Other
Physician group: 22
Nurse group: 34
Only 7.6% of transports originated at the scene during the study period.

No details provided about the procedures conducted by each team.

Intervention Scoring System (TISS).

Period 1990-1991

Male (%)

Physician group: 49

Hours after transfer

Number of hospital days

Physician group: 17.6

P=0.09

Period 1991-1992

Physician group: 33.4

Nurse group: 22.5

P=0.005

Limitations and Conclusions

• Only 7.6% of transports originated at the scene.
• No details provided about the procedures conducted by each group.
• Measures of injury severity used were different from the normal approach. No use of the ISS so it was not possible to assess probability of survival with reference to a suitable population such as MTS.
• Imperfect validity of APACHE, TISS and ISS may have implications regarding balance of groups at baseline.
• Authors documented, in relation to year 2 of the study, that physicians were involved in transferring a smaller number of patients with very complicated injuries, therefore they expected mortality to be higher in this group. There was no analysis adjusting for the variation in severity.
• Observation study is susceptible to confounding.
• Unclear how many receiving hospitals were included – if there was more than one it may have resulted in variation in quality of care at different hospitals, resulting in different outcomes.
• Stratified analysis by clinical subgroup and patient origin subgroup likely had low study power.
Table 7  Evidence tables of studies comparing the outcome or patients transported by helicopter with and without a medical doctor on board (continued)

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<tr>
<td>(Burney et al. 1995) USA</td>
<td></td>
<td>APACHE2 score, Physician group: 12.0 Nurse group: 11.9</td>
<td>Outcome measures: Hospital mortality, ICU length of stay, Hospital length of stay. Analysis: Patients stratified into three groups: cardiac, trauma and other. Origins of the transport and transfer times were included in the analysis. Data analysed using SYSTAT. Continuous variables were analysed using Student's T test and categorical data using the χ² test.</td>
<td><strong>Nurse group: 11.9</strong> <strong>ICU length of stay 21.6</strong> <strong>Hospital length of stay 15.9</strong> <strong>Analysis</strong> Patients stratified into three groups: cardiac, trauma and other. Origins of the transport and transfer times were included in the analysis. Data analysed using SYSTAT. Continuous variables were analysed using Student’s T test and categorical data using the χ² test.</td>
<td>• No subgroup analyses presented by different markers of injury severity. • Significant differences in baseline measures in the time period 1990-1991: Physician group of patients were older, more likely to be from hospital or scene, and had higher RTS3 scores. During second period (1991-1992), physician group had higher TISS1 and TISS2 scores. • No overall results presented for duration of stay (all results stratified by the two study years). • If the study was to have 80% power to detect a 8% difference in mortality at the 5% significance level, approximately 2,000 patients would have been required. Comments • Complete outcome data obtained on 1,169 of 1,170 eligible patients. Reported conclusions (by authors). Two years of detailed prospective measurement of air medical patient characteristics and outcomes confirmed the initial finding that no significant differences in clinical outcomes could be identified between patients managed by P/N versus N/N crews.</td>
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Table 7  Evidence tables of studies comparing the outcome of patients transported by helicopter with and without a medical doctor on board (continued)

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<tr>
<td>(Burney et al. 1995) USA continued</td>
<td>TISS3</td>
<td>Physician group: 29.7 Nurse group: 28.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>TISS4</td>
<td>Physician group: 32.7 Nurse group: 32.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</table>
Summary and Conclusions

Results were conflicting among the seven studies eligible for the review examining the effectiveness of including a doctor on board helicopter transportation. Some studies suggested there was some benefit to including doctors on board helicopters (Baxt and Moody 1987; Garner et al. 1999; Schmidt et al. 1992) while others found no difference in outcomes of interest between study groups (Burney et al. 1992; Cameron et al. 2005; Hamman et al. 1991). One study found no difference in mortality but found a significantly shorter hospital stay among the non-doctor group (Burney et al. 1995). It should be noted that the two papers by Burney et al are of marginal relevance to the use of air ambulances in New Zealand as the great preponderance of patients in these studies were inter-hospital transfers rather than transports directly from the scene. Each study had limitations that might help to explain the discrepant results.

There was variation in study design among the three studies that suggested some benefit from the inclusion of doctors on the helicopter. One made use of registry data (Schmidt et al. 1992), one used a pseudorandomised controlled trial design (Baxt and Moody 1987), and the other made use of a retrospective design (Garner et al. 1999). In relation to the pseudorandomised controlled trial, a particular consideration was the use of limiting the mortality outcome to deaths that were thought to be directly due to the trauma or complications of the trauma. This may have produced outcome misclassification with the potential for underestimating mortality in either group. The use of all-cause mortality as an outcome would have avoided this limitation. Nevertheless this was the strongest study in this section of the review. There were also limitations to the registry based study but the effect of these limitations on the study estimates was not clear. Firstly, a significant proportion of eligible patients were excluded from the doctor group due to missing charts. There were no deaths among these patients, thus the level of reduced mortality in the doctor group may have been underestimated. However, time to arrival on the scene was shorter in the doctor group. This may have resulted in an improved prognosis in the doctor group and may not be replicated in other settings where time to arrival of the doctor group may be delayed. Perhaps most significantly, the two groups (doctor and no doctor) were located in two different countries so there may have been other reasons that explain differences in outcomes other that the personnel supplying pre-hospital care. For example, level of hospital care may vary between the two settings. In the retrospective study (Garner et al. 1999), seven deaths in the non-doctor group were omitted due to missing case sheets, potentially underestimating the effectiveness of care provided by doctor crewed helicopters. Patients were also directed to different hospitals in this study depending on the helicopter crew mix. Based on the above limitations there is uncertainty about the robustness of the findings in these three studies.

There were similar limitations in the three studies that did not find any difference in outcome between the doctor and no doctor groups. Hamman et al. (1991) used a before and after design which is associated with low level evidence (level III-3). The study was underpowered to compare mortality across study groups, potentially explaining the lack of difference between groups. Burney et al. (1992) published a retrospective study that examined patient transfers to a base hospital. Unfortunately only 5.5% of these transfers were directly from the scene thus severely limiting the relevance of the study to this review. It should also be noted that the non-doctor group appeared to carry a more stable group of patients potentially underestimating any benefit from doctor involvement in helicopter transportation. Cameron et al. (2005) also published a retrospective chart review. This study was limited by the inclusion of limited injury severity data and low study power to detect a difference in mortality. Burney et al. also published a prospective study following on from their retrospective study and found no difference in mortality between doctor and no doctor groups but did find a reduced period of hospitalisation in the no doctor group. However, the authors noted that this wasn’t surprising given the less severe case mix in the no doctor group. Again this study was of limited applicability given the high proportion of inter-hospital transfers.

While overall there was more support for the inclusion of doctors on board helicopters there is a significant level of uncertainty across the literature examining this question. There certainly was not sufficient evidence to suggest that doctors should not be included on board helicopters. Other issues should also be noted:

1. The literature examined in this section does not answer the question whether wider training in procedures currently accessible to doctors would have an impact on patient outcome. For example, others have suggested that task specific crewing should be
adhered to and noted that the “utilisation of experienced critical care physicians, nurses or paramedics with enhanced skills, including rapid sequence intubation, must be entertained” (Rashford and Myers 2004). Others have documented the use of rapid sequence intubation by non-doctor personnel (Bernard et al. 2002; Bernard 2006; Sloane et al. 2000). However, such an approach does not consider the role of assessment in determining outcome. Hamman et al. (1991) commented in their conclusions in their study included in this review that “it appears that experienced nurses and paramedics, operating with well established protocols, can provide aggressive care that yields equal outcome results compared with those of a flight team that includes a physician. However, their study appeared to be underpowered to establish such equivalence.

2. Whether there may be variation in outcome across crew mixes for different clinical scenarios. For example, the inclusion of doctors on the helicopters tended to be associated with longer at scene times. This longer period of stabilization could be associated with improved outcome in some circumstances but not others. Cameron commented that advanced life support skills are more likely to be beneficial in the blunt trauma patient (Cameron 1999). Two of the three studies with reduced mortality among the doctor treated group were restricted to patients with blunt trauma.

3. The literature identified related to trauma only. There was no literature identified that was eligible for inclusion and examined the effect of different crew configurations in medical emergencies.

4. There was insufficient information to compare outcomes in paediatric and adult age groups or to stratify results by ISS score.

5. There was variation in the level of experience across both study teams in the selected studies.

Further research would be useful. Firstly, a well designed prospective study that follows clear and well documented dispatch criteria and provides for carriage to the same hospital (that is equipped to manage all patients). The study would need to have an adequate sample size to ensure meaningful results could be obtained. Appropriate control for injury severity and other factors associated with mortality would be required (a randomised controlled trial would be the ideal method of doing this). The study would need to encompass the study population for which any proposed helicopter services would provide coverage. Secondly, a study evaluating the role of training non-doctor crews to perform certain procedures such as rapid sequence intubation should be conducted. The specific comparison of interest would be doctors versus fully trained non-doctor personnel. The study should be adequately powered to detect equivalence in outcome.

**Doctor versus no doctor on board road ambulances**

From the search strategy for question two (outcome by time from ambulance callout to emergency department delivery) we identified, 516 potentially relevant articles/abstracts of which 34 were retrieved. Of these retrieved articles, 30 were excluded. These excluded papers are presented in Appendix 4. Reasons for exclusion of studies before retrieval in full text are outlined in Table 8. Reasons for exclusion of studies retrieved in full text are detailed in Table 9.
Table 8  Reasons for exclusion of studies before retrieval in full text: doctor versus no doctor on board road ambulances

<table>
<thead>
<tr>
<th>Reason for exclusion</th>
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</tr>
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<tbody>
<tr>
<td>Not relevant to review question aim</td>
<td>413</td>
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<tr>
<td>Methods were not clearly described</td>
<td>0</td>
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<tr>
<td>Wrong publication type</td>
<td>51</td>
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<tr>
<td>Incorrect population</td>
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<td>Incorrect comparator</td>
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<tr>
<td>Incorrect outcomes</td>
<td>3</td>
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<tr>
<td>Publication superseded</td>
<td>0</td>
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<tr>
<td>Non-English language</td>
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<tr>
<td>Neonatal study</td>
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</tr>
<tr>
<td>Duplicate reference</td>
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<td>Total</td>
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Table 9  Reasons for exclusion of studies retrieved in full text: doctor versus no doctor on board road ambulances

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<td>24</td>
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<tr>
<td>Methods were not clearly described</td>
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<tr>
<td>Wrong publication type</td>
<td>2</td>
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<tr>
<td>Incorrect population</td>
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<tr>
<td>Sample size less than 50</td>
<td>0</td>
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<tr>
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<tr>
<td>Neonatal study</td>
<td>0</td>
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<tr>
<td>Total</td>
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</table>

Four retrieved articles were appraised and are listed in the references and Appendix 7. Included papers are presented in the evidence table below. Three studies were level III-3 (before and after studies) and the other was level III-2 (cohort study) according to NHMRC’s hierarchy of evidence.

Frandsen et al. 1991

This study (level III-3 evidence) compared three different emergency medical service configurations over three different time periods in the city of Odense, Denmark. The three configurations were:

1. Advanced EMS (n=85): included a tiered response service incorporating specifically trained doctors.
2. Intermediate EMS (n=160): included a tiered response service without doctors.

The focus was on out of hospital cardiac arrest. The study measured mortality and cerebral status (amongst the survivors). Non-adjusted statistical analyses were conducted.

Survival between the three groups was:
- Advanced EMS (with doctors): 13% (95% CI 7-22)
- Intermediate EMS (without doctors): 1% (95% CI 0-6)
- Basic EMS (without doctors): 5% (95% CI 2-10)
- \( P<0.001 \).

However, there were significant limitations to this study:
it was not possible to be certain that any difference in outcome was due to the different crew configurations

the study was highly susceptible to confounding and the analyses have not adjusted for potential confounding factors

the advanced EMS group treated a younger group of patients, which could explain the improved outcome in this group

there was missing data.

These factors make it difficult to interpret the results of this study.

Koefoed-Nielsen et al. 2002

This before and after study (level III-3 evidence) compared 28 day mortality in acute myocardial infarction (MI) patients over two time periods:

1. A period preceding introduction of a mobile emergency care unit (MECU), (September to November 1996).
2. A period with a MECU (plus standard ambulances) that included anaesthetist staffing (September to November 1997).

There were 54 patients in each period.

The crude mortality rate was higher in the pre-MECU period (20.6% versus 11.1%). Multivariate regression (controlling for age, gender, pulse and systolic blood pressure) found a significantly lower odds of 28 day mortality in the time period that included a MECU (OR 0.3, \( P < 0.025 \)). Forty-four percent of patients in the second time period were treated by the MECU. Another multivariate model also estimated lower odds of 28 day mortality in the group treated by MECU than the non-MECU group (OR 0.2, \( P < 0.05 \)).

As with all before and after studies, there were limitations:

- it was not possible to be certain that any difference in outcome was due to the different crew configurations. The authors noted the increased proportion of patients undergoing angioplasty may explain the results.
- potential selection bias, with 25 people being excluded on the basis of insufficient information about the diagnosis.
- the multivariate models controlled for a limited range of potential confounders. Most importantly, the estimated odds ratio comparing MECU with non-MECU patients may underestimate the effectiveness of MECU due to the selection of more severely unwell patients for the MECU service.
- it was unclear if the differences in outcome would be maintained if non-anaesthetist groups were trained in further procedures.

Lee et al. 2003

A retrospective cohort study (level III-2 evidence) was conducted in Australia (Lee et al. 2003). This study compared the outcome across different levels of ambulance officer and physicians. There were three levels of ambulance officer (two classified as providing basic life support and the third providing advanced life support). Details of the procedures available to these groups are provided in Table 10. Logistic regression was used to control for confounding with the following predictor variables being included in initial models: level of pre-hospital care, time from injury to arrival in hospital, type of injury, mechanism of injury, age, sex, ISS, GCS and systolic blood pressure.

The effect of pre-hospital care on mortality was dependent on level of ICU care. Key results in the group that did not receive ICU care were (using basic life support as the reference group):

- level 5 ambulance: OR 2.18 (95% CI 1.05-4.55)
- physician: OR 4.27 (95% CI 1.46-12.45).
The majority of these deaths occurred within 24 hours of admission, which the authors suggested was on the basis of not surviving initial resuscitation.

Key results in the group that did receive ICU care were (using basic life support as the reference group):

- level 5 ambulance: OR 0.70 (95% CI 0.53-1.18)
- physician: OR 0.63 (95% CI 0.28-1.39)

There were significant limitations to this study:

- the study used a retrospective design
- a selective dispatch strategy was used which probably explains the increased mortality rates in the level 5 ambulance group and the physician group in the non-ICU population
- paramedics may have involved the physician group when patient death was imminent
- the observational study design is susceptible to residual confounding.

Christenszen et al. 2003

Christenszen et al. (2003) examined the effect of introducing a mobile emergency care unit (MECU) in a before and after study (level III-3 evidence) set in Denmark. Two time periods were studied: in the first a consecutive sample of ambulance users was studied and in the second a consecutive sample of ambulance or MECU users was sampled. Twenty-eight percent of the second period sample used the MECU. There were 5,819 users overall. There was no significant difference in 180 day mortality between the two time periods although the mortality rate was significantly higher in the MECU group than the non-MECU group in the second study period. However, this was an unadjusted analysis and most notably did not control for injury severity.

There were significant unanswered questions in this study due to the nature of the study design. Most notably, due to the lack of control over injury severity it was not possible to form any conclusions about the effectiveness of MECU in reducing mortality. Other limitations included:

- poor control over confounding
- lack of statistical detail in some analyses
- a difference in outcome may have been noted if a higher proportion of users had been attended by a MECU in the second study period.

More detail is provided in Table 10.
Table 10  Evidence tables of studies comparing the outcome of patients transported by road ambulance with and without a medical doctor on board

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Frandsen et al. 1991) Denmark</td>
<td>Before and after Level III-3.</td>
<td>Study setting, Set in Odense (a city with a population of 238,000 in Denmark). Three different time periods were studied. Out of hospital cardiac arrests were the focus of the study. Participants: Intervention (n=88). Six month period of advanced EMS with specifically trained doctors providing advanced life support at arrival in a tiered response system. Comparator: Two time periods: one provided basic EMS (n=160) and an “intermediate EMS period” (n=148) which involved a tiered response. Neither of these periods used doctors in the pre-hospital care. Baseline analyses Mean age: 66 years Males: 64% Bystander CPR: 14% Collapse time &gt; 6 minutes: 66%</td>
<td>incl/excl criteria. Assumed to be all transports in the three relevant time periods who suffered an out of hospital cardiac arrest. Outcome measures Measured mortality and cerebral status Analysis Z test, Mann-Whitney U test and Kruskal-Wallis analysis of variance. Significance level set at 0.05.</td>
<td>Survival rate (95% CI) Basic EMS (non-doctor): 5% (2-10) Intermediate EMS (non-doctor): 1% (0-6) Advanced EMS (Doctor): 13% (7-22) P&lt;0.001</td>
<td>Limitations: Low study power. No control of confounding in the analysis which is particularly problematic in this before and after design. The mean age was younger in the advanced EMS phase – which may explain the improved survival in this group. Central communication was not documented for either group. Data missing for some background variables. For example, collapse time documented in 85%. Response time and VF ratio at arrival of ambulance staff was not documented in the basic EMS group (41% of the sample). Unclear what the P value referred to in comparing survival – was it a test for trend or a comparison of certain EMS categories.</td>
</tr>
</tbody>
</table>

**Transportation of emergency patients**
### Table 10  Evidence tables of studies comparing the outcome of patients transported by road ambulance with and without a medical doctor on board (continued)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Frandsen et al. 1991)</td>
<td>Denmark</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reported conclusions (by authors). The results of the investigation demonstrate that the more intensive the pre-hospital treatment of out-of-hospital cardiac arrest, the more patients survive and the more patients survive with good cerebral function.</td>
</tr>
</tbody>
</table>
Table 10 Evidence tables of studies comparing the outcome of patients transported by road ambulance with and without a medical doctor on board (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Koefoed-Nielsen et al. 2022) Denmark</td>
<td>Before and after</td>
<td>Study setting: A mobile-emergency care unit (MECU), which included an anaesthetist, was set up in a region of Denmark. Consecutive patients with acute MI were studied in two time periods: 1. Sept to Nov 1996 (before MECU) 2. Sept to Nov 1997 (with MECU). The area covered approximated 800km². Median response time for MECU was 8.9 minutes and 6.5 minutes for standard ambulances. Participants: Intervention (n=54) Anaesthetist present (with MECU) MECU was also crewed with a specially trained emergency technician. Additional treatment provided by anaesthetist: tracheal intubation, translucent anesthesia, anaesthetics (hypnotics and muscle relaxants), opioids, heart-stimulating drugs and antiarrhythmics. Pre-hospital thrombolysis was not provided. Comparator (n=54) Non physician crew (before MECU).</td>
<td>Incl/excl criteria. Use of emergency services (based on ambulance company’s patient tools) who were classified as a diagnosis of MI (ICD-10 codes I21-I22) on admission to an emergency department or coronary care unit in one of three hospitals in Aarhus, Denmark. The patient was alive when reaching hospital. The hospital record confirmed MI diagnosis, based on enzyme tests and ECG. The hospital record provided sufficient information on diagnosis and treatment. Outcome measures: 28 day mortality. Analysis: Pearson’s χ², Fisher’s exact test, Spearman’s non-parametric rank correlation, Kaplan-Meier survival analysis and multiple logistic regression were conducted.</td>
<td>Crude mortality rate at 28 days, by study period. Pre-MECU: 20.6% MECU: 11.1%. Adjusted odds ratio by study period: (28 day mortality), (pre-MECU as the reference) OR 0.3 (P&lt;0.025). Adjusted for age, gender, pulse and systolic blood pressure. Adjusted odds ratio by use of MECU. (28 day mortality), (pre-MECU as the reference) OR 0.2 (P&lt;0.05). Adjusted for age, gender, pulse and systolic blood pressure.</td>
<td>Retrospective study. Exclusions: six were either dead on arrival or died immediately after arrival (four pre MECU and two with MECU). Specific MI diagnosis could not be confirmed in 25. Unclear if any were excluded due to insufficient information on treatment. Limited data provided at time of first attendance of pre-hospital care. Before and after study is a low quality design – features other than the intervention of interest may have changed so it is unclear to what extent any change in outcome is a result of the introduction of MECU. In this study, the improved prognosis may have been due to angioplasty rather than MECU. Basis of diagnosis of MI not precisely defined: potential for inappropriate selection. Potential for misclassification of outcome, though the size and direction of such misclassification is difficult to determine. During the MECU period, some patients were not attended by MECU (56%). However, although MECU patients were more likely to be considered as severe, MECU patients had higher adjusted odds of survival compared with non-MECU patients.</td>
</tr>
</tbody>
</table>

**Transportation of emergency patients**
Table 10  Evidence tables of studies comparing the outcome of patients transported by road ambulance with and without a medical doctor on board (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Koefoed-Nielsen et al. 2022) Denmark continued</td>
<td></td>
<td>Analyses comparing groups at baseline: Age ≤ 69 years (%) Pre MECU: 41 MECU: 41</td>
<td></td>
<td></td>
<td>Comments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male sex (%) Pre MECU: 63 MECU: 72</td>
<td></td>
<td></td>
<td>- Aimed to assess the impact of a MECU on survival among patients with acute MI.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PTCA performed (%) Pre MECU: 19 MECU: 26</td>
<td></td>
<td></td>
<td>- MECU patients were more likely to receive thrombolysis.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thrombolysis given (%) Pre MECU: 28 MECU: 33</td>
<td></td>
<td></td>
<td>Reported conclusions (by authors). In the present study, MI patients treated in a MECU staffed by an anaesthetist and/or having angioplasty was found to be associated with a reduced mortality. These observations have been based on quasi-experimental rather than randomised experimental data, and randomised data would be highly desirable.</td>
</tr>
<tr>
<td>Authors Country</td>
<td>Study Design</td>
<td>Sample and Interventions</td>
<td>Methods</td>
<td>Results</td>
<td>Limitations and Conclusions</td>
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<tr>
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<tr>
<td>(Lee et al. 2003)</td>
<td>Retrospective cohort study</td>
<td>Severe blunt trauma patients admitted to Westmead Hospital, Sydney between July 1986 and December 2000. Ambulance officers trained to three different levels: two levels of basic life support and one level of advanced life support. Also had two physician-staffed emergency medical services which respond to accident scenes either by road or helicopter. Level 3 ambulance officer: basic life support with external control of haemorrhage, splinting, non-invasive airway manoeuvres and bag-valve-mask ventilation. Level 4 ambulance officer: basic life support plus intravenous cannulation and administration of IV fluids, in addition to a limited range of IV medications and needle thoracotomy. Level 5 ambulance officer: Advanced life support. Able to perform all the above procedures plus oral endotracheal intubation. Access to a wider range of IV medications (but not neuromuscular blockade, anaesthetic agents or sedative agents to facilitate intubation). Physicians are free to exercise their clinical judgement in each case.</td>
<td>Risk in odds ratio of mortality by level of pre-hospital care and ICU treatment (basic life support as the reference), (95% CI). No ICU admission: Level 5 ambulance: 2.18 (1.05-4.55) Physician: 4.47 (1.46-12.45) ICU admission: Level 5 ambulance: 0.70 (0.53-1.18) Physician: 0.63 (0.28-1.39)</td>
<td>• Retrospective study. • A selective dispatch strategy was used which probably explains the increased mortality rates in the level 5 ambulance group and the physician group in the non-ICU population. • Paramedics may have involved the physician group when patient death was imminent. • Unclear if some physician group patients may have been transported by helicopter. • Different levels of access to procedures in the non-doctor groups may not be generalisable to other settings, may guide dispatch decisions and may result in bias in comparative estimates. • Observation study is susceptible to confounding.</td>
<td>Comments • Aimed to determine the association between mortality and level of pre-hospital care in severely injured blunt trauma patients with or without severe head trauma. • No online medical control provided. • Well described and conducted statistical methodology.</td>
</tr>
</tbody>
</table>
### Table 10  Evidence tables of studies comparing the outcome of patients transported by road ambulance with and without a medical doctor on board (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee et al. 2003</td>
<td></td>
<td>Participants (n=2010):</td>
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<tr>
<td>Australia</td>
<td></td>
<td>Intervention.</td>
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<tr>
<td></td>
<td></td>
<td>Level of pre-hospital care was classified into three groups: basic life support, advanced life support and physician care.</td>
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<tr>
<td></td>
<td></td>
<td>Analyses comparing groups at baseline.</td>
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<tr>
<td></td>
<td></td>
<td>Median age 30 years (interquartile range 21-49 years)</td>
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<tr>
<td></td>
<td></td>
<td>Males: 76%</td>
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<td></td>
<td></td>
<td>Causes:</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Road traffic accident 67%</td>
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<tr>
<td></td>
<td></td>
<td>Falls: 13%</td>
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<td></td>
<td></td>
<td>Assault 5%</td>
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<tr>
<td></td>
<td></td>
<td>No head injuries: 36%</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Isolated head injury: 52%</td>
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<tr>
<td></td>
<td></td>
<td>Head injury with abdominal/chest injuries: 12%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Pre-hospital care:</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Non-EMS transport 5%</td>
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<td></td>
<td></td>
<td>Level 3 ambulance 23%</td>
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<td></td>
<td></td>
<td>Level 4 ambulance 2%</td>
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<tr>
<td></td>
<td></td>
<td>Level 5 ambulance 59%</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Physician EMS 11%</td>
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</tr>
</tbody>
</table>
Table 10   Evidence tables of studies comparing the outcome of patients transported by road ambulance with and without a medical doctor on board (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Christensen et al. 2003) Denmark</td>
<td>Before and after study Level III-3.</td>
<td>Study setting: covers an area of ~800km² and a population of ~330,000. Most of the population is an urban centre (~250,000). A mobile emergency care unit (staffed with an anesthetist) is dispatched for the most serious cases. The mobile emergency care unit (MECU) was set up in 1997.</td>
<td>- Inclusion criteria: Consecutive ambulance users in the periods of interest. When there was more than one ambulance call during the study period the user was included only on the day of the initial call. - Outcome measures: Hospitalisation, Diagnostic pattern, Survival at 1, 7, 28 and 180 days. Analysis: Multiple logistic regression was used for data analysis.</td>
<td>180 day mortality: comparison between period before and after introduction of MECU (period before introduction as the reference): OR 1.06 (not statistically significant) Adjusted for age and gender 180 day mortality: comparison between MECU use and non-use in the period after introduction of MECU. MECU users: 14.7% mortality Non-MECU users: 8.9% mortality P&lt;0.001</td>
<td>- Before and after study is a low quality design – features other than the intervention of interest may have changed so it is unclear to what extent any change in outcome is a result of the introduction of MECU. - The second period includes a mix of MECU and ambulance retrievals. - No control for measures of injury severity in comparing the period pre and post introduction of MECU or in a comparison of MECU with non-MECU users in the period after introduction of MECU. - Confidence intervals were not presented for the adjusted comparisons of mortality. Comments: The study aim was (1) to describe mortality, hospitalisation, and the diagnostic pattern among emergency ambulance users and (2) to evaluate the impact of one MECU staffed by an anesthetist. Median response time for MECU 8.9 minutes and 6.5 minutes for ambulance. Reported conclusions (by authors). After the MECU fewer were brought to hospital. The overall mortality for all ambulance users was not influenced by the MECU. For the subgroups, especially AMI, mortality was lower after the introduction of the MECU.</td>
</tr>
</tbody>
</table>
Summary and Conclusions

Results were conflicting among the four studies eligible for the review examining the effectiveness of including a doctor on board ambulance transportation. Two studies estimated an increased level of effectiveness in services with a doctor on board (Frandsen et al. 1991; Koefoed-Nielsen et al. 2002), one had variable results depending on the comparator group and the use of ICU (Lee et al. 2003) and one found a significantly worse outcome associated with incorporation of a doctor (Christenszen et al. 2003). However, it is useful to consider the results more critically. Three of the four studies used a before and after design. This is a weak study design since it is not possible to be certain that the intervention of interest has resulted in any change in outcome or if some other factor has changed over time that has resulted in the change in outcome.

Three studies were set in Denmark. Two of these studies evaluated MECUs. Both these studies used before and after designs with the later period having access to MECUs. However, only 56% and 28% of patients in this later period were actually attended by a MECU. One of these studies reported on a population of patients with acute MI (Koefoed-Nielsen et al. 2002) and the other had no such restriction (Christenszen et al. 2003). In the study reporting on MI patients there were significantly lower odds of 28 day mortality both in the period with MECU available and in the direct comparison between MECU and non-MECU patients. The latter result is pertinent since the MECU was directed towards more severe patients. However, the results in the other evaluation of MECU were different. Specifically, there was no difference in 180 day mortality between the time periods with and without MECU and the 180 day mortality was significantly higher in MECU users compared with non-users. The latter may represent the casemix with more severe cases being attended by MECU. The other Danish study compared three different approaches for the pre-hospital care of out of hospital cardiac arrest (Frandsen et al. 1991). The survival rate was higher in the group that included a doctor on board compared with two non-doctor arrangements (survival rate 13% versus 5% and 1%). However, this study did not control for potential confounders. This lack of control of confounders was problematic because, amongst other potential issues, the mean age was lower in the doctor group compared with the other groups. This difference in age could explain the difference in outcome between groups. The fourth study was set in Australia (Lee et al. 2003). The study population consisted of patients with severe blunt trauma. Three types of pre-hospital care were studied. The most basic level of life support was used as the reference category and was compared with another non-medical configuration and a configuration with a doctor on board. The results varied by whether the patients were subsequently admitted to ICU. The odds of mortality were significantly higher in the two more advanced pre-hospital configurations when the patient was not admitted to ICU. However, when the patient was admitted to ICU there were no statistically significant differences between pre-hospital care groups. It should be noted that a selective dispatch strategy was used so the more severely injured patients were seen by the more advanced ambulance group and the doctor group. The authors also commented that paramedics may have involved the physician group when patient death was imminent. These factors may explain the poorer prognosis in the two more advanced pre-hospital care groups among the patients who did not proceed on to ICU care.

Similar considerations applied in the comparison of effectiveness of doctors versus non-doctor configurations on road ambulances as they did on helicopters. Specifically, the literature identified had limitations as identified above. These limitations are such that no clear conclusions can be drawn on the question of benefit from having a doctor on board road ambulances. Further considerations also apply:

1. The literature examined in this section does not answer the question whether wider training in procedures accessible to doctors would have an impact on patient outcome.
2. Whether there may be variation in outcome across crew mixes for different clinical scenarios. For example, the inclusion of doctors on road ambulances may be associated with longer at scene times. This longer period of stabilization could be associated with improved outcome in some circumstances but not others.
3. There was insufficient information to compare outcomes in paediatric and adult age groups or to stratify results by ISS score. Note the one study limited to trauma patients was restricted to patients with an ISS>15.

Like the section above examining doctors versus no doctors on board helicopters further research is required to adequately answer the question about the effectiveness of doctors versus no doctors on
board road ambulances. A similar approach would be useful to that proposed in the helicopter section to further elucidate this issue.

**Comparison of outcomes amongst crews that do and do not perform rapid sequence intubation and/or thoracostomy**

The identification of studies for inclusion in review question three (comparison of outcomes in patients transported by crews that do and do not have the ability to perform rapid sequence intubation and/or thoracostomy) were identified from three searches. The first two searches were the same as those used in questions 1 and 2. An additional search was conducted that identified 253 additional potentially relevant articles/abstracts. Therefore, there were 1837 potentially relevant articles/abstracts. One hundred of these were retrieved. Of these retrieved articles, 95 were excluded. These excluded papers are presented in Appendix 5. Two additional articles were identified from reference lists. Both these studies were excluded: one was not relevant to the review question and the other used an incorrect comparator. Reasons for exclusion of studies before retrieval in full text are outlined in Table 11. Reasons for exclusion of studies retrieved in full text are detailed in Table 12.

Table 11  Reasons for exclusion of studies before retrieval in full text (from additional search): patients transported by crews that do and do not have the ability to perform rapid sequence intubation and/or thoracostomy

<table>
<thead>
<tr>
<th>Reason for exclusion</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not relevant to review question aim</td>
<td>1473</td>
</tr>
<tr>
<td>Methods were not clearly described</td>
<td>0</td>
</tr>
<tr>
<td>Wrong publication type</td>
<td>220</td>
</tr>
<tr>
<td>Incorrect population</td>
<td>1</td>
</tr>
<tr>
<td>Sample size less than 50</td>
<td>21</td>
</tr>
<tr>
<td>Incorrect comparator</td>
<td>10</td>
</tr>
<tr>
<td>Incorrect outcomes</td>
<td>7</td>
</tr>
<tr>
<td>Publication superseded</td>
<td>0</td>
</tr>
<tr>
<td>Non-English language</td>
<td>0</td>
</tr>
<tr>
<td>Neonatal study</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>1737</td>
</tr>
</tbody>
</table>

Table 12  Reasons for exclusion of studies retrieved in full text: patients transported by crews that do and do not have the ability to perform rapid sequence intubation and/or thoracostomy

<table>
<thead>
<tr>
<th>Reason for exclusion</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not relevant to review question aim</td>
<td>26</td>
</tr>
<tr>
<td>Methods were not clearly described</td>
<td>3</td>
</tr>
<tr>
<td>Wrong publication type</td>
<td>23</td>
</tr>
<tr>
<td>Incorrect population</td>
<td>1</td>
</tr>
<tr>
<td>Sample size less than 50</td>
<td>0</td>
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<tr>
<td>Incorrect comparator</td>
<td>10</td>
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<tr>
<td>Incorrect outcomes</td>
<td>5</td>
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<tr>
<td>Publication superseded</td>
<td>0</td>
</tr>
<tr>
<td>Non-English language</td>
<td>1</td>
</tr>
<tr>
<td>Neonatal study</td>
<td>0</td>
</tr>
<tr>
<td>No documentation of procedures by different crews</td>
<td>25</td>
</tr>
<tr>
<td>Patient transfer</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
</tr>
</tbody>
</table>

Five retrieved articles were appraised and are listed in the references and Appendix 7. Included papers are presented in the evidence table below. Included studies were all level III-3 and above according to NHMRC’s hierarchy of evidence, including a pseudorandomised controlled trial, two cohort studies and two before and after studies.
Baxt et al. 1987

Baxt et al. (1987) conducted a pseudorandomised controlled trial (Level III-1 evidence) comparing mortality in a group of consecutive patients with blunt trauma transported by helicopter with physician and nurse on board with another group with paramedic and nurse on board. In relation to the procedures of interest, the physician group was able to perform both needle and tube thoracostomies whereas the paramedic group was not. There were also other differences in procedures performed and these are noted in Table 13. There were 574 participants (316 in the physician group and 258 in the comparator group). Actual mortality was compared with predicted mortality using TRISS methodology. The trauma score scale rather than the revised trauma score scale was included in this calculation. Actual mortality was not statistically significantly different from predicted mortality in the paramedic group while, in the physician group, actual mortality was significantly lower than predicted \((P<0.05)\). There was a statistically significant difference in the \(Z\) statistic between the two groups, supporting reduced mortality in the physician group compared with the paramedic group. This reduction in mortality may have been related to the difference in procedures available to the physician group.

There were potential sources of confounding and bias that should be considered when interpreting this study. Key issues included:

- the study was not truly randomised so is susceptible to confounding. However, significant baseline differences were not observed for transport time, trauma score, ISS, GCS, predicted survival or patient age
- the key difference between the groups related to the category of patients who survived but were expected to die. There were only 22 patients who were expected to die in the physician group (five survived) and 16 who were expected to die in the paramedic group (none survived)
- the TRISS methodology used in this review did not assess the degree of match in injury severity between the two groups, or adjust for different casemix in the study groups
- the study did not use all-cause mortality, resulting in the potential for misclassification of outcome.

It should also be noted that although the results supported reduced mortality in the physician group and that this was the only group that was able to perform thoracostomies it does not necessarily mean that the difference in outcome is due to the ability to perform this procedure. It is possible that if the paramedic group had also been able to perform thoracostomies there may not have been support for reducing mortality in the physician group compared with the paramedic group but again this was not the focus of the study so no conclusion can be formed on this point. For such a conclusion to be made, a study with three arms would be required: the two arms included in the present study plus another arm for a paramedic group that was able to perform thoracostomy.

Garner et al. 1999

Garner et al. (1999) reported on a retrospective study set in Australia (level III-2 evidence). They compared the outcome (mortality) between groups transported via helicopter with a physician on board versus patients transported with a paramedic on board. The physician group performed a number of rapid sequence intubations (28 of the 34 intubations in this group were conducted after muscle relaxant drugs were provided). The use of muscle relaxant drugs was beyond the paramedic protocol. In general, the physician group was treated more aggressively. All patients were transported directly from the scene to the relevant hospital (hospitals varied by the crew mix on the helicopter). There were 67 patients in the physician group and 140 in the paramedic group. The patients were restricted to those with blunt trauma and an ISS score greater than 10. Actual mortality was compared with predicted mortality using TRISS methodology (MTOS as the reference population) and the adjusted \(W\) statistic was also used to directly compare the physician and paramedic groups. The degree of match on injury severity between the MTOS population and the physician and paramedic groups was poor, therefore the adjusted \(W\) statistic was appropriately presented. When comparing the physician group with the MTOS population it was estimated that 9.48 (95% CI 3.84-15.12) extra lives per 100 population were saved in the physician group. There was no significant difference in mortality between the MTOS population and the paramedic group. Direct comparison between the paramedic and physician groups suggested 13.44 (95% CI 7.80-19.08) extra lives per 100 population were saved in the physician group.

Transportation of emergency patients
There were differences in the procedures performed between the two groups so these differences may have contributed to the difference in outcome. These are detailed in Table 13.

The study had limitations:

- it was a retrospective study
- there were sources of selection bias – with differences in baseline measures between the two study groups (the physician group appeared to manage a more severely injured group) and seven patients who died were excluded from the paramedic group due to missing case sheets
- confounding was a potential problem between the two groups although use of the $W$ statistic should have partially controlled confounding (based on injury severity)
- the degree of match in injury severity with the MTOS study was poor and there were variations in methods adopted in the MTOS study and this study (most notably related to the timing of RTS measurement) which limits the usefulness of the MTOS cohort as a reference population.

It should also be noted that although the results supported reduced mortality in the physician group and that this was the only group that performed rapid sequence intubations it does not necessarily mean that the difference in outcome is due to the ability to perform this procedure. It is possible that if the paramedic group had performed rapid sequence intubations there may not have been support for reducing mortality in the physician group compared with the paramedic group but again this was not the focus of the study so no conclusion can be formed on this point. For such a conclusion to be made, a study with three arms would be required: the two arms included in the present study plus another arm for a paramedic group that performed rapid sequence intubation.

Koefoed-Nielsen et al. 2002

This before and after study (level III-3 evidence) compared 28 day mortality in acute MI patients over two time periods:

1. A period preceding introduction of a mobile emergency care unit (MECU), (September to November 1996).
2. A period with a MECU (plus standard ambulances) that included anaesthetist staffing (September to November 1997).

There were 54 patients in each period. The anaesthetist was able to perform the following additional procedures: tracheal intubation, transcutaneous pacing, anaesthetics (hypnotics and muscle relaxants), opioids, heart stimulating drugs and antiarrhythmics. On the basis of this description, it was interpreted that the anaesthetist was able to perform rapid sequence intubation in the field.

The crude mortality rate was higher in the pre-MECU period (20.6% versus 11.1%). Multivariate regression (controlling for age, gender, pulse and systolic blood pressure) found a significantly lower odds of 28 day mortality in the time period that included a MECU (OR 0.3, $P < 0.025$). Forty-four percent of patients in the second time period were treated by the MECU. Another multivariate model also estimated lower odds of 28 day mortality in the group treated by MECU than the non-MECU group (OR 0.2, $P < 0.05$).

As with all before and after studies, there were limitations:

- it is not possible to be certain that any difference in outcome is due to the different crew configurations. The authors noted the increased proportion of patients undergoing angioplasty may explain the results.
- potential selection bias, with 25 people being excluded on the basis of insufficient information about the diagnosis.
- the multivariate models controlled for a limited range of potential confounders. Most importantly, the estimated odds ratio comparing MECU with non-MECU patients may underestimate the effectiveness of MECU due to the selection of more severely unwell patients for this service.
- it was unclear if the differences in outcome would be maintained if non-anaesthetist groups were trained in further procedures.
It should also be noted that although the results supported reduced mortality in the anaesthetist group (MECU) and that this was the only group that performed rapid sequence intubations it does not necessarily mean that the difference in outcome is due to the ability to perform this procedure. It is possible that if the non-anaesthetist group had performed rapid sequence intubations there may not have been support for reducing mortality in the anaesthetist group compared with the non-anaesthetist group but again this was not the focus of the study so no conclusion can be formed on this point. For such a conclusion to be made, a study with three arms would be required: the two arms included in the present study plus another arm for a non-anaesthetist group that performed rapid sequence intubation.

Lee et al. 2003

A retrospective cohort study (level III-2 evidence) was conducted in Australia (Lee et al. 2003). This study compared the outcome across different levels of ambulance officer and physicians. There were three levels of ambulance officer (two classified as providing basic life support and the third providing advanced life support). Details of the procedures available to these groups are provided in Table 10. Most notably, physicians were able to perform any procedure they considered warranted, whereas other groups were not able to perform rapid sequence intubation or tube thoracocentesis. Logistic regression was used to control for confounding with the following predictor variables being included in initial models: level of pre-hospital care, time from injury to arrival in hospital, type of injury, mechanism of injury, age, sex, ISS, GCS and systolic blood pressure.

The effect of pre-hospital care on mortality was dependent on level of ICU care. Key results in the group that did not receive ICU care were (using basic life support as the reference group):
- level 5 ambulance: OR 2.18 (95% CI, 1.05-4.55)
- physician: OR 4.27 (95% CI 1.46-12.45).

The majority of these deaths occurred within 24 hours of admission, which the authors suggested was on the basis of not surviving initial resuscitation. Thus it is not clear if the logistic regression model adequately controlled for injury severity.

Key results in the group that did receive ICU care were (using basic life support as the reference group):
- level 5 ambulance: OR 0.70 (95% CI 0.53-1.18)
- physician: OR 0.63 (95% CI 0.28-1.39).

There were significant limitations to this study:
- the study used a retrospective design
- a selective dispatch strategy was used which probably explains the increased mortality rates in the level 5 ambulance group and the physician group in the non-ICU population
- paramedics may have involved the physician group when patient death was imminent
- the observational study is susceptible to residual confounding.

Cameron et al. 2005

A retrospective chart review was conducted in Australia (Cameron et al. 2005). This study used a before and after design (Level III-3 evidence) to compare outcome in a period where helicopters included emergency physicians with a subsequent period where the helicopter did not include an emergency physician (intensive care paramedics were used). The physicians were able to perform all the usual treatment and monitoring facilities that they could normally provide in the emergency department. In contrast, the non-physician team was unable to do rapid sequence intubations. Given the nature of the data recorded measures of injury severity were restricted to the RTS. Chart abstraction was primarily performed by one person but a 10% sample was validated by another abstractor. There was an excellent level of agreement between the two abstractors. There were 163 patients in the physician group and 211 in the paramedic group. Mortality was measured at 30 days. There were 10 deaths in total and no significant difference was detected between the study groups. There was also no
significant difference in the length of stay, although the length of stay was only two days and one day respectively in the physician and paramedic groups.

There were significant limitations to this study:

- the effects of a retrospective design were apparent. As the authors documented, they were unable to extract data that would have provided a better indication of injury/illness severity.
- there was no control over potential confounders. Given baseline differences suggestive of a more severe casemix in the physician group this may have led to bias in the comparison.
- the outcome of the group discharged from ED was not obtained.
- the study power was low, particularly for mortality, so the lack of a significant difference in outcome was not surprising.

Wirtz et al. 2002

There was one other study of interest identified, although it did not meet the eligibility criteria for the review. It is included here for completeness. Wirtz et al. (2002) noted that both paramedics and flight nurses performed rapid sequence intubation. There was therefore no comparison group in this study involving a crew that did not perform rapid sequence intubation. Therefore, the study could not be included. Mortality was similar in both groups. However, it leaves the question whether there truly would be a difference in outcome between:

1. Doctors and other crew configurations that are both able to conduct rapid sequence intubation.
2. Non-doctor crews able to perform rapid sequence intubation and non-doctor crews that are not able to perform rapid sequence intubation.
Table 13  Evidence tables of studies comparing crews that do and do not perform rapid sequence intubation and/or thoracostomy

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Baxt and Moody 1987) USA</td>
<td>Pseudo-randomised controlled trial Level III-1</td>
<td>Study setting. Consecutive patients with blunt trauma over a 24 month period. All patients were transported to the University of California, San Diego, Medical Trauma Center where they were cared for until discharge. Participants: Total sample 574. Intervention: Helicopter staffed by flight nurse and physician (n=316). Procedures: oral/nasal endotracheal intubation. Needle/thoracotomy placement Peripheral/central IV line placement Pericardiotomies* Cricothyrotomy placement* Expanded medications* Comparator: Helicopter staffed by flight nurse and paramedic (n=258). Procedures: oral endotracheal intubation IV line placement Limited medications Pneumatic antishock garment placement*</td>
<td>Inclusion criteria: Patients with blunt trauma Excluded patients who did not have any resuscitative procedures in the field. Data collection: Trauma score calculated on patient contact by the crew. Injury severity score calculated from patient records and autopsy reports. Outcome measures: Mortality: defined as death due to the initial injuries or complications of the injuries. Follow-up interval: Minimum of six months. Analysis: Predicted mortality estimated using the TRISS methodology, utilizing the most recent coefficients available at the time. Analytic methods included using two-tailed Student t test, Mantel-Haenszel test and the Z statistic of comparison between predicted and actual survival.</td>
<td>Number of actual deaths by the number predicted to die (based on Ps ≤ 0.05) Paramedic group: Predicted = 19.5 Actual = 19 Z statistic 0.208 (P &gt; 0.05) Physician group: Predicted 16.9 Actual 11 Z statistic 2.284 (P &lt; 0.05) Difference in Z statistic between the two groups: 2.076 (P &lt; 0.05) indicating a statistically significant improved outcome in the physician group. Distribution of patients by probability of survival: Expected to die but lived: Paramedic: 0 Physician: 5 Expected to live but died: Paramedic: 5 Physician: 3 Expected to die and died: Paramedic: 14 Physician: 8</td>
<td>Limitations: • Not truly randomised: dispatch depended on rotation of calls or which helicopter was closer to the scene at time of dispatch. • Central communication did not appear to be available for either staff group. • The level of experience of both staff groups was unclear. • TRISS methodology included the trauma score (TS) rather than the revised trauma score (RTS). In later years the RTS score was considered to be more accurate than the TS score. Subsequent developments in TRISS methodology made use of the M statistic which allows an assessment of the injury severity mix between study groups and, if appropriate, the W statistic, which deals with different case mixes across samples. • All-cause mortality not used. May have lead to outcome misclassification. • No documentation of blinding in the assessment of cause of death. • Unclear if there were differences in the duration of follow-up between study groups (although all recorded deaths occurred within 48 hours of admission).</td>
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</table>
Table 13  Evidence tables of studies comparing crews that do and do not perform rapid sequence intubation and/or thoracostomy (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
</table>
| (Baxt and Moody 1987) USA | Analyses comparing groups at baseline. Paramedic crew: 0.95-1.0 Physician crew: 0.95-1.0 Median Glasgow Coma Score of severe brain injured patients (GCS=8) Paramedic crew (n=44, 17% of total): 4 Physician crew (n=54, 17% of total): 5 | Blinded chart analysis assessing adherence to written medical treatment protocols. 1. patients who survived Paramedic group: 18 of 239 patients with inconsistencies from the recommended protocols Physician group: 2 of 305 patients with inconsistencies from the recommended protocols 2. patients who died Paramedic group: 9 of 19 patients with inconsistencies from the recommended protocols Physician group: 0 of 11 patients with inconsistencies from the recommended protocols Note inconsistencies included failure to conduct the indicated procedure or medical procedure not followed. | - Potential for confounding, although baseline analyses indicate little difference in transport time, trauma score, injury severity score, GCS, predicted survival and patient age between groups. - Key results are based on a small number of patients who survived but were expected to die (5 of 22 in the physician group and 0 of 16 in the paramedic group). | Comments - All patients attended a single trauma centre. - The TRISS methodology was applied to the two study groups using data that were collected at the same time between the two groups. - Used appropriate methodology to estimate injury severity. - These patients were excluded in each group due to the lack of resuscitative measures in the field.

Reported conclusions (by authors): A statistically significant reduction in the mortality of patients with blunt trauma treated by a medical helicopter emergency care service staffed by a nurse/physician combination could be demonstrated compared with that staffed by a nurse/paramedic combination. |

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<thead>
<tr>
<th>Authors Country</th>
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<th>Sample and Interventions</th>
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<th>Results</th>
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</table>

* Difference in procedures available to the two staffing groups

**Transportation of emergency patients**
Table 13  Evidence tables of studies comparing crews that do and do not perform rapid sequence intubation and/or thoracostomy (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Garner et al. 1999) Australia</td>
<td>Retrospective cohort study Level III-2.</td>
<td>Study setting: Helicopter transportation of patients from the scene over a 28 month period. Participants (n=207):</td>
<td>Incl/excl criteria: Blunt trauma ISS &gt;10 Transformed directly from the incident scene Incident occurred between January 1996 and April 1998. Data collection Paramedic group retrospectively identified from the trauma registry at John Hunter Hospital, Newcastle.</td>
<td>Number of actual deaths by the number predicted to die (based on Ps = 0.50) Physician group Z statistic: 2.72 P&lt;0.01 M statistic: 0.62 Adjusted W statistic: 9.48 (95% CI 3.84-15.12) compared with the MTOs population. Paramedic group Z statistic: -1.16 P=0.25 M statistic: 0.68 Adjusted W statistic: -2.37 (95% CI -6.81 to 2.07-15.12) compared with the MTOs population. Direct comparison between physician and paramedic group Adjusted W statistic: 13.44 (95% CI 7.80-19.08) suggesting an additional 13 survivors per 100 patients treated in the physician group compared with the paramedic group. Road transported patients: Direct comparison between physician and paramedic group Adjusted W statistic: 2.11 (95% CI -0.34 to 4.56)</td>
<td>retrospective study. Groups treated in different hospitals – paramedic group treated in a level 6 hospital, physician group in a level 5 or level 6 hospital. Statistically significant difference in baseline GCS and ISS scores consistent with increased severity in the physician group. Unclear if there were differences in the duration of follow-up between study groups. Observation study is susceptible to confounding although use of the W statistic helps adjust for TRISS variables between the study populations. Central communication was not documented for either group. RTS score in the MTOs study was calculated at admission rather than at the scene as performed in this study. The approach used in this study has the advantage of collecting RTS data before intubation and comparing RTS in both groups at approximately the same time. However, comparison with MTOs is not so valid given the difference in timing. Seven patients were excluded due to missing case sheets. All 7 were in the paramedic group producing a selection bias.</td>
</tr>
</tbody>
</table>
### Table 13  Evidence tables of studies comparing crews that do and do not perform rapid sequence intubation and/or thoracostomy (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
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<tbody>
<tr>
<td>(Garner et al. 1999)</td>
<td>Falls</td>
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<tr>
<td>Australia</td>
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<td>continued</td>
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<tr>
<td>Physician group: 10%</td>
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<td>Paramedic group: 6%</td>
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<td>Median time intervals (minutes)</td>
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<td>Call to scene arrival</td>
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<tr>
<td>Physician group: 29</td>
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<tr>
<td>Paramedic group: 26</td>
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<tr>
<td>Scene time (excluding trapped and winched patients)</td>
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<tr>
<td>Physician group: 33</td>
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<td>Paramedic group: 34</td>
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<td>Transport time to hospital</td>
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<td>Physician group: 15</td>
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<td>Paramedic group: 12</td>
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<td>Total pre-hospital time</td>
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<td>Physician group: 86</td>
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<td>Paramedic group: 82</td>
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<td>Median RTS</td>
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<tr>
<td>Physician group: 6.90</td>
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<td>Paramedic group: 7.55</td>
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<td>Median GCS</td>
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<td>Physician group: 13</td>
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<tr>
<td>Paramedic group: 14</td>
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<tr>
<td>P&lt;0.05</td>
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<td>Median ISS</td>
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<td>Physician group: 25</td>
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<td>Paramedic group: 18</td>
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<tr>
<td>P&lt;0.05</td>
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<tr>
<td>Follow-up interval</td>
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<tr>
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<tr>
<td>Analysis</td>
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<tr>
<td>Categorical variables: y² or Fisher’s exact test, as appropriate.</td>
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<tr>
<td>Continuous variables: Mann-Whitney U test.</td>
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<tr>
<td>Comparison between predicted and observed mortality using Z, W and M statistics. An adjusted W statistic was calculated by the method of Younge when the M statistic indicated a poor match with the MTOS cohort and to directly compare the paramedic and physician treated groups.</td>
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<tr>
<td>Procedures at scene</td>
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<tr>
<td>Median volume of fluid infused in patients who received &gt; 50mL</td>
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<tr>
<td>Physician group: 2500</td>
<td></td>
<td></td>
<td>P&lt;0.001</td>
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<tr>
<td>Paramedic group: 825</td>
<td></td>
<td></td>
<td>P&lt;0.001</td>
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<tr>
<td>Median volume of fluid (mL) infused in patients with initial hypotension (systolic BP&lt;90mmHg)</td>
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<tr>
<td>Physician group: 5035</td>
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<td></td>
<td>P&lt;0.001</td>
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<tr>
<td>Paramedic group: 1475</td>
<td></td>
<td></td>
<td>P&lt;0.001</td>
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<tr>
<td>Number of patients intubated</td>
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<tr>
<td>Physician group: 34/67 (1 cricothyroidotomy, muscle relaxant; drugs used in 28 of the 34 intubations)</td>
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<tr>
<td>Paramedic group: 14/140</td>
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<td></td>
<td>P&lt;0.001</td>
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<tr>
<td>Proportion of patients with GCS&lt;9 intubated</td>
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<tr>
<td>Physician group: 23/23</td>
<td></td>
<td></td>
<td>P&lt;0.001</td>
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<tr>
<td>Paramedic group: 14/136</td>
<td></td>
<td></td>
<td>P&lt;0.001</td>
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<tr>
<td>Thoracic decompressions</td>
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<tr>
<td>Physician group: 8/67 (6 tube, 2 needle)</td>
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<tr>
<td>Paramedic group: 2/140 (both needle)</td>
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<tr>
<td>P&lt;0.01</td>
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<td>Comments</td>
<td></td>
<td></td>
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<tr>
<td>All patients attended a single trauma centre in each country.</td>
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<tr>
<td>TRISS methodology appropriately used RTS score.</td>
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<tr>
<td>TRISS analysis appropriately included estimation of the M and W statistics.</td>
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<tr>
<td>Used appropriate methodology to estimate injury severity.</td>
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<tr>
<td>Differences in procedures performed between study groups.</td>
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</tr>
<tr>
<td>Reported conclusions (by authors): Physicians perform a greater number of procedures at accident scenes without increasing scene time. This results in significantly lower mortality. Critical care physicians should be added to paramedic helicopter services for scene response to blunt trauma.</td>
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</tbody>
</table>

**Transportation of emergency patients**
### Table 13  Evidence tables of studies comparing crews that do and do not perform rapid sequence intubation and/or thoracostomy (continued)

| Authors Country       | Study Design | Sample and Interventions                                                                                                                                                                                                 | Methods                                                                                                                                                                                                 | Results                                                                                      | Limitations and Conclusions                                                                 |
|-----------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| (Kroed-Nielsen et al. 2022) Denmark | Before and after | Study setting. A mobile emergency care unit (MECU), which included an anaesthetist, was set up in a region of Denmark. Consecutive patients with acute MI were studied in two time periods: 1. Sept to Nov 1996 (before MECU) 2. Sept to Nov 1997 (with MECU). The area covered approximately 800km². Median response time for MECU was 8.9 minutes and 6.5 minutes for standard ambulances. | Incl/excl criteria. Inclusion of emergency services (based on ambulance company’s patient rolls) who were classified as a diagnosis of MI (ICD-10 codes I21-I22) on an admission to an emergency department or coronary care unit in one of three hospitals in Aarhus, Denmark. The patient was alive when reaching hospital. The hospital record confirmed MI diagnosis, based on enzyme tests and ECG. The hospital record provided sufficient information on diagnosis and treatment. Outcome measures 28 day mortality analysis. Pearson’s χ², Fisher’s exact test, Spearman’s non-parametric rank correlation, Kaplan-Meier survival analysis and multiple logistic regression were conducted. | Crude mortality rate at 28 days, by study period. Pre-MECU: 20.6% MECU: 11.1% Adjusted odds ratio by study period: (28 day mortality), (pre-MECU as the reference) OR 0.3 (P<0.025) Adjusted for age, gender, pulse and systolic blood pressure. Adjusted odds ratio by use of MECU: (28 day mortality), (pre-MECU as the reference) OR 0.2 (P<0.05) Adjusted for age, gender, pulse and systolic blood pressure. | Limitations  
- Retrospective study.  
- Exclusions: six were either dead on arrival or died immediately after arrival (four pre-MECU and two with MECU), specific MI diagnosis could not be confirmed in 25. Unclear if any were excluded due to insufficient information on treatment.  
- Limited data provided at time of first attendance of pre-hospital care.  
- Before and after study is a low quality design – features other than the intervention of interest may have changed so it is unclear to what extent any change in outcome is a result of the introduction of MECU. In this study, the improved prognosis may have been due to angiplasty rather than MECU.  
- Basis of diagnosis of MI not precisely defined; potential for inappropriate selection.  
- Potential for misclassification of outcome, though the size and direction of such misclassification is difficult to determine.  
- During the MECU period, some patients were not attended by MECU (56%). However, although MECU patients were more likely to be considered as severe, MECU patients had higher adjusted odds of survival compared with non-MECU patients.  
- Unclear if results could be replicated if other crews were staffed with people capable of performing rapid sequence intubation. |

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**Transportation of emergency patients**
Table 13  Evidence tables of studies comparing crews that do and do not perform rapid sequence intubation and/or thoracostomy (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Koefoed-Nielsen et al. 2022) Denmark continued</td>
<td>Analyses comparing groups at baseline</td>
<td>Age ≤ 69 years (%)</td>
<td>Pre MECU: 41</td>
<td>MECU: 41</td>
<td>Male sex (%)</td>
</tr>
</tbody>
</table>
Table 13  Evidence tables of studies comparing crews that do and do not perform rapid sequence intubation and/or thoracostomy (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee et al. 2003</td>
<td>Retrospective cohort study</td>
<td>Study setting. Severe blunt trauma patients admitted to Westmead Hospital, Sydney between July 1986 and December 2000. Ambulance officers trained to three different levels: two levels of basic life support and one level of advanced life support. Also had two physician-staffed emergency medical services which respond to accident scenes either by road or helicopter. Level 3 ambulance officer: basic life support plus external control of haemorrhage, splinting, non-invasive airway manoeuvres and bag-valve-mask ventilation. Level 4 ambulance officer: basic life support plus intravenous cannulation and administration of IV fluids, in addition to a limited range of IV medications and needle thoracostesis. Level 5 ambulance officer: Advanced life support. Able to perform all the above procedures plus oral endotracheal intubation. Access to a wider range of IV medications (but not neuromuscular blockade, anaesthetic agents or sedative agents to facilitate intubation). Physicians are free to exercise their clinical judgement in each case.</td>
<td>Incl/excl criteria. Blunt trauma patients with ISS &gt; 15. Outcome measures. Mortality during hospital admission. Analysis. Logistic regression used with the following predictor variables: level of pre-hospital care, time from injury to arrival in hospital, type of injury, mechanism of injury, age, sex, ISS, GCS and systolic blood pressure. Model calibration assessed by the Haemer-Lemeshow goodness-of-fit $\chi^2$ test and predictive accuracy assessed by the area under the receiver operating characteristic curve.</td>
<td>Risk in odds ratio of mortality by level of pre-hospital care and ICU treatment (basic life support as the reference). (95% CI) No ICU admission: Level 5 ambulance: 2.18 (1.05-4.55); Physician: 4.27 (1.46-12.45) ICU admission: Level 5 ambulance: 0.70 (0.53-1.18); Physician: 0.63 (0.28-1.39)</td>
<td>Limitations. Retrospective study. A selective dispatch strategy was used which probably explains the increased mortality rates in the Level 5 ambulance group and the physician group in the non-ICU population. Paramedics may have involved the physician group when patient death was imminent. Unclear if some physician group patients may have been transported by helicopter. Different levels of access to procedures in the non-doctor groups may not be generalizable to other settings, may guide dispatch decisions and may result in bias in comparative estimates. Observation study is susceptible to confounding.</td>
</tr>
</tbody>
</table>

Comments
- Aimed to determine the association between mortality and level of pre-hospital care in severely injured blunt trauma patients with or without severe head trauma.
- No online medical control provided.
- Well described and conducted statistical methodology.

Reported conclusions (by authors).
The level of pre-hospital care was associated with the risk of mortality. This was modified by whether the patient survived long enough to be admitted to the ICU.
<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee et al. 2003</td>
<td></td>
<td>Participants (n=2010):</td>
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<tr>
<td>Australia</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>continued</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Intervention.</td>
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<tr>
<td></td>
<td></td>
<td>Level of pre-hospital care was classified into three groups: basic life support, advanced life support and physician care.</td>
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<tr>
<td></td>
<td></td>
<td>Analyses comparing groups at baseline.</td>
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<tr>
<td></td>
<td></td>
<td>Mean ISS by level of pre-hospital care:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-EMS transport: 20</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Level 3 ambulance: 24</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Level 4 ambulance: 25</td>
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<tr>
<td></td>
<td></td>
<td>Level 5 ambulance: 31</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Physician: 31</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Median age 30 years (interquartile range 21-49 years)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Males: 76%</td>
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<tr>
<td></td>
<td></td>
<td>Causes:</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Road traffic accident: 67%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Falls: 13%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assault: 5%</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>No head injuries: 36%</td>
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<tr>
<td></td>
<td></td>
<td>Isolated head injury: 52%</td>
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<tr>
<td></td>
<td></td>
<td>Head injury with abdominal/chest injuries: 12%</td>
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<tr>
<td></td>
<td></td>
<td>Pre-hospital care:</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Non-EMS transport: 5%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Level 3 ambulance: 23%</td>
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<tr>
<td></td>
<td></td>
<td>Level 4 ambulance: 2%</td>
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<tr>
<td></td>
<td></td>
<td>Level 5 ambulance: 59%</td>
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<tr>
<td></td>
<td></td>
<td>Physician EMS: 11%</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 13  Evidence tables of studies comparing crews that do and do not perform rapid sequence intubation and/or thoracostomy (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
</table>
| (Cameron et al. 2005) Australia | Before and after study, Retrospective chart review, Level III-3. | Study setting: Calais Base hospital. Until 2001 helicopters included emergency physicians. Since 2001 they have been staffed by intensive care paramedics. | Incl/exl criteria: Any primary tasking of the helicopter. Cases were identified by the 'mode of arrival' field recorded on the ED information system. | 30 day mortality proportion, by study group (%): Physician group: 2.8%, Paramedic group: 2.9% *P*<0.01 | Limitations:  
- Retrospective study. 
- The accuracy of coding the mode of arrival (used to identify relevant patients) was not documented. However, this is not likely to be a major source of bias. 
- Unclear if the timing of the measurements used to assess RTS was the same in both groups. 
- Measures of injury severity used were different from the normal approach. No use of the ISS so it was not possible to assess probability of survival with reference to a suitable population such as MIOS. 
- Observation study is susceptible to confounding. 
- Central communication was not documented for either group. 
- Baseline differences in patients admitted with higher proportion of the physician group being admitted. 
- Very low number of deaths consistent with low study power (10 deaths in total). 
- Authors suggested RTS was a poor predictor of need for admission and postulated that APACHE may have been a better measure. 
- No follow-up of patients discharged directly from ED. |
| | | Participants (n=374): Intervention (n=163): Stopped the presence of an emergency physician on an emergency helicopter. Crew mix was unable to perform rapid sequence intubation or tube thoracostomy. Comparator (n=211): Emergency physician (EP) on board. The EP was able to perform any procedure that they can perform in the emergency department. | Data collection: The RTS was calculated using the initial clinical observations in the medical records and ambulance forms. Outcome measures: 30 day mortality, Length of in-hospital stay, Transfer rates, Rates of discharge directly from hospital. Analysis: Analyses comparing groups at baseline. One way analysis of variance was undertaken and *P* values and a *χ*² test with Yates correction were calculated where appropriate. Kappa statistic was used to assess inter-rater reliability in the chart extraction. | Mean hospital length of stay, by study group (days): Physician group: 2, Paramedic group: 1 *P*<0.001 | |
Table 13  Evidence tables of studies comparing crews that do and do not perform rapid sequence intubation and/or thoracostomy (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Cameron et al. 2005) Australia continued</td>
<td></td>
<td>Proportion discharged from ED</td>
<td></td>
<td></td>
<td>Comments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Physician group: 14.7% Paramedic group: 33.1% P=0.0001</td>
<td></td>
<td></td>
<td>- Two consecutive years for each group were examined in the chart review.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proportion of trauma patients admitted Physician group: 86.7% Paramedic group: 68.9% P=0.002</td>
<td></td>
<td></td>
<td>- A second reviewer validated the chart extraction in 40 randomly selected charts (10.7% of the total). Excellent level of agreement achieved (Kappa 0.937).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proportion of non-trauma patients admitted Physician group: 83.7% Paramedic group: 64.4% P=0.004</td>
<td></td>
<td></td>
<td>- All patients transported to the same base hospital.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proportion of trauma patients with maximum RTS Physician group: 89.4% Paramedic group: 90.0</td>
<td></td>
<td></td>
<td>Reported conclusions (by authors). The similarities in outcomes for admitted patients support the view that both groups have similar tasking criteria for high acuity patients and suggest that paramedics are as efficacious as physicians in delivering pre-hospital care in this group of patients. However, for lower acuity patients, there is a statistically significant higher rate of clinically unnecessary taskings by the ambulance group. Given the recent fatal aeromedical accidents in Queensland it would seem prudent to reduce clinically unnecessary retrievals through clinical coordination with appropriately qualified emergency physicians.</td>
</tr>
</tbody>
</table>
Summary and Conclusions

Five studies were identified that were eligible for examining the question “In adults and children with a medical or trauma related emergency, does the presence of a medical crew able to perform rapid sequence intubation and/or thoracostomy improve health outcome when compared with a medical crew unable to perform rapid sequence intubation and/or tube thoracostomy and/or thoracotomy?” In three studies the mortality rate was lower in the group receiving care from crews able to provide at least one of the stipulated procedures (Baxt and Moody 1987; Garner et al. 1999; Koefoed-Nielsen et al. 2002). One other study demonstrated mixed results when stratified by admission to ICU (Lee et al. 2003) and the final study found no significant difference in mortality or hospital length of stay between the two groups (Cameron et al. 2005).

The included studies were only partially helpful in answering this review question as the additional procedures (rapid sequence intubation, tube thoracostomy or thoracotomy) were performed by crews with a doctor present. That is, there were no studies that compared one non-doctor crew that was able to perform any of these procedures with another non-doctor crew that were not able to perform those procedures. Therefore, although the overall results suggest an improved outcome when being attended by crews that were able to perform at least one of rapid sequence intubation, tube thoracostomy or thoracotomy, there could be other reasons for any such improved outcome. For example, if the assessment process differed between crews and subsequent management decisions differed based on the assessments made by the different groups then this may explain any difference in outcome (rather than a difference in procedures).

There were other inherent limitations in the five studies selected. There was variation in study design among the three studies that suggested some benefit from being attended by crews with the additional procedural capabilities. One used a pseudorandomised controlled trial design (Baxt and Moody 1987), one used a retrospective design (Garner et al. 1999) and the other used a before and after design (Koefoed-Nielsen et al. 2002). In relation to the pseudorandomised controlled trial, a particular consideration was the use of limiting the mortality outcome to deaths that were thought to be directly due to the trauma or complications of the trauma. This may have produced outcome misclassification with the potential for underestimating mortality in either group. The use of all-cause mortality as an outcome would have avoided this limitation. There were also limitations to the registry based study but the effect of these limitations on the study estimates was not clear. Firstly, a significant proportion of eligible patients were excluded from the doctor group due to missing charts. There were no deaths among these patients, thus the level of reduced mortality in the doctor group may have been underestimated. However, time to arrival on the scene was shorter in the doctor group. This may have resulted in an improved prognosis in the doctor group and may not be replicated in other settings where time to arrival of the doctor group may be delayed. Perhaps most significantly, the two groups (doctor and no doctor) were located in two different countries so there may have been other reasons that explain differences in outcomes other than the personnel supplying pre-hospital care. For example, level of hospital care may vary between the two settings. In the retrospective study (Garner et al. 1999), seven deaths in the non-doctor group were omitted due to missing case sheets, potentially underestimating the effectiveness of care provided by doctor crewed helicopters. Patients were also directed to different hospitals in this study depending on the helicopter crew mix. The before and after study was restricted to patients with acute MI. The before and after design (Koefoed-Nielsen et al. 2002) is the biggest limitation since it is not possible to be certain the improved outcome was a result of the different crewing mix or other factors that had changed over time. Based on the above limitations there is uncertainty about the robustness of the findings in these three studies.

Cameron et al. (2005) published a retrospective chart review. This study found no significant difference in outcome between study groups. However, it was limited by the inclusion of limited injury severity data and low study power to detect a difference in mortality.

The other study was set in Australia (Lee et al. 2003). The study population consisted of patients with severe blunt trauma. Three types of pre-hospital care were studied. The most basic level of life support was used as the reference category and was compared with another non-medical configuration and a configuration with a doctor on board. It was only the latter group that was able to perform rapid sequence intubation or tube thoracostesis. The results varied by whether the patients were subsequently admitted to ICU. The odds of mortality were significantly higher in the two more advanced pre-hospital configurations when the patient was not admitted to ICU. However, when the patient was admitted to
ICU there were no statistically significant differences between pre-hospital care groups. It should be noted that a selective dispatch strategy was used so the more severely injured patients were seen by the more advanced ambulance group and the doctor group. The authors also commented that paramedics may have involved the physician group when patient death was imminent. These factors may explain the poorer prognosis in the two more advance pre-hospital care groups among the patients who did not proceed on to ICU care.

As in previous sections, more research is required to answer this question. A useful study would be to compare doctors versus fully trained non-doctor personnel. The study should be adequately powered to detect equivalence in outcome. Other considerations include

1. Whether there may be variation in outcome across crew mixes for different clinical scenarios. For example, the inclusion of doctors on road ambulances may be associated with longer at scene times. This longer period of stabilisation could be associated with improved outcome in some circumstances but not others.

2. Comparing outcomes in paediatric and adult age groups and stratifying results by ISS score.

**Outcomes by time from ambulance call out to emergency department delivery**

From the search strategy for question four (outcome by time from ambulance callout to emergency department delivery) we identified, 1863 potentially relevant articles/abstracts of which 152 were retrieved. Of these retrieved articles, 132 were excluded. These papers, annotated with the reason for exclusion, are presented in Appendix 6. One study was identified from reference lists and was included in the papers for appraisal. Reasons for exclusion of studies before retrieval in full text are outlined in Table 14. Reasons for exclusion of studies retrieved in full text are detailed in Table 15.

**Table 14 Reasons for exclusion of studies before retrieval in full text: time from callout to emergency department delivery**

<table>
<thead>
<tr>
<th>Reason for exclusion</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not relevant to review question aim</td>
<td>1424</td>
</tr>
<tr>
<td>Methods were not clearly described</td>
<td>0</td>
</tr>
<tr>
<td>Wrong publication type</td>
<td>184</td>
</tr>
<tr>
<td>Incorrect population</td>
<td>4</td>
</tr>
<tr>
<td>Sample size less than 50</td>
<td>71</td>
</tr>
<tr>
<td>Incorrect comparator</td>
<td>5</td>
</tr>
<tr>
<td>Incorrect outcomes</td>
<td>11</td>
</tr>
<tr>
<td>Publication superseded</td>
<td>0</td>
</tr>
<tr>
<td>Non-English language</td>
<td>0</td>
</tr>
<tr>
<td>Neonatal study</td>
<td>1</td>
</tr>
<tr>
<td>Duplicate abstract</td>
<td>1</td>
</tr>
<tr>
<td>Wrong or uncertain time component presented</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>1711</td>
</tr>
</tbody>
</table>

**Table 15 Reasons for exclusion of studies retrieved in full text: time from callout to emergency department delivery**

<table>
<thead>
<tr>
<th>Reason for exclusion</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not relevant to review question aim</td>
<td>49</td>
</tr>
<tr>
<td>Methods were not clearly described</td>
<td>0</td>
</tr>
<tr>
<td>Wrong publication type</td>
<td>2</td>
</tr>
<tr>
<td>Incorrect population</td>
<td>3</td>
</tr>
<tr>
<td>Sample size less than 50</td>
<td>1</td>
</tr>
<tr>
<td>Incorrect comparator</td>
<td>16</td>
</tr>
<tr>
<td>Incorrect outcomes</td>
<td>4</td>
</tr>
<tr>
<td>Publication superseded</td>
<td>0</td>
</tr>
<tr>
<td>Non-English language</td>
<td>1</td>
</tr>
<tr>
<td>Neonatal study</td>
<td>0</td>
</tr>
<tr>
<td>Wrong or uncertain time component presented</td>
<td>55</td>
</tr>
<tr>
<td>Duplicate study</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>132</td>
</tr>
</tbody>
</table>
Twenty-one retrieved articles were appraised and are listed in the references and Appendix 7. Included papers are presented in the evidence table below. Included studies were all level III-2 according to NHMRC’s hierarchy of evidence, including 21 cohort studies and one case control study.

Pepe et al. 1987

Pepe et al. (1987) investigated the outcome of patients following penetrating trauma. The 498 consecutive patients were stratified into four groups based on trauma scores and survival was assessed by total pre-hospital time across these four trauma group categories. Chi square analysis was used to compare survival by four groups of total pre-hospital time. The sample size varied across the four categories of trauma score (35-317). The study was set in Texas, average age was 31 years and the mean total pre-hospital time was 32.6 minutes. There was no significant difference in survival across the four categories of total pre-hospital time within each trauma score stratum.

There were limitations to this study:

- stratifying by trauma score reduced study power. The trauma score category with the largest number of participants consisted of patients with >90% probability of surviving (based on TRISS methodology).
- the observational design is susceptible to confounding. Although the authors have stratified by trauma score, this measure provides a physiological assessment (rather than anatomical assessment) and can change rapidly over time. Therefore, injury severity may vary within the trauma score strata. Although some reassurance is provided by the relative uniformity of predicted survival (based on TRISS methodology) within trauma score strata, small sample sizes in some categories mean residual confounding could remain as an issue.
- the results of this study can only be applied to patients with penetrating trauma given the selection criteria for the study population.

Schiller et al. 1988

Schiller et al. (1988) compared helicopter with ground transportation in a group of patients with blunt trauma and ISS of 20-39. This was a retrospective chart review and total pre-hospital time had to be estimated in 15% of patients due to lack of recording. There were 259 patients transported by ground ambulance and 347 by helicopter. Statistical analysis was restricted to univariate analyses by Student’s t test and chi square test. The mean mission time for ambulances was 39 minutes and 50 minutes for the helicopters. Mortality was significantly higher in the helicopter group (18% versus 13%, \(P<0.05\)). There was no difference in length of stay between the two groups (26 days in both groups). There was no comparison between pre-hospital time and the outcome of interest.

Potential sources of bias in this study included:

- the arbitrary estimation of pre-hospital time in 15% of participants.
- the ecological nature of comparing two different transportation groups and basing any association with pre-hospital time on the mean pre-hospital times of the two groups.
- the lack of control over potential confounders.
- uncertainty whether consecutive patients were used in the study.
- uncertainty whether any difference in mortality between the two groups is due to a difference in pre-hospital time or other factors such as the dispatch strategy. The skill mix may also result in bias in the comparative outcome estimates if the crews in the two different modes of transport have different levels of skill.

Sloan et al. 1989

A study set in Chicago investigated the effects of taking trauma patients directly to a level 1 trauma centre whether or not they bypassed other hospitals (Sloan et al. 1989). Thus two groups were formed: a direct group and a bypass group with the latter group bypassing other hospitals en route to the level 1 trauma centre. On that basis the total run time (time from dispatch to trauma centre arrival) varied by patient. Data comparing the mortality and survival groups were presented including total run time in the two groups. Eligibility criteria included one of the following three categories:
1. Life threatening injury, including traumatic arrest, penetrating neck trauma, and/or blunt or penetrating chest or abdominal trauma with systolic BP < 100mmHg

2. Field trauma score ≤ 12

3. Limb threatening injury.

Patients were excluded if they arrived at the trauma centre without vital signs and were unable to be resuscitated or if outcome data were missing.

There was no significant difference in total run time between the mortality and survival groups (32 minutes versus 35 minutes respectively) although the study had 90% power to detect a 6% difference in survival.

However, there were limitations:

- the observational design was susceptible to confounding and the method of analysis did not help to control confounding (multivariate or stratified analyses were not presented)
- the method of deriving time data was unclear therefore the accuracy of the total run time was uncertain
- fifty five (21%) patients were excluded, including 48 who presented to the trauma centre without vital signs.

Schwartz et al. 1990

Schwartz et al. (1990) compared air and ground ambulance programmes to determine whether pre-hospital time or pre-hospital care was the major contributor towards survival in a group of patients following blunt trauma. All patients were transported directly from the scene to definitive care. There were 126 patients, 93 transported by air and 33 by ground. The authors extracted data from three registries and chart review.

The average pre-hospital time was longer in the air group (65 minutes versus 34 minutes). However, Z scores (based on TRISS methodology via comparison with the MTOS cohort) found a significantly improved survival in the air group (Z=2.23) and significantly poorer outcome in the ground group (Z=-2.69).

There were a number of limitations to this study:

- confounding was a potential problem in this observational study. In this study it is likely that the crew mix was a more important determinant of outcome than the pre-hospital time. On this basis the study results are difficult to interpret.
- the basis for dispatching a helicopter rather than a ground crew was not clear. There may have been a potential selection bias as a result, although it is noted that if there is a bias other studies have tended to dispatch helicopters to the more severely unwell patients.
- the degree of match between the study data and the MTOS cohort data was unclear as the M statistic was not documented.
- the ecological nature of comparing two different transportation groups and basing any association with pre-hospital time on the mean pre-hospital times of the two groups.

Sampalis et al. 1992

Sampalis et al. (1992) conducted a study that aimed to compare observed and expected mortality (using TRISS methodology and based on the MTOS cohort) overall and by subgroups (including pre-hospital time, level of pre-hospital care and level of in hospital care). The investigators used a complicated three stage sampling process. The aim of this sampling process was to select patients with severe but survivable injuries. It was unclear if the approach was set prior to selecting the sample. The final sample consisted of 355 patients with a mean ISS of 13.7. However, there was a wide range of ISS scores (1-59) so some patients did not fulfil the severe injury aim of the sampling strategy. There were three broad data analyses:
1. Comparison of the overall data (using the Z score and the SMR)
2. A subanalysis of different strata defined on pre-hospital time, pre-hospital care and in-hospital care (using the Z score and the SMR)
3. An adjusted comparison of the above strata using logistic regression.

Overall there were more deaths than expected as reflected in the Z score (6.77, P<0.0001) and SMR (1.81, 95% CI 1.42-2.21). Within strata defined by pre-hospital time (>60 minutes compared with reference of 0-60 minutes) there were greater excess deaths in the > 60 minute group with an SMR ratio (> 60 minutes versus 0-60 minutes) of 6.41 (95% CI 1.69-17.37). Logistic regression also found an association between prolonged pre-hospital time and poor survival (OR 29.9, 95% CI 2.7-33.3).

There were strong aspects to this study, not the least of which was to incorporate a multivariate analysis within the methodology. However, limitations also existed:

- it was unclear from the selection process whether the criteria were preset and just how representative the selected sample was of the group the investigators were aiming to explore. The reviewers are unclear why an approach such as stratified random selection based on ISS score were not used.
- there were further sources of selection bias due to missing data. In particular, 30 of 385 potential patients from the final sample were excluded due to missing charts and pre-hospital time data was only available on 270 of 355 eligible participants (76%).
- there were only 13 patients with a pre-hospital time > 60 minutes.
- the accuracy of the pre-hospital time was not clear.
- although a multivariate analysis was conducted this study is still susceptible to confounding by other unknown and uncontrolled factors. However, it is important to recognize that these findings suggest in this study population that prolonged pre-hospital time (> 60 minutes) was associated with poorer outcome even after controlling for different mixes of pre-hospital crews (including the presence of a physician). Furthermore, the level of care provided by the hospital (based on the American College of Surgeons criteria for trauma centre categorisation) was also controlled.

Sampalis et al. 1993

Sampalis et al. (1993) also published a case control study where cases died within 6 days of injury and controls survived more than 6 days after injury. There were similarities to their 1992 study and it is assumed the study populations overlapped. Specifically, the first two stages of the three stage sampling process were the same with the same number of patients selected at the end of sampling stage 2. The difference was at stage 3 of the sampling process where the selection was based on specific criteria to fulfil either a case or a control. More detail is provided in Table 16. There were 72 cases and 288 controls. Again the study focused on three factors, total pre-hospital time, the crew mix at the pre-hospital phase and the level of care provided in-hospital. Both univariate and multivariate analyses were conducted. A wide range of variables were considered in the stepwise selection of the logistic regression model before finishing with a relatively simple model.

There were increased odds of survival of more than six days in association with a pre-hospital time under 60 minutes (OR 3.01, 95% CI 1.27-5.06).

Similar quality considerations apply to this study as they did with the 1992 study. There were strong aspects to this study, not the least of which was to incorporate a multivariate analysis within the methodology. However, limitations also existed:

- it was unclear from the selection process whether the criteria were preset and just how representative the selected sample was of the group the investigators were aiming to explore. The reviewers are unclear why an approach such as stratified random selection based on ISS score was not used.
- there were further sources of selection bias due to missing data. In particular, 34 of 337 potential patients with a PHI>3 were excluded from the final sample due to missing charts.
- the accuracy of the pre-hospital time was not clear.
although a multivariate analysis was conducted this study is still susceptible to confounding by other unknown factors. However, it is important to recognize that these findings suggest in this study population that prolonged pre-hospital time (> 60 minutes) was associated with poorer outcome even after controlling for different mixes of pre-hospital crews (including the presence of a physician). Furthermore, the level of care provided by the hospital (based on the American College of Surgeons criteria for trauma centre categorisation) was also controlled. It is interesting to note the odds ratio in this study was much smaller than in the previous study, although still indicating that pre-hospital time more than 60 minutes appears to have an adverse outcome on survival.

Bonatti et al. 1995

Bonatti et al. (1995) aimed to identify predictors of short-term survival in their Austrian setting. The study was based on a HEMS unit that included physician staffing. There were no specific eligibility criteria listed but it is presumed that all missions between 1989 and 1991 were included. There were 2139 participants with a preponderance of sporting injuries (53.7%). Data were extracted from medical records, flight logs and discharge summaries. Univariate and multivariate analyses were conducted.

The univariate analyses showed decreasing survival with increasing total mission time ($P=0.0001$):
- 0-20 minutes: 95.5% survival
- 21-40 minutes: 91.7% survival
- 41-60 minutes: 87.6% survival
- 61-80 minutes: 86.8% survival
- > 80 minutes: 78.8% survival.

However, on multivariate analysis, there was no association between total mission time and survival after adjusting for cause of injury/emergency, flight time to scene, scene time, patient age, patient gender, NACA score, state of consciousness, respiratory status, circulatory status, emergency physician.

There was relatively little methodological data given. It is difficult to assess the probability of selection bias given the lack of details about the process although it should be recognised that there were a high proportion of sporting injuries in this population. The accuracy of data recording in the sources used for data extraction was not documented. Adjusting for components of the total mission time in the multivariate model may have contributed to the lack of association observed. Finally, despite the use of a multivariate model, the possibility of residual confounding cannot be discounted.

Feero et al. 1995

This group used a different study design where they compared unexpected survivors with unexpected deaths (based on TRISS methodology). (Feero et al. 1995). While there were 848 eligible trauma victims in the study time period, there were only 13 unexpected survivors and 20 unexpected deaths. The study relied on identifying patients from a local registry. Entry on this registry consisted of a set of mandatory criteria and a set of optional criteria. The mandatory criteria were divided into physiological, anatomical and mechanism of injury characteristics. The key result was a prolonged total EMS time interval in the unexpected death group when compared with the unexpected survivor group (29.3 minutes compared with 20.8 minutes, $P=0.02$). However, the unexpected death group was also significantly older than the unexpected survivor group (50.8 years versus 29.5 years, $P=0.01$).

Study limitations included:
- while the TRISS methodology was useful for identifying the two unexpected outcome groups (and there was a high degree of concordance between the reference population and the actual population), the lack of control for potential confounders in this study was problematic
- there were small numbers in the two study groups of interest (total of 33 patients)
- probability of selection bias due to the lack of consistent use of objective criteria for study inclusion (a reflection of the retrospective design that made use of registry data).
Young et al. 1998

Young et al. (1998) presented a study comparing mortality and length of hospital stay across two groups: trauma patients transported directly to a level 1 trauma centre versus trauma patients transferred via another hospital en route to the level 1 trauma centre. The study was restricted to patients over 18 years with an ISS greater than 15. The study used a retrospective design and relied on registry plus hospital note data. The time from injury to arrival at the trauma centre averaged 480 minutes in the transfer group and 92 minutes in the direct group. There was no significant difference in length of hospital stay or overall mortality between the two groups. The authors studied two mortality subgroups (deaths within 24 hours and deaths more than 24 hours after injury). Unexpected deaths (based on TRISS methods) were analysed further in the group of deaths in the first 24 hours and found a higher proportion of unexpected deaths in the transfer patients (75% versus 28%, \( P<0.05 \)).

The study had significant limitations

- there were discrepancies in the number of deaths within the paper (three deaths were not accounted for when categorizing to the first 24 hours and more than 24 hours after injury)
- M statistic indicated a poor match between the reference data and the actual data casting doubt on the validity of the probability of survival data
- no direct comparison between pre-hospital time and outcome
- observational study design that is susceptible to confounding.

Frezza et al. 1999

A study set in the USA examined the effect of pre-hospital time on outcome in patients undergoing emergency room thoracotomy (ERT), (Frezza and Mezghbe 1999). There were 58 adult patients with penetrating chest trauma, although the analysis was restricted to 33 of these patients who actually received ERT. Twenty-four hour survival was higher in the group with a pre-hospital time <30 minutes compared with the group with a pre-hospital time >30 minutes (20/27 (63%) versus 0/6 (0%)).

This study had significant limitations making it difficult to interpret the above results. In particular:

- scant details were presented in the methods
- there were apparent deaths > 24 hours post injury thus incorporation of those deaths in the analysis of pre-hospital time would have reduced the difference in survival between the two groups
- the components of the pre-hospital time recorded were not documented so it is unclear if this time refers to time from dispatch of emergency services to time of arrival at hospital
- data were missing on nine patients and a further 16 were excluded due to lack of vital signs being recorded from the field.

Phillips et al. 1999

Phillips et al. (1999) compared the outcome in patients transported by road and air ambulance. The aim of this study was to assess outcome against national standards. Patients retrieved by air ambulance had, on average, a longer period of pre-hospital time than the road ambulance group (77 minutes versus 54 minutes). The air ambulance crew was permitted to conduct more advanced procedures than the road ambulance crew so therefore were preferentially given the more severely injured patients to transport.

As background, based on TRISS methodology, the mean predicted survival rate was 93.9% in the road ambulance group and 83.1% in the air ambulance group. There was a significantly longer hospital stay in the air ambulance group than the road ambulance group (77 minutes versus 54 minutes). The air ambulance crew was permitted to conduct more advanced procedures than the air ambulance crew so therefore were preferentially given the more severely injured patients to transport.

Estimation of Z scores (based on comparison with the MTOS cohort using TRISS methodology) showed no significant difference in actual versus predicted mortality either within the road ambulance group or the air ambulance group. The \( M \) statistic was not estimated so the degree of fit between the MTOS cohort and the study cohort was not clear.

Other limitations also existed. The most significant was that this study was not designed to compare pre-hospital time against outcome thus the differences in outcome (especially hospital length of stay) could be fully explained by the increased severity of injury in the air transport group. It is not possible...
to determine whether the prolonged hospital stay in the air ambulance group was partially due to the longer pre-hospital period in this group. There were other limitations that are outlined in Table 16. These limitations are such that it would be inadvisable to form any conclusions regarding the effect of different pre-hospital times on patient outcome based on this study.

Sampalis et al. 1999

Following the two earlier studies by Sampalis et al. (1992; 1993) a programme of regionalization of the trauma services occurred. This cohort study aimed to assess the impact of regionalization on mortality. It also investigated the association between pre-hospital time and mortality. There were 12,208 patients included in the study. Selection criteria were

- treated for injuries at acute care hospitals in Montreal and Quebec
- one of:
  - Death as a result of injury
  - ISS>12
  - At least two injuries with AIS ≥3
  - Hospital stays > 3 days.

Patients who died at the scene were excluded.

The analytic method varied by hypothesis tested. In relation to the association between pre-hospital time and mortality, logistic regression was used. The mean age of the sample was 48 years. This decreased over the six study years. Mean ISS was 26.1. The majority were discharged alive (72%).

During the six years of the study 3,453 (28%) of the patients died. The adjusted odds ratio for the association between each additional minute of pre-hospital time and mortality was 1.046 (95% CI 1.044-1.050). This was adjusted for time to admission, trauma centre designation, transfer versus direct transport, patient age and ISS. This result indicates a 5% increase in risk of mortality for every minute’s pre-hospital delay.

This was a well conducted study and it had the advantage of a large sample size. Any biases present are likely to be small and could arise for inaccurate pre-hospital times, confounding (given the observational design) and potential selection biases resulting from the selection methods.

Grzybowski et al. 2000

This study compared patients surviving at least seven days with deaths within that time period after presenting with chest pain or shortness of breath (Grzybowski et al. 2000). Ninety-six percent of patients had an acute MI. The study population was restricted to patients 18 years and over and nine patients were excluded due to missing outcome data. There were 244 patients in the final study population. Bivariate comparison found a significantly longer total pre-hospital time in the deaths than the survivors (50.6 minutes versus 42.8 minutes, P≤0.01).

Limitations of this study included:

- while multivariate regression was used, indices of pre-hospital time were not included in this model, so there was no control over potential confounders in the pre-hospital time to outcome relationship
- it is unclear if the prolonged time in the non-survivors may have been due to more severe disease requiring immediate management on the scene.

Berns et al. 2001

Berns et al. (2001) compared outcome amongst a group of cardiac patients transported by helicopter with another group transported by road ambulance. There were 266 helicopter patients and 28 road ambulance patients. Most patients were transferred from referring emergency departments rather than the site of onset of cardiac symptoms and the pre-hospital time reflected time from the request for
transfer to arrival at the definitive treatment hospital. Data on hospital length of stay and mortality were presented.

The pre-hospital times were a mean of 104 minutes in the helicopter group and 142 minutes in the ground ambulance group. Hospital length of stay was significantly shorter in the helicopter group (6.4 versus 8 days, \( P=0.04 \)) but there was no significant difference in mortality between the two groups (7% in helicopter group and 4% in ground group).

In regards to the review question of interest, this study was difficult to interpret as the difference in hospital length of stay may have reflected differences in staffing mixes by the two different forms of transport. The study was underpowered to detect a difference in mortality. There were no comparisons with individual pre-hospital time data further limiting this study.

Clarke et al. 2002

This study focused on patients with severe abdominal trauma who had systolic BP < 90mmHg on ED arrival and either died in ED or were transferred to the operating room for laparotomy. There were 243 patients included in the study. Interval risk ratios for death were estimated based on pre-hospital time. All risk ratios included one indicating no increased risk of death for any pre-hospital time interval. However, the time interval 31-60 minutes neared significance (RR 1.268, 95% CI 0.980-1.641). There were 117 patients in this time category (including 63 who survived and 54 who died).

There were potential sources of selection bias (omission of patients who did not have appropriate time intervals recorded in the registry and exclusion of patients who had extreme time intervals), misclassification (due to reliance on registry data that the authors may have been frequently rounded to the nearest five minutes) and confounding based on the observational design and lack of analyses that could control for known confounding factors. In general, the study was well conducted but the main focus was on ED time rather than pre-hospital time.

Lim et al. 2002

A study set in Singapore investigated survival following out of hospital cardiac arrest (OHCA), (Lim and Seow 2002). This study divided the 93 patients into two groups: patients who survived post ED resuscitation and patients who did not survive beyond this time. There were 15 survivors using this classification although only one survived to hospital discharge. All patients with non-traumatic OHCA presenting during a three month period from November 2001 were included. Data were extracted from various records, including ambulance case records, ED resuscitation charts and in-patient records. Univariate analyses were conducted using the t test and the chi square test. There was no significant difference in total pre-hospital time between the survivors and non-survivors (38.3 minutes versus 35.4 minutes respectively).

There were significant limitations to this study:

- the sample size was low so the power to detect a significant difference in pre-hospital time across the two groups was low
- there is likely to be misclassification of the total pre-hospital time since the recordings were only documented once the ambulance arrived at the hospital
- the combination of the observational design and the lack of multivariate analysis mean the results are highly susceptible to confounding.

Osterwalder et al. 2002

Osterwalder et al. (2002), in their Swiss based study, aimed to test the hypothesis that exceeding the 60 minute limit for the entire pre-hospital time increases mortality of blunt trauma patients. There were 254 participants including 107 with a rescue time up to 60 minutes and 147 with a rescue time over 60 minutes. All the blunt trauma patients were treated at a single hospital (St Gallen Cantonal Hospital) and had an AIS of at least two for at least two of six defined body regions. The actual 30 day mortality was compared with predicted mortality (based on ASCOT score). Flora’s z statistic was used to compare actual with expected mortality. Univariate and multivariate analyses (logistic regression) were also conducted. The adjusted odds ratio found increased odds of dying in the group with a transport
time up to 60 minutes compared with the group with a transport time more than 60 minutes (OR 8, 95% CI 1.7-38.5).

There were limitations to this study:

- the observational design is susceptible to confounding and while a multivariate analysis was conducted, the variables included in the model were not documented. There were differences between the two groups at baseline
- while consecutive patients were included in the study, 9% were omitted due to missing time data.

Lerner et al. 2003

Lerner et al. (2003) conducted a chart review examining the association between total pre-hospital time and mortality. Charts were selected for patients who were transported directly to the study hospital and were either admitted to hospital or died in ED. Patients were excluded if there was incomplete data, more than one day between the time of injury and time of admission, CPR was initiated in the field, or the patient was transported from a correctional facility. Most of the data were extracted from the trauma registry. Univariate and multivariate analyses (logistic regression) were conducted. There were 1877 participants.

On univariate analysis the total pre-hospital time was longer in the survivors than the non-survivors (35.26 minutes versus 31.58 minutes, difference 3.69 minutes, 95% CI -.52-6.85 minutes). There was no association between total out of hospital time and mortality on multivariate analysis (OR 0.987, 0.97-1.00).

Limitations of the study included:

- the limitations associated with chart reviews including missing data and inconsistent recording of data
- the authors commented they expected the pre-hospital time to be randomly misclassified, thus diluting any association
- approximately 20% of the study population had to be omitted due to missing data, resulting in selection bias
- the design is susceptible to confounding although the use of logistic regression helps to control this.

Biewener et al. 2004

Biewener et al. (2004) studied four pathways for the transportation of polytrauma patients:

1. Helicopter transportation to a level 1 trauma centre (HEMS-UNI group).
2. Ambulance transportation to a level 1 trauma centre (AMB-UNI group).
3. Ambulance transportation to a level 2 or 3 trauma centre (AMB-REG group).
4. Ambulance transportation to a level 2 or 3 trauma centre followed by transfer to a level 1 trauma centre (INTER group).

In the context of this review, the first two categories were of interest. The AMB-REG group did not fulfil the criteria for definitive care and the pre-hospital times were not stated for the INTER group.

There were 403 patients in total, including 140 in the HEMS-UNI group and 70 in the AMB-UNI group. Inclusion was limited to patients with an ISS at least 16, alive at time of hospital arrival and had complete documentation of all patent data. Patients over 75 years were excluded as were patients with an ISS score over 67. There were no differences in age, gender or ISS across the groups.

The mean pre-hospital time in the HEMS-UNI and AMB-UNI groups were 90 minutes and 68 minutes respectively. There was no significant difference in mortality between the two groups on logistic regression (controlling for study group, age and ISS).
Limitations of this study included:

- in relation to the review question of interest our primary interest is with pre-hospital time whereas the authors’ primary interest was with comparing different transport pathways. As a consequence there was no comparison between different pre-hospital times at an individual level. This also had the consequence of lack of control over other differences between study groups, such as aggressiveness of management during the pre-hospital phase.

- the study made use of registry collected data but there was no indication of the accuracy of data recording.

- it is noted that there were no cases of penetrating trauma within the study population.

Gao et al. 2006

A retrospective review of polytrauma patients was conducted in China (Gao et al. 2006). There were 15,340 eligible patients during the ten year study period (1993-2003). To be included there needed to be injuries to more than two ISS regions and at least one region needed to include an AIS of at least three. Data were extracted on sex, age, causes of injury, duration of preadmission and injured regions, shock state on admission, amount of blood transfusion, severity of injuries, method of diagnosis, therapeutic procedures. The chi square test was used in data analysis. Mortality was significantly higher in the group with a preadmission time of at least one hour (7.7% versus 3.9%, *P*<0.01).

Limitations of this study included:

- potential limitations of this type of retrospective review, including inconsistent recording of data (e.g. some may round pre-hospital time and others may not) and uncertainty about the accuracy of data

- no control of potential confounders (absence of multivariate analysis in this observational design)

- potential lack of applicability to other populations.

Hartl et al. 2006

Hartl et al. (2006) explored the effect of pre-hospital management decisions on early mortality following severe traumatic brain injury (TBI). A major focus was on the decision to indirectly transport patients to definitive care via an intermediate hospital. Nevertheless the investigators also examined the pre-hospital time and its influence on two week mortality. Patients were restricted to those with head injury with GCS<9 for at least six hours after injury and arrival at a level 1 or level 2 trauma centre within 24 hours of injury. More detail is provided in Table 16. Data were extracted from the TBI-trac registry. There was no significant association between pre-hospital time and two week mortality (OR for each minute increase in transport time 1.00, 95% CI 1.00, 1.00).

There were potential sources of bias:

- there were patient exclusions, some of which fulfilled the *a priori* eligibility criteria and some did not. Specifically from 1449 patients entered in the TBI-trac data base, 1123 were included in the study. From the list of exclusion criteria documented in the study methods, 210 of the 326 exclusions appeared to fulfil those pre-set criteria. There was also incomplete participation of the trauma centres throughout New York State with 54% of all trauma centres participating in the New York State quality improvement program (which was used as the source of trauma centres) being included in the study. These limitations indicate potential selection biases.

- while a multivariate model was developed that included some potential confounders other potential confounders may have been present in this observational study that were overlooked.

- there was no information presented on the accuracy of the registry data. Misclassification may have occurred due to for example coding errors. Misclassification of pre-hospital time may also have occurred if, for example there was a tendency to round times.
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
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<tr>
<td>(Pepe et al., 1987) USA</td>
<td>Cohort study Level III-2.</td>
<td>Study setting, Subjects with penetrating injuries delivered to a single regional trauma centre in Houston, Texas. Response area covers close to 700 square miles and transport times to the trauma centre can exceed 30 minutes. Participants: 498 consecutive participants Baseline measurements Average age 31.3 years Mean trauma score 11.1 Mean ISS 20.2 Mean response time 5.3 minutes Mean scene time 15.8 minutes Mean transport time 11.7 minutes Mean total pre-hospital time 32.6 minutes</td>
<td>Incl/excl criteria: Penetrating trauma Systolic BP ≤ 90mmHg Transferred directly to Ben Taube General Hospital Data collection Fire Department records times of receipt of call, dispatch of paramedics, paramedics’ arrival at incident location, leaving incident location, and hospital arrival. The total pre-hospital time (TPT) was defined as the time from receipt of the call until the time of arrival at the trauma centre. Outcome measures Discharged alive from hospital Analysis Patients stratified into four groups based on their initial pre-hospital trauma score (1, 2-6, 7-11, 12-15). Each of these groups was studied independently in relation to TPT. Four groups of TPT were formed: 0-20 minutes, 21-30 minutes, 31-40 minutes and &gt;40 minutes. All patients were also assessed in terms of their probability of survival using TRISS methodology. Survival rates were compared using chi-square analysis (or Fisher’s exact test when n&lt;7). Continuous variables were assessed using analysis of variance.</td>
<td>Within the four trauma score groupings, there was no significant difference in survival by TPT Trauma score =1 TPT (Mins)</td>
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<td>Trauma score =7-11 TPT (Mins)</td>
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<td></td>
<td></td>
<td>Trauma score =12-15 TPT (Mins)</td>
<td>Observed (%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>≤20</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>21-30</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>31-40</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&gt;40</td>
<td>91</td>
</tr>
</tbody>
</table>

Limitations
- Observation study is susceptible to confounding. Limited control of potential confounding (stratification by pre-hospital trauma score).
- Timing of BP measurement unclear and may have resulted in variable application of selection criteria.
- Trauma score is a physiological measure that can change over time, thus time of measurement is critical to ensuring consistency in grouping.
- Small samples in some cells limiting power to detect significant differences across the time categories.
- Study limited to penetrating injuries so lacks generalisability to blunt trauma and medical emergencies.
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Pepe et al. 1987) USA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Comments</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Aimed to examine the relationship between the survival rates of patients with presumed haemorrhagic shock due to penetrating injuries and the total pre-hospital time required to manage and deliver these patients to a single regional trauma centre in a large urban area.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>• Paramedics operate under a management plan. Key points for penetrating injuries include control of any significant external haemorrhage, aggressive airway management (preferably by intubation), large bore IV cannulation en route, patients placed on backboards and cervical spine immobilised. Primary goal is rapid evacuation. Patient’s condition is radioed en route.</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>• Consecutive participants selected.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reported conclusions (by authors). The time factor involved in managing and transporting hypotensive penetrating injury victims directly to a regional trauma centre does not appear to be related to an adverse outcome, at least during the first hour of injury.</td>
</tr>
</tbody>
</table>
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schiller et al. 1988 USA</td>
<td>Retrospective cohort study</td>
<td>Study setting: Patients admitted to the trauma centre at St Joseph’s Hospital, Phoenix, Arizona during 1983-1986. Approximately 800 Category I trauma patients admitted annually. Participants: 606 participants with 259 transported by ground ambulance and 347 by helicopter. Analyses comparing groups at baseline: Mean age (years), Ambulance 31, Helicopter 30, Male (%), Ambulance 74, Helicopter 78, Mean trauma score Ambulance 12.7, Helicopter 12.1, Mean GCS Ambulance 10.4, Helicopter 9.6</td>
<td>Incl/excl criteria: ISS 20-39 Blunt trauma Data collection: Mode of transportation, site of origin, elapsed time of the rescue mission, GCS, age, gender and injuries. Outcome measures: Hospital days Mortality Analysis: Student’s unpaired t test, chi square test</td>
<td>Mean mission times (minutes) Ambulance 39 Helicopter 50 Mortality (%) Ambulance 13 Helicopter 18 P&lt;0.05 Hospital length of stay (days) Ambulance 26 Helicopter 26</td>
<td>Limitations: • Total pre-hospital time frequently missing. When necessary (~15%), this was estimated by doubling the time from the scene and adding 10 minutes. Thus pre-hospital time is subject to misclassification and the direction of any bias is unclear although the authors felt this would underestimate mission time in the helicopter group. • Observation study is susceptible to confounding. • Elements of ecological analysis for the results of interest to this review. Specifically, there was no comparison between individual time data and outcome, rather the comparison was between helicopter and ground transportation. • Retrospective analysis. • Unclear if consecutive patients were used. • No documentation about the experience and skills of the crews in the air versus ground comparision. • No documentation of the basis for deciding whether a helicopter or ground ambulance should be dispatched.</td>
</tr>
</tbody>
</table>
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Schiller et al. 1988) USA continued</td>
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</tbody>
</table>

Comments
- Primary aim was to assess whether transportation of patients with ISS 20-39 by helicopter resulted in improved survival when compared with ground transportation.

Reported conclusions (by authors).
- There is no survival advantage in the helicopter transported group in an urban area with a sophisticated pre-hospital care system. Patients of rural origin deserve further study.
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
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<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sloan et al. 1989</td>
<td>Cohort study</td>
<td>Study setting: Study in Chicago that compared trauma patients transported directly to the nearest level 1 trauma center with patients who had to bypass other emergency departments to get to the nearest level 1 trauma center. Study period: March to November 1987.</td>
<td>Excluded: 1. Patients who arrived at Cook County Hospital in traumatic arrest who were unable to be resuscitated; 2. Patients with missing outcome data.</td>
<td>Comparison of mortality and survival groups: Total run time (minutes); Mortality group 32 Survival group 35 no significant difference</td>
<td>Limitations: Observation study is susceptible to confounding. Multivariate analysis was not conducted thus further limiting control over potential confounders (although there were no significant differences in baseline data between direct and bypass patients). Small number of deaths (n=29) reducing power of the study. Accuracy of time data uncertain. Injury severity score only known for 190 of the 203 patients. Measurement of trauma score conducted on hospital arrival rather than on scene. Mechanism of trauma documented in 196 of 203 patients. Unsuccessfully resuscitated traumatic arrest was the reason for exclusion in 48 (19%) with higher proportion excluded for this reason in direct transport group (28% versus 14%, P=0.05). Seven patients excluded due to inadequate outcome data.</td>
</tr>
<tr>
<td>USA</td>
<td>Level III-2.</td>
<td>Participants (n=203): Intervention (n=66). Direct transport group. Taken directly to Cook County Hospital without bypassing any other hospitals. Comparator (n=137): Required hospital bypass. Patients bypassed other hospitals on route to Cook County Hospital. Baseline analysis: Average age 26 years Male 83% Blunt trauma 57% Operative trauma 63% Average ISS 17 Hospital trauma score 13 Average total run time 35 minutes Average hospital stay 12 days</td>
<td>Data collection: Total run time was the time from Chicago Fire Department (CFD) dispatch to arrival at trauma centre. Overall pre-hospital time also included delay time from time of injury to CFD dispatch. Registry data used to extract mechanism of injury, initial hospital trauma score, estimated abbreviated injury scale and injury severity score.</td>
<td></td>
<td>Comments: Studied the influence of hospital bypass on pre-hospital times and level 1 trauma patient survival. Study had 90% power to detect a difference in survival of 6% or more.</td>
</tr>
</tbody>
</table>

**TRANSPORTATION OF EMERGENCY PATIENTS**
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors</th>
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<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sloan et al. 1989</td>
<td>USA</td>
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<td></td>
<td>Reported conclusions (by authors).</td>
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<td>The urban use of hospital bypass does not decrease trauma patient survival in those who arrive at the trauma centre with vital signs. We also conclude that attempts should be made to shorten delay in CFD contact to reduce overall pre-hospital time and maximise patient survival. Further study in both urban and rural settings should determine whether bypass allows death to occur during transport and whether longer bypass times influence overall pre-hospital time and mortality.</td>
</tr>
</tbody>
</table>
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
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<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Schwartz et al. 1990) USA</td>
<td>Retrospective cohort study</td>
<td>Level III-2.</td>
<td>Study setting: EMS system in Connecticut 60% of population covered by ground ambulance and entire population can be reached by air ambulance.</td>
<td>Survival (Z score compared with MTOS dataset)</td>
<td>Differences in crewing between the air and ground services. Therefore, difficult to establish if difference in outcome was due to the difference in pre-hospital time, the crew mix or something else. There were differences in procedures performed between the two groups (the air group was more interventional). On the basis that the poorer outcome was associated with the group with shorter pre-hospital times it seems likely that skill mix was a bigger contributor than the pre-hospital time.</td>
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<td></td>
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<td>Participants: 126 patients, 93 transported by air and 33 by ground.</td>
<td>Air ambulance Z=2.23</td>
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<td>Analyses comparing groups at baseline. Average response time (time to scene). Air 34 minutes. Ground 6 minutes.</td>
<td>SIGNIFICANTLY IMPROVED COMPARED WITH MTOS COHORT</td>
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<td>Average scene time Air 22 minutes. Ground 18 minutes.</td>
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<td>Average time to hospital Air 10 minutes. Ground 11 minutes.</td>
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<td>Average total pre-hospital time Air 65 minutes. Ground 34 minutes.</td>
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<td></td>
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<td>Data collection. Data obtained from three separate computerised data management registries and medical records. Paramedic and LIFE STAR registries contain data on pre-hospital times. Interventions and individuals who performed procedures. Trauma registry contains inpatient data including length of stay. Patient charts were examined for outcome and confirmation of registry data.</td>
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<td>Data collected included age, sex, mode of transport, mechanism of injury, pre-hospital times, medical interventions, trauma score, ISS and outcome. Time of dispatch was used to approximate the time of injury.</td>
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<td>Analysis. Analysis of pre-hospital times was made by the ttest. TRISS methods were used to compare survival between the two groups.</td>
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<td></td>
<td></td>
<td></td>
<td>LIMITATIONS AND CONCLUSIONS</td>
<td></td>
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</tr>
<tr>
<td>Authors</td>
<td>Study Design</td>
<td>Sample and Interventions</td>
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</tr>
<tr>
<td>Schwartz et al. 1990</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Compared a hospital based aeromedical programme to a ground paramedic service in order to determine whether pre-hospital time or pre-hospital care is the major contributor towards survival.</td>
</tr>
<tr>
<td>USA</td>
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<tr>
<td>continued</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reported conclusions (by authors): Since the scene time of both aeromedical and ground services were similar, the improved survival of the air patients may be due to the technical intervention procedures performed.</td>
</tr>
</tbody>
</table>

**Table 16 Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)**
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
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<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Sampalis et al. 1992) Canada</td>
<td>Retrospective cohort study, Level III-2.</td>
<td>Study setting, All EMS in Montreal is controlled by Urgences-sante. Urgences-sante coordinates pre-hospital emergency services, coordinates ambulance transport, plans emergency room use in collaboration with hospitals and controls admitting policies and data accumulation on the regional availability of hospital beds. Crews attending are dependent on the severity of injury. For critically ill, a physician is included whereas in less severe cases an ambulance and emergency medical technician will be dispatched. Participants: Sample 1: 3293 (2956 with minor trauma and 337 with major trauma) Sample 2: 928 Sample 3: 355. Baseline analyses Mean age 33 years (range 0-84) Injury sustained at home 28% Motor vehicle crash 37% Head injury 37% Chest injury 29% Abdominal injury 25% Penetrating injury 22% Mean ISS 13.7 (range 1-59) Mean total pre-hospital time 36 minutes Mean time on scene 20 minutes Deaths 70/355</td>
<td>Incl/excl criteria, Three study samples. Sample 1. Retrieved records of 4722 of 5553 patients treated by a physician at the scene, 1477 patients for which a nurse requested a physician but none were available and of 977 patients for which only an EMT was requested and dispatched. The latter group was selected by randomly sampling one of eight days for the last seven months of the study. Exclusions: declared dead at scene or not taken to hospital.</td>
<td>Overall results (observed compared with expected based on MTOG population as reference) Z=6.77 P=0.0001 SMR 1.81 (95% CI 1.42-2.21) Both indicate higher observed than expected deaths. Results by total pre-hospital time Pre-hospital time 0-60 minutes SMR (observed compared with expected): 1.56 (95% CI 1.13-1.97) Z=3.92 Pre-hospital time &gt;60 minutes SMR (observed compared with expected): 10.0 (95% CI 2.96-19.96) Z=5.00 SMR ratio (pre-hospital time 0-60 minutes versus &gt;60 minutes) 95% CI 1.69-17.37 Indicating increased excess mortality in the longer pre-hospital time group. Adjusted odds ratio (95% CI) for pre-hospital time &gt;60 minutes compared with 0-60 minutes: OR 29.9 (2.7-33.3) Controlled for pre-hospital crew mix, in-hospital care level and ISS.</td>
<td>Controlling sampling approach. It was unclear if components of sample 1 were randomly selected – specifically there was no documentation about how the patients treated at the scene by a physician were selected or whether the 1477 cases where a nurse requested a physician to attend the scene but none were available represented the entire cohort or whether some undescribed selection process applied. On the basis of the sample selection bias cannot be excluded. It was unclear if sampling rules were set before selecting the sample. Further sources of selection bias amongst some exclusions. For example, 30 of 385 patients were excluded from sample 3 due to hospital charting not being available. A t-statistic comparing match between the actual data and the reference data was not presented (although in the question and answer section Sampalis stated it was not significantly lower than 0.9) so there may have been a poor match between data. Therefore a statistic data may be unreliable.</td>
</tr>
</tbody>
</table>
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Sampalis et al. 1992 Canada continued</td>
<td></td>
<td></td>
<td>Analysis: Two methods used to compare the observed mortality with the expected mortality (based on the MTCS population). First was estimating the Z score and the second by estimating the standardised mortality ratio (SMR).</td>
<td>Three steps to the data analysis: 1. The Z score and the SMR were estimated in sample 3. 2. Aimed to evaluate the difference between expected and observed deaths in different strata defined to represent pre-hospital care, in-hospital care and total pre-hospital time. Z scores and SMRs were estimated for each of these strata. 3. Aimed to perform adjusted comparisons of the SMRs in different levels of the variables described above. Logistic regression was used in this analysis. The model compared the outcome rate in one level of an independent variable with the rate expected according to indirect standardisation while controlling for the effect of other covariates.</td>
<td>• Observation study is susceptible to confounding though multivariate analysis was conducted which is an improvement on other studies. • Pre-hospital time data restricted to 270 of 355 (76%) with complete data. • Only 13 patients with a pre-hospital time &gt; 60 minutes so dealing with small patient numbers in this group. Comments: Primary aim was to apply Flora’s Z statistic and indirect standardisation to the MTCS in a sample of severely injured patients. A second aim was to assess the association between pre-hospital and in-hospital components of the Montreal EMS with the SMR in this sample of trauma victims. • Sampling had the aim of selecting patients with severe but survivable injuries. Reported conclusions (by authors): Standardisation to the MTCS population indicated a significantly high overall excess mortality in the Montreal sample. Being treated in a level I or level II compatible hospital was associated with lower excess mortality. Total pre-hospital time over 60 minutes was associated with a significant increase in excess mortality.</td>
</tr>
</tbody>
</table>
### Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
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</tr>
</thead>
</table>
| (Sampalis et al. 1993) Canada | Case control study | Study setting: All EMS in Montreal is controlled by Urgences-sante. Urgences-sante coordinates pre-hospital emergency services, coordinates ambulance transport, plans emergency room use in collaboration with hospitals and control admitting policies and data accumulation on the regional availability of hospital beds. Crews attending are dependent on the severity of injury. For critically ill, a physician is included whereas in less severe cases an ambulance and emergency medical technician will be dispatched. | Incl/excl criteria: | Odds of 6 day survival (pre-hospital time ≤60 minutes versus > 60 minutes): OR 2.09 (95% CI 0.67-6.29) | - Confusing sampling approach. It was unclear if components of sample 1 were randomly selected – specifically there was no documentation about how the patients treated at the scene by a physician were selected or whether the 1477 cases where “a nurse requested a physician to attend the scene but none were available” represented the entire cohort or whether some undescibed selection process applied. On this basis selection bias cannot be excluded. It was unclear if sampling rules were set before selecting the sample.  
- Further sources of selection bias amongst some exclusions. For example, 34 of 337 with a Piti>3 were excluded from sample 3 due to hospital charts being not available.  
- Observation study is susceptible to confounding though multivariate analysis was conducted which is an improvement on other studies. |
|                | Level III-2  | Participants: Cases 72 Controls 288 Baseline analyses: Mean age 33.9 years Males 71% At least one comatose condition 12% Motor vehicle crash 32% Total pre-hospital time 35.6 minutes | Three study samples: Sample 1: Retrieved records of 4722 of 5553 patients treated by a physician at the scene, 1477 patients for which a nurse requested a physician but none were available and of 977 patients for which only an EMT was requested and dispatched. The latter group was selected by randomly sampling one of eight days for the last seven months of the study. Exclusions: declared dead at scene or not taken to hospital. Sample 2: A random 10% subsample of patients with minor trauma (Pre-hospital Index ≤3) and treated by a physician, all patients with major trauma and one 13% random sample of patients treated by EMT only. | Adjusted odds of 6 day survival (pre-hospital time ≤60 minutes versus > 60 minutes): OR 3.01 (95% CI 1.27-5.06) | |
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors</th>
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<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampalis et al.</td>
<td>Canada</td>
<td></td>
<td></td>
<td>Sample 3 (final sample). Cases from:</td>
<td>Sample 2 who fulfilled the criteria for:</td>
<td>Comments:</td>
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<td>being a case or a control were</td>
<td>alive at time of ambulance arrival at scene</td>
<td>Aimed to assess the association between use of on-site advanced life</td>
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<td></td>
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<td>included. Cases: alive at time of ambulance arrival at scene</td>
<td>transported to a hospital by an Urgences-sante ambulance, died</td>
<td>support, total pre-hospital time and level of in-hospital care with six</td>
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<td>by an Urgences-sante ambulance, died</td>
<td>survived &gt;6 days of time of injury,</td>
<td>day survival in severely</td>
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<td>fulfilled any of: admitted to hospital had surgery, treated in ICU,</td>
<td>admitted to urgent cases, pre-hospital index&gt;3.</td>
<td>injured patients.</td>
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<td>multiple logistic regression used to control for potentially confounding</td>
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<td>Undoubtedly</td>
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<td>factors. Pre-set variables added to the model and final model was</td>
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<td>considerable overlap in</td>
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<td>derived from the stepwise selection method.</td>
<td></td>
<td>patients.</td>
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<td></td>
<td>Higher proportion of cases</td>
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<td></td>
<td></td>
<td>had at least one comorbidity</td>
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<td></td>
<td></td>
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<td>(22% v 10%).</td>
</tr>
</tbody>
</table>

Reported conclusions (by authors). No benefit is associated with the use of physician-provided on-site advanced life support in reducing the risk of death in severely injured patients. The data strongly supports the significance of reduced pre-hospital time and high level in-hospital care for the control of trauma related mortality.
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Bonatti et al. (1995)</td>
<td>Retrospective cohort study</td>
<td>Study setting: Conducted at the HEMS unit Christopher I based at Innsbruck, Austria during a three year period from 1989 to 1991 inclusive.</td>
<td>Incl/excl criteria. Not stated. Data collection.</td>
<td>30 day survival by total mission time. 0-20 minutes: 96.5% survival. 21-40 minutes: 91.7% survival. 41-60 minutes: 87.6% survival. 61-80 minutes: 88.8% survival. &gt; 80 minutes: 78.8% survival. Univariate analysis, p=0.001 Multivariate analysis, no significant association, adjusted for cause of injury/emergency, flight time to scene, scene time, patient age, patient gender, NACA score, state of consciousness, respiratory status, circulatory status, emergency physician.</td>
<td>• No documentation of selection criteria. It is assumed all patients were included. • Observation study is susceptible to confounding though multivariate analysis was conducted which is an improvement over other studies. • Accuracy of data recording in the data bases used was not recorded. • Patients appeared to be taken to multiple hospitals - criteria for taking patients to specific hospitals were not stated and may have influenced outcome. • Adjusting for flight time to the scene and scene time may have diminished the association between total mission time and survival since these measures are subsets of total mission time. Comments: Aimed to identify easily obtainable predictors of short-term outcome for emergency victims treated by a physician staffed helicopter emergency medical system. Reported conclusions (by authors). The following parameters can be used in an initial predictive assessment by the flight physician and the admitting institution: severity of emergency, initial respiratory status, time at scene, patient age and patient gender.</td>
</tr>
<tr>
<td>Austria</td>
<td>Level III-2</td>
<td>Participants: 2139 participants. Baseline analyses. Sporting accidents 53.7%. Motor vehicle accidents 11.1%. Occupational injuries 5.6%. Medical emergencies 16.1%. Neurological emergencies 2.8%. Other missions 10.7%. 30 day survival 87.9%.</td>
<td>Analysis. Univariate survival analysis by the life table method and Wilcoxon test. Cox proportional hazards model for multivariate analysis.</td>
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</tbody>
</table>
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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<tr>
<th>Authors Country</th>
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<th>Limitations and Conclusions</th>
</tr>
</thead>
</table>
| Feero et al. 1995 USA | Retrospective cohort study Level III-2. | Study setting, Study set in Portland Oregon (population 500,000 200 square miles). Emergency services work under a two tier system: basic and advanced life support | Incl/excl criteria. All major trauma cases for 1990 were obtained from the State of Oregon Injury Registry and the Medical Resource Hospital. Major trauma defined as those cases entered by EMS providers into the local trauma system. Mandatory criteria included: Systolic BP < 90 mmHg Respiratory rate <10 or >29 breaths/min GCS<13 Penetrating injury of head, neck, torso, thigh. >20% total body surface area burns Amputation above the wrist or ankle Spinal cord injury with limb paralysis Flail chest Two or more obvious proximal long bone fractures Death of same car occupant Exclusion of encumbered vehicle Extrication time longer than 20 minutes. Patients could be entered if: High energy transfer Based on comorbid conditions | Total EMS time interval (minutes) unexpected survivors 20.8 minutes Unexpected survivors: 20.8 minutes Unexpected deaths: 29.3 minutes P<0.02 | - Small numbers of patients in the unexpected survivor and unexpected death groups. 
- Possible misclassification of the unexpected survivor and unexpected death groups (although M statistic was 0.98 suggesting a good fit between the reference data and the actual data). 
- Potential for inconsistency in the selection process given a category of non-mandatory reporting. 
- Potential for confounding in this observational study. 
- Mixture of RTS data used – some from scene and some from hospital, although similar proportions used hospital data in the unexpected survivors and the unexpected deaths (42% vs 39%). 

Comments
- Aims to determine if out of hospital emergency medical services time intervals are associated with unexpected death and survival in urban major trauma.
- All trauma cases taken to a single hospital.
- Reported conclusions by authors. Short out of hospital time interval may positively affect patient survival in selected urban major trauma patients

Transportation of emergency patients
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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<tbody>
<tr>
<td>(Feero et al. 1995)</td>
<td>USA</td>
<td></td>
<td></td>
<td>Analysis</td>
<td>TRISS methodology used to calculate probability of survival,</td>
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<td></td>
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<td></td>
<td>Flora’s Z statistic used to compare expected and observed deaths.</td>
<td>Unpaired t test used to compare mean time intervals for the late deaths</td>
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<td>continued</td>
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<td>unexpected survivor and death groups</td>
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Table 16   Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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<tbody>
<tr>
<td>Young et al. 1998 USA</td>
<td>Retrospective cohort study Level III-2</td>
<td>Study setting. Set in the University of Virginia Health Sciences Center which is a level 1 trauma centre serving central and western Virginia. An aeromedical programme exists that transfers patients from the scene and from outlying hospitals. Study conducted during 1994-1995. Participants: 316 participants divided into direct patients (n=165) and transfer patients (n=151). Analyses comparing groups at baseline Age (years) Transfer group 46 Direct group 44 ISS Transfer group 23.1 Direct group 24.8 GCS in ED Transfer group 11.4 Direct group 11.4 Expected number of deaths Transfer group 23 Direct group 34</td>
<td>Incl/excl criteria. Age &gt; 18 years ISS &gt; 15 Data collection Data extracted from trauma registry and patient records. ISS, delay at outside hospital, patient demographics collected. Outcome measures Hospital length of stay and mortality. Analysis TRISS calculated with reference to MTRIS coefficients. Chi square test used for categorical data and Student’s t test for continuous data</td>
<td>Time from injury to arrival at trauma centre Transfer group 480 minutes Direct group 92 minutes Length of hospital stay Transfer group 19.1 days Direct group 15.4 days No significant difference Mortality &gt; 24 hours after injury Transfer group 12 deaths Direct group 10 deaths No significant difference Mortality &lt; 24 hours after injury Transfer group 16 deaths Direct group 25 deaths No significant difference Deaths with probability of survival &gt; 50% in first 24 hours Transfer group 12 of 16 Direct group 7 of 25 P&lt;0.05</td>
<td>Elements of ecological analysis for the results of interest to this review. Specifically, there was no comparison between individual time data and outcome, rather the comparison was between outcome transfer and direct data (and thus used as a proxy for time, given the longer transportation time in the transfer group than the direct group, 480 minutes versus 92 minutes). Accuracy of trauma registry not stated. Observation study is susceptible to confounding. Multivariate analysis was not conducted thus further limiting control over potential confounders (although there were no significant differences in baseline data between direct and bypass patients). Discrepant results presented in that the total deaths presented in the direct group (n=38) is not consistent with total deaths in first 24 hours in direct group (n=10) plus total deaths after 24 hours in the direct group (n=25).</td>
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</table>

Transportation of emergency patients
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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<tr>
<td>(Young et al. 1998)</td>
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<td>continued</td>
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<td></td>
<td>• Did not present unexpected deaths more than 24 hours after injury and did not present unexpected survivors.</td>
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<td>• M score was &lt; 0.88 indicating a poor match with the MIOS dataset.</td>
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<td>Comments</td>
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<td>• Examined the hypothesis that delay at the referring hospital is detrimental to patient outcome.</td>
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<td></td>
<td>Reported conclusions (by authors).</td>
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<td>Patients with major trauma taken directly to the trauma centre had shorter hospital stay and lower mortality. The study supports transferring major trauma patients directly to trauma centres from the injury scene.</td>
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</table>
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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<tbody>
<tr>
<td>(Frezza and Mezghebe 1999) USA</td>
<td>Retrospective cohort study</td>
<td>Study setting: Trauma patients attending the Howard University Hospital Emergency Department between 1992 and 1995. Participants: 58 adult patients with penetrating chest trauma. Baseline analyses: Gunshot wounds 70%, Stab wounds 12%, Systolic BP &lt; 70mmHg 24%, Transfer to ICU 63%. Average pre-hospital time: At the scene 11 minutes. Transist 8 minutes. ED 10 minutes.</td>
<td>Incl/excl criteria: Patients who underwent emergency room thoracotomy (ERT) and had vital signs in the field. Penetrating chest trauma. Data collection: Pre-admission data extracted from EMS reports. Analysis: Corrected chi square test.</td>
<td>Survival within 24 hours by pre-hospital time: Pre-hospital time &lt; 30 minutes: 63% survival (20/27) Pre-hospital time &gt; 30 minutes: 0% survival (0/6)</td>
<td>Scant details presented in methods. Reviewer is not aware of Fisher corrected chi square test – other corrections are available – the method is not referenced. Accuracy of pre-hospital time unclear. Observation study is susceptible to confounding. Multivariate analysis was not conducted thus further limiting control over potential confounders. Data only presented on 33 of the 58 patients (data were missing on nine patients and 16 were excluded from further analysis due to lack of vital signs in the field. Pre-hospital time not clearly defined. In particular it was unclear if it included time from dispatch to time of arrival at scene. Appeared to be deaths after 24 hours but it was not possible to establish how many deaths there were in this time period. Therefore, if the number of deaths presented by pre-hospital time had been extended beyond 24 hours, the difference in survival between the two time groups would have been less.</td>
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Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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<tr>
<td>Frezza and Mezghebe 1999</td>
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<td>Comment: Aimed to assess if pre-hospital time could be used as the principle parameter to predict whether emergency room thoracotomy in penetrating chest trauma is useful. Reported conclusions (by authors). The only role of ERT in our opinion is in patients who arrive within 30 minutes of pre-hospital time.</td>
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<td>USA continued</td>
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<tr>
<td>(Phillips et al. 1999)</td>
<td>Retrospective cohort study</td>
<td>Patients transported to Brooke Army Medical Centre level 1 trauma centre by either air or road ambulance during 1995-6.</td>
<td>Incl/excl criteria: Consecutive ambulance transported trauma patients. Excluded patients who did not have TRISS values. Data collection: Extracted data required for TRISS calculations. Outcome measures: Survival Analysis: Z statistic calculated based on comparison with the MTOS population.</td>
<td>Comparison of actual and expected mortality by transport group. Ground transport (shorter time) Expected deaths 39.1 Actual deaths 41 ( Z=0.04 ) Air transport (longer average transport time) Expected deaths 16.3 Actual deaths 15 ( Z=-0.151 ) Mean length of stay: Ground transport 4.21 days Air ambulance 8.97 days ( P&lt;0.001 )</td>
<td>Limitations: Missing information on 38 patients led to their exclusion (4.8%). Different staffing on the two modes of delivery: road ambulance had two paramedics; air ambulance had a paramedic and a flight nurse. More severely injured patients were preferentially treated by air ambulance. Air ambulance patients received a higher level of care en route. M statistic not presented so degree of fit with MTOS data was unclear. Observation study is susceptible to confounding. Multivariate analysis was not conducted thus further limiting control over potential confounders. Elements of ecological analysis for the results of interest to this review are not made. Specifically, there was no comparison between individual time data and outcome, rather the comparison was between air and road ambulance (and thus used as a proxy for time, given the longer transportation time in the air group).</td>
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**Table 16** Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)
### Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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</table>
| (Phillips et al. 1999) | USA | continued | | | Comments  
* Aimed to review whether air ambulance transportation of trauma patients to a level 1 trauma centre contributed to maintaining national mortality standards in the trauma care of these patients.  

Reported conclusions (by authors).  
Results suggest that aeromedical evacuation of the more severely injured patients farthest from the trauma centre resulted in mortality rates that met national standards. |
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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<tr>
<td>Sampalis et al. 1999</td>
<td>Prospective cohort study</td>
<td>Study setting: Study set in Montreal and Quebec during and after a time of regionalisation of trauma care services. Participants (n=12,208): Baseline analyses Mean age 48 years Male 67.6% Mean ISS 26.1 Discharged alive 71.6%</td>
<td>Incl/excl criteria: Treated for injuries at acute care hospitals in Montreal and Quebec. One of: Death as a result of injury ISS&gt;12 Pht&gt;3 ≥2 injuries with AIS ≥3 Hospital stay &gt; 3 days Exclusions: died at scene Data collection: Data extracted from records using a standardised data extraction form and then entered into a customised data management software program. Final analysis was conducted in SPSS. Outcome measures: Death during hospital admission Analysis: The analytical methods were divided by hypothesis. Hypothesis 1 tested that trauma care regionalisation is associated with a reduction in trauma related mortality. Analysis consisted of comparison of mortality rates during each fiscal year before and after regionalisation, comparison of mortality rates during each phase of implementation of the regionalised Quebec system. Logistic regression was used.</td>
<td>Overall mortality rate 28% through the six years. Adjusted odds of death by pre-hospital time (OR for each additional minute of pre-hospital time) OR 1.046 (95% CI 1.044-1.050) Adjusted for time to admission, trauma centre designation, transfer versus direct transport, patient age and ISS.</td>
<td>Limitations: • Accuracy of pre-hospital time unclear. • Observation study is susceptible to confounding although with the multivariate modelling the risk of confounding by known confounders is reduced. • Potential for inappropriate selection as the final process relied on chart review. Comments: • This study aimed to assess the impact of regionalisation of trauma care services on mortality. Regionalisation was initiated in 1993. Note the two earlier Sampalis studies (1992 and 1993) supported such regionalisation. • No risk of loss to follow-up due to the nature of the study design. Reported conclusions (by authors): This study produced empirical evidence that the integration of trauma care services into a regionalised system reduces mortality. The results show that tertiary trauma centres and reduced pre-hospital times are the essential components of an efficient trauma care system.</td>
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Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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<tbody>
<tr>
<td>Sampalis et al. (1999)</td>
<td>Canada continued</td>
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<td>- Hypothesis 2a: tested mortality rates of patients treated at tertiary care centres compared with patients at less specialised hospitals. Also tested mortality rates in those who were transported directly from the scene to the tertiary centre and those who were transported indirectly.</td>
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<td>- Hypothesis 2b (tested the association between process of trauma care regionalisation and mortality as it related to the Quebec trauma system - where the rate of appropriate patient triage will increase and pre-hospital time will decrease over time). This component was not relevant to this review.</td>
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<td>- Hypothesis 2c (reduced pre-hospital time is associated with reduced mortality). Logistic regression used.</td>
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Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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<tbody>
<tr>
<td>Grzybowski et al. 2000</td>
<td>USA</td>
<td>Retrospective cohort study</td>
<td>Study setting: Study conducted in 1996 and 1997 consisting of patients having an AMI who were transported by ambulance to one of three hospitals in the suburbs of Detroit.</td>
<td>Incl/excl criteria. 218 years. Chief complaint of chest pain or shortness of breath. Patients with suitable outcome data.</td>
<td>Mean total EMS time, survivors v deaths (minutes) Survivors 42.8 Deaths 50.6 P&lt;0.01</td>
<td>Limitations: - Initial population of 291 selected for study. Exclusions: ineligible chief complaint (n=37), missing ED chief complaint (n=1), missing outcome data (n=9). - Observational study is susceptible to confounding. While multivariate modelling was conducted, pre-hospital time was not included in the model, thus comparison of pre-hospital times was based on univariate analysis only.</td>
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<td>Level II-2</td>
<td>Participants: 253 eligible but 244 selected due to missing outcome data in the other nine patients. Baseline analysis Mean age 66.6 years Male 60.2% Cardiac arrest 7%. Mean total EMS time 44 minutes EMS vital signs: Heart rate 78.9 Respiratory rate 23.1 Systolic BP 128.1 Diastolic BP 80.</td>
<td>Data collection Ambulance run sheets: age, gender, race, EMS vital signs, ambulance run times, type of hospital.</td>
<td>Outcome measures Death within seven days of ED arrival Analysis Predictor variables were compared by survival status. Odds ratios and 95% confidence intervals were estimated for each predictor variable. A forward stepwise logistic regression model was fitted.</td>
<td>Comments: - Assessed which independent variables predict death within seven days in-patients with suspected AMI transported by EMS. - Robustness of the data for estimating total pre-hospital time was not clear but any error seems likely to be small. - Low risk of outcome misclassification.</td>
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</table>

Reported conclusions (by authors): A triage rule based on a multivariate model can identify the group at high risk of early cardiac death. This decision rule needs to be prospectively validated.
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<tr>
<td>Berns et al. (2001) USA</td>
<td>Retrospective cohort study Level III-2</td>
<td>Study setting: A hospital based helicopter program in Minnesota. Conducted over January 1998 to June 1999. Participants: 266 helicopter patients and 28 road ambulance patients. Analyses comparing groups at baseline. Mean age (years) Helicopter 65 Ground 67 Male: Helicopter 67% Ground 61% Time from call to hospital arrival (minutes) Helicopter 104 Ground 142</td>
<td>Incl/exc criteria: All cardiac patients transported by the Mayo One Rochester helicopter, including patients with chest pain, angina, MI and arrhythmias. Exclusion criteria included patients transported to a different hospital, by the Mayo fixed wing service, by ground with a flight nurse on board, by the Mayo Eau Claire helicopter and by another helicopter service. Data collection: Chart review. Outcome measure: Hospital length of stay (LOS). Mortality Analysis: t tests performed on transport time, time from call until hospital arrival, CCULOS and hospital LOS.</td>
<td>Hospital length of stay (days) Helicopter 6.4 Ground 8 P=0.04 Mortality data Helicopter 7% Ground 4%</td>
<td>limitations: While there were 50 eligible ground ambulance patients records were only received in 28 of these resulting in a significant selection bias. Different staffing mixes between helicopter and road ambulances means it is not possible to ascribe any difference in outcome to difference in pre-hospital time. Observational study is susceptible to confounding. Elements of ecological analysis for the results of interest to this review. Specifically, there was no comparison between individual time data and outcome, rather the comparison was between air and road ambulance (and thus used as a proxy for time, given the longer transportation time in the ground group). Comments: Aimed to investigate the outcome in cardiac patients transported by helicopter versus ground ambulance. Helicopter transport benefits the cardiac patient with decreased chest pain as a result of fewer treatments en route; decreased time from call to arrival, resulting in decreased time to intervention; and shortened pre-hospital time and hospital stays.</td>
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Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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</table>
| (Clarke et al. 2002) | Retrospective cohort study | Study setting: Injured patients who were cared for at a Pennsylvania trauma centre  
Participants: 250 patients met a prior eligibility criteria but seven were excluded due to extreme pre-hospital or ED times.  
Baseline analyses: Systolic BP range 30-90mmHg  
Elapsed time to ED range 7-185 minutes  
Time in ED range 7-915 minutes | Incl/excl criteria: Made use of trauma registry data which omits information on patients who died, were transferred to other trauma centres or had a hospital stay of more than two days. Patients with isolated hip fractures were excluded. Patients were restricted to those brought directly to the trauma centre from the scene, were not transferred from the ED to another hospital, did not have confounding burns or pre-existing conditions. Patients were then selected based on: Systolic BP < 90mmHg on arrival at ED  
Patient either died in ED or was transferred to the operating room for laparotomy  
Abdominal vascular, solid organ or wall injury with an abbreviated injury scale score (AIS) of 3-6  
No other injuries with an AIS >2 except for a lacerated diaphragm or open, displaced, comminuted pelvic fracture  
Either the time of injury or ambulance dispatch and the time of arrival in ED and time of departure from ED or death in ED or arrival at OR. | Risk ratios for death by minutes to ED:  
RR 1.286 (0.980-1.641)  
RR 1.268 (0.980-1.641)  
RR 1.268 (0.980-1.641)  
RR 1.268 (0.980-1.641)  
RR 1.268 (0.980-1.641)  
RR 1.268 (0.980-1.641)  
RR 1.268 (0.980-1.641)  
RR 1.268 (0.980-1.641) | Limitations:  
Relied on accuracy of registry data.  
No data presented on the accuracy of that source.  
Generalisability restricted to a narrow range of injuries resulting from trauma due to the narrow selection criteria.  
Observational study is susceptible to confounding.  
Focus of the study was more on ED time than the pre-hospital period.  
Seven of the 250 eligible patients were excluded due to extreme pre-hospital timings (8 hours for one and 7 days 20-hours for another) and prolonged ED time (>24 hours).  
Potential biases identified by the authors included misclassification of timing intervals due to a tendency to round to the nearest 5 minutes, failure to identify pre-existing conditions in individuals who died shortly after arrival, selection bias due to missing time data. |
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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<td>(Clarke et al. 2002)</td>
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<td>Data collection</td>
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<td>(Lim and Seow 2002) Singapore</td>
<td>Retrospective cohort study Level 2</td>
<td>Study setting: Ambulance service in Singapore uses a single tier system. Study set in ED of Tan Tock Seng Hospital, which sees about 350 patients per day. Participants: n=93 (15 survivors, 78 non-survivors) Analyzes comparing groups at baseline: Mean age (years) Survivors 63.1 Non-survivors 65.5 Male (%) Survivors 53.3 Non-survivors 62.8 Initial cardiac rhythm: asystole (%) Survivors 53.3 Non-survivors 71.3 Bystander CPR (%) Survivors 6.6 Non-survivors 18.0 Pre-hospital defibrillation (%) Survivors 6.6 Non-survivors 18.0 ROSC (%) Survivors 46.7 Non-survivors 0.0 P&lt;0.001</td>
<td>Incl/excl criteria: All out-of-hospital cardiac arrest (OHCA) patients presenting from Nov 2001 through Jan 2002 with non-traumatic OHCA. Data collection: Data collected from ambulance case records, ED resuscitation charts and ED VHF Case Log Sheets, in-patient hospital records. Collected demographic information, time related data, initial cardiac rhythm, use of automatic external defibrillator, result of resuscitation on scene or en-route to hospital, patient's pre-mortal condition. Outcome measures: Survival post ED resuscitation Analysis: Data analysed using two tailed t test for all continuous variables and chi-square test for all discrete variables.</td>
<td>Comparison of survivors (post ED resuscitation) and non-survivors, total pre-hospital time (minutes) Survivors: 38.3 Non-survivors: 35.4 P&lt;0.02 Note only one patient survived to hospital discharge.</td>
<td>Limitations • Rely on accuracy of recorded data. The paramedics are only able to complete the relevant form containing the time data on arrival at ED so the time recorded is likely to be susceptible to misclassification. • Observational study is susceptible to confounding and method of analysis was not useful for controlling potential confounders. • Small patient numbers, particularly amongst the survivors (n=15), reduced study power. • Not the most useful outcome measure (survival post ED resuscitation). It is noteworthy that only 1 of the 15 patients surviving ED resuscitation actually survived to hospital discharge. • Some inconsistencies in the paper eg. One statement suggested 15 survived ED resuscitation and another suggested seven survived ED resuscitation.</td>
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### Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

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</table>
| (Lim and Seow 2002) | Singapore | continued | | | | **Comments**  
- Aimed to evaluate characteristics  
  and outcome of out-of-hospital cardiac arrest patients presenting to the ED, and to examine factors that could be used to determine whether to prolong or abort resuscitation for these patients.  
- Included consecutive patients.  

Reported conclusions (by authors).  
The survival rate for patients with OHCA after ED resuscitation is similar to the results from other studies. Prolonged resuscitation efforts appear to be futile for OHCA patients if the time from cardiac arrest until arrival in the ED is at least 30 minutes coupled with ROSC, and if continuous asystole has been documented for more than 10 minutes.
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Osterwalder 2002) Switzerland</td>
<td>Prospective cohort study</td>
<td>Study setting: Study hospital (St Gallen Cantonal Hospital) serves Eastern Switzerland, has an immediate catchment population of about 100,000 and has about 800 beds (including two ICUs). EMS included helicopters (often with a physician on board) and ground ambulances. Participants: N=254 including 107 with a rescue period ≤60 minutes and 147 with a rescue period &gt; 60 minutes. Analyses comparing groups at baseline: Mean age (years): ≤60 minutes group: 30 &gt;60 minutes group: 29 Male (%): ≤60 minutes group: 66 &gt;60 minutes group: 78 Median ISS: ≤60 minutes group: 24 &gt;60 minutes group: 24</td>
<td>Incl/excl criteria. Blunt trauma Treatment in the shock room, ED, St. Gallen Cantonal Hospital Presence of injuries with a minimum AIS of ≥2 in at least two of six defined body regions Either transfer to ICU or a stay of at least three days in hospital or death following admission. Outcome measures: 30 day mortality Predicted mortality based on ASCOT score Resulting excess mortality rate (actual – expected deaths) Analysis: Fisk’s Z statistic used to compare actual with expected mortality. Possible confounding variables and further comparisons were tested using the independent Student’s t test, Mann Whitney U test, chi square test and logistic regression</td>
<td>Actual versus predicted mortality (30 days) Transport time ≤60 minutes Actual: 14% Predicted: 9.5% P=0.06 Transport time &gt;60 minutes Actual: 10.2% Predicted: 13.1% P=0.19 Adjusted comparison between transport time ≤60 minutes and &gt;60 minutes, and mortality OR (&gt;60 minutes as reference) 8 (99% Cl 1.7-38.5)</td>
<td>Limitations: M statistic not presented so degree of fit with MTOs data was unclear. Observational study is susceptible to confounding although multivariate analysis is a useful method to control for known confounders. However, the variables included in the multivariate model were not documented. Study restricted to blunt trauma patients which needs to be recognised when considering generalisability. Relied on accuracy of registry data. No data presented on the accuracy of that source.</td>
</tr>
</tbody>
</table>
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Osterwalder 2002) Switzerland continued</td>
<td></td>
<td>Cause of trauma: road traffic accident (%) ≤60 minutes group: 77 &gt;60 minutes group: 69 Work (%) ≤60 minutes group: 11 &gt;60 minutes group: 12 Sport (%) ≤60 minutes group: 1 &gt;60 minutes group: 13 P&lt;0.005 Suicide/violence (%) ≤60 minutes group: 9 &gt;60 minutes group: 1 P&lt;0.004</td>
<td></td>
<td></td>
<td>• Significant differences in baseline measures in relation to cause of trauma; sport was associated with longer transport time and suicide/violence with shorter transport time. Also fewer patients were treated with a physician in the ≤60 minutes group. • 26 patients were omitted due to missing time data (overall there was missing data in 9% of the study population). Comments • Aims to evaluate the hypothesis that exceeding the 60 minute limit for the entire pre-hospital time increases mortality of blunt polytrauma patients. • All patients treated at the same Level 1 trauma hospital. Reported conclusions (by authors). It appears in this trauma system, in which emergency physicians often are deployed, that the golden hour of shock can be extended safely in many blunt polytrauma patients, since this was associated with better survival figures than in those patients for whom the time was &lt; 1 hour.</td>
</tr>
</tbody>
</table>
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
</table>
| (Lerner et al. 2003) USA | Retrospective cohort study Level III-2 | Study setting: Data obtained from records maintained by the only adult regional trauma centre in western New York. The centre was a 389 bed tertiary care teaching facility with about 13,500 annual admissions (approximately 1,600 of which resulted from trauma). Participants: N=1877 | Incl/excl criteria: All patients from Jan 1993 to Oct 1996 if the patient had been transported directly from the scene by ambulance or helicopter. Patients were admitted from ED or died in the ED. Excluded patients with incomplete data, with more than one day difference between the date of injury and the date of admission. CPR initiated in the field or transported from a correctional facility. Data collection: Most data were extracted from the trauma registry. Out-of-hospital patient care report and dispatch agency records used to supplement the registry time data as it was often incomplete. Out of hospital variables: transport mode, total out-of-hospital time, patient’s CUPS status. Hospital variables included: revised trauma scale, ISS, E code, admission date, sex, type of injury. Outcome measures: Mortality | Difference in mean total out-of-hospital time between survivors and non-survivors Survivors: 35.26 minutes Non-survivors: 31.58 minutes Difference 3.69 minutes (95% CI 0.52-6.85 minutes) Adjusted OR, total out of hospital time, increasing pre-hospital time and odds of mortality OR 0.987 (95% CI 0.97-1.00) | Limitations:  
- Medical records review with inherent limitations of this source. Possible limitations include missing data and inconsistent methods of recording.  
- Potential for misclassification of total pre-hospital time or potential confounding variables. Most likely to be random, resulting in dilution of the effect.  
- Likely selection bias due to the omission of patients with missing data (462 of 2359 were omitted due to missing data, 20%).  
- Observational study is susceptible to confounding although multivariate analysis is a useful method to control for known confounders.  
- It is possible that providers transport the patients they believed to be most severely injured quicker, thus biasing the results. |
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Lerner et al. 2003)</td>
<td></td>
<td></td>
<td>Analysis</td>
<td>Bivariate analyses conducted to determine which variables were associated with mortality. Student's t-test used for continuous variables and chi square or Fisher's exact test used for categorical variables. Stratification by injury severity and type also conducted. Multiple predictors logistic regression used to determine if total out of hospital time was a significant predictor of trauma mortality. Variables associated with mortality on univariate analysis were included in the model.</td>
<td>Comments</td>
</tr>
<tr>
<td>USA</td>
<td></td>
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<td>continued</td>
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</tbody>
</table>

**TRANSPORTATION OF EMERGENCY PATIENTS**
### Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Biewener et al. 2004) Germany</td>
<td>Retrospective cohort study</td>
<td>Study setting: Studied four possible pathways of polytrauma patients in Dresden, Germany: 1. Helicopter transportation to Level 1 trauma centre (HEMS-UNI), 2. Ambulance transportation to Level 1 trauma centre (AMB-UNI), 3. Ambulance transportation to Level 2 or 3 trauma centre (AMB-REG), 4. Ambulance transportation to Level 2 or 3 trauma centre with subsequent transfer to Level 1 trauma centre (INTER). Participants: 403 participants, HEMS-UNI 140, AMB-REG 102, AMB-UNI 70, INTER 92. Analyses comparing groups at baseline: No differences between the four groups by age, gender or ISS. Mean age 36.8 years Male 73.3%</td>
<td>Incl/excl criteria: ISS ≥ 16. Arrival of patient alive at the hospital. Complete documentation of all patient data. Exclusion criteria: age &gt; 75 years, ISS ≥ 67. Data collection: Data extraction for all but the AMB-REG group from polytrauma database of a single Level 1 trauma centre (compiled prospectively). Data collection performed retrospectively in the AMB-REG group. Documented ISS, age, gender, rescue time.</td>
<td>Pre-hospital times (minutes) HEMS-UNI group: 90 AMB-UNI 68 Univariate comparison of 30 day mortality: HEMS-UNI 22.1% AMB-UNI: 15.7% Multivariate comparison of mortality (HEMS-UNI as reference) AMB-UNI: OR 1.06 (95% CI 0.427-2.635) Interpretation: No significant difference in mortality between the two transportation methods involving direct transportation to Level 1 trauma centre despite prolonged transportation time in the helicopter group.</td>
<td>Limitations: • Registry based study with some retrospective data collection and incomplete TRISS data available (lacking in the AMB-REG group). • Accuracy of data unclear. • Observational study is susceptible to confounding. • Elements of ecological analysis for the results of interest to this review. Specifically, there was no comparison between individual time data and outcome, rather the comparison was between different groups (and thus used as a proxy for time). • Different staffing mixes between transportation methods (more procedures tend to be performed in the helicopter patients) and differences in management across the different hospitals mean it is not possible to ascribe any difference in outcome to difference in pre-hospital time.</td>
</tr>
</tbody>
</table>
### Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Bewener et al. 2004)</td>
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<tr>
<td>Germany</td>
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<td>continued</td>
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</tbody>
</table>

Comments
- Aimed to compare the mortality of four typical and complete pathways of polytrauma patients: air or ground transport to a level 1 trauma centre, ground transport into level II or III community hospitals or interhospital transfer.

Reported conclusions (by authors):
- Primary transfer into a Level 1 trauma centre reduces mortality markedly. In principle, this benefit can be attributed to superior preclinical therapy, primary admission to a Level 1 trauma centre or both. However, the identical probability of survival of the AMB-UNI and HEMS-UNI groups in this and comparable studies does not confirm generally better survival rates an account of a more aggressive on-site approach.
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
<th>Study Design</th>
<th>Sample and Interventions</th>
<th>Methods</th>
<th>Results</th>
<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Gao et al. 2006) China</td>
<td>Retrospective cohort study Level III-2</td>
<td>Study setting: Polytrauma patients with thoracic and/or abdominal injuries treated at Chongqing Emergency Medical Center, China from Oct 1993 to Sept 2003. Participants: n=1540 Baseline analyses. Mean age 28.8 years Males 79% Duration of preadmission (%) &lt; 1 hour: 38.4% 1-6 hours: 40.6% &gt;6 hours: 21.0% Blunt trauma: 61.7%</td>
<td>Incl/exl criteria. Injuries to more than two ISS body regions and at least one region had AIS ≥3. Data collection: Extracted data on sex, age, causes of injury, duration of preadmission and injured regions, shock state on admission, amount of blood transfusion, severity of injuries, method of diagnosis, therapeutic procedures. Outcome measures: Mortality Analysis: Chi square test.</td>
<td>Relationship between preadmission time and mortality: Preadmission &lt; 1 hour: 3.9% mortality Preadmission ≥ 1 hour: 7.7% mortality P&lt;0.01</td>
<td>Limitations: Retrospective review. Potential limitations of this approach include missing data, and inconsistent recording of data. Accuracy of data unclear. Observational study is susceptible to confounding. No multivariate analysis to control for confounding. Comments: Aimed to investigate the early diagnosis and treatment of polytrauma patients with thoracic and/or abdominal injuries. All patients taken to the same hospital. Reported conclusions (by authors): The first golden hour after trauma should be grasped, since the treatment in this hour can determine greatly whether the critically injured victim could survive. Prompt diagnosis and proper treatment contribute more greatly to the survival of the victim than the severity of injury.</td>
</tr>
<tr>
<td>Authors</td>
<td>Study Design</td>
<td>Sample and Interventions</td>
<td>Methods</td>
<td>Results</td>
<td>Limitations and Conclusions</td>
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</tr>
<tr>
<td>Hartl et al. 2006</td>
<td>Retrospective</td>
<td>Study setting: Patients treated at 22 trauma centres in a New York State quality improvement program between 2000 and 2004.</td>
<td>Incl/excl criteria. Data extracted from TBI-trac. TBI-trac includes: Arrival at level 1 or level 2 trauma centre within 24 hours of injury; GCS&lt;9 for at least 6 hours after injury and after resuscitation efforts including airway management, ventilatory support, and circulatory support. Mechanism of injury must be consistent with trauma. Excludes: Subarachnoid haemorrhage secondary to aneurysm or stroke, patients who expired in the ED, or admitted with a diagnosis of brain death, or were transferred to the study hospital &gt; 24 hours after injury. Nonparalysed patients with a GCS of 3 or 4 and fixed and dilated pupils were excluded from analysis.</td>
<td>Association between time to trauma centre and two week mortality, adjusted odds ratio (95% CI) OR 1.00 (1.00, 1.00) for each one minute increase in transport time. Adjusted for hypotension status on day 1, &lt; or &gt; 60 years of age, pupillary status on day 1 and initial GCS.</td>
<td>Limitations: • Study conducted in 54% of the total trauma centres in the state. • Unclear if consecutive patients were selected in the participating trauma centres. • Registry based data with inherent limitations about reliance on data collected. • Accuracy of data collected not stated. • Observational study is susceptible to confounding. A limited range of potential confounders were adjusted for in the multivariate model. • Data for 1447 patients entered in the database but further exclusions reduced sample sizes to 1123. Exclusions were: GCS=9 (n=71), GCS motor score &gt; 6 (n=14), fixed and dilated pupils and not paralysed (n=126), GCS&lt;3 and bilaterally fixed and dilated or missing pupil information (n=79), time to hospital &gt; 24 hours (n=13), transport time &lt; 10 minutes (n=17), missing outcome assessment (n=6). Comments: • Aimed to explore the effect of pre-hospital management decisions on early mortality after severe TBI. • Time of injury was based on time of dispatch of EMS. • 20 of 22 trauma centres were level 1 trauma centres.</td>
</tr>
</tbody>
</table>
Table 16  Evidence tables of studies examining time from ambulance callout to emergency department arrival (continued)

<table>
<thead>
<tr>
<th>Authors Country</th>
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<th>Limitations and Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hartl et al. 2006</td>
<td></td>
<td></td>
<td>Analysis</td>
<td>Chi square test used to evaluate pre-hospital characteristics versus direct/indirect transportation. Student's t test used for comparing means of continuous variables. Mann-Whitney test was used when sample sizes were too small for the t test. Logistic regression analyses predicting two week mortality were used to estimate odds ratios.</td>
<td>Reported conclusions (by authors). The present study provides class II evidence that demonstrates a 50% increase in mortality associated with indirect transfer of TBI patients.</td>
</tr>
</tbody>
</table>

USA

Continued
Summary and Conclusions

There were 21 articles selected for the time component of the review. The selection criteria required that the time from receipt of alarm to the time of arrival at hospital should be recorded. This criterion effectively resulted in a focus on trauma. Medical emergencies were frequently ruled out because the time interval started with the time symptoms started (rather than the time the alarm was received by emergency services) or, in the case of out of hospital cardiac arrest, the time interval recorded was usually from the time of alarm until either arrival at the scene or time of first defibrillation. There was a large body of literature on cardiac arrest that was excluded for that reason. As a consequence there was only one study included that examined out of hospital cardiac arrest.

In general, most studies were retrospective and thus relied on the accuracy of recording. The original purpose of recording was for reasons other than the studies of this nature. There is also likely to be variation in recording practices by different staff within the settings studied. For example, in some studies there may have been rounding of the time component by some staff and not by others. There is certainly the potential for misclassification of time components and also potentially in other variables that may have resulted in residual confounding.

There was wide variation in sample sizes and eligibility criteria as shown through Table 16. The results have been summarised into four sections:

1. Studies that found an association between prolonged pre-hospital time and poor prognosis.

2. Studies where there was no direct comparison between pre-hospital time and outcome. These studies assessed various groupings that happened to have different mean pre-hospital times.

3. Studies that did not identify a statistically significant association between pre-hospital time and outcome.

4. Studies that found an association between shorter pre-hospital time and increased mortality.

Three of the seven studies that found a statistically significant association between prolonged pre-hospital time and poor outcome included multivariate analyses. These three studies were all conducted by Sampalis et al and two had overlapping populations. The largest study (Sampalis et al. 1999) had over 12,000 participants and the study population was distinct from two earlier studies (Sampalis et al. 1992; Sampalis et al. 1993) by the same group. In this study there was a linear association between pre-hospital duration and odds of death such that the odds of death increased by 1.046 for an additional minute of pre-hospital time. On that basis, the odds of death would increase by 1.252 for a five minute increase in pre-hospital time. This study was well conducted. The focus was on patients with severe trauma. This large study was conducted during and after regionalisation of emergency services. The two other studies were conducted before regionalisation. One used a case control design and the other a cohort design. Although there was overlap in the study populations, the estimated odds ratios were quite different (varying between 3 and 30) although both were statistically significant.

The other four studies in this section were limited by their lack of control over potential confounders. Two of these studies focussed on set pre-hospital times. One dichotomised pre-hospital time at 1 hour (Gao et al. 2006) and one at 30 minutes (Frezza and Mezghebe 1999). In both cases mortality was significantly higher in the group with longer pre-hospital times. The other two studies focussed on survivors or unexpected survivors versus deaths and unexpected deaths. The mean times for each respective group across the two studies were quite different although there was also a difference in the mean pre-hospital time between survivors and deaths within each study. For example the mean pre-hospital time in the unexpected survivors in one study was 20.8 minutes (Feero et al. 1995) whereas the mean pre-hospital time in the survivors from the other study was 42.8 minutes (Grzybowski et al. 2000). Based on the information presented from these studies it is not clear that there is a threshold in the pre-hospital time that should be aimed at. The findings from the largest study would support the hypothesis that the shorter the pre-hospital time the better. These results are summarised in Table 17.
Table 17  Key results for studies examining time from ambulance callout to emergency department arrival that found an association between prolonged pre-hospital time and poor outcome

<table>
<thead>
<tr>
<th>Reference</th>
<th>Sample size</th>
<th>Multivariate analysis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Sampalis et al. 1999)</td>
<td>12,208</td>
<td>Yes</td>
<td>Odds of death for each additional minute of pre-hospital time: OR 1.046 (1.044-1.050)</td>
</tr>
<tr>
<td>(Sampalis et al. 1993)</td>
<td>360</td>
<td>Yes</td>
<td>OR (mortality by 6 days, pre-hospital time &gt; 60 minutes compared with up to 60 minutes): 3.01 (1.27-5.06)</td>
</tr>
<tr>
<td>(Sampalis et al. 1992)</td>
<td>355</td>
<td>Yes</td>
<td>OR (mortality, pre-hospital time &gt; 60 minutes compared with up to 60 minutes): 29.9 (2.7-33.3)</td>
</tr>
<tr>
<td>(Gao et al. 2006)</td>
<td>1,540</td>
<td>No</td>
<td>Preadmission &lt; 1 hour: 3.9% mortality</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Preadmission ≥ 1 hour: 7.7% mortality</td>
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<td></td>
<td></td>
<td>$P&lt;0.01$</td>
</tr>
<tr>
<td>(Feero et al. 1995)</td>
<td>848</td>
<td>No</td>
<td>Mean pre-hospital time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unexpected survivors: 20.8 minutes</td>
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<td></td>
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<td></td>
<td>Unexpected deaths: 29.3 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$P=0.02$</td>
</tr>
<tr>
<td>(Grzybowski et al. 2000)</td>
<td>244</td>
<td>No</td>
<td>Mean total EMS time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Survivors: 42.8 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Deaths: 50.6 minutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$P&lt;0.01$</td>
</tr>
<tr>
<td>(Frezza and Mezghbane 1999)</td>
<td>58</td>
<td>No</td>
<td>Pre-hospital time &lt; 30 minutes: 63% survival</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Pre-hospital time &gt; 30 minutes: 0% survival</td>
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<td></td>
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<td>$P=0.002$</td>
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</tbody>
</table>

The second group of studies that compared groups that had different mean pre-hospital times have the limitation that it could not be established if there was a relationship between pre-hospital time and outcome. For example, the studies comparing ground ambulance with helicopters, although having different pre-hospital times may also have other factors that explain any difference in outcome. Such differences could include a difference in crew mix that also contributes to a difference in outcome. In general, crews with a doctor on board may tend to spend a longer time at the scene than other crews. It is therefore possible that the longer pre-hospital time may be balanced by the presence of a doctor. These studies have elements of an ecological analysis weakening the study design. There were six studies in this group. A statistically significant difference in mortality between groups was not observed in these studies. Two studies found a significantly longer length of hospital stay in groups transported by the mode of transport with the longer pre-hospital time (Berns et al. 2001; Phillips et al. 1999). However, neither of these studies conducted multivariate analyses so confounding is likely to be a problem. These results are summarised in Table 18.
Table 18  Key results for studies examining time from ambulance callout to emergency
department arrival in studies that did not directly compare pre-hospital time with
outcome

<table>
<thead>
<tr>
<th>Reference</th>
<th>Sample size</th>
<th>Multivariate analysis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Biewener et al. 2004)</td>
<td>403</td>
<td>Yes</td>
<td>Mortality comparing ambulance use with HEMS use): OR 1.06 (0.427-2.635),</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pre-hospital times: helicopter 90 minutes, ambulance 68 minutes</td>
</tr>
<tr>
<td>(Phillips et al. 1999)</td>
<td>792</td>
<td>No</td>
<td>Ground transport: 54 minutes, length of stay 4.21 days</td>
</tr>
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<td></td>
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<td></td>
<td>Air transport, 77 minutes, length of stay 8.97 days</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nil significant in mortality findings</td>
</tr>
<tr>
<td>(Schiller et al. 1988)</td>
<td>606</td>
<td>No</td>
<td>Ambulance: mission time 39 minutes, mortality 13%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Helicopter: mission time 50 minutes, mortality 18%</td>
</tr>
<tr>
<td>(Young et al. 1998)</td>
<td>316</td>
<td>No</td>
<td>Transfer group: 480 minutes pre-hospital time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Direct group: 92 minutes pre-hospital time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No significant difference in mortality within 24 hours of injury or beyond 24 hours of injury</td>
</tr>
<tr>
<td>(Berns et al. 2001)</td>
<td>294</td>
<td>No</td>
<td>Ground, 142 minutes, length of stay 8 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Helicopter, 104 minutes, length of stay 6.4 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>P=0.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nil significant in mortality</td>
</tr>
<tr>
<td>(Schwartz et al. 1990)</td>
<td>126</td>
<td>No</td>
<td>Air ambulance, 65 minutes, Z=2.23 (improved compared with MTOS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ground ambulance, 34 minutes, Z=2.69 (worse than MTOS)</td>
</tr>
</tbody>
</table>

There were also seven studies that found no association between pre-hospital time and outcome. It should be noted that two of these studies found an association between improved survival and shorter pre-hospital times on univariate analysis but both disappeared on multivariate analysis (Lerner et al. 2003). It should be observed that Lerner et al. (2003) estimated the odds of mortality were higher in patients with shorter pre-hospital time, but this finding was of borderline significance (OR 0.987, 95% CI 0.97-1.00). There were two other multivariate analyses conducted. One examined risk ratios for death by minutes to ED and found increased risk of death in the pre-hospital period 31-60 minutes but this association was not sustained in the 61-90 minutes and 91-185 minutes groups (Clarke et al. 2002). There were also three other studies that did not find a significant association on univariate analysis.
Table 19  Key results for studies examining time from ambulance callout to emergency department arrival in studies that did not find an association between pre-hospital time and outcome

<table>
<thead>
<tr>
<th>Reference</th>
<th>Sample size</th>
<th>Multivariate analysis</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Bonatti et al. 1995)</td>
<td>2139</td>
<td>Yes</td>
<td>No significant difference between total mission time and survival on multivariate analysis (there was a significant decrease in survival with longer mission times on univariate analysis)</td>
</tr>
<tr>
<td>(Lerner et al. 2003)</td>
<td>1877</td>
<td>Yes</td>
<td>Total out of hospital time and mortality OR 0.987 (0.97-1.00). Note univariate analysis significantly longer pre-hospital time in the survivors (difference 3.69 minutes, 95% CI 0.52-6.85 minutes)</td>
</tr>
<tr>
<td>(Hartl et al. 2006)</td>
<td>1123</td>
<td>Yes</td>
<td>Mortality for each extra minute in transport time OR 1.00 (1.00-1.00)</td>
</tr>
<tr>
<td>(Clarke et al. 2002)</td>
<td>250</td>
<td>Yes</td>
<td>Risk ratios for death by minutes to ED (95% CI) 1-30 minutes RR 0.773 (0.501-1.194) 31-60 minutes RR 1.268 (0.980-1.641) 61-90 minutes RR 0.832 (0.496-1.396) 91-185 minutes RR 0.740 (0.189-2.888)</td>
</tr>
<tr>
<td>(Pepe et al. 1987)</td>
<td>498</td>
<td>No</td>
<td>Results stratified across four different trauma score categories. No association between pre-hospital time and mortality within each trauma score stratum</td>
</tr>
<tr>
<td>(Sloan et al. 1989)</td>
<td>203</td>
<td>No</td>
<td>Total run time (minutes): Mortality group 32 Survival group 35</td>
</tr>
<tr>
<td>(Lim and Seow 2002)</td>
<td>93</td>
<td>No</td>
<td>Pre-hospital time Survivors: 38.3 minutes Non-survivors: 35.4 minutes</td>
</tr>
</tbody>
</table>

One study estimated that a pre-hospital time up to 60 minutes was associated with an increased odds of mortality when compared with a pre-hospital time more than 60 minutes (OR 8, 95% CI 1.7-38.5), (Osterwalder 2002). This finding may have been due to a tendency to shorten the on scene time in patients who appeared critical, recognising the need for urgent definitive care. This study had a sample size of 254 and included a multivariate analysis.

There was some information provided that was helpful in considering whether pre-hospital time had an effect on outcome after controlling for crew mix. The two smaller studies by Sampalis et al. (1992; 1993) both controlled for crew mix and in-hospital parameters. In these studies, physicians were available to attend the scene although their attendance was reserved for severe cases. In both studies (which had overlapping populations), there was a significant association between shorter pre-hospital time and improved survival after controlling for crew mix but there was no association between crew mix and survival after controlling for pre-hospital time. However, Bonatti et al. (1995) did not identify any association between pre-hospital time and outcome after controlling for crew mix and they also did not find any association between the attendance of a physician and outcome after controlling for pre-hospital time.

In conclusion, there was some inconsistent support for shorter pre-hospital times being associated with improved survival. However, it is not clear if there is a threshold time to aim for or if any reduction in pre-hospital time is associated with improved outcome. There is therefore no clear pre-hospital time to aim for based on the literature reviewed. It seems biologically plausible that severity of injury may operate as an effect modifier in the relationship between pre-hospital time and outcome. In other words, the relationship between pre-hospital time and outcome may be influenced by measures of severity. Unfortunately, there was insufficient information to investigate this further within the studies eligible for this review.
OVERVIEW

Main findings

This report has four main areas of assessment:

1. In adults and children with a medical or trauma related emergency, does the presence of a medical doctor on emergency helicopter services improve health outcome when compared with transportation by emergency helicopter without a medical doctor?

2. In adults and children with a medical or trauma related emergency, does the presence of a medical doctor on a road ambulance service improve health outcome when compared with transportation by a road ambulance service without a medical doctor?

3. In adults and children with a medical or trauma related emergency, does the presence of a medical crew able to perform rapid sequence intubation and/or thoracostomy improve health outcome when compared with a medical crew unable to perform rapid sequence intubation and/or tube thoracostomy and/or thoracotomy?

4. In adults and children with a medical or trauma related emergency how does variation in the time from callout to arrival at a medical facility with definitive care influence health outcome?

Summaries and conclusions have been included for each question earlier in this report. This overview provides links across the sections and identifies unanswered issues.

The first three questions were intended to examine the usefulness of including medical doctors on emergency transportation. The inclusion of medical doctors on emergency transportation is more consistent with the “stay and treat” strategy described earlier. That is, a period of stabilisation is implied before transportation to a definitive care hospital. In contrast, question four was particularly designed to assess whether there was a set time to aim for in relation to total pre-hospital transportation time. A short time would be consistent with the “scoop and run” strategy. Key results of these issues have been summarised earlier but, to reiterate the major points:

1. There was generally more support for the inclusion of doctors on helicopters in the seven studies appraised in this section. However, there were uncertainties due to study design issues (levels of evidence ranged between III-1 and III-3), lack of consideration about whether non-doctor groups can be trained to perform certain procedures that would improve patient outcome and whether there may be different clinical scenarios that would favour one crew mix type over another.

2. Similar considerations applied in the studies examining the use of doctors on board road ambulances. There were four studies in this section with levels of evidence ranging between III-2 and III-3.

3. When considering the outcome in patients who were treated by crews able to perform rapid sequence intubation and/or thoracostomy with other crews who were not able to perform these procedures, the only studies identified that met the study eligibility criteria included doctors amongst those able to perform the procedures of interest. It was therefore not possible to examine this issue in relation to non doctor groups. There were five studies in this section with levels of evidence ranging between III-1 and III-3.

4. There was inconsistent evidence on the association between pre-hospital time and patient outcome. There were 21 studies in this section with levels of evidence all being III-2. However, the general direction was to support improved outcome in association with shorter pre-hospital times. There was no clear time threshold to aim for. Two studies provided information to consider whether crew mix or rapid transport had a more significant bearing on outcome. The results were conflicting across these two studies.

5. Most of the studies included related to trauma rather than medical emergencies.

6. There was insufficient information to consider subgroups based on injury severity or age group.
Limitations

The studies included ranged from evidence level III-1 to III-3. Study limitations are described in earlier sections of this report. In addition, it is important to note that this Technical Brief is not a full systematic review, although a systematic approach to search for and retrieve relevant studies was used. This report constitutes a rapidly produced assessment and summary of the best available evidence. Wider searches of the Internet, hand searching of journals and contacting of authors for unpublished research were not undertaken.

Research gaps

Specific study designs that would be useful to further consider the review questions have been detailed throughout this report. Some general areas of future research that would be helpful include:

1. Is there some form of interaction between pre-hospital time and pre-hospital crew that has impact on patient outcome? Linked to this is whether the same pre-hospital approach (time and crew) results in improved outcome in all emergency patients or whether the best approach is dependent on the clinical situation.

2. Given differences in procedures performed and clinical assessment processes adopted by doctors compared with non-doctor pre-hospital personnel, to what extent would enhanced procedure training for non-doctor groups be helpful?

3. There are cost differences between the “scoop and run” and “stay and treat” approaches, along with the crew mixes used that ideally should be examined in relation to cost effectiveness of different approaches. However, given current uncertainties in effectiveness of the different strategies, incremental cost effectiveness can not be robustly examined at this time.

Conclusions

While the balance of studies support improved outcome associated with doctors on board emergency transportation, the robustness of these studies and the areas of uncertainty that remain (see under research gaps) provide uncertainty about the best approach. The best study supported the use of doctors on board helicopters. The balance of studies supported improved outcome associated with more rapid pre-hospital times. The studies identifying such improved outcome frequently assessed the linear relationship between pre-hospital outcome and time, meaning that the focus was on any improvement in outcome rather than a set threshold of pre-hospital time to meet in order to achieve improved outcome.
REFERENCES


National Health and Medical Research Council (2000). *How to use the evidence: assessment and application of scientific evidence*. Canberra: NHMRC.


**APPENDIX 1: SEARCH STRATEGY**

**Medline 1**

1. air ambulances/ (1024)  
2. aircraft/ (5261)  
3. helicopterm$.mp. (1541)  
4. (medevac or medivac or casivac or casevac).mp. (31)  
5. aeromedic$.mp. (673)  
6. (air ambulanc$ or flight ambulan$).mp. (1125)  
7. or/1-6 (7198)  
8. "personnel staffing and scheduling"/ (9920)  
9. personnel selection/ (7837)  
10. patient care team/ (36954)  
11. physician's role/ (19199)  
12. (doctor$ or staff$ or personnel$ or physician$).tw. (291307)  
13. exp physicians/ (56725)  
14. medical practitioner$.tw. (2394)  
15. (medical$ adj qualif$).tw. (187)  
16. ma.fs. (43025)  
17. or/8-16 (398761)  
18. 7 and 17 (1113)  
19. limit 18 to english (918)  
20. limit 19 to yr=1980-2006 (853)  
21. (letter or news or historical article).pt. (916855)  
22. 20 not 21 (802)  
23. (commercial adj (airline$ or aircrew)).tw. (151)  
24. (spaceflight or space flight).tw. (3422)  
25. 22 not (23 or 24) (788)  
26. allied health personnel/ (8563)  
27. (paramedic$ or medic or medics).tw. (4114)  
28. nurse's role/ (15545)  
29. nurses/ (21869)  
30. flight nurse$.mp. (138)  
31. or/26-30 (48520)  
32. 7 and 31 (267)  
33. limit 32 to english (249)  
34. limit 33 to yr=1980-2006 (241)  
35. 34 not (21 or 23 or 24) (226)  
36. 35 not 25 (118)  
37. emergency medical technicians/ (3409)  
38. 7 and 37 (160)  
39. limit 38 to english (155)  
40. limit 39 to yr=1980-2006 (153)  
41. 40 not (21 or 23 or 24) (150)  
42. 41 not (25 or 36) (52)

**Medline 2**

1. ambulances/ (3697)  
2. ambulance$.tw. (4057)  
3. 1 or 2 (5887)  
4. aircraft/ (5261)  
5. air ambulances/ (1024)  
6. helicopterm$.mp. (1541)  
7. or/4-6 (6776)  
8. 3 not 7 (5131)
Transportation of Emergency Patients

Medline 3

1 *time factors/ (904)
2 (time adj3 delay$).tw. (6849)
3 (time or delay).ti. (88449)
4 ((prehospital or pre-hospital) adj (time or care or treatment)).tw. (1157)
5 ((call-out or callout) and (arrival or admission or admit$ or hospital or emergency department or ED)).tw. (20)
6 (delay$ adj3 (arrival or admission or admit$ or hospital or medical facility or definitive care or emergency department or ED)).tw. (1246)
7 (time adj3 (arrival or admission or admit$ or hospital or medical facility or definitive care or emergency department or ED)).tw. (8465)
8 ((call-out or callout) and (arrival or admission or admit$ or hospital or medical facility or definitive care or emergency department or ED)).tw. (20)
9 (scene time or "out of hospital time").tw. (105)
10 (transport adj time$).tw. (506)
11 (transfer$ adj time$).tw. (281)
12 (prehospital index or pre-hospital index).tw. (21)
13 or/1-12 (105221)
14 survival analysis/ (65345)
15 exp treatment outcome/ (299801)
16 length of stay/ (35699)
17 patient discharge/ (12043)
18 morbidity/ (17555)
19 mortality/ (25394)
20 "Outcome Assessment (Health Care)"/ (25869)
21 (survival or outcome).tw. (599960)
22 or/14-21 (900262)
23 *emergencies/ (7692)
24 exp emergency medical services/ (58193)
TRANSPORTATION OF EMERGENCY PATIENTS

emergent service, hospital/ (24370)
transportation of patients/ (6348)
ambulances/ (3694)
air ambulances/ (1024)
helicopters/ (5256)
or/23-29 (68719)
13 and 22 and 30 (908)
(news or letter).pt. (688417)
infant, newborn/ or infant, premature/ or neonat$.ti. (406994)
case reports.pt. (1291342)
or/32-34 (2194216)
31 not 35 (855)
(golden hour or golden minute$).mp. (76)
36 or 37 (927)
limit 38 to yr=1980-2006 (918)
limit 39 to english (832)

Embase 1

1 air medical transport/ (70)
AIRCRAFT/ (1958)
HELCOPTER/ (786)
aeromedical$.tw. (384)
flight ambulance$.tw. (0)
air ambulance$.tw. (91)
(medevac or medivac or casivac or casevac).tw. (21)
or/1-7 (3043)
medical personnel/ (2810)
Airplane Crew/ (1080)
health care personnel/ (23462)
manpower/ (1093)
Health Care Manpower/ (1025)
(doctor$ or staff$ or personnel$ or physician$).tw. (164842)
medical practitioner$ .tw. (1560)
medical$ adj qualif$ .tw. (135)
patient care team.tw. (37)
physician/ or emergency physician/ (33974)
or/9-18 (199007)
8 and 19 (687)
limit 20 to english (621)
letter.pt. (330316)
21 not 22 (600)
(commercial adj (airline$ or aircrew or attendant$)).tw. (113)
(spaceflight or space flight).tw. (1262)
24 or 25 (1375)
23 not 26 (580)
Paramedical Personnel/ (1706)
paramedical personnel/ (1706)
rescue personnel/ (1043)
(medic or medics or paramedic$).tw. (2030)
Nursing Role/ (25)
nurse/ (11528)
nursing staff/ (2233)
flight nurse$.tw. (34)
or/28-35 (17487)
8 and 36 (224)
limit 37 to english (196)
38 not (22 or 26) (181)
39 not 27 (68)
EMBASE 2

1. ambulance/ (1942)
2. ambulance$.tw. (2198)
3. 1 or 2 (2915)
4. air medical transport/ (70)
5. aircraft/ (1958)
6. helicopter/ (786)
7. (aeromedical$ or flight ambulance$ or air ambulance$).tw. (460)
8. or/4-7 (3031)
9. 3 not 8 (2606)
10. medical personnel/ (2810)
11. health care personnel/ (23462)
12. manpower/ (1093)
13. health care manpower/ (1025)
14. (doctor$ or staff$ or personnel$ or physician$).tw. (164842)
15. medical practitioner$ .tw. (1560)
16. (medic$ adj qualif$).tw. (154)
17. patient care team.tw. (37)
18. physician/ or emergency physician/ (33974)
19. paramedical personnel/ (1706)
20. rescue personnel/ (1043)
21. (paramedic or medics or medic$).tw. (2030)
22. nursing role/ (25)
23. nurse/ (11528)
24. nursing staff/ (2233)
25. or/10-24 (207253)
26. 9 and 25 (1149)
27. MORTALITY/ (124790)
28. survival/ (46091)
29. Survival Rate/ (42525)
30. (mortality or survival).tw. (372312)
31. "length of stay".ti. (17989)
32. exp Treatment Outcome/ (348062)
33. Outcome Assessment/ (10452)
34. or/27-33 (730660)
35. 26 and 34 (298)
36. limit 35 to english (256)
37. letter.pt. (330316)
38. 36 not 37 (250)

EMBASE 3

1. exp *time/ (2667)
2. time factor$.tw. (455)
3. (time or delay).ti. (51255)
4. (time adj3 delay).tw. (3194)
5. ((prehospital or pre-hospital) adj (time or care or treatment or delay)).tw. (859)
6. (delay$ adj3 (arrival or admission or admit$ or hospital or medical facility or definitive care or emergency department or ED)).tw. (922)
7. (time adj3 (arrival or admission or admit$ or hospital or medical facility or definitive care or emergency department or ED)).tw. (6337)
8. ((callout or call-out) and (arrival or admission or admit$ or hospital or medical facility or definitive care or emergency department or ED)).tw. (15)
9. (scene time or "out of hospital time").tw. (68)
10. (transport adj time$).tw. (360)
11. (transport$ adj time$).tw. (211)
12. (prehospital index or pre-hospital index).tw. (17)
13. or/1-12 (63376)
14. Survival/ (45956)
15. exp treatment outcome/ (345878)
16 length of stay/ (17884)
17 hospital discharge/ (18041)
18 morbidity/ (63032)
19 mortality/ (124143)
20 (survival or outcome).tw. (452728)
21 survival rate/ (42297)
22 Outcome Assessment/ (9819)
23 or/14-22 (830528)
24 Emergency Care/ (1145)
25 Emergency Health Service/ (9413)
26 emergency/ (3558)
27 Emergency Treatment/ (7782)
28 ambulance/ (1930)
29 HELICOPTER/ (777)
30 Patient Transport/ (5227)
31 air ambulan$.tw. (91)
32 or/24-31 (20670)
33 13 and 23 and 32 (597)
34 letter.pt. (329150)
35 Case Report/ (680614)
36 33 not (34 or 35) (575)
37 Newborn/ (127209)
38 Prematurity/ (20771)
39 neonat$.ti. (33939)
40 or/37-39 (146969)
41 36 not 40 (565)
42 (golden hour or golden minutes).mp. (58)
43 41 or 42 (620)
44 limit 43 to english (539)

Cinahl 1

1 Aeromedical Transport/ (1390)
2 aircraft/ (528)
3 helicopter$.mp. (352)
4 (medevac or casevac or medivac or casivac or evac).tw. (19)
5 (aeromedic$ or aero medic$).tw. (94)
6 (air ambulance$ or flight ambulance$).tw. (77)
7 or/1-6 (1918)
8 "Personnel Staffing and Scheduling"/ (7243)
9 Multidisciplinary Care Team/ (9627)
10 personnel selection/ (1476)
11 exp PHYSICIANS/ (20310)
12 Physician's Role/ (1736)
13 (medical practitioner$ or (medic$ adj qualif$)).tw. (427)
14 (doctor$ or physician$ or staff$ or personnel$).tw. (69968)
15 (medical$.adj2 (staff$ or personnel$)).tw. (1303)
16 or/8-15 (96867)
17 7 and 16 (249)
18 limit 17 to english (249)
19 letter.pt. (37113)
21 pamphlet.pt. (2446)
22 18 not (19 or 20 or 21) (247)
23 (commercial adj2 (airline or aircraft$)).tw. (22)
24 (spaceflight or space flight).tw. (43)
25 22 not (23 or 24) (243)
26 biography.pt. (27112)
27 25 not 26 (242)
**Cinahl 2**

1. AMBULANCES/ (1030)
2. ambulance$.tw. (1408)
3. 1 or 2 (1916)
4. AIRCRAFT/ (528)
5. helicopter$.mp. (352)
6. Aeromedical Transport/ (1391)
7. air ambulance$.tw. (77)
8. or/4-7 (1884)
9. 3 not 8 (1747)
10. (doctor$ or staff$ or personnel).mp. (95811)
11. "personnel staffing and scheduling"/ (7270)
12. Personnel Selection/ (1485)
13. Multidisciplinary Care Team/ (9658)
14. Physician’s Role/ (1742)
15. exp physicians/ (20428)
16. (medical practitioner$ or physician$).tw. (26538)
17. (medic$ adj qualif$).tw. (17)
18. Emergency Medical Technicians/ (3793)
19. allied health personnel/ (824)
20. (paramedic$ or medic or medics).tw. (1367)
21. ma.fs. (4504)
22. Nursing Role/ (18909)
23. nurses/ (23300)
24. or/10-23 (176466)
25. 9 and 24 (687)
26. mortality/ (5012)
27. survival/ (4141)
28. Survival Analysis/ (3532)
29. (survival or mortality).tw. (25643)
30. "Length of Stay"/ (6142)
31. exp Treatment Outcomes/ (32058)
32. Outcome Assessment/ (4204)
33. or/26-32 (67621)
34. 25 and 33 (67)
35. limit 34 to english (66)
36. neonat$.ti. (5674)
37. 35 not 36 (66)
38. letter.pt. (37444)
39. 37 not 38 (66)

**Cinahl 3**

1. *Time Factors/ (1377)
2. (time adj3 delay$).tw. (283)
3. (time or delay).ti. (12147)
4. ((prehospital or pre-hospital) adj (time or care or treatment or index)).tw. (427)
5. ((call-out or callout) and (arrival or admission or admit$ or hospital or emergency department or ED)).tw. (1)
6. (delay adj3 (arrival or admission or admit$ or hospital or definitive care or medical facility or emergency department or ED)).tw. (78)
7. (time adj3 (arrival or admission or admit$ or hospital or definitive care or medical facility or emergency department or ED)).tw. (1124)
8. ((call-out or callout) and (definitive care or medical facility)).tw. (0)
9. (scene time or "out of hospital time").tw. (48)
10. (transport$ adj time$).tw. (71)
11. (transfer$ adj time$).tw. (12)
12. or/1-11 (14842)
13. Survival Analysis/ (3508)
14. exp Treatment Outcomes/ (31790)
15 length of stay/ (6118)
16 Patient Discharge/ (3187)
17 Outcome Assessment/ (4172)
18 (survival or outcome).tw. (42380)
19 morbidity/ (1503)
20 mortality/ (4997)
21 or/13-20 (81805)
22 *EMERGENCIES/ (1205)
23 exp Emergency Service/ (8794)
24 "Transportation of Patients"/ (1527)
25 AMBULANCES/ (1025)
26 Aircraft/ (528)
27 Ambulance* OR air ambulance* OR flight ambulance*
28 Aircraft
29 Medevac OR medivac OR casevac OR casivac OR evac
30 Aeromedical*
31 Commercial SAME (airline OR aircraft OR aircrew)
32 Spaceflight OR space flight
33 Personnel OR medical practitioner*
34 (medic* SAME qualif*)
35 Doctor * OR physician*
36 Staffing OR staffed OR staff
37 #1 OR #2 OR #3 OR #4
38 #7 OR #8 OR #9 OR #10
39 #11 AND #12
40 Allied health OR paramedic* OR medic OR medics
41 Flight nurse*
42 Nurse OR nurses OR nursing
43 #14 OR #15 OR #16
44 #12 AND #17
45 #18 NOT #13
46 #19 NOT (#5 OR #6)

**Current Contents/ Citation Indexes 1**

1. Helicopter* OR air ambulance* OR flight ambulance*
2. Aircraft
3. Medevac OR medivac OR casevac OR casivac OR evac
4. Aeromedical*
5. Commercial SAME (airline OR aircraft OR aircrew)
6. Spaceflight OR space flight
7. Personnel OR medical practitioner*
8. (medic* SAME qualif*)
9. Doctor * OR physician*
10. Staffing OR staffed OR staff
11. #1 OR #2 OR #3 OR #4
12. #7 OR #8 OR #9 OR #10
13. #11 AND #12
14. Allied health OR paramedic* OR medic OR medics
15. Flight nurse*
16. Nurse OR nurses OR nursing
17. #14 OR #15 OR #16
18. #12 AND #17
19. #18 NOT #13
20. #19 NOT (#5 OR #6)

**Current Contents/ Citation Indexes 2**

1. Ambulance*
2. Aircraft OR helicopter* OR aeromedical or air ambulance*
3. #1 NOT #2
4. personnel OR staff OR staffing OR staffed
5. patient SAME care SAME team
6. doctor* OR physician*
7. medical practitioner* OR (medic* SAME qualif*) OR paramedic* OR medic OR medics
8. emergency technician* OR allied health OR manpower
9. nurse’s role OR physician’s role OR nursing role
10. nurse OR nurses
11. #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10
12. #3 AND #11
13. #12 AND (survival OR mortality)
14. #12 AND outcome
15. #12 AND (length SAME stay)
16. #13 OR #14 OR #15

Current Contents/ Citation Indexes 3
1. (Prehospital OR pre-hospital) SAME (index OR care OR time OR treatment OR delay)
2. (transport* OR transfer*) SAME time
3. Scene time OR “out of hospital time”
4. (callout OR call out) SAME (arrival OR admission OR admit* OR hospital OR emergency department OR emergency room OR definitive care OR medical facilit* OR ED OR ER)
5. (time OR delay) SAME (arrival OR admission OR admit* OR hospital OR emergency department OR emergency room OR definitive care OR medical facilit* OR ED OR ER)
6. Emergency OR emergencies
7. Patient SAME (transport* OR transfer*)
8. Ambulan* OR helicopter*
9. #6 OR #7 OR #8
10. (newborn OR neonat*)
11. (infant* OR baby OR babies) SAME premature
12. Case study
13. Case report
14. Golden hour
15. #1 OR #2 OR #3 OR #4 OR #5
16. #9 AND #15
17. #16 NOT (#10 OR #11 OR #12 OR #13)
18. #17 AND (survival OR outcome)
19. #14 OR #18

PubMed (last 90 days)

PubMed searches were substantially the same as the strategies for Current Contents and the Citation Indexes.

Additional searching

Several small additional searches were carried out as required during the course of the project to obtain information on the merits of the respective scales for predicting mortality and morbidity after trauma.
APPENDIX 2: LEVELS OF EVIDENCE*

Level I Evidence obtained from a systematic review (or meta-analysis) of relevant randomised controlled trials.

Level II Evidence obtained from at least one randomised controlled trial.

Level III. 1 Evidence obtained from pseudorandomised controlled trials (alternate allocation or some other method).

2 Evidence obtained from comparative studies (including systematic reviews of such studies) with concurrent controls and allocation not randomised, cohort studies, case control studies or interrupted time series with a control group).

3 Evidence obtained from comparative studies with historical control, two or more single-arm studies or interrupted time series without a parallel control group.

Level IV Evidence obtained from case series, either post-test or pre-test/post-test.

* From National Health and Medical Research Council (2000)
APPENDIX 3:  EXCLUDED RETRIEVED PAPERS: DOCTOR VERSUS NO DOCTOR ON HELICOPTERS


APPENDIX 4: EXCLUDED RETRIEVED PAPERS: DOCTOR VERSUS NO DOCTOR ON ROAD AMBULANCES


APPENDIX 5: EXCLUDED RETRIEVED PAPERS: COMPARISON OF OUTCOMES AMONGST CREWS THAT DO AND DO NOT PERFORM RAPID SEQUENCE INTUBATION AND/OR THORACOSTOMY


APPENDIX 6: EXCLUDED RETRIEVED PAPERS: OUTCOMES BY TIME FROM AMBULANCE CALL OUT TO EMERGENCY DEPARTMENT DELIVERY


Adams, J., Aldag, G., & Wolford, R. (1996). Does the level of prehospital care influence the outcome of patients with altered levels of consciousness? Prehospital & Disaster Medicine, 11, 101-104.


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APPENDIX 7: INCLUDED PAPERS


Osterwalder, J. J. (2002). Can the "golden hour of shock" safely be extended in blunt polytrauma patients? Prospective cohort study at a level I hospital in eastern Switzerland. Prehospital & Disaster Medicine, 17, 75-80.


