The accuracy of existing prehospital triage tools for injured children in England—an analysis using trauma registry data

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ABSTRACT

Objectives To investigate the performance characteristics of prehospital paediatric triage tools for identifying seriously injured children in England.

Design Eight prehospital paediatric triage tools were identified by literature review and by survey of the Lead Trauma Clinicians across English Strategic Health Authorities. Retrospective clinical registry data from the Trauma Audit and Research Network were used to determine the performance characteristics of each tool, using 'gold standards' for under- and over-triage of <5% and <25—50%, respectively, as benchmarks for performance.

Participants 701 patient records were included. Inclusion criteria were all injured patients aged <16 years admitted to a receiving unit direct from the scene of accident in the period 2007—2010, for whom all key discriminator fields were recorded in the Trauma Audit and Research Network database.

Outcome measures The main outcome measure was how each tool functioned with regard to their under- and over-triaging features. Other performance characteristics, for example, predictive values and likelihood ratios were also calculated.

Results Two (of eight) triage tools demonstrated acceptable under-triage rates (3% and 4%) but had unacceptably high over-triage rates (83% and 72%). Two tools demonstrated acceptable over-triage rates (7% and 16%), but with unacceptably high under-triage rates (61% and 63%). Four tools had unacceptably high under- and over-triage rates.

Conclusions None of the prehospital triage tools currently used or being developed in England meet recommended criteria for over- and under-triage rates. There is an urgent need for the development of triage tools to accurately risk-stratify injured children in the prehospital setting.

INTRODUCTION

The organisation of care for seriously injured children in England is changing. Evidence in both adult and children's trauma care has shown that the organisation of care has a direct impact on morbidity and mortality, and it is this evidence which is the driving force behind the reconfiguration of trauma services to a regional network model.[1] The process of implementing regional networks for adult trauma care across England is well underway.[2] A Department of Health-convened clinical advisory group has made recommendations for the implementation of regional networks for the treatment of seriously injured children.[3]

Under the regional network system, expertise in major paediatric trauma will be concentrated in designated major trauma centres (MTC). Other facilities, which can provide care for most injured children and adults, but are not optimised to treat those with the most severe injuries, will be designated as a trauma unit (TU). Seriously injured children (excluding those who require time-critical interventions, such as airway stabilisation) will be moved directly from the scene of injury to receive treatment in an MTC. Children with minor or moderate injury (as well as those with time-critical injuries) will be transferred to the nearest TU for initial treatment, with subsequent secondary transfer if their injuries require specialist input.[4]

The new system will place heavy reliance on the ability of prehospital teams to assess the severity of injury, in order to determine whether the primary destination should be a TU or an MTC. This is vital to ensure that seriously injured children are moved to centres with the requisite expertise to treat their injuries. However, it is also important to ensure those specialist centres are not overwhelmed by a large volume of children with minor or moderate injuries who could be treated at the local TU.[1]

Given the relatively low incidence of major trauma in children, even the most experienced prehospital emergency practitioner may find this challenging. A robust prehospital triage tool may mitigate this.

Many validated prehospital triage tools for injured adults exist. However, there are few prehospital trauma triage tools for injured children in existence, and fewer still that have been validated using clinical data, rather than by expert or consensus opinion.[4–7]

There is currently no national or international consensus on an optimal prehospital triage tool for injured children. A survey of lead clinicians for trauma care across all 10 Strategic Health Authorities (SHAs) in England revealed that each region is currently using, or is developing independently of each other, prehospital triage tools to assess seriously injured children in the prehospital setting, with a view to directing them to the most appropriate receiving unit.

This study used clinical trauma registry data to assess the performance characteristics of several paediatric prehospital triage tools. We assessed tools for identifying seriously injured children which are currently in use (or planned for use) in

regional networks in England, or which are commonly used elsewhere.

METHODS

In August 2011, Lead Clinicians for Trauma care in each of the ten SHAs in England were contacted and asked to provide details of the prehospital triage tools for injured children in current use within their region. Responses were received from eight SHAs, with seven individual tools identified.

A literature review also identified other published prehospital triage tools for injured children, of which two were described in sufficient detail to allow analysis using historical clinical data. These were the Paediatric Trauma Score and the Paediatric Triage Tape.[4–6]

The full list of tools included in the analysis is displayed in table 1.

Clinical data from the UK Trauma Audit & Research Network (TARN) database were used to interrogate each of the triage tools. TARN is a data collection system to which hospitals in England and Wales receiving and treating trauma patients subscribe. Data collected include both process and outcome data for trauma patients, analysis of which can then be used to improve care for injured patients.[8]

For the purposes of analysis, the injury severity score (ISS) was used to identify severely injured children deemed to require optimal management at an MTC. The ISS is the most commonly used scoring system for assessing severity of injury. The higher the ISS, the more severe the injury sustained, with a score >15 being designated as major trauma or polytrauma.[9] The ISS is routinely recorded for each patient by TARN.

Inclusion criteria for the study were people aged below 16 years sustaining injury or trauma and admitted to a receiving unit direct from the scene of incident, for whom all relevant discriminator fields (as set out in table 2) were recorded in the TARN database. Data were then extracted from all relevant entries recorded in the TARN database between January 2007 and December 2011. Approximately 60% of trauma-receiving hospitals in England and Wales submitted data over this time period.

Individual patient consent was not sought explicitly for this study, as TARN data are routinely stored in an anonymised fashion. Research on TARN data is approved by the National Information Governance Board for Health & Social Care. (NIGB reference number ECC 7-05(g)/2011)

Statistical analysis

Each triage tool was broken down into constituent discriminators (such as physiological signs or mechanism of injury). The constituent discriminators for each tool were then retrospectively applied to the TARN sample dataset of injured children to derive sensitivity, specificity, positive predictive value, negative predictive value and likelihood ratio measures for each tool's ability to identify seriously injured children (defined as those with an ISS >15).

Rates for under-triage (where a severely injured child is incorrectly streamed to receive care at a TU by the triage tool) and over-triage (where the opposite situation arises, of a child with minor or moderate trauma being incorrectly assessed to require care at an MTC) were also calculated. Under-triage rate was calculated using the formula (1-sensitivity), and over-triage as (1-specificity).[10]

Where discriminators describe physiological values relative to a 'normal' range, Advanced Life Support Group guidelines ranges were used.[11]

Data were analysed using SPSS (version 16) and STATA (version 11) statistical software.

Table 1 Prehospital triage tools included in the study

Triage tool	Region in which the tool is used
East Midlands Standard Operating Procedure	East Midlands
London Triage Tool	London
North West	North West
Northern	Northern
South West London and Surrey	South West London; Surrey
Wessex Triage Tool	South Central
Paediatric Trauma Score	Not routinely used in England
Paediatric Triage Tape	Not routinely used in England

Table 2 Key discriminators used for the analysis of prehospital triage tools

Key Discriminators	Examples of indicators
Auxology	Age Weight (recorded or estimated)
Airway	Airway obstruction Airway support required
Respiratory status	Respiratory rate Need for ventilator support
Cardiovascular status	Pulse rate Systolic blood pressure
Neurological status	Glasgow Coma Scale score
Anatomical data	eg, major head injury, open chest wound, penetrating abdominal trauma, etc
Mechanism of injury	eg, pedestrian/vehicle, fall from significant height.

RESULTS

Seven hundred and one patient records were identified which fit the inclusion criteria. Of these, 230 were recorded as having an ISS >15. Detailed demography of the study population is shown in table 3.

The paediatric triage tape is suitable only for children under 32 kg. As a result, this triage tool was analysed against only the children who had an estimated (using Advanced Life Support Group guidelines for weight estimation[11]) or recorded weight within this weight range. Two hundred eighty-three children (out of the total 701 children) were identified as weighing below 32 kg. Of these, 94 had an ISS>15.

The results for each tool are shown in table 4.

DISCUSSION

Overall, the prehospital triage tools in common usage across England appear to sacrifice specificity for sensitivity. In doing so, they favour over-triage (a triage decision where a patient requiring low-level trauma care is transported to a high-intensity MTC) rather than under-triage (where a patient requiring a higher level of trauma care is transported to a lower-level unit). This is understandable given the potential for death and morbidity to which under-triage would expose seriously injured children, and is well recognised in the literature.[10 12–14]

Using an ISS level >15 as the criterion for determining severely injured children requiring treatment at an MTC, target

Table 3 Demographic data on the study population

Age range (yrs)	<1 yr	1–3 yrs	4–11 yrs	12–15 yrs	Total
Total	29	38	250	384	701
Male (% in brackets)	17 (58.6%)	27 (71.0%)	184 (73.6%)	264 (68.7%)	492 (70.2%)

Table 4 The performance characteristics of prehospital paediatric trauma triage tools for children. (Range in brackets) = (95% CI)

Tool	n	ISS >15	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	Positive Likelihood Ratio	Negative Likelihood Ratio	Under-triage rate (%)	Over-triage rate (%)
East Midlands	701	230	0.97 (0.93 to 0.99)	0.17 (0.14 to 0.21)	0.36 (0.33 to 0.40)	0.91 (0.83 to 0.96)	1.17 (1.11 to 1.22)	0.20 (0.10 to 0.41)	3	83
London			0.96 (0.92 to 0.98)	0.28 (0.24 to 0.33)	0.39 (0.35 to 0.44)	0.93 (0.88 to 0.97)	1.33 (1.25 to 1.42)	0.15 (0.08 to 0.29)	4	72
North West			0.93 (0.89 to 0.96)	0.20 (0.17 to 0.24)	0.36 (0.32 to 0.40)	0.86 (0.78 to 0.92)	1.17 (1.10 to 1.24)	0.34 (0.21 to 0.57)	7	80
Northern			0.91 (0.87 to 0.95)	0.23 (0.19 to 0.27)	0.37 (0.33 to 0.41)	0.85 (0.77 to 0.90)	1.19 (1.11 to 1.27)	0.38 (0.24 to 0.59)	9	77
South West London; Surrey			0.88 (0.83 to 0.92)	0.41 (0.37 to 0.46)	0.42 (0.38 to 0.47)	0.87 (0.82 to 0.91)	1.49 (1.36 to 1.63)	0.30 (0.21 to 0.43)	12	59
Wessex			0.77 (0.71 to 0.83)	0.47 (0.43 to 0.52)	0.42 (0.37 to 0.47)	0.81 (0.76 to 0.86)	1.46 (1.31 to 1.63)	0.48 (0.37 to 0.62)	23	53
Paediatric Trauma Score			0.39 (0.33 to 0.46)	0.93 (0.91 to 0.96)	0.74 (0.66 to 0.82)	0.76 (0.72 to 0.79)	5.9 (4.08 to 8.66)	0.65 (0.59 to 0.73)	61	7
Paediatric Triage Tape	283	94	0.36 (0.27 to 0.47)	0.84 (0.78 to 0.89)	0.53 (0.40 to 0.66)	0.73 (0.66 to 0.78)	2.28 (1.49 to 3.48)	0.76 (0.64 to 0.89)	63	16

ISS, injury severity score.

levels for under-triage of 0–5% (ie, sensitivity >95%) and over-triage of 25–50% or less (ie, specificity of 50–75% or more) have been suggested.[10 15]

Only two of the eight triage tools analysed here (East Midlands and London Triage tools) fulfil the target under-triage, but both at the expense of over-triage rates of 83% and 72% respectively. The remaining six tools all underestimate the severity of trauma in an unacceptable proportion of injured children, with implications for increased mortality and morbidity in a vulnerable group.

Over-triage has its own implications for cost and capacity for MTC and prehospital services, and in a major incident involving mass casualties, clinical care and outcomes may be seriously compromised. While two of the tools we analysed (Paediatric Trauma Score and Paediatric Triage Tape) meet or exceed the target range for over-triage, this is accompanied by an unacceptably high under-triage rate of 61% and 63% respectively.

Comparison with the published literature for under- and over-triage rates should be interpreted in light of the fact that definitions and methodology are not uniformly applied. We have used the classical definition of (1-sensitivity) for under-triage and (1-specificity) for over-triage,[10] but other studies have used (1-negative predictive value) and (1-positive predictive value) respectively.[16 17] Applying this alternative methodology would not significantly alter our results; however, under the alternative calculation, none of the triage tools would achieve the 5% target for under-triage, with findings unchanged for over-triage rates.

Many of the lead trauma clinicians who were contacted at the outset of this study had expressed a belief that the prehospital paediatric triage tools in current use would require significant modification and validation to facilitate trauma network development for injured children. Our findings corroborate this view. It is our intention that the next stage of the study will be to identify key discriminators to inform the development of any future paediatric prehospital triage tools.

Strengths and limitations of the study

Given the low incidence of paediatric major trauma in the UK, the use of trauma registry data has allowed us to assess the efficacy of each triage tool against a large population of children. In addition, TARN data is nationwide and therefore minimises the effect on analysis of geographical or historical idiosyncrasies in local trauma management. The relevance of the study is enhanced by using TARN data which closely matches the population in which these triage tools are being, or will be, used.

However, we recognise that there are significant limitations to using a registry dataset in this way. Although the timescale of 2007–2011 is relatively recent, it is possible that there may have been significant advancements in trauma care on a temporal or geographical basis.

The process of identifying the tools was itself performed several months prior to the full implementation of trauma networks for children. Therefore, it is possible that those tools have undergone adaptation and modification in the interim to better reflect each network's experience with new patient flows, which may alter our findings.

Because we have had to apply retrospectively discriminator data from various triage tools into a set of data points already collected by TARN, possible bias is introduced on the occasions when we have had to apply clinical interpretations to discriminators—for example, mechanism of injury data (which are described differently for many triage tools), or different ranges used in physiological markers.

Importantly, as TARN only collects data on moderately or seriously injured children, this analysis is based on a selected population of injured children. It could be argued that, for the purpose of assisting prehospital teams to risk-stratify children for transfer to an MTC or otherwise, an analysis of only moderately or severely injured children is adequate. However, for true assessment and validation, tools should be tested against an unselected population, as the implications of high over-triage rates will be more significant if they also apply to those children with minor injuries. We intend to pursue such a prospective, unselected analysis of injured children in the next phase of our study.

CONCLUSION

Most prehospital triage tools used, or being developed for use, in England fail to meet recommended criteria for rates of under- and over-triage, with over-triage rates being particularly problematic. This has major operational, resource and safety implications for the imminent introduction of regional trauma networks for children in England. There is an urgent need for the development of evidence-based triage tools to allow accurate risk-stratification of injured children in the prehospital setting.

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Competing interests None.

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Data sharing statement Technical appendix, statistical code and dataset available from the corresponding author on request. Individual patient consent was not obtained but the presented data are anonymised and risk of identification is low.

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