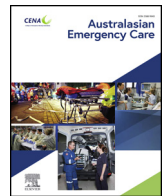




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Research paper

Determining the priorities for change in paediatric trauma care delivery in NSW, Australia

Kate Curtis^{a,b,c,d}, Belinda Kennedy^{a,*}, Andrew J.A. Holland^{e,f}, Rebecca J. Mitchell^g, Gary Tall^h, Holly Smithⁱ, Soundappan S.V. Soundappan^{e,f}, Allan Loudfoot^h, Brian Burns^{e,h}, Michael Dinh^{j,k}

^a Susan Wakil School of Nursing and Midwifery, The University of Sydney, 88 Mallett St, Camperdown, NSW, Australia

^b Illawarra Shoalhaven Local Health District, NSW, Australia

^c The George Institute for Global Health, Sydney, Australia

^d Illawarra Health and Medical Research Institute, NSW, Australia

^e Sydney Medical School, The University of Sydney, Sydney, NSW, Australia

^f The Children's Hospital at Westmead, Sydney, NSW, Australia

^g Australian Institute of Health Innovation, Faculty of Medicine and Health Sciences, Macquarie University, Sydney, Australia

^h NSW Ambulance, Sydney, NSW, Australia

ⁱ Northern Sydney LHD, NSW, Australia

^j Sydney Local Health District, NSW, Australia

^k NSW Institute of Trauma and Injury Management (ITIM), Chatswood, Australia

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ABSTRACT

Background: Injury remains the leading cause of death and disability for Australian children. There is known variability in the quality of care delivered to injured children in Australia. This study prioritises recommendations developed from an expert review of paediatric trauma cases, for implementation with the aim of improving health service delivery to children sustaining severe injury.

Methods: A modified-Delphi study was conducted between October 2018 and February 2019. Two rounds of an online survey to rank the suitability and importance of each of the 26 recommendations was conducted. Final decisions on the priorities for change in the paediatric trauma system was determined by a consensus of $\geq 80\%$ for importance and/or suitability.

Results: One hundred and one participants completed Round 1, and 60 participants completed Round 2 of the modified-Delphi. In Round 1, 13 recommendations reached $\geq 80\%$ and in round 2, 11 recommendations reached $\geq 80\%$. Those ranked highest focussed on pre-hospital airway management, streamlining retrieval and transfer processes, improving hospital nursing ratios and radiology reporting.

Conclusion: This modified-Delphi study identified the priority areas for recommended change to the NSW paediatric trauma system. Work to address these areas has the potential to provide more coordinated and timely care to children sustaining severe injury.

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Background

There remains variability in the quality of care for injured youth across the globe [1]. Deficiencies have been reported in the quality of care for 8%–45% of severely injured children and an estimated 6%–32% of in-hospital trauma deaths seem preventable [2].

Further, considerable variability in the implementation and compliance with evidence-based guidelines in clinical practice has been reported [3], although this appears largely unexplored in paediatric trauma care.

Injury remains the leading cause of death and disability for children in Australia [4]. The 2016–17 Australian Trauma Registry report demonstrated a variance in in-hospital mortality rates around Australia [5]. A retrospective review in 2010 of 1138 severely injured children using data from the New South Wales (NSW) Trauma Registry found children who received definitive treatment at a Paediatric Trauma Centre (PTC) were between three

* Corresponding author at: Belinda Kennedy, The University of Sydney, M02, 88 Mallett St, Camperdown, NSW, Australia.

E-mail address: Belinda.kennedy@sydney.edu.au (B. Kennedy).

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Table 1
Participant sources in modified Delphi study to prioritise recommendations for change to NSW Paediatric Trauma system.

NSW Ambulance	NSW Ministry of Health	Clinician groups
Selected rural/ metropolitan paramedics Retrieval specialists Director of Clinical Operations Medical Advisor Manager Education	NSW Agency for Clinical Innovation NSW Institute Trauma and Injury Management Trauma Clinical Nurse Consultants Trauma Directors Emergency Care Institute NSW Emergency Clinical Nurse Consultants Paediatric Healthcare Paediatric Clinical Nurse Consultants	Newborn & paediatric Emergency Transport Service Sydney Children's Hospital Network (SCHN) and John Hunter Hospital Operations Manager Directors of Nursing Emergency Nurse Unit Managers Intensive Care Consultants

to six times more likely to survive than if they were treated at an Adult Trauma Centre (ATC) [6]. A more recent study in 2014 demonstrated this outcome was unchanged [7].

To address this gap in knowledge in Australian paediatric trauma care, a comprehensive review of care delivery processes and outcomes of 490 major paediatric trauma patients in NSW was completed in 2018 [8]. As part of this review, cases of children who died or if they were identified as potentially having suboptimal care were reviewed using a major trauma case review tool [9], which enables categorization of care delivery problems and associated causative factors. This multidisciplinary review identified contributing factors to clinical incidents in trauma care resulting in 26 recommendations for change [8]. This study reports the prioritization of these recommendations for implementation.

The purpose of this modified-Delphi study was to rank the suitability and importance of priorities for clinical and system development or change in NSW Paediatric Trauma Management. In particular, to obtain consensus about the suitability and importance of recommendations for change to the paediatric trauma system in NSW.

Methods

Following ethics approval by NSW Population & Health Service Research Ethics Committee (HREC/15/CIPHS/6), a modified-Delphi study of clinicians, health service administrators, government representatives and consumers was conducted between October 2018 and February 2019. This study is part of a larger multi-method study NHMRC funded partnership grant investigating paediatric trauma care delivery and outcomes in NSW [10]. A panel of trauma experts (including paediatric surgeons, emergency physicians, retrieval specialists, paramedics, trauma clinical nurse consultants, forensic pathologist and a human factors consultant), identified 26 recommendations for change during earlier phases of the study. The recommendations were formed following a review of records for children aged less than 16 years, presenting to the three paediatric trauma centres in NSW between July 2015 and September 2016, where they required intensive care admission, or had an injury severity score of ≥ 9 , or died following injury [8]. The results of the medical record and peer-review informed the content for the modified-Delphi study.

Participant recruitment

Key stakeholder participants were identified from across NSW to ensure broad representation of key stakeholders in the policy development and service delivery of NSW Paediatric trauma care. Eligible participants were those who at the time of the study were; directly involved in the delivery of clinical care to injured children; responsible for service delivery at an organisational level; employed in a position that provides oversight and management of service delivery to injured children in NSW and research partner consumers with a lived experience of the NSW paediatric trauma system. Representatives from specialist clinical

and policy networks were invited to participate to ensure the study population has relevant qualifications and expertise. Participant sources included NSW Ambulance, NSW Ministry of Health, clinician groups and consumer groups (Table 1).

Procedure

The surveys were administered online using REDcap (Vanderbilt University, USA), a secure web-based application for data management and survey tool. The modified-Delphi was completed in two rounds.

Round One: Designated representatives for each organisation forwarded the study information, via email to key stakeholder participants meeting the eligibility criteria to participate. On completion of the survey, participants were asked to enter their email address to facilitate invitation to complete the next round. Consent was implied upon completion of the survey.

Round Two: All participants who completed round one, and provided an email contact, were sent an invitation to complete round two of the modified-Delphi.

First round reminder emails were sent to all those initially invited to participate three weeks post the original invitation by the designated representative, and again one week prior to deadline for completion. Second round reminders were distributed via REDCap.

Survey tools

The first round survey contained 54 questions based on 25 of the 26 recommendations for change in the way paediatric trauma care is delivered in NSW. One of the recommendations (the revision of paediatric pre hospital triage criteria) was implemented prior to commencement of the Delphi. Each recommendation was accompanied by supporting evidence (Fig. 1). The second round survey consisted of recommendations that over 80% of respondents felt were important and suitable priorities for change in the first round survey). In each round participants were asked to rate the suitability and the importance of each recommendation separately on a 5 point Likert scale (from "not at all" to extremely). Suitability was scored based on a participant's opinion of how acceptable, practical, safe and equitable the recommendation was. Importance was scored based on whether the participant viewed the proposed recommendation as a priority in the provision of healthcare to severely injured children in NSW. Participants were asked to suggest modifications to any recommendations and to list the key factors that led to their rating of recommendations. At the completion of each round, data were downloaded and managed according to a Research Data Management Plan at The University of Sydney.

Analysis

Responses on the suitability and importance of each recommendation were analysed using descriptive statistics. High panel consensus was defined a priori as $\geq 80\%$, moderate consensus

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Determining the priorities for change in paediatric trauma care delivery in NSW

Section 2 - Transport and referral of injured children (cont.)

2.2 Review transport practices for both pre-hospital and inter-hospital transfers.

a) Review current guidelines for retrieval tasking to ensure consistent activation to paediatric trauma patients requiring higher level care

Background

The peer review identified inconsistent dispatch of resources by NSW Ambulance Aeromedical Coordination Centre (ACC) in Sydney in the pre-hospital phase, to children with similar clinical presentation resulting in significant variance in transport times to definitive care. This means, that you could have two children with similar injuries, with significantly different times to arrival at definitive care.

An example in the study, two children injured in regional NSW similar distance from Sydney by road, both sustained similar injuries with clinical signs present on scene. One child transported direct to Sydney from scene taking 4 ½ hours from the time of injury. Whereas the second child transported to the local hospital, with retrieval not activated until notification from the local hospital resulting in 11hrs from the time of injury to arrival at a specialist paediatric centre.

It is well established that treatment of severely injured children at designated paediatric trauma centres improves outcomes^{16,26}, limiting the time to definitive care for seriously injured children in NSW is a priority. Early activation in geographically remote locations, will provide early support to health facilities, ultimately limiting the time for inter-hospital transfer.

Recommendation 8: NSW Ambulance Aeromedical Retrieval Service is to revise, and implement, guidelines related to the activation of medical retrieval services by the Aeromedical Coordination Centre (ACC) in Sydney. With emphasis on the timely dispatch of medical retrieval services, focusing on direct transfer to a tertiary paediatric facility where feasible and safe.



Fig. 1. Example of the Modified-Delphi online survey.

Table 2

Participant work locations and roles to prioritise recommendations for change to NSW Paediatric Trauma system.

Characteristic	Round 1 (n = 101) n (%)	Round 2 (n = 60) n (%)
Work location ^a		
Prehospital/ interhospital transport	28 (27.7)	15 (25.0)
Health Facility	84 (83.2)	51 (85.0)
Administration/ Government	5 (5.0)	4 (6.7)
Unknown	1 (1.0)	0 (0.0)
Work role		
Clinical only	80 (79.2)	52 (86.7)
Non-clinical only	16 (15.8)	6 (10.0)
Both clinical and non-clinical	5 (5.0)	2 (3.3)

^a some participants had more than one work location.

50–79% and low consensus <50% [11]. Final decisions on the priorities for change in the paediatric trauma system were determined by a consensus of greater than or equal to 80% in both suitability and importance. The recommendations were grouped according to potential operationalisation categories.

Results

One hundred and one participants completed Round 1, and 60 participants completed Round 2 of the modified-Delphi. The 97-seven participants (who provided their email addresses) from round one were invited to participate in round two, resulting in a 62% response rate. Participant work locations and roles are presented in Table 2. In Round 1, 13 recommendations reached ≥80%

consensus for importance and/or suitability, while in Round 2, nine recommendations reached ≥80% consensus for importance and/or suitability (Table 3).

The recommendations ranked highest were related to levels of staffing and expedition of referral, acceptance and transport processes of critically ill children to major trauma centres. Those ranked lowest were around education and training, and standardisation of trauma documentation and guidelines.

Discussion

Children are particularly vulnerable to severe injury, having the highest age standardised injury rates [12] as well as a higher mortality rates after major trauma than adults less than 65 years [13,14]. Although recommendations for improving the care of severely injured children were previously known, prioritization of these recommendations was required to ensure the changes were feasible, based on stakeholder consensus and aligned with other clinical and health system priorities. This study presents the findings of a state-wide modified-Delphi study to prioritise recommendations for change to the paediatric trauma system in NSW. The recommendations ranked most important and suitable for change focussed on pre-hospital airway management, streamlining retrieval and transfer processes, improving hospital nursing ratios and radiology reporting.

Timely care is essential, and children requiring paediatric critical care should be stabilised and rapidly transferred to a specialised paediatric facility by retrieval teams expert in both prehospital and

Table 3

Recommendation suitability and importance rating of priorities for change in the NSW paediatric trauma system.

Recommendation/category	Round 1 suitability*			Round 1 importance			Round 2 suitability			Round 2 importance		
	1–2 n (%)	3 n (%)	4–5 n (%)	1–2 n (%)	3 n (%)	4–5 n (%)	1–2 n (%)	3 n (%)	4–5 n (%)	1–2 n (%)	3 n (%)	4–5 n (%)
1–2: (not at all/somewhat) 3: (moderate), 4–5(very/extremely)												
Equipment												
Mandatory waveform capnography equipment (ETCO2) for all patients intubated in pre-hospital setting	4 (3.96)	6 (5.94)	91 (90.10)	5 (4.95)	9 (8.91)	87 (86.14)	2 (3.33)	4 (6.67)	54 (90.00)	2 (3.33)	8 (13.33)	50 (83.33)
Communication/Documentation												
Mandatory waveform ETCO2 airway confirmation and monitoring	8 (7.92)	15 (14.85)	78 (77.23)	11 (10.89)	16 (15.84)	74 (73.27)						
Standardise NSW documentation for initial assessment of trauma	11 (10.89)	21 (20.79)	69 (68.32)	10 (9.90)	26 (25.74)	65 (64.36)						
Mandated framework for referral communication of trauma patients	2 (1.98)	16 (15.84)	83 (82.18)	6 (5.94)	17 (16.83)	78 (77.23)	3 (5.00)	12 (20.00)	45 (75.00)	5 (8.33)	16 (26.67)	39 (65.00)
Data Collection												
NSW Ambulance establish airway registry to monitor intubation data	8 (7.92)	16 (15.84)	77 (76.24)	8 (7.92)	27 (26.73)	66 (65.35)						
Develop standardised data dictionary for use by all health services collecting data related to paediatric trauma care	14 (13.86)	23 (22.77)	64 (63.37)	21 (20.79)	28 (27.72)	52 (54.49)						
Single medical record identifier for use across NSW	9 (8.91)	12 (11.88)	80 (79.21)	10 (9.90)	21 (20.79)	70 (69.31)						
Clinical Guidelines												
Guidelines to improve pre-hospital airway management practices	5 (4.95)	2 (1.98)	94 (93.07)	5 (4.95)	5 (4.95)	91 (90.10)	1 (1.67)	6 (10.00)	53 (88.33)	0	7 (11.67)	53 (88.33)
Standardise NSW paediatric trauma call activation criteria, incorporating physiological, anatomical, developmental differences	8 (7.92)	8 (7.92)	85 (84.16)	9 (8.91)	11 (10.89)	81 (80.20)	2 (3.33)	10 (16.67)	48 (80.00)	3 (3.33)	8 (13.33)	49 (81.67)

Table 3 (Continued)

Recommendation/category	Round 1 suitability*			Round 1 importance			Round 2 suitability			Round 2 importance		
	1–2: n (%)	3 n (%)	4–5 n (%)	1–2 n (%)	3 n (%)	4–5 n (%)	1–2 n (%)	3 n (%)	4–5 n (%)	1–2 n (%)	3 n (%)	4–5 n (%)
1–2: (not at all/somewhat) 3: (moderate), 4–5(very/extremely)												
Standardise guidelines for paediatric trauma care across NSW (adapt for local implementation)	5 (4.95)	18 (17.82)	78 (77.23)	6 (5.94)	20 (19.80)	75 (74.26)						
Framework for damage control and haemostatic resuscitation for use across NSW Health Facilities	4 (3.96)	14 (13.86)	83 (82.18)	5 (4.95)	16 (18.84)	80 (79.21)	1 (1.67)	9 (15.00)	50 (83.33)	1 (1.67)	9 (15.00)	50 (83.33)
System guidelines												
Establish statewide referral system with single point of contact for injured children requiring transfer to a pediatric facility in NSW	3 (2.97)	14 (13.86)	84 (83.17)	5 (4.95)	12 (11.88)	84 (83.17)	0	7 (11.67)	53 (88.33)	0	6 (10.00)	54 (90.00)
No refusal policy for paediatric trauma centres for injured children meeting trauma transfer criteria	8 (7.92)	8 (7.92)	85 (84.16)	6 (5.94)	8 (7.92)	87 (86.14)	1 (1.67)	5 (8.33)	54 (90.00)	1 (1.67)	6 (10.00)	53 (88.33)
NSW Ambulance revise activation of retrieval guidelines by the Aeromedical Coordination Centre	5 (4.95)	11 (10.89)	85 (84.16)	5 (4.95)	12 (11.88)	84 (83.17)	2 (3.33)	12 (20.00)	46 (76.67)	4 (6.67)	10 (16.67)	46 (76.67)
Increase cross-referral between NETS, and non-NETS teams to use the closest appropriate retrieval team for inter-hospital transfer	5 (4.95)	14 (13.86)	82 (81.19)	1 (0.99)	19 (18.81)	81 (80.20)	3 (5.00)	3 (5.00)	54 (90.00)	3 (5.00)	5 (8.33)	52 (86.67)
Roles and response guidelines												
Establish and implement state-wide trauma team roles to provide clinical leadership in resuscitation	16 (15.84)	21 (20.79)	64 (63.37)	12 (11.88)	25 (24.75)	64 (63.37)						
Any paediatric patient meeting trauma criteria be reviewed, in person, by the consultant, registrar or fellow on-call within 30 min. of patient arrival	6 (5.94)	11 (10.89)	84 (83.17)	2 (1.98)	12 (11.88)	87 (86.14)	5 (8.33)	8 (13.33)	47 (78.33)	2 (3.33)	8 (13.33)	50 (83.33)

Table 3 (Continued)

Recommendation/category	Round 1 suitability*			Round 1 importance			Round 2 suitability			Round 2 importance		
	1–2: n (%)	3 n (%)	4–5 n (%)	1–2 n (%)	3 n (%)	4–5 n (%)	1–2 n (%)	3 n (%)	4–5 n (%)	1–2 n (%)	3 n (%)	4–5 n (%)
1–2: (not at all/somewhat) 3: (moderate), 4–5(very/extremely)												
Consultant, registrar or fellow on-call for sub-specialty, eg orthopaedics physically review the patient within 30 min. of call	10 (9.90)	20 (19.80)	71 (70.30)	5 (4.95)	21 (20.80)	75 (74.26)						
The radiology consultant, registrar, on call provide report within 60 min. of imaging completion	5 (4.95)	10 (9.90)	86 (85.15)	2 (1.98)	10 (9.90)	89 (88.12)	4 (6.67)	9 (15.00)	47 (78.33)	1 (1.67)	8 (13.33)	51 (85.00)
All imaging reviewed and formally reported within 24 hrs and clinical team formally notified of any changes to original reporting	4 (3.96)	7 (6.93)	90 (89.11)	3 (2.97)	14 (13.86)	84 (83.17)	1 (1.67)	4 (6.67)	55 (91.67)	3 (5.00)	4 (6.67)	53 (88.33)
Establish routine follow-up for seriously injured children for physical and psychological needs	4 (3.96)	17 (16.83)	80 (79.21)	6 (5.94)	20 (19.80)	75 (74.26)						
Nurse to patient ratios should be 1:1 in the ED resuscitation area	5 (4.95)	8 (7.92)	88 (87.13)	3 (2.97)	4 (3.96)	94 (93.07)	3 (5.00)	5 (8.33)	51 (85.00)	3 (5.00)	3 (5.00)	54 (90.00)
Education and Training												
Establish trauma team training dedicated to paediatric trauma with a focus on non-technical skills	7 (6.93)	21 (20.79)	73 (72.28)	9 (8.91)	19 (18.81)	73 (72.28)						
NSW trauma courses teaching clinical skills and knowledge should incorporate non-technical skills	5 (4.95)	20 (19.80)	76 (75.25)	7 (6.93)	24 (23.76)	70 (69.31)						
Education and training to ensure consistency in infrequently performed critical tasks in paediatric trauma care	8 (7.92)	18 (17.82)	75 (74.26)	8 (7.92)	20 (19.80)	73 (72.28)						

hospital trauma care [15]. It has been internationally established that treatment of severely injured children at designated paediatric trauma centres improves care and outcomes [16]. This allows access to tertiary level skills and resources to provide the highest level of trauma care for those severely injured children who require it. The provision of a single point of contact to coordinate and arrange transfer of severely injured children can reduce length of stay at the referring facility [17] which in other studies has been shown to result in poorer patient outcomes [18]. Additionally, an inordinate burden is placed upon clinicians at referring rural or regional facilities in the prolonged ongoing management in a relatively resource-poor environment. At present the most critically unwell children can have significant delays in transport to a PTC [19]. Based on findings from this study, NSW Ambulance in consultation with NSW Institute of Trauma and Injury Management have reviewed both the major trauma T1 protocol and trauma transfer criteria to ensure that children are either transported from the scene directly to a paediatric trauma centre where appropriate or referred as quickly as possible from the initial presenting hospital. Further work is required to better coordinate interhospital retrieval transfers for children with the establishment of a no refusal policy for paediatric trauma centres for injured children and implementation of cross-referral between retrieval teams to ensure the use of the closest appropriate medical retrieval team.

The recommendation that nurse to patient ratios should be 1:1 in the emergency department (ED) resuscitation area for paediatric trauma are reflective of the peer-review findings: when nursing staff were managing more than one patient in the resuscitation area this resulted in suboptimal patient care in some cases due to insufficient resources to complete the required treatments [8]. For example timely fluid/drug administration was either not completed, or was deemed to have been delayed. The benefits with increased nurse-to-patient ratios are well reported, resulting in reduced ED LOS, time to treatment, inpatient complications and mortality rates [20,21]. Victoria is the only Australian state with mandated nurse-to-patient ratios, including emergency departments [22], with Queensland legislation currently covering only select acute adult wards [23]. Workforce standards developed by Australian College of Critical Care Nurses recommend minimum of 1:1 for critically ill patients, with staffing determined through appropriate formula/ ratio-based systems to ensure both adequate skills and ratios [24]. A paediatric trauma patient initially cared for in the Emergency department resuscitation area warrants similar staffing ratios.

Diagnostic imaging has a critical role in the delivery of health-care [25]. Reports are formal communication findings that aid to inform clinical decision making [26]. The peer-review found that delays in trauma image reporting influenced clinical decision making and diagnostic delay [8]. Processes are required to communicate significant, unexpected findings at the time of initial scanning, particularly for those sites with off-site/remote reporting [27]. All imaging should be reviewed within one hour [28] and as recommended formally reported within 24 h with the treating team notified of any changes to original reporting [8].

Waveform capnography is considered gold standard for airway confirmation [29,30] and may be used to guide ventilation settings [30]. The recommendation to ensure airway confirmation by capnography and continuous monitoring of EndTidal CO₂ (ETCO₂) in the pre-hospital setting is a result of the peer-review identifying insufficient documentation and inconsistent capnography device use in intubated patients, both pre-hospital and in EDs. Capnography should be used to confirm endotracheal tube and monitor ETCO₂ following laryngeal mask placement and monitored in all

settings to manage ventilation [31]. This will assist in recognition of patient deterioration and inadequate ventilation.

The low ranking of some recommendations could be a result of the initiation of processes to address these areas since the initial peer-review. For example, routine patient follow up and a standardised data dictionary for trauma registries. NSW ITIM will begin a two year follow-up of trauma patients following discharge in late 2019 and work to refine the state-wide data dictionary for Trauma Registries has commenced. Although some years away, the eHealth branch of NSW Ministry of Health is working towards a single medical record number.

These and all the recommendations from this study require review from the organisations responsible for implementing change. Each of these organisations has been engaged throughout the study process in line with translational research principles. Any attempt to implement new guidelines or policy must also incorporate a clear understanding of the associated barriers to, and facilitators of change as well as commitment to the capital expenditure required to purchase hardware to enable the change process. In addition, human behavior is central to successful sustained compliance with policy and uptake of new guidelines. Interventions to ensure compliance are most successful if principles of behavioural change psychology are applied. Three validated tools to use to achieve this either in isolation or together are the Theoretical Domains Framework, the Behaviour Change Wheel and the Behaviour Change Technique Taxonomy (BCTT) [32]. Application of these principles upon implementation of new policy needs to become standard practice in Health

Conclusion

This modified-Delphi study identified the priority areas for recommendations for change to the NSW paediatric trauma system, as determined by those experienced in the management and delivery of paediatric trauma care in NSW. Work to address these areas has the potential to provide more coordinated and timely care to children sustaining severe injury.

Author contributions

KC secured funding, KC, BK, RM, developed the study protocol, BK, KC, AH, GT, HS, SS, AL, MD contributed to the tool design. KC and BK tested the tool, supervised data collection and completed analysis. All authors contributed to the preparation and approval of the manuscript.

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Conflicts of interest

Kate Curtis is Associate Editor (Trauma) for Australasian Emergency Care but had no role to play in the peer review or editorial decision-making of this paper whatsoever. The authors declare no other conflicts of interest.

Data statement

Access to the study data can be provided on request.

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