



## Identifying areas for improvement in paediatric trauma care in NSW Australia using a clinical, system and human factors peer-review tool

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### ABSTRACT

**Background:** There is known variability in the quality of care delivered to injured children. Identifying where care improvement can be made is critical. This study aimed to review paediatric trauma cases across the most populous Australian State to identify factors contributing to clinical incidents.

**Methods:** Medical records from three New South Wales Paediatric Trauma Centres were reviewed for children <16 years requiring intensive care; with an injury severity score of  $\geq 9$ , or who died following injury between July 2015 and September 2016. Records were peer-reviewed by nurse surveyors who identified cases that might not meet the expected standard of care or where the child died following the injury. A multidisciplinary panel conducted the peer-review using a major trauma peer-review tool. Records were reviewed independently, then discussed to establish consensus.

**Results:** A total 535 records were reviewed and 41 cases were peer-reviewed. The median (IQR) age was 7 (2–12) years, the median ISS was 25 (IQR 16–30). The peer-review identified a combination of clinical (85%), systems (51%) and communication (12%) problems that contributed to difficulties in care delivery. In 85% of records, staff actions were identified to contribute to events; with medical task failure the most frequently identified cause (89%).

**Conclusion:** The peer-review of paediatric trauma cases assisted in the identification of contributing factors to clinical incidents in trauma care resulting in 26 recommendations for change. The prioritisation and implementation of these recommendations, alongside a uniform State-wide trauma case review process with consistent criteria (definitions), performance indicators, monitoring and reporting would facilitate improvement in health service delivery to children sustaining severe injury.

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### Background

Quality improvement programs, including morbidity and mortality meetings, can result in improved trauma care and patient outcomes. A multidisciplinary standardised approach to reviewing trauma patient care is required [1] for effective quality

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improvement strategies [2]. Clinical review should incorporate system and human factors, to enable the identification of the underlying causes of any adverse clinical event [3]. Adverse events and near misses are rarely caused by a single factor, but rather a combination of causal factors that influence events. To understand how an adverse event or near miss has occurred it is necessary to review the patient journey, reviewing care preceding and following the identified events [2].

There remains variability in the quality of care for injured youth across the globe [4]. 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 [5]. Further, considerable variability in the implementation and compliance with evidence-based guidelines in clinical practice has been reported [6], although this appears largely unexplored in paediatric trauma care.

Injury remains the leading cause of death and disability for children in Australia [7]. The 2016–17 Australian Trauma Registry report demonstrated a variance in hospital mortality rates around Australia [8]. 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 3 to 6 times more likely to survive than if they were treated at an Adult Trauma Centre (ATC) [9]. A repeat study in 2014 demonstrated this outcome was unchanged [10]. Despite this, there has been no comprehensive analysis of the processes of care and the systems for treating severe paediatric injury in Australia, to establish factors (if any) that influence the variability in outcomes.

To address this gap in knowledge in Australian paediatric trauma care, a review of care delivery processes and outcomes of 535 major paediatric trauma patients in NSW, the most populous state of Australia, was undertaken in 2016–17. As part of this review, cases of children that died or were identified as potentially having suboptimal care were reviewed using the major trauma

case review tool [3], which enables categorization of care delivery problems and associated causative factors. This study reports the findings of the cases identified during this review that underwent expert peer-review.

## Methods

The study is embedded within a larger statewide evaluation of all major paediatric trauma care [11]. Ethical approval was provided by NSW Population & Health Services Research Ethics Committee (HREC/15/CIPHS/6).

Medical records were reviewed at three NSW Paediatric Trauma Centres for children <16 years requiring intensive care; with an injury severity score of greater than or equal to nine, or who died following their injury between July 2015 and September 2016.

Five hundred and seventy five notifications were received from NSW Paediatric Trauma Centres, via a secure online notification form, for children identified to meet study criteria. The medical records were then reviewed by nurse surveyors, who collected data on clinical status and care delivery from the time of injury to discharge using a purpose built web-based database held on a secure server. Nurse surveyors were experienced critical care clinicians and following training in the collection tool, used a standardized data dictionary. Data collection underwent inter-rater reliability. Following removal of duplicates and exclusion of children not meeting the study inclusion criteria, 490 records remained (Fig. 1). In cases where nurse surveyors identified that care was either suboptimal, or potentially did not meet pre-determined clinical indicators, they were selected for potential peer-review. Key clinical indicators were selected based on the available evidence [5,12] and expert consensus, then grouped into the standardised trauma assessment of Airway, Breathing, Circulation and Disability. Indicators were defined as aspects of care known to potentially result in adverse outcomes if not met. Clinical indicators included, but were not limited to, airway

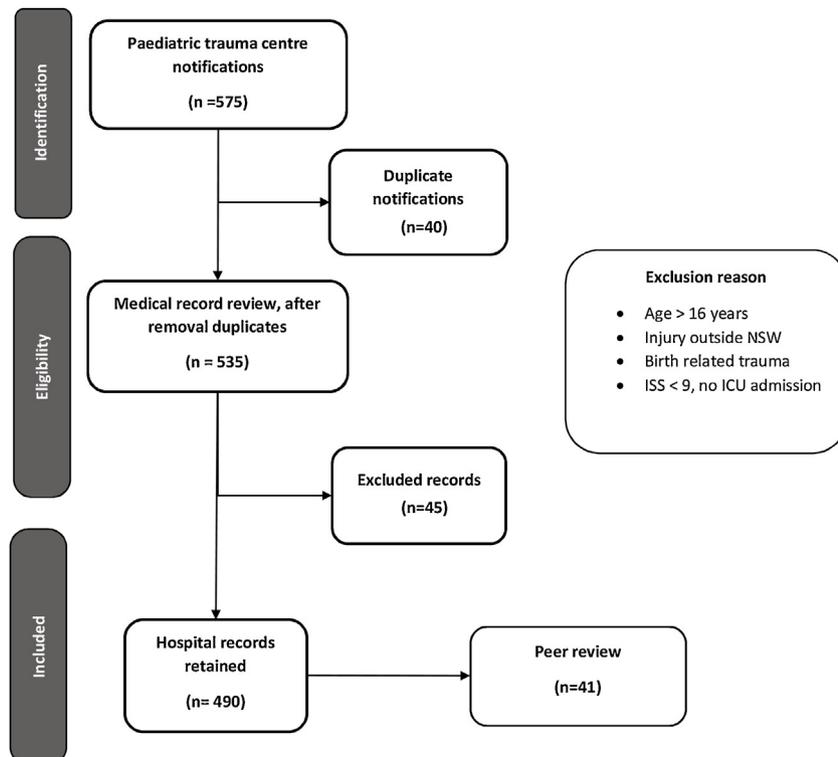


Fig. 1. Selection of major paediatric trauma cases for inclusion in peer-review.

management (such as failed intubation) [5], appropriate fluid resuscitation in hypotensive patient, and time to critical interventions (for example CT Brain where GCS < 13 within one hour [12]). For each case identified, a detailed timeline of events was recorded; nurse surveyors and the lead investigator discussed the cases to make a final decision regarding the cases to be provided for review by the panel. During the medical record review, 41 cases (8.4%) were identified for peer-review.

#### Major trauma case review tool

The peer-review team used a major trauma case review tool, developed and validated for the purposes of this research [3]. The tool collects both trauma system components and information on human factors that may have influenced clinical practice to assist in the determination of cause of action. The trauma system components include demographic and injury information, providing an overview of the chronological detail for each case. Information related to clinical management and service delivery was recorded in the standardised Airway, Breathing, Circulation and Disability format.

Information on human factors that may have influenced clinical practice was collected including: equipment, work environment, staff action, patient, organisational, individual and other factors (Table 1).

The peer-review tool classifies error using Rasmussen's [13] skill, rule or knowledge-based error classifications, or a violation classification [14]. Skill-based errors referred to unintentional failures in the execution of a well-rehearsed action or routine task that require little conscious attention. Rule-based errors referred to unintentional failures during activities conducted in familiar situations that were controlled by stored rules. Knowledge-based errors referred to unintentional failures during a novel situation that require conscious analytic processing and stored knowledge. A violation was considered to be an intentional failure to follow accepted work practices, guidelines or procedures during the execution of a task. It is noted that within this classification system a violation does not indicate the intent to cause harm.

#### Data collection

The eleven member peer-review team comprised multiple disciplines; surgeons, emergency physicians, an intensive care paramedic, prehospital and retrieval specialists, trauma clinical nurse consultants, a forensic pathologist and a human factors specialist. The role of the human factors specialist was to provide assistance in the application of the human factor framework and associated concepts. When opinion was required beyond the expertise of the group, for example neurosurgery, the case was sent for external, independent specialist review. There were six full day meetings over a 15-month period between February 2016 and May

2017. The panel reviewed between six and eight records on each occasion.

De-identified medical records were provided to the panel members to review independently using the Major trauma case review tool [3]. Section 1-3 of the major trauma case review tool included patient factors (demographic information, co-morbidities, referral source), presenting problem (mechanism, injuries, signs and symptoms) a chronology of events were pre-completed, for the purposes of timeliness and provide an overview of the case to reviewers.

Where reviewers identified problems in care delivery, they were required to determine the causes according to one of seven categories, as outlined in Table 1. Relevant subcategories were characterised that contributed to the identified event, providing more in depth understanding of the contributing factors.

Following independent review the panel discussed their findings to establish consensus on the findings for each case. If required, further information was obtained to enable the panel to make a decision on specific points identified; this was provided at subsequent meetings. Results of the discussion were collated and recorded by the lead investigator using the major trauma case review template. Where no further information was required the panel determined the case outcome, they were classified as:

- 1 Clinically preventable trauma death
- 2 Clinically near-preventable trauma death
- 3 Clinically non-preventable trauma death
- 4 Near miss of death
- 5 Near miss of incident that did not result in death
- 6 Preventable error causing lasting disability
- 7 No problems identified

On completion of the peer-review of all cases, preliminary analysis was conducted, the peer-review panel met on one final occasion where outcomes of analysis were presented. The final meeting enabled the panel to discuss the identified trends and draft recommendations for change in the delivery of paediatric trauma care in NSW.

Data from each peer-review meeting were entered into an Excel™ spreadsheet. Descriptive statistics were conducted using in SPSS v24 [15]. Injuries were coded using the Abbreviated Injury Scale [16].

## Results

#### Study population and injury characteristics

The median (IQR) age of children whose trauma care underwent peer-review was 7 (2–12) years, ranging 1 month to 15 years, with gender evenly distributed. The median injury severity score (ISS) was 25 (16–30), range 6–75, reflecting a

**Table 1**  
Definition of factors contributing to care delivery [3].

Equipment	Events that involved subcategories of equipment or device failures, breakages or malfunctions, lack of medical equipment and medical supplies.
Work environment	Events resulting from the location of the incident that could not have changed by personnel at the time, including lighting, temperature, noise and physical layout
Staff action/ communication	Referred to as staff action events. These resulted from direct involvement by a staff member, including subcategories of communication failures and documentation issues, medical task failures
Patient	Events resulting from direct involvement of the patient that influenced events
Organisational	Organisational aspects that directly or indirectly influenced safety and quality of medical and nursing activities and their management, including work practices, policies or guidelines, supervision, available resources (including staffing and equipment), work pressure and other organisational factors.
Individual	Characteristics of staff members, including knowledge and skills, experience, stress, fatigue and other individual factors
Other	Additional events not elsewhere classified

severely injured cohort. Fifteen (36.6%) had a serious head injury, that is an injury to the head with an Abbreviated Injury Scale severity score >2 [17], with 16 (39%) identified with polytrauma, injuries to more than two body regions [18]. The majority were admitted to intensive care (71%). The leading cause of injury was motor vehicle collision (22%) followed by pedestrian-related injuries (17%) (Table 2). Children who sustained their injury in rural/regional areas formed 41% of the cohort and 46% of children were initially treated at a non PTC.

#### Problems identified in care delivery

In 24 (59%) cases there were problems identified in more than one aspect of care delivery (i.e., clinical, systems, communication). The largest number of problems were identified in the clinical delivery of care (85%), followed by systems (51%) and communication (12%). There were no problems identified in four (10%) of the cases reviewed, which were children who had clinically non-preventable deaths. This equates to an overall adverse event rate of 7.6% in the study population. Nearly half the cases reviewed were determined to be non-preventable trauma deaths (42%). Over a third (37%) of cases reviewed were determined to be a near miss that did not result in death, 15% of cases were classified as preventable errors that resulted in lasting disability for a child, and there was one case identified as near miss of death. There was one case for which the peer-review team was unable to determine the case outcome. The majority of airway management problems occurred in the prehospital environment. Circulation, burn management and neurological related problems were more frequent in-hospital, regardless of trauma centre status (Table 3).

Of the clinical problems identified, most were related to circulation (60%) and airway management (57%), followed equally by breathing and disability (23%) management. Problems identified in the management of circulation predominantly related to establishing intravenous or intraosseous access (n=8), assessment and monitoring (n=8) and adequate fluid administration/resuscitation (n=6). The majority of airway problems were classified as airway management (other): this included incorrect endotracheal size and multiple intubation attempts (Table 3).

**Table 2**

Demographics, injury characteristics and mechanism of injury for children reviewed.

Characteristic	Study sample (n = 41) Median (IQR)
Age (years)	7 (2–12)
ISS	25 (16–30)
NISS	26 (25–43) n (%)
Gender	
Female	20 (48.8)
Male	21 (51.2)
ICU admission	
Yes	29 (70.7)
No	12 (29.3)
Head injury AIS > 2	15 (36.6)
Polytrauma	16 (39.0)
Mechanism of Injury	
Assault	3 (7.3)
Burns	3 (7.3)
Drowning	6 (14.6)
Falls	5 (12.2)
Road trauma	18 (44.0)
Scooter/skateboard	1 (2.4)
Other incident	5 (12.2)
Injury Location	
Major city	22 (53.7)
Regional	17 (41.5)
Unknown	2 (4.9)
Outcomes	
Deceased	18 (43.9)
Survived	23 (56.1)

#### Causal factors

The most frequently identifiable causal factors were staff action (85%), organisational (59%) and individual (49%) factors, with equipment and patient characteristics (32%) equally reported. For each of the categories there were a small number (i.e. < 5) of cases where the peer-review team was unable to determine whether the factors contributed with the information available in the medical record, the majority of these were related to the individual or organisational factors.

**Table 3**

Classification of clinical problems identified through peer-review.

Clinical problems identified	Number of cases (%)	Location n = number of problems <sup>a</sup>		
		Pre hospital	Referring hospital/ transfer	PTC
Clinical problems identified	35 children			
Airway	20 children (57)	19	5	10
Delayed intubation	8 (40) <sup>a</sup>	2	2	4
Incorrect tube placement	7 (35)	7	1	1
Airway management other	12 (60)	8	2	2
C-spine management	3 (15)	2		3
Breathing	8 children (23)	7	3	4
ETCO <sub>2</sub> monitoring	4 (50)	5		2
Ventilation issues	3 (38)		2	1
Chest decompression	2 (25)	2	1	
ICC insertion	2 (25)			1
Circulation	21 children (60)	11	10	10
Fluid administration/ resuscitation	6 (29)	6	5	3
IV/ IO access	8 (38)	6	2	2
Haemodynamic monitoring/ assessment	8 (38)	2	3	4
Pelvic/ fracture immobilisation	4 (19)	3		1
Disability	8 children (23)	0	2	5
Neurological assessment/ management	3 (38)		2	1
Neurosurgery delay	4 (50)			4
Exposure	2 children (6)	0	2	1
Burn management	2 (100)		2	1

<sup>a</sup> The number of problems identified by sub category and location exceed the number of children who experienced the problem. For example, in Circulation, a child may have had 3 problems identified in both prehospital and in hospital locations.

In regard to staff action, medical task failure, that is, execution failures in medical treatment were the most frequently identified contributing factor identified in 31 (89%) cases, and delays to diagnosis, treatment or transfer in 26 (74%) cases. Skill-based error (n = 19), was the largest identified cause related to medical task failure. The cause for delays related to staff action were largely unknown (n = 14), as there was insufficient detail in the medical record to enable the peer-review team to classify the cause of the identified delay: these included problems such as delay in imaging (Table 4).

Work practice, policies or guidelines was the largest cause identified related to organisational problems (n = 19), this included not following existing policies/guidelines (48%), available guidelines considered to be unclear (22%), or a recognised work practice where there is no published guideline available (17%). Poor, inadequate or lack of training (n = 14) and lack of skill or competence to perform the task (n = 13) were the most commonly determined cause to contribute to individual performance in the delivery of paediatric trauma care with both determined to contribute in thirteen cases where the individual was identified as contributing to the problems identified in care delivery.

The work environment and the individual were both recognised as contributing factors to identified problems in 32% of cases reviewed. Where the work environment was identified as a causal factor the majority could not be classified into a specific subcategory (n = 4); although all those able to be determined from the medical record occurred in the prehospital environment. Pre-existing physical health (n = 6) and communication problems (n = 6) were the two greatest factors identified as a contributing cause within the patient category.

## Discussion

This study presents the findings of a state-wide peer-review of the care provided to a severely injured cohort of children as reflected in the ISS, rates of serious head injury, polytrauma and intensive care admission. The rate of adverse events in the study population was 7.6%, slightly less than the 8%–45% reported in the international literature. No absolutely preventable deaths were identified, in contrast to the reported 2%–32% [5,19,20]. Efforts to address the quality of care in the paediatric population is important because injury is the leading cause of hospitalisation, death and disability in children, and there remains unwarranted clinical variation in the care of children and young people hospitalised for injury [21]. The effects, and costs, of injury are multifactorial and can be difficult to capture and report. Although a 2018 Australian study demonstrated that 5.5% of paediatric trauma patients were readmitted within 28 days of injury, the direct treatment costs for this cohort were almost double the median costs for all injury-related Australian hospitalisations [22]. Further, injury results in both direct and indirect costs to the individual, family and society as described by the LOAD framework [23]. Improvement in the quality of care delivery ultimately has the potential to improve outcomes, which in turn may reduce some of the direct and indirect costs related to injury.

Human factors, in particular staff action were the biggest contributor to problems identified in the care delivery. Case records provide documentation on actions and events associated with the case, but rarely provide detail on conditions and contributing factors present in the environment. As such, it is recognised that there are likely to be other factors that contributed to the occurrence of staff actions that were not represented in the data. However, the data suggest these factors likely signify a highly stressful work environment, inadequate processes and equipment resources, which has been reflected in the 26 recommendations. Although staff action was the biggest identified contributor,

**Table 4**

Causative factors identified related to staff action identified to contribute to problems in care delivery.<sup>a</sup>

Staff Action (n = 35)	n(%)	Case examples
Communication	15 (43)	Absence of appropriate written communication and handover related to poor limb perfusion resulting in delays in management.
Frequency of communication problems	21	
Verbal with staff-handover	7 (33)	
Verbal with staff- no handover	3 (14)	
Written with staff	6 (29)	
Other communication	5 (24)	
Medical task failure	31 (89)	Incorrect anatomical location used for needle decompression
Frequency medical task failure problems	50	
Skill based error	19 (38)	
Rule based error	14 (28)	
Knowledge based error	13 (26)	
Violation	3 (6)	
Not known	1 (2)	
Monitoring	6 (17)	
Frequency monitoring problems	8	
Skill based error	1 (13)	
Rule based error	2 (25)	
Knowledge based error	3 (38)	
Violation	1 (13)	
Not known	1(13)	
Delay	26 (74)	
Frequency delay problems	39	Delay in escalation and referral of care at referring hospital resulted in poorer outcome, child arrived at pediatric trauma centre > 36 hrs post initial presentation
Skill based error	5 (13)	
Rule based error	10 (26)	
Knowledge based error	7 (18)	
Violation	3 (8)	
Not known	14 (36)	
Misdiagnosis	8 (23)	
Frequency misdiagnosis problems	12	
Skill based error	2 (17)	
Rule based error	1 (8)	
Knowledge based error	6 (50)	
Violation	1 (8)	
Not known	2 (17)	
Medication Issue	11 (31)	Inaccurate calculation of paediatric drug doses for intubation
Frequency of medication problems	14	
Skill based error		
Rule based error	2 (14)	
Knowledge based error	9 (64)	
Violation	1 (7)	
Not known	2 (14)	
Human Factors not elsewhere classified	3 (9)	
Frequency of unclassified problems	4	Evidence of confirmation bias with incorrect assessment from initial responder repeated through initial hospital presentation, resulting in delayed referral and appropriate management
Skill based error		
Rule based error		
Knowledge based error	1 (25)	
Violation	1 (25)	
Not known	2 (50)	

<sup>a</sup> multiple problems within the same category were identified, both the number of cases identified within the category and the number of problems classified in the subcategory are reported.

humans remain fallible and staff action or inaction represents one of the last lines of defence in the causal chain of adverse events. Human error should be considered a consequence rather than a cause of the adverse event [24]. Adverse events most often originate in “upstream” systemic factors [24] and as those factors

are identified, efforts to alleviate them can be instituted and reduce the likelihood of error in care [25]. This upstream system is incredibly complex in the injury context given the many and varied paths that trauma patients (both paediatric and adult) take to access definitive care. Health services should enable and support front line clinicians by inclusion and resourcing of adequate equipment, trauma teams, communications processes, protocols, education, audit and feedback, infrastructure, staffing and inter-hospital patient transfer systems [19,26].

Organisational factors were identified as a cause of the adverse event in almost 60% of cases reviewed, and 71% of those with staff action identified. Failure to follow existing policies and guidelines was the most frequent causative factor to problems in care delivery, reiterating the evidence that there is universal poor compliance with existing guidelines in the provision of medical treatment. For example, in Australia, clinician compliance with providing appropriate care for 17 child health conditions, including head injury was 59.8% with substantial variation across conditions [27]. It is challenging to introduce and sustain protocols in the context of competing priorities in healthcare, which are often introduced following adverse events to reduce “human error” [25]. However policy introduction does not always reduce the number of failures in the system as overt failures are rare and any quiet period that follows institution of these new policies may convince administrators that changes have been effective. When a new overt failure occurs, it seems to be unique, and the cycle repeats. With each cycle, more policies make the system more complicated, increasing the opportunities for failures [25]. Further organisational and individual factors impact implementation and uptake such as clinician behaviour, lack of time and a lack of continuing education [28].

Despite injury being the largest cause of death and disability in people aged less than 45 years, major trauma as an emergency

cohort remains relatively small compared to other presentations. The infrequency of presentation leads to clinicians applying skills they may not have used clinically or in high fidelity simulation recently. This, coupled with a highly emotive and stressful situation, poses a unique set of circumstances to clinicians providing adult and paediatric trauma care. The management of severely injured patients is complex, and requires the ability to make time-critical decisions in a dynamic environment with variable team structure and skills [29]. This complex environment, if not managed effectively, can increase the likelihood of errors [30]. This is reflected in this severely injured study cohort where in nearly half of the cases reviewed individual clinician factors lead to problems in care delivery, mainly related to training and experience, in particular around pre-hospital airway management. It is important to consider that individual factors are potentially under reported given factors such as fatigue and stress are difficult to identify from a retrospective review of medical records, review of cases by individuals directly involved in care delivery would provide greater insight. These findings are not unique to the paediatric trauma population [19].

The outcome for the deceased patients was determined to be clinically non-preventable. This suggests that the demonstrated survival benefit in direct transfer to a paediatric trauma centre [9,10] may reflect catastrophic non-survivable injuries in the patient cohort rather than inadequate treatment. These findings are in contrast to the adult trauma population where level of trauma centre is known to impact mortality [31–33]. Given this finding, the long-term functional outcomes and patient-centred quality care, which includes psychosocial care [34] from the acute hospital phase to at least two years post-discharge [35] should be the focus of future health policy and system change. This could be achieved with a state-wide mandatory reporting system of clinical

**Table 5**

Recommendations informed by adverse events causative factors identified in peer review.

1. Ensure mandatory waveform capnography equipment (ETCO2) is used for all intubated patients in the pre-hospital setting.
2. Revise the current NSW Ambulance documentation practice for waveform ETCO2 in the clinical record to ensure mandatory waveform ETCO2 airway confirmation and repeated documentation.
3. Develop and implement guidelines to improve pre-hospital airway management practices.
4. NSW Ambulance is to establish an airway registry consistent with existing airway registry models to enable monitoring of intubation data for paediatric population.
5. Establishment of a statewide referral system with a single point of contact for injured children requiring transfer to a pediatric trauma facility within NSW.
6. Implementation of a no refusal policy for paediatric trauma centres for injured children meeting specified criteria requiring transfer
7. Develop and implement a mandated framework for referral communication of trauma patients to ensure communication of necessary information.
8. NSW Ambulance Aeromedical and Medical Retrieval Service (AMRS) 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.
9. Develop and implement guidelines to increase the cross-referral between NETS, and non-NETS retrieval teams ensuring the use of the closest appropriate medical retrieval team for inter-hospital transfer.
10. It is recommended a pre-hospital trauma triage tool be developed, and implemented, taking into account physiological, anatomical and developmental differences of infants and children in order to facilitate transport to an appropriate facility in a timely manner.
11. Develop and implement standardised paediatric trauma call activation criteria across NSW Health facilities, incorporating the physiological, anatomical and developmental differences of infants and children.
12. Develop and implement a standardised statewide document for the initial assessment of paediatric trauma presentations across all NSW Health facilities.
13. Develop and implement standardised, evidence-based, guidelines for paediatric trauma care for use across all NSW Health facilities, adapted for local implementation.
14. Develop a standardised data dictionary for use by all health services collecting data related to pediatric trauma care
15. Develop and implement a framework for best practice damage control resuscitation and haemostatic resuscitation, taking into account anatomy, physiology and age-specific considerations for the pediatric population, for use across NSW Health Facilities.
16. Establish and implement state-wide trauma team roles to provide clinical leadership and clarity in the resuscitation area.
17. Establish trauma team training dedicated to paediatric trauma with a focus on non-technical skills.
18. NSW trauma courses teaching clinical skills and knowledge should incorporate non-technical skills.
19. Develop and implement an education and training strategy to ensure consistency in infrequently performed critical tasks in paediatric trauma care.
20. Any paediatric patient fulfilling trauma criteria are to be reviewed, in person, by the consultant, registrar or fellow on-call for trauma within 30 minutes of arrival.
21. The consultant, registrar or fellow on-call for a trauma sub-specialty, including but not limited to, orthopaedic surgery, neurosurgery, plastic surgery, ENT, ophthalmology, urology, should be available on-site to physically review the paediatric patient within 30 minutes of being called.
22. The consultant, registrar, or fellow on call for radiology be available to provide a verbal report within 60 minutes on imaging completed, on arrival, for a trauma patient.
23. All imaging, and reports, should be reviewed and formally reported within 24 hours, with the responsible clinical team formally notified of any changes to original reporting.
24. Nurse to patient ratios should be 1:1 in the emergency department resuscitation area for paediatric trauma.
25. Establish a single medical record identifier for use across all health facilities in NSW
26. A means of routine follow-up for seriously injured children in NSW to be established to address both physical and psychological needs

incidents, and long-term follow-up of patient health outcomes [36]. To facilitate the recommendations of this study, all trauma services should be commensurate with patient admission rates, acuity and long-term needs. At present, the majority of Australian trauma services do not meet the human resource criteria set out in the Royal Australasian College of Surgeons Australasian Trauma Verification Program [37]. The enforcement of specialist trauma nurse roles, which are known to improve outcomes through education, performance improvement activity, coordination of care, improved communication, trauma registry management consistency and advocacy would go some way to addressing some of the in-hospital problems around implementation and uptake of evidence based protocols [26,38].

The peer review process resulted in 26 recommendations for change in the delivery of trauma care in NSW, which were informed by the categorisation of causative factors and peer review team consensus during an additional meeting where the summary data were presented (Table 5). These recommendations are to be prioritised through a modified-Delphi study, by clinicians, managers and government representatives, to establish consensus on the priorities for change.

There were some limitations to this study, as it was conducted retrospectively using blinded medical records. This method provided informative timelines and information about procedures and immediate patient outcomes. However, it was more difficult to extract human factors information. The review of cases undertaken at a local level with the clinicians directly involved and/or with knowledge of local systems and processes is likely to yield more detail to aid in the categorisation of the cause of the problems identified. Quality trauma improvement programmes that include structured trauma education, implementation of quality benchmarks that form the basis of trauma case reviews on every admitted trauma patient and monthly committee meetings are known to improve patient outcomes [39] and are particularly relevant in low volume trauma centres [40]. A uniform State-wide case review process with standardised criteria (definitions) and measures of trauma care quality, along with consistent monitoring and reporting between hospitals is required to ascertain system wide areas for improvements in care and identify corrective strategies [3]. These data could be included in the NSW State Trauma Registry to link adverse events to longer term patient outcomes as well as collation of care delivery problems to inform targeted interventions.

## Conclusion

The use of a standardised tool in the peer review of paediatric trauma cases assisted in the identification of contributing factors to clinical incidents in care resulting in 26 recommendations for change. The prioritisation and implementation of these recommendations, alongside a uniform State-wide trauma case review process with consistent criteria (definitions), performance indicators, monitoring and reporting would facilitate improvement in health service delivery to children sustaining severe injury.

## Conflict of interest

The authors declare no conflict of interest.

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Trauma Coordinators at each site who notified the research team of potential participants in addition to their day to day duties.

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