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Prehospital care and transport costs of severely injured children in NSW Australia

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ABSTRACT

Background: Injury is the leading cause of childhood death and disability in Australia. Prehospital emergency services in New South Wales (NSW) are provided by NSW Ambulance. The incidence, pre-hospital care provided and outcomes of children suffering major injury in NSW has not previously been described.

Methods: This retrospective study was conducted between July 2015 and September 2016 and included children <16 years with an injury severity score (ISS) >9, or requiring intensive care admission, or deceased following injury and treated in NSW. Children were identified through the three NSW Paediatric Trauma Centres, the NSW Trauma Registry, NSW Medical Retrieval Registry (*AirMaestro*, Avinet, Australia).

Results: There were 359 majorly injured children treated by NSW-based emergency service providers, the majority were male (73.3%) with a mean (SD) age of 8.0 (5.2) years. The median (IQR) injury severity score (ISS) for those transported via NSW emergency medical services was 10 (9-17), with almost half (44.1%) treated prehospital having an ISS >12. The most common documented interventions were intravenous access (44.1%) and oxygen therapy (39.6%). Intubation and chest decompression were recorded in 15.3% and 3.1% of cases respectively. The calculated median (IQR) transport charges for NSW Emergency Services was AUD $942 ($841.3-$1184.6).

Conclusion: Critical interventions are performed infrequently in children with major injuries in the prehospital environment. The monitoring of the incidence and success rates for staff performing these interventions is not readily available from all prehospital emergency medical services operating in NSW. The capacity and processes to monitor and audit all critical interventions in the paediatric population should be resourced and clearly defined.

Background

Childhood injury is the leading cause of death and disability for children in developed countries [1,2]. In Australia, it accounts for more potential life years lost than cancer and heart disease combined [2]. There were over half a million paediatric presentations to Australian emergency departments following injury between 2017 and 2018 [3]. New South Wales (NSW) Ambulance is the primary provider of prehospital care to injured patients across NSW coordinating both the road and aeromedical response. NSW Ambulance is one of the largest ambulance service in the world, with more than one million emergency responses in the 2017-18 financial year [4]. NSW Ambulance provides a road response, along

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with Aeromedical Operations, coordinated through a multidisciplinary team located at the NSW Ambulance Aeromedical Control Centre (ACC) in Sydney [5]. Other helicopter services while not a part of NSW Ambulance are contracted and their services are also coordinated through the ACC.

Prehospital care to children <16 years accounts for around 4-7% of the emergency service workload around the world [6–8]. This low volume of prehospital care for paediatric patients results in a low incidence of exposure to critical procedures performed in the prehospital environment [6,7,9,10]. Low exposure can result in higher complication rate for rarely performed skills, such as intubation, when compared to the adult cohort [9]. The injury pattern for paediatric patients differ from those of adults and the anatomical differences create additional potential challenges in the delivery of care and management of trauma [11]. Little is known in Australia regarding the prehospital care characteristics of children sustaining a major injury. This study aims to examine the patient characteristics, treatment provided, transport costs, timelines and outcomes for a cohort of injured children receiving prehospital care from NSW emergency medical services (EMS).

Methods

This retrospective study included children < 16 years requiring intensive care unit (ICU) admission, or who had an injury severity score (ISS) ≥ 9 treated in NSW or who died following injury between July 2015 and September 2016. This study was undertaken as part of a larger study, ISS ≥ 9 were included in the study due to the recognition that isolated injuries, such as distal limb amputations, would likely affect a child's health related quality of life (HRQoL) post-injury being measure as part of the larger study.

Setting

NSW is the most populous state in Australia, encompassing an area of around 800,000km [2]. At June 2015 there were 1.42 million children under 15 years of age residing in NSW [12]. NSW has three designated paediatric trauma centres (PTC) and seven adult trauma centres. These facilities are all located within the major city regions on the east coast of NSW and are equipped to provide the full spectrum of trauma care. Ten designated regional trauma centres are equipped to manage minor to moderately injured patients, providing initial assessment and stabilisation of major trauma patients prior to transfer to a major trauma centre [13]. Fig. 1 shows the location of NSW rural and regional trauma services.

NSW Ambulance road ambulances are staffed by paramedics, with treatment guided by predetermined protocols [14]. Aeromedical services (road, rotary and fixed wing) are staffed with a physician primarily trained in a critical care specialty, such as emergency medicine or anesthesia with prehospital and retrieval medicine training, plus critical care paramedics (road/rotary) or flight nurses (fixed wing only) [10]. Treatment and transport destination are guided by the NSW Health trauma plan [15] and NSW Ambulance pre-hospital trauma (T1) protocol [16]. At the time of the study the T1 protocol did not mandate transport of injured children to a PTC. While transport to a PTC was directed as the preferred destination, in the greater metropolitan region, paramedic crews were not to bypass an adult trauma centre [17]. NSW EMS were considered to include NSW Ambulance and any aeromedical service provider based in NSW. Aeromedical Retrieval Service (AMRS) refers to all cases where a NSW-based retrieval service was involved in delivery of care prehospital.

Identification of injured children

Children receiving transport/ treatment by emergency services prehospital were identified via the three NSW PTCs, the NSW Trauma Registry (Collector) or NSW Medical Retrieval Registry (Air-Maestro). The NSW Trauma Registry only provided the mode of prehospital transport, data related to prehospital time and treatment were only available for children identified through NSW PTCs or NSW Medical Retrieval registry (n=296), eight records had no prehospital record and were excluded from analysis.

Ethical consideration

Ethics approval was obtained through NSW Population and Health Services research Ethics committee (HREC/15/CIPHS/6).

Data analysis

Analyses were performed using SPSS (version 25, IBM, USA); with descriptive and inferential statistics reported. For descriptive statistics, categorical variables were reported using counts and percentage. Continuous variables were reported using mean and standard deviation (SD) for normally distributed data, and median and interquartile range (IQR) for non-normally distributed data. Associations between categorical variables was tested using chi-square, Yates' continuity correction were applied where 2 × 2 analysis were completed. The differences between non-normally distributed continuous variable were examined using Mann-Whitney U (MW) test.

Injury severity

Severity of injury was measured using injury severity score (ISS) and new injury severity score (NISS), both calculated based upon the anatomical injury severity classification, Abbreviated Injury Scale (AIS) [18]. Severe head injury was defined as a head injury with an AIS classification of >2 [19] and polytrauma as injury to more than two body regions [20]. Injury severity could not be reported for cases identified through the medical retrieval registry. While sufficient data were present to ensure cases met study criteria, there were inadequate clinical records to classify injuries according to the AIS.

Injury location

The Australian Statistical Geography standard (ASGS) [21] was used, with the postcode of injury location to determine the remoteness of injury location in NSW according to major city/ inner regional/ outer regional/ remote/very remote. Where injury occurred outside NSW, or injury location was unknown, this was recorded separately.

Physiological abnormality

The physiological parameters for injured children were defined as abnormal if they were outside the age based range as defined by the NSW Ambulance T1 protocol [22], or where cardiopulmonary resuscitation (CPR) was documented as occurring at the time of observation.

Prehospital transport charges

Where cases were identified to be transported by an EMS to a health facility, prehospital transport costs were calculated according to NSW Ministry of Health Policy Directive- Ambulance Service Charges [23] applicable to the study period 2015-2016.

Fig. 1. NSW rural and regional trauma services [13].

Results

There were 595 injured children identified through the PTCs, the NSW Trauma Registry and the NSW Medical Retrieval Registry. Almost half the children (n=284, 47.7%) received care from a NSW Ambulance road crew, with an additional 12.6% (n=75) requiring treatment from an aeromedical retrieval service. One-third of patients (n=197, 33.1%) were recorded as self-presenting to hospital following injury, in small number of cases (n= 39, 6.6%) the mode of presentation could not be determined from healthcare records, or an interstate emergency service was used (Fig. 2).

PTCs treated the highest proportion of children (n=249, 42.0%); the majority (n=199, 79.9%) of these children were transported by NSW EMS. Almost a third (n=168, 28.3%) were initially treated at another trauma centre. For those treated at another trauma centre, more than half (n=100, 59.5%) were transported by NSW Ambulance. For those treated at non-trauma designated health facility, a greater proportion of children were recorded as self-presenting (n=99, 59.3%) (Fig. 2).

Patient characteristics

Of the 359 children treated prehospital by NSW EMS the mean (SD) age was 8.0 (5.2) years. Almost three-quarters (73.3%) of children were male and for more than half of all children (56.3%) injury occurred in a major city. The median (IQR) ISS for those transported via NSW EMS was 10 (9-17), almost half (n=154, 44.1%) treated prehospital sustained an ISS >12 (Table 1). The majority of children treated by EMS survived (92.8%) to hospital discharge, with no difference in outcome for those transported directly to a PTC (16/199, 8.0%) versus an alternate health facility initially (8/158, 5.0%) (χ^2 (1) =0.815, p=0.367).

Injuries were primarily blunt (80.8%), with a small number (2.8%) of penetrating injuries. Falls (27.6%), motor vehicle/ motorcycle collisions (17.3%) and pedestrian-related incidents (11.9%) were the leading causes of injury (Table 1). The highest proportion of injuries occurred on weekends with 38.4% (n=138/359) of injuries treated on weekends, equally distributed across the two days. The peak time for injuries to occur was in the afternoon, with more than half of injuries (58.9%, 192/326) occurring between 12:00-17:59 hours. The time of injury was unknown in a small number of cases (n=33, 9.2%).

Emergency response time

The median (IQR) time from emergency call to scene arrival was 14 (9.75-21) minutes, with time increasing to 20 (13-26) minutes for outer regional/remote areas. For cases where aeromedical

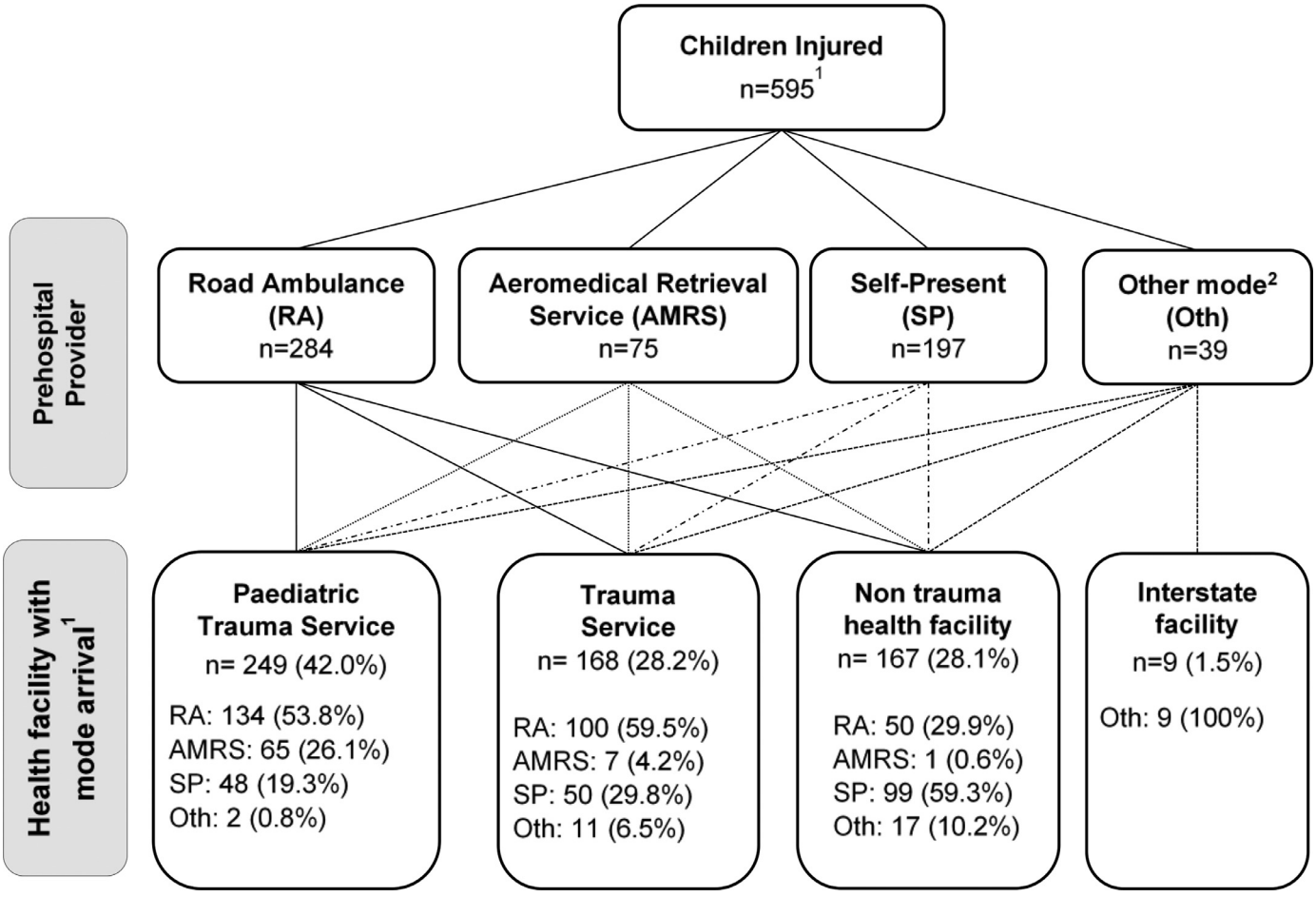

Fig. 2. Prehospital care provider and journey to first health facility.

services were documented to attend, the arrival on scene for the first EMS responder was shorter at 11.5 (9.3 – 14.8) minutes, with the overall median (IQR) time on scene for EMS longer for these cases at 56 (34-84) minutes. Overall the median (IQR) time spent on scene was 20 (13-34) minutes, this also increased outside major city areas.

For cases where an aeromedical team attended, their median (IQR) time to tasking from emergency call was 6.5 (10-15) minutes, increasing to 10.5 (5.75-26.75) minutes for injuries occurring in outer regional/ remote areas.

The median time that the aeromedical team was on scene, from arrival at the patient, was 30 (20-55) minutes, increasing to 47 (36.5-71) minutes for those in outer regional/remote areas. The overall time from initial emergency call to arrival at the first health facility was 69 (50-92.8) minutes, this was shorter for those injured in a major city at 60 (45-81) minutes (Table 2).

Physiological profile and interventions

CPR was performed in 21 (7.3%) cases. For children with cardiac output at initial assessment (n=268), heart rate, systolic blood pressure, respiratory rate, oxygen saturations and Glasgow coma scale (GCS) were all recorded in 52.2% (n=140) of cases. Blood pressure was not documented in 40% (n=91) of records, particularly in the younger age groups <1year (18/19, 94.7%) and 1-5 years (47/83, 56.6%). For children with an ISS >12 (n=98) the physiological parameter with the highest number of abnormalities was GCS. GCS≤13 on initial assessment by emergency service providers was documented in 37.8% (n=37) of cases as was elevated heart rate (n=17, 17.3%) and respiratory rate (n=14, 14.3%).

The most common interventions documented by emergency services were intravenous access (44.1%) and oxygen therapy (39.6%). Interventions such as intubation and chest decompression were recorded in a smaller number of cases, 15.3% and 3.1% respectively (Table 3).

Factors influencing transport time and treatment

The median (IQR) time to the first health facility from arrival on scene was shorter for those with an initial GCS ≤ 13, 43 (30.5 - 68.5) minutes, compared to those with a GCS > 13, 54 (38-71) minutes ($p = 0.035$). When injury occurred in a major city, the median (IQR) time to the first health facility from scene was 10 minutes quicker for those with abnormal respiratory observations and 12 minutes quicker for those with GCS ≤ 13, when compared to those with normal vital sign parameters as defined by the NSWA T1 protocol.

For children intubated in the prehospital setting, for either resuscitation or emergency anesthesia, the time taken to the first health facility from arrival on scene was 72 (50.5-121) minutes compared to 48 (34-68) minutes for those who were not intubated ($p = 0.001$). For those injured in major cities there was no significant difference in median time to hospital from scene arrival between those who were intubated and those who were not, 53 (36-69) v 45 (32-59) minutes ($p = 0.210$). There was no relationship found with other physiological parameters (i.e. heart rate, systolic blood pressure), or those requiring CPR, and the time taken

Table 1
Characteristics study population.

	NSW Emergency services (n=359)
Age (years)[1]	
Mean (SD)	8.0 (5.2)
Age group	n (%)
Less than 1 year	38 (10.6)
1-5	99 (27.6)
6-10	76 (21.2)
11-15	145 (40.4)
Gender[1]	
Female	95 (26.5)
Male	263 (73.3)
Injury location	
Major city	202 (56.3)
Inner Regional	85 (23.7)
Outer Regional/Remote/ very Remote	54 (15.0)
Outside NSW/ Unknown	18 (5.0)
Injury type	
Blunt	290 (80.8)
Penetrating	10 (2.8)
Other	59 (16.4)
Mechanism of injury	
Fall	99 (27.6)
Motorcycle/ motor vehicle collision	62 (17.3)
Pedestrian	41 (11.4)
Pedal cyclist/ scooter/ skateboard	39 (10.9)
Drowning	35 (9.7)
Other	26 (7.2)
Sports-related	22 (6.1)
Burns	18 (5.0)
Assault	14 (3.9)
Ingestion	3 (0.8)
Outcomes[2,3]	
Survived	333 (92.8)
Deceased	26 (7.2)
	n=349
ICU admission	117 (33.5)
Polytrauma	107 (30.7)
Head injuries AIS > 2	103 (29.5)
Injury Severity Score (ISS)	
Median (IQR)	10 (9-17)
New Injury Severity Score (NISS)	
Median (IQR)	14 (9-22)
Length of stay (days)	
Overall	n=329
Median (IQR)	4 (2-11)
Survival to hospital discharge	n=309
Median (IQR)	5 (2.0-11.5)

[1] Age and gender for one child treated by emergency service unknown.
[2] Survival outcome for children identified through Trauma Registry known at the time of discharge from trauma service.
[3] Records identified via NSW Medical Retrieval Registry excluded from analysis ISS, NISS, Polytrauma and ICU admission as data not available.

Table 2
Response, scene and transport time of emergency services[1].

Emergency response	n	**Minutes** Median (IQR)
Emergency call to scene	254	14 (9.75-21)
Time on scene	246	20 (13-34)
NSWA only	211	18 (12-30)
Retrieval +/- NSWA	35	56 (34-87)
Scene arrival to health facility	254	51 (34-70)
Major city[2]	156	46 (33-60)
Inner regional	57	69 (48-86)
Outer regional/ remote	33	52 (35-79)
Transport time from scene	275	28 (17-40)
Direct to PTC	190	32 (23-42.25)
Non-PTC	85	20 (9.5-32.5)
Aeromedical response		
Time to tasking from call	42	6.5 (2-15)
Time to arrival from tasking	62	29.5 (23.75-47.25)
Major city[2]	20	24.5 (19-29)
Inner regional	25	33 (22.5-50)
Outer regional/ remote	13	43 (37.5-55)
Retrieval time on scene	63	30 (20-55)

[1] Time data only available for records pediatric trauma centre and aeromedical records.
[2] Breakdown by region refers to location of injury.

Table 3
Interventions performed by emergency services.

Intervention	n=288[1][] n (%)
Cardiopulmonary resuscitation	21 (7.3)
Airway	
Airway adjuncts	16 (5.6)
Intubated	44 (15.3)
Breathing	
Oxygen therapy	114 (39.6)
Chest decompression	9 (3.1)
Circulation	
Intravenous access[2]	127 (44.1)
Intraosseous	18 (6.3)
IV fluids	59 (20.5)
Blood products	6 (2.1)
FAST[3]	23 (32.9)
Analgesia[4]	
Morphine	59 (20.5)
Fentanyl	98 (34.0)
Ketamine	12 (4.2)
Methoxyflurane	53 (18.4)

[1] Data related to prehospital intervention were only available from records identified through PTC and Medical retrieval registry, n=8 records were excluded as no record for prehospital care were available.
[2] Four cases both intravenous and intraosseous access.
[3] Focussed Assessment with Sonography for Trauma (FAST) only available for those treated by retrieval services (n=70), Ultrasound is also used in respiratory assessment, for the purpose of this project it was recorded where used in assessment of abdomen.
[4] Some cases recorded more than one type of analgesia administered.
[5] Data related to fracture reduction and splinting were not consistently recorded to enable data extraction and analysis.

to the first health facility from arrival at scene overall (Table 4). A greater proportion of children with an ISS >12 were intubated (31/104, 28.8%) compared to those with an ISS ≤ 12 (8/153, 5.2%) (χ^2 (1) =27.18 (1), p < 0.0001). Where intravenous/ intraosseous was recorded, children with an ISS > 12 (35/64, 54.7%) had IV fluids administered compared to 29.9% (20/67) of children with an ISS ≤ 12 (χ^2 (1) =7.31, p=0.007). For children receiving narcotic analgesia (i.e. morphine, fentanyl, ketamine), more than half with an ISS ≤ 12 (97/168, 57.7%) received narcotic analgesia compared to 45% (50/111) with an ISS > 12 (χ^2 (1) =3.83, p=0.05).

Outcomes

The majority of injured children treated by NSW emergency services survived (92.8%). A greater proportion of children treated by aeromedical retrieval services sustained an ISS>12 (39/60, 65%) (χ^2(1) =17.18, p<0.0001), were admitted to an ICU (37/ 60, 61.7%) (χ^2 (1) =24.42, p<0.0001), or died (11/60, 18.3%) (χ^2 (1) =19.57, p<0.0001) when compared those treated and transported by road ambulance . These children also had a longer median (IQR) length of stay 8.5 (2-26) days versus 4 (2-10) days (p=0.011).

Prehospital transport charges

The calculated median (IQR) transport cost for NSW Emergency Services was AUD $942 ($841.3-$1184.6). It was less for those where transport was completed by NSW Ambulance road crews, AUD$895 ($823.1-$1033.8), compared to those requiring retrieval service AUD$1504.5 ($1060.3 -$2437.1) (p=<0.001).

Table 4
Factors influencing time from arrival at scene to first hospital.

Physiology/ Intervention	ValidN	Time (minutes) Median (IQR)	P value[1]
Heart rate			0.922
Abnormal	56	49 (35-70)	
Normal	188	51 (35.5-71.5)	
Systolic blood pressure			0.55
Abnormal	19	61 (38-118)	
Normal	154	58 (41-78)	
Respiratory rate			0.385
Abnormal	44	46.5 (34-64)	
Normal	198	51 (36-72)	
Glasgow coma scale			0.035
≤13	64	43 (30.5-68.5)	
>13	177	54 (38-71)	
Intubation			0.001
Yes	24	72 (50.5-121)	
No	230	48 (34-68)	
Cardiopulmonary resuscitation			0.739
Yes	13	52 (36-68)	
No	230	51 (34-70)	
Major city[2]			
Respiratory rate			0.032
Abnormal	29	38 (32-52)	
Normal	119	48 (35-66)	
Glasgow coma scale			0.009
≤13	40	36 (29.5-52.5)	
>13	106	48 (38-66)	

[1] MW test;
[2] Injuries occurring a major city region.

Discussion

This study examined the characteristics, treatment and outcomes of children who sustained major injury in NSW and were treated by NSW emergency services. Less than one child per day was treated by NSW emergency services, with a low number of critical interventions undertaken. Such a low volume of work reduces prehospital clinicians' exposure to major trauma intervention and management, which raises questions about the best way to maintain paediatric critical care skills.

Critical interventions, such as intubation, intraosseous access and chest decompression (needle or finger thoracostomy) were infrequent, consistent with the literature [6,8,10,24]. Less than three prehospital intubations per month were identified as performed in this study. NSW Ambulance intensive care paramedics are trained for non-drug assisted intubation ('cold' intubation in cardiac arrest), which further reduces the number of children for whom paramedics are likely to perform an intubation. This low exposure potentially contributed to the number of clinical incidents relating to airway management in the prehospital setting identified during peer-review of these cases [25]. This finding is similar to other research that report low incidence of paediatric intubation for EMS providers [6,24,26,27], with higher rates of complications when performed by non-physician led providers [9,28,29]. Previous work in the aeromedical setting in Australia, where there is strict governance processes with structured education and compulsory certification of skill currency, demonstrated overall high first pass success rates (91%) among providers for paediatric intubation, these success rates reflect that of primarily physicians [10]. Following review of paediatric trauma cases, an expert panel identified the need for similar targeted education and training on infrequently performed critical tasks in paediatric trauma care for paramedics [25]. The panel also recommended the development and implementation of guidelines to improve pre-hospital airway management practices, following review identifying a large proportion of airway management problems, were in prehospital setting [25], with the focus of training and airway management policy to be around perfecting basic airway manoeuvres such as airway opening/adjuncts, bag valve mask ventilation and supraglottic airway insertion where indicated . Skill retention for bag valve mask is maintained at a higher rate than endotracheal intubation over time following training [30], and more favourable outcomes have been reported for paediatric patients provided with basic airway interventions when compared with those who received advanced airway interventions pre-hospital [31,32].

An established airway registry exists for NSW Ambulance Aeromedical retrieval services, however, no such registry exists for intubations, or other critical interventions, conducted by NSW Ambulance paramedics. Without a registry the incidence and success of paediatric, or adult airway interventions, conducted by NSW Ambulance paramedics is unknown. The benefits of an appropriately designed and managed clinical registry are widespread. Primarily they enable service providers to review care delivery to monitor and assess appropriateness and effectiveness of care delivery [33,34]. They also enable benchmarking against other service providers, and the opportunity to review of practice and identify areas for improvement and or change [35]. The challenge of maintenance of skill competence is not new, nor is it unique to the prehospital clinicians, with paediatric emergency physicians recognising that clinical exposure alone is not generally sufficient to maintain skill competency for critical procedures [36]. While the limited clinical exposure to critical interventions in clinical setting is reported [6,8,10], literature examining methods to maintain clinical competence for infrequently performed clinical skills is scarce.

Comparison of the initial recorded clinical observations to the NSW Ambulance T1 protocol [22], demonstrated that only a small proportion of children with major injury (ISS>12) would be identified based on their clinical observations. This highlights the importance of paramedics having an understanding of paediatric physiology and protocols to enable safe decision-making regarding treatment and transport of injured children. Given children with a reduced GCS and increased respiratory rate spent less time on scene than those with normal vital signs, this is potentially reflective of the recognition of paramedics for the need to expedite transfer to a health facility. At the time of the study the T1 Protocol directed paramedics not to pass a major trauma centre [17].

The revised NSW Ambulance T1 protocol incorporating a paediatric transport algorithm was released in July 2018. The paediatric algorithm provides direction to the nearest trauma centre where there is an immediate threat to life, for all other cases direct transported to paediatric trauma centre if transport from scene is within 60 minutes for metropolitan areas or 90 minutes in regional areas [22]. Further work is required to determine whether the changes have resulted in an increase in the number of direct transfers to paediatric trauma centres in NSW, and any subsequent impact on patient outcomes.

This study had some limitations. While every effort was made to access all prehospital records for children treated at paediatric trauma centres, in some cases multiple crews responded and potentially not all prehospital records related to the record were identified. Another limitation was that multiple tests of statistical significance were undertaking in this study without adjustment for Type 1 errors. This may increase the chance of making a Type 1 error that is concluding there is a statistically significant difference when there is not a true difference.

Conclusions

Care of injured children in the prehospital environment represents a small proportion of the NSW Emergency Service workload. Critical interventions were performed infrequently for this cohort of injured children and data were not readily available to enable timely reporting of the actual incidence and success rates for NSW Ambulance paramedics carrying out these interventions. The capacity to routinely report, monitor and audit critical interventions in the paediatric population remains important and should be prioritised.

Declaration of Competing Interests

The authors declare no conflict of interest.

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