



Pathways and factors that influence time to definitive trauma care for injured children in New South Wales, Australia



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ABSTRACT

Background: Timely definitive paediatric trauma care influences patient and parental physical and emotional outcomes. New South Wales (NSW) covers a large geographical area with all three NSW paediatric trauma centres (PTC) located in two approximated major cities, meaning it is inevitable that some injured children receive initial treatment locally and then require transfer. Little is known about the factors that then impact timely arrival of injured children to definitive care.

Methods: This included children admitted between July 2015 and September 2016, <16 years with an injury severity (ISS) ≥ 9 ; or requiring intensive care admission; or deceased following injury. Children were identified through the three PTCs, NSW Trauma Registry and NSW Medical Retrieval Registry.

Results: There were 593 children admitted following injury and 46% required transfer to a PTC. There was no significant difference in age, ISS, ICU admission or head injury (AIS >2) between transferred and directly transported cohorts. There were significant differences in mechanism of injury between the two groups ($\chi^2(9) = 45.9, p < 0.001$). The median (IQR) time to book a transfer from arrival at the referring facility, was 146.5 (86–238) minutes. Time from injury to arrival at the PTC more than doubled for children transferred, with significant and unwarranted variability between transporting agencies resulting in unwarranted delays to surgical intervention. For example, time spent at the referring facility by Aeromedical Retrieval Service was less than half that of the Newborn & paediatric Emergency Transport Service [53 (IQR:47–61) vs 115 (84–155) minutes ($p < 0.001$)].

Conclusion: Clinicians caring for paediatric trauma patients in facilities outside trauma centres require the capability and opportunity to identify and notify early those requiring transfer for ongoing management.

Abbreviations PTC, Paediatric Trauma Centre; ED, Emergency Department; AMRS, Aeromedical Retrieval Service; NETS, Newborn & paediatric Emergency Transport Service; LOS, length of stay; IHT, interhospital transfer.

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The provision of a streamlined referral and transfer process for all paediatric trauma patients requiring treatment in NSW PTCs would reduce the burden on the referring facility, reduce variation amongst transport providers and improve time to definitive care.

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Background

Injury remains the leading cause of death and disability for children worldwide¹. In Australia, presentation to the emergency department (ED) as a result of injury or poisoning accounts for the greatest number of presentations (31% of 1.75 million) for children under 15 years². The incidence of major paediatric trauma, both in Australia and internationally, is considerably lower than that for the adult population^{3,4}. Further, not all health facilities are adequately equipped or prepared to provide the necessary care to severely injured children^{5,6}, resulting in variation in outcomes for injured children treated at different facilities^{7,8}.

Australian and international evidence suggests critically injured children are best managed in specialist Paediatric Trauma Centres (PTC)^{8–11}. In a country with geographical challenges such as Australia it is inevitable that children injured in rural and remote areas, requiring transfer, will receive treatment and stabilisation locally prior to transfer to a PTC. Local and international guidelines advocate for ensuring transfer is initiated as soon as possible once the need for higher level care is ascertained^{12–14}. Little is known about the factors that impact timely arrival of injured children to a PTC in New South Wales.

Methods

This retrospective study, undertaken as part of a larger longitudinal study to determine 12 month outcomes of children with major injury¹⁵, included injured children < 16 years that were transferred to a PTC requiring intensive care (ICU) or with an injury severity score (ISS) ≥ 9 treated in New South Wales (NSW) or who died following transfer identified between July 2015 and September 2016. The aim of the study was to report the incidence of inter-hospital transfer (IHT) in paediatric trauma patients requiring care at PTC, the characteristics of the cohort, and the time and influencers to definitive care.

The study had ethics approval through NSW Population and Health Services Research Ethics Committee (HREC/15/CIPHS/6).

Setting

At the time of the study there were 1.52 million children under 16 years of age residing in NSW¹⁶. NSW covers an area of around 800,000 km² and has three PTCs, all located on the eastern seaboard within two approximated major cities. Along with the adult major trauma centres located in metropolitan areas, there are ten regional trauma centres equipped to manage minor to moderately injured patients and provide initial stabilisation and assessment prior to transfer where required¹⁷.

Retrieval processes for injured children in NSW to PTCs

IHT are provided through several mechanisms and agencies in NSW. Predominantly: NSW Ambulance staffed by paramedics, NSW Ambulance Aeromedical and Medical Retrieval Services (AMRS) and Newborn & paediatric Emergency Transport Service (NETS). When injured children require critical care support, interhospital

transfers are completed by NETS or physician staffed AMRS. This may be by road, rotary or fixed wing. NETS are staffed with an advanced trainee in paediatrics or critical care (emergency medicine/intensive care or anaesthesia) and a nurse with remote specialist oversight. AMRS teams are staffed by an advanced trainee or specialist in emergency medicine/ anaesthetics or intensive care and a flight nurse if severely injured for fixed-wing transport, or with a critical care paramedic for rotary wing transport. AMRS teams also attend pre-hospital paediatric major trauma. NSW Ambulance AMRS has seven rotary-wing bases in NSW, NETS has one. In this paper AMRS refers to the services staffed with physicians.

When injured children require interhospital transfer with medical support to a PTC, treating clinicians currently contact the NETS for advice and/ or transfer¹⁸. This transport is then arranged and usually performed by NETS or occasionally an AMRS team if requested by NETS. For cases where medical retrieval is not required, the arrangement of appropriate transfer remains with the referring and accepting clinicians in consultation with NSW Ambulance.

Identification of injured children

Children transported to a health facility were identified through the three NSW PTC, the NSW Trauma Registry (Collector) and NSW Aeromedical Retrieval Registry (AirMaestro, Avinet). Trauma coordinators at each of the PTCs completed a secure online notification when children were admitted meeting study inclusion.

Data for eligible cases were extracted from Collector by a representative from the NSW Institute of Trauma and Injury Management and an extract of the minimum data set were provided¹⁹. The NSW Ambulance Aeromedical Retrieval Registry data manager provided records of paediatric transfers for the study period. Deterministic linkage using name and date of birth was conducted with PTC records, together with manual review of remaining records to identify any transfer records not linked.

Medical record review

Review of medical records was completed at the PTC's by independent nurses experienced in the provision of trauma and emergency care and clinical audit. Data were extracted related to injury, treatment provided, and details related to transfer during the medical record review. Data related to transfer were provided by NSW Ambulance and NETS, where it was not available for extraction from the medical record, this assisted in providing an accurate timeline. Full details related to transfer were not available for records identified via NSW Trauma Registry or NSW Ambulance Aeromedical Retrieval Registry. Data collection was completed by more than one nurse at two sites therefore inter-rater reliability using percent agreement was completed at these sites between all data collectors, on 42 records (10%) randomly selected, with 83.1% agreement demonstrated²⁰.

Data analysis

Analyses were completed using SPSS v26 (IBM USA), descriptive statistics are reported using counts and percentages for categorical variables. Continuous variables were tested for normality using

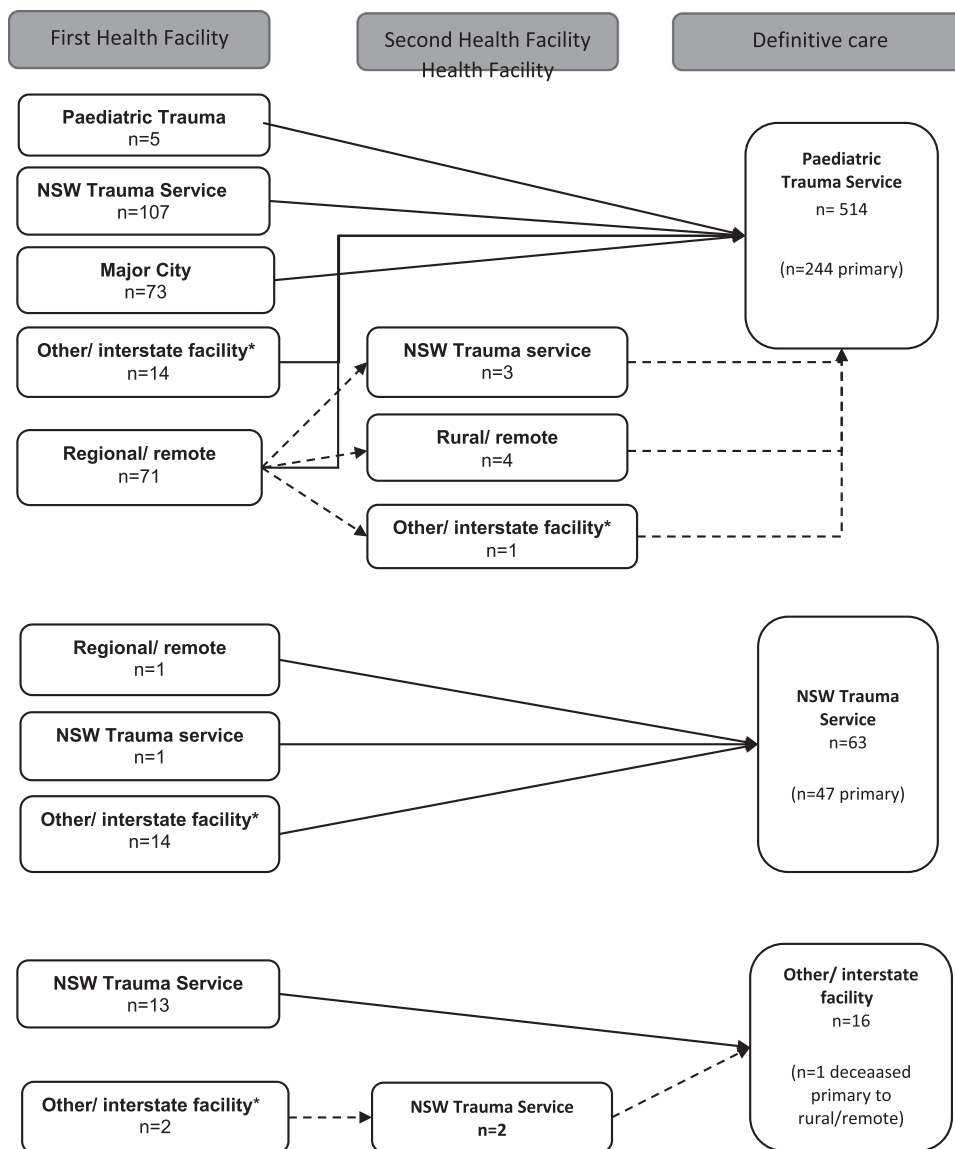


Fig. 1. Journey for children to definitive care.

Kolmogorov-Smirnov test. Where data were normally distributed, means and standard deviations (SD) are reported, medians and interquartile ranges (IQR) are reported for skewed data. Bivariate analysis was completed for differences in continuous variables using Mann-Whitney U (MW) for skewed data and *t*-test for normally distributed data and Chi square (χ^2) for relationships between categorical variables, with Yates' continuity correction applied for all 2×2 tables. Results were considered significant at a level of significance of 0.05.

Hospital LOS were calculated in days, based on admission date/ time at first health facility to discharge date/ time at definitive care facility, where time of admission were missing the mode determined by the data set was inserted to enable calculation. LOS was not available for records identified through NSW Trauma registry where they were transferred for ongoing acute care. Definitive care was considered the final destination (acute health facility) where care was provided.

Results

Almost half (46%, $n = 270$) of the 593 children admitted following injury required transfer for ongoing management to a PTC,

including five that required transfer to another PTC. A small proportion (5%) were transferred interstate or to a NSW adult or regional trauma facility for definitive care. Almost a third of children transferred to the PTC (27%, $n = 73/270$) were transported from a health facility (non-trauma) located in a major city region. The pathways for children to reach the definitive care destination are outlined in Fig. 1.

There were 311 transfer events, with 301 (51%) children transferred from the initial treating facility, and ten children required two transfers to reach definitive care. NSW Ambulance paramedics completed the most transfers (49%), 24% were completed by a NSW medical retrieval service (NETS or AMRS) and 4% by NSW Ambulance flight nurse via fixed wing. The remaining 70 (23%) were completed by the Royal Flying Doctor Service (RFDS), hospital transport (managed by the local health district), private transport or the mode of transfer could not be ascertained from the records. The mean (SD) age for children requiring transfer was 6.9 (5.2) years. Children transferred by NSW Ambulance paramedics had a median ISS of 9 (IQR:9–14), whereas those transferred by NETS and AMRS were higher at 16 (IQR:9–25) and 14 (IQR:10–18) respectively. Only NETS and AMRS transferred children who were intubated. An overview of the characteristics of children trans-

Table 1
Characteristics of injured children requiring interhospital transfer according to transfer agency ^a.

	NSW Ambulance, road (paramedic)	NSW Ambulance fixed wing (nurse)	NETS	AMRS
N	n = 153	n = 13	n = 47	n = 28
Age (years)				
Mean (SD)	6.5 (5)	9.6 (4.4)	6.2 (5.3)	10.1 (4.7)
Gender	n (%)	n (%)	n (%)	n (%)
Female	41 (27)	3 (23)	17 (36)	7 (25)
Male	112 (73)	10 (77)	30 (64)	21 (75)
Health facility location ^b	140	12	47	25
Major city	108 (77)	0 (0)	21 (45)	2 (8)
Inner Regional	20 (14)	1 (8)	6 (13)	8 (32)
Outer Regional/ Remote/ Very Remote	12 (7)	9 (75)	17 (36)	11 (44)
Outside NSW	0 (0)	2 (17)	3 (6)	4 (16)
Injury Severity ^d	153	13	47	25
ISS (Median IQR)	9 (9–14)	10 (9–11)	16 (9–25)	14 (10–18)
NISS (Median IQR)	9 (9–17)	11 (9–14)	18 (12–26)	17 (13–22)
Polytrauma	n (%)	n (%)	n (%)	n (%)
No	126 (82)	11 (85)	40 (85)	17 (68)
Yes	27 (18)	2 (15)	7 (15)	8 (32)
Head injury AIS >2	44 (29)	5 (39)	21 (45)	7 (28)
Intubated	153	13	47	28
	0 (0)	0 (0)	24 (51)	16 (57)
Outcome				
Survived	153 (100)	13 (100)	43 (91)	27 (96) ^c
Deceased	0 (0)	0 (0)	4 (9)	0 (0)

^a There were $n = 10$ children with two interhospital transfers. Data for $n = 70$ documented as other mode of interhospital transfer are not reported in the table.

^b Records from NSW Trauma registry, location of referring hospital unknown.

^c Data not available for children identified through AMRS.

^d Outcome for one child transferred by AMRS unknown.

ferred by the different interhospital service providers is shown in [Table 1](#).

Children treated at a paediatric trauma centre

There were 510 children that received definitive care at a PTC identified through the NSW Trauma registry and PTCs. There was no significant difference in the mean (SD) age, 6.6 (5.0) years vs 6.9 (5.2) years for those who required transfer compared to those who were transported directly to the PTC ($p = 0.505$). The median ISS was 9 (IQR:9–16) for both the direct transport group and those arriving by transfer, with no significant difference in the proportion with an ISS > 12, polytrauma, significant head injury (AIS > 2) or ICU admission ([Table 2](#)). There was a significant relationship between mechanism of injury reported and children who were transported directly versus those requiring transfer to the PTC ($\chi^2(9) = 45.9$, $p < 0.001$). For children that required interhospital transfer almost half ($n = 121$, 45%) were injured because of a fall compared with a third of children presenting directly to the PTC (77/241, 32%), and more children injured following motorcycle/ motor vehicle collisions (15% vs 7%), pedestrian incidents (11% vs 5%) and drowning (11% vs 3%) were taken directly to the PTC. More children with burns required interhospital transfer, with 80% ($n = 24/30$) requiring transfer for definitive care at a PTC ([Table 2](#)).

A significant relationship was also found between the mode of arrival at the initial treating facility and those requiring transfer ($\chi^2(2) = 82.4$, $p < 0.001$). For the children requiring transfer, nearly half of the children arrived at the initial treating facility by their own means (128/269, 48%), ie. arrival with parent/ guardian, compared to those who did not require interhospital transfer (48/241, 20%). Only 41% (110/269) were transported by a NSW emergency medical service to the initial treating facility, compared with 79% (191/241) of those children who were transported directly to a PTC. A greater number of those transported by NSW emergency medical services to the initial treating facility requiring transfer were

injured in outer regional/ remote areas (26%, $n = 29$) compared to 6% ($n = 12$) of those transported directly. With more injured in inner regional areas [52 (27%) vs 18 (16%)] and major city regions [119 (27%) vs 58 (53%)] transported directly to the PTC. For a small number arriving directly, and via transfer to the PTC, injury was documented to occur outside NSW or was unknown in 8 (4%) and 5 (5%) respectively.

Transfer time to paediatric trauma centre

Analysis of available data for children identified through the three PTCs ($n = 441$), showed the median time from injury to arrival at the PTC was 224 (IQR:88–475) minutes. The median arrival time was shorter for children injured in major cities and inner regional areas, at 131 (IQR:70–360) and 148 (IQR:99–337) minutes respectively, compared to 493 (IQR:336.5–691) minutes for children injured in outer regional areas. There was a significant reduction in travel time to PTC by direct transport compared with cases where there was an interhospital transfer (IHT) across all regions ($p < 0.001$) ([Fig. 2](#)).

The median time to request transfer from arrival at the first health facility was 146.5 (IQR:86–238) minutes. The transfer request time (ie. arrival at the ED to booking/ first contact) was longer for those who were transported by NSW Ambulance paramedics, 183.5 (IQR:109–266) minutes, and shortest for NETS, 76.5 (IQR:31.0–112.5) minutes. For ten records the notification to the transferring service occurred prior to arrival at the facility where the child was transferred from. The median time spent at the referring health facility by the transfer agency for all transfers was 29 (IQR:16–61) minutes. NSW Ambulance paramedics completed the most transfers and spent the shortest time on scene at referring facility, 18 (IQR:12–28) minutes. The full details related to the time for interhospital transfer from time to request, to transport time and time on scene at the referring hospital for service providers, according to geographical location for all transfer events are reported (supplemental file).

Table 2
IHT^a and no IHT for children receiving definitive care at PTC.

	IHT, n = 269	No IHT, n = 241	Test stat	P value
Age (years) mean (SD)	6.58 (5.0)	6.88 (5.2)	$t_{508} = -0.67$	0.505
Mechanism of injury	n (%)	n (%)	$\chi^2_9 = 45.9$	<0.001
Assault	13 (5)	6 (2)		
Burns	24 (9)	6 (2)		
Drowning	9 (3)	27 (11)		
Fall	121 (45)	77 (32)		
Ingestion	10 (4)	3 (1)		
Motorcycle/ motor vehicle collision	20 (7)	37 (15)		
Pedal cyclist/ scooter/ skateboard	32 (12)	24 (10)		
Pedestrian	14 (5)	27 (11)		
Sports-related	14 (5)	18 (7)		
Other	12 (4)	16 (7)		
Mode of arrival primary health facility			$\chi^2_2 = 82.4$	<0.001
NSW Emergency service	110 (41)	191 (79)		
Self present	128 (48)	48 (20)		
Other mode	31 (12)	2 (1)		
Injury Severity ²			$\chi^2_1 = 0.39$	0.535
ISS > 12	94 (35)	77 (32)		
ISS ≤ 12	175 (65)	164 (68)		
Polytrauma			$\chi^2_1 = 3.38$	0.066
Yes	47 (17)	59 (24)		
No	222 (83)	182 (76)		
ICU admission			$\chi^2_1 = 2.84$	0.092
Yes	85 (32)	59 (24)		
No	184 (68)	182 (76)		
Head injury AIS >2			$\chi^2_1 = 1.36$	0.243
Yes	91 (34)	69 (29)		
No	178 (66)	172 (71)		
Outcome ³			$\chi^2_1 = 5.76$	0.016
Survived	265 (99)	227 (94)		
Deceased	4 (1)	14 (6)		
Length of stay				
ED1 LOS (minutes)	n = 247	n = 241		
median (IQR)	245 (170–350)	233 (125–396)	MW=28,130.5	0.294
Hospital LOS (days) ^b	n = 252	n = 241		
	4 (2–8)	3 (1–10)	MW=27,805.5	0.104

^a IHT- interhospital transfer.

^b Length of stay (LOS) not available for records identified through trauma registry where there was transfer to an acute facility.

NETS completed more interhospital transfers than AMRS (47 vs 28), but took significantly longer to arrive at and depart from, the transfer destination despite no significant difference in the injury severity [ISS (MW=437, $p = 0.300$), NISS (MW=426.5, $p = 0.243$)] or the number of children intubated during transfer [$\chi^2_1 = 0.517$, $p = 0.472$], 14/22 AMRS and 24/47 NETS]. NETS transported younger children, mean (SD) 6.2 (5.3) vs 10.1 (4.7) years ($t_{52.6} = 3.5$, $p = 0.001$). For records where there was a single transfer to reach the PTC, the median time from child arrival at the first ED, to arrival at the PTC was 5.5 hrs (4–9) for AMRS vs 6 hrs (4.5–8) for NETS. This is despite the median time to transfer request being nearly double for AMRS [138 (IQR:110–215) minutes] than for NETS [72 (IQR:31–99)] ($p = 0.002$). Once the transfer was booked, the median time to the PTC was also longer for NETS 318 (IQR:232–460) minutes compared to AMRS 261 (IQR:199–379) minutes ($p = 0.06$) (Fig. 3). Time spent at the referring facility by AMRS was less than half that of NETS [53 (IQR:47–61) vs 115 (84–155) minutes ($p < 0.001$)].

Outcomes

There was a significant difference in mortality at the PTC between children arriving via IHT and those transported directly following injury at 1.5% and 5.8% respectively, (Chi-sq=5.76, df=1, $p = 0.016$). The children deceased at PTC post transfer were transported by NETS, but a previous peer-review demonstrated these were not preventable deaths²¹. There was no significant difference in the proportion of children with an ISS > 12 ($p = 0.535$),

those with polytrauma ($p = 0.066$), significant head injury (AIS >2) ($p = 0.243$), or ICU admission ($p = 0.092$). The time spent in the initial treating ED was not significantly different for those transported directly compared to those who required interhospital transfers ($p = 0.294$). Hospital LOS for children requiring IHT was longer, 4 (2–8) versus 3 (1–10) days, but this was not statistically significant (Table 2).

Surgical interventions

Details related to interventions prior to transfer were only known for children identified through the three PTCs ($n = 252$). Only twelve children (5%) had procedures attended prior to transfer, most commonly neurosurgical ($n = 5$, 2%). Two were for intracranial pressure monitoring and three had a craniotomy. Only one of these procedures was outside a major city region. Exploratory laparotomy, arterial embolisation, surgical management of wounds and fixation of a femur fracture were each documented in one case.

Children requiring transfer by medical retrieval services (NETS and AMRS) where there was documented surgical intervention the time to the first procedure from arrival at the first treating ED varied. The median time to neurosurgical surgery for children transported by AMRS ($n = 2$) was 3.5 (IQR:1–6) hours, compared to 5 (IQR:2–7) hours for those transported by NETS ($n = 5$). For all children who required surgery transported by medical retrieval, the median time to first surgical procedure for those transferred by

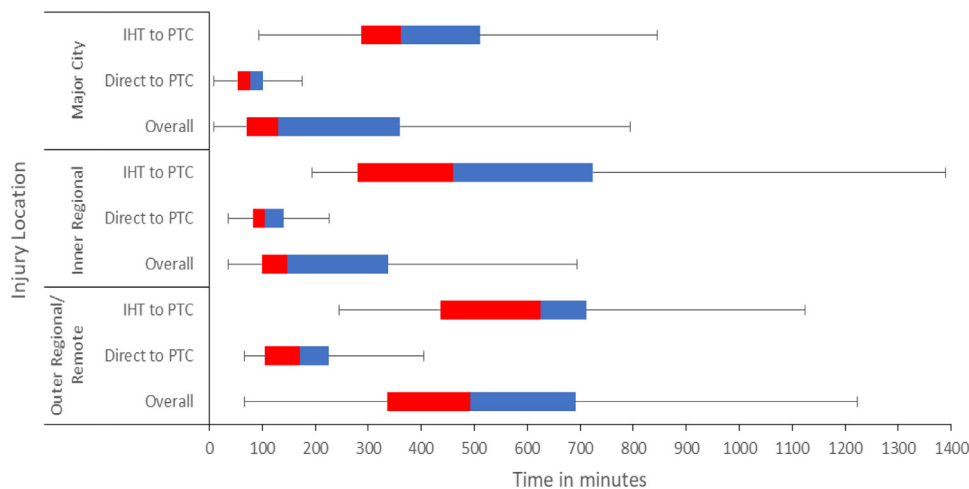


Fig. 2. Time to paediatric trauma centre from injury according to location of injury
 Due to large outlier values, the upper boundary of the box and whiskers plot was created using 1.5*IQR above the 75th percentile. Any values beyond that value are considered an outlier. The lower boundary reflects the minimum value. Number of outliers: Major city- Direct (11) range: 181– 26,279 min, IHT (12) range 857–5802 min; Inner regional- Direct (2) range 230–9327 min, IHT (4) range 1465–1825 min; Outer regional/remote: IHT (5) range 1350–2411 min. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

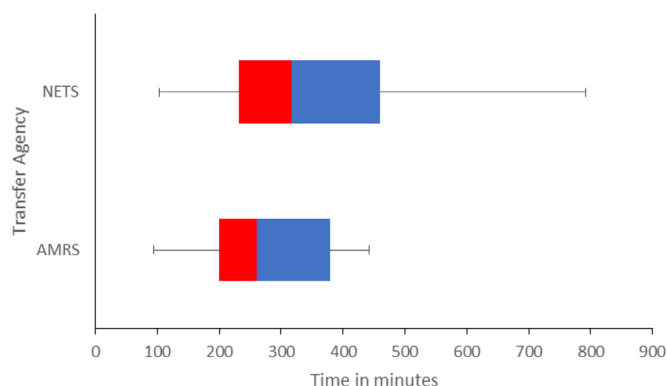


Fig. 3. Time from transfer request to paediatric trauma centre arrival for NSW Ambulance AMRS and NETS The upper and lower boundaries of the box and whisker plot reflect minimum and maximum values. NETS range 103–792 min, AMRS range 94–442 min.

NETS ($n = 21$) was 12 (IQR:5–18) hours versus 5 (IQR:2–20) hours for AMRS ($n = 10$).

Discussion

This study examined the journey undertaken by all children with major injury to reach definitive care in NSW, Australia. Significant associations were demonstrated between patient characteristics and transport providers and time to transfer to the PTC. These include rural geographic location and inter-hospital transport by NETS.

Managing injured children that require transfer places considerable burden on those referring where they have reduced resources and exposure to major paediatric trauma^{22,23}.

The time of arrival at PTC for children requiring transfer was significantly longer across all geographical regions compared to those transported directly, this is not dissimilar to international experiences²⁴. In NSW there are two key policies, NSW Critical Care Tertiary Referral Networks (Paediatrics) and Emergency Paediatric Referrals Policy, related to the transfer of paediatric trauma patients^{18,25}. These policies are inconsistent and 10 and 15 years old. The processes of referral for transfer of critically ill patients in NSW are under review with contributions to paediatric trauma

transfer policy by the study investigators and findings. To minimise time to definitive care there are three key areas that should be addressed and considered in any new policy development, as evidenced by our study findings. Specifically, identifying and implementing methods to improve: 1) identification and direct transport of severe paediatric trauma to a PTC where geographically possible; 2) identification of need and timely referral for transfer and 3) expediting of retrieval response and on scene times. This could be achieved by establishing a state-wide referral system and standardisation of NSW paediatric trauma call activation criteria²⁶.

Identification and direct transport

Almost half of children treated at the PTC arrived directly. However for children transported to the initial treating facility by a NSW emergency medical service, that required transfer, more than half were injured in a major city region. Prehospital transport decisions for children with major injury are guided by the NSW T1 Ambulance protocol²⁷. Since completion of the study NSW Ambulance has revised the pre hospital trauma protocol (July 2018), this revision identifies children < 16 years as a high risk group. The protocol now includes a paediatric transport algorithm for direct transport to a PTC if within 60 min for metropolitan areas and 90 min for regional areas, where there is no immediate threat to life²⁷. Furthermore, there is mandatory notification for paramedics to the Aeromedical Control Centre (ACC) for direction on a suitable destination for patients unable to be transported directly to the appropriate facility. To date there has been no evaluation, of updated prehospital trauma protocol, to determine whether there is any change in the number of children transported directly to a PTC following injury. Activation of AMRS teams by ACC operatives was not measured in this study and it is possible that oversights exist these areas.

Request for Transfer

There were considerable delays (more than 2 h) in the request for transfer and booking transport. It is not possible from this study to reliably identify what factors contribute to the prolonged times. However, it is plausible that clinicians are prioritising patient stabilisation, or those with limited experience in managing paediatric patients risk cognitively overloaded which is known to impact performance and decision making. Cognitive overload is a situation where there is a large volume of information and

tasks for the individual to process simultaneously^{28–31}. Further, the model of referral to NETS often involves protracted teleconference (+/- video) prior to NETS retrieval team activation. This teleconference often includes requests for blood and imaging results. An actual, or perceived, need to complete investigations likely influence the timing to request transfer in some instances.

For children requiring critical care support, the time the referring facility took to contact the provider who ultimately undertook the transfer was almost double for AMRS compared to NETS. This variation is likely reflective of current policy whereby clinicians are required to first contact NETS. If NETS are then unable to complete the transfer, the case is referred to AMRS. This study found that despite AMRS having a delayed notification, they attend the site sooner than NETS. This could be explained by the AMRS processes that include a rapid launch in much the same manner as a primary prehospital major trauma.

Currently the clinical requirements of the child dictate the process for organising transfer, with clinicians required to contact NETS where it is considered life threatening or with the potential need for intensive care. For less severe cases referral is made to the ED for the designated PTC for the region²⁵. Since the study, Sydney Children's Hospital Network (SCHN) have implemented PATCH (Paediatric Acute Trauma Care Hotline), a streamlined referral process where referring clinicians can receive advice and support regarding the need for transfer¹², where the child doesn't meet criteria for NETS transfer. However, the PATCH service is not applicable state-wide, and only available for transfers required to SCHN (two Sydney based PTCs) and not applicable to the other PTC in NSW. While the service aims to address the identified gap, it also creates another additional referral process for clinicians to adhere to. The impact of PATCH on timeliness of transfer has not been examined.

Response to transfer

Once a request for transfer had been made, there was inordinate variance in the response and on scene times amongst transport agencies. NETS and AMRS were involved in the transfer of children generally requiring intensive care management. This complexity also explains a longer on scene at the referring facility for NETS and AMRS. However, it does not explain the almost double on scene time for NETS teams. There was no statistically significant difference in the injury severity or the number of children who were intubated during transfer.

The different NETS and AMRS processes likely impact the time spent on scene. NETS consultants provide remote oversight and are consulted with changes in care by the treating team. AMRS teams are essentially independent and have high staffing rates of specialists, subspecialised in prehospital and retrieval medicine. Furthermore, AMRS are also tasked to severe prehospital major trauma and are specifically trained to perform meaningful critical procedures under cognitive and time pressure. We recommend that the AMRS teams who have the expertise in trauma care are tasked to paediatric inter-hospital trauma transfers. This argument is further strengthened by logistics- AMRS rotary wing bases are spread around the state, whilst NETS are based in Sydney alone. In NSW 99% of the population would be within 60 min rotary flight of a major trauma centre³². These assertions are also supported by a comprehensive peer-review of our study population and NSW trauma clinician consensus²¹.

Urgent surgical care

Only a small number of children attended operating theatre prior to transfer, predominantly for time critical interventions (neurosurgery, exploratory laparotomy and arterial embolisation). In Australia, guidelines for the management of acute neurotrauma

in rural/ remote areas recommend transfer within two hours for specialist services, where transfer will take longer it is recommended a burr hole be performed at the regional facility where neurosurgery is not available³³. NETS implemented a protocol to provide paediatric consultant neurosurgery service in NSW in 2009, in specific circumstances for children at facilities that do not routinely offer neurosurgery, although the logistics to provide this service are not consistently available³⁴. This single service study of nine patients reported an estimated three hours reduction in time to surgery. This is a small sample, and the time reduction is an internal measure and does not make comparison to alternate service models.

Limitations

The number of children critically injured requiring medical retrieval services were small limiting further analysis of this subgroup. Medical records were reviewed at the PTCs, data related care, and time at referring hospitals was limited to that available with the hospital and transfer provider records stored at the PTC medical record. While data were provided by both NSW Ambulance and NETS, transfer records were not always available for review. Inferences are based on descriptive statistics of a cross-sectional study and may not reflect other jurisdictions.

Conclusion

Direct transfer to a PTC and specialist services in remote locations are not always possible. Measures are required to reduce the time for transfer and support clinicians to manage the case until retrieval teams arrive. The provision of a streamlined referral process for all paediatric trauma patients requiring treatment in NSW PTCs would reduce the burden on the referring facility and address the significant unwarranted variation in time to definitive care and surgical intervention. Updated NSW policy informed by evidence to facilitate more timely and equitable access to definitive care is essential.

Declaration of Competing Interest

BB is employed by NSW Ambulance, however he had no role in data collection or analysis for this project.

All other authors declare no conflicts of interest.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.injury.2021.02.036](https://doi.org/10.1016/j.injury.2021.02.036).

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