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Cause, treatment costs and 12-month functional outcomes of children with major injury in NSW, Australia

Kate Curtis[a], Belinda Kennedy[a,*], Mary K. Lam[b], Rebecca J. Mitchell[c], Deborah Black[d], Brian Burns[e], Leslie White[c], Allan Loudfoot[f], Alfa D'Amato[g], Michael Dinh[h], Andrew J.A. Holland[i]

[a] Susan Wakil School of Nursing and Midwifery, Faculty of Medicine and Health, The University of Sydney, MO2 88 Mallett St, NSW 2006, Australia
[b] Faculty of Health, University of Technology Sydney, PO Box 123, Broadway NSW 2007, Australia
[c] Australian Institute of Health Innovation, Faculty of Medicine and Health Sciences, Macquarie University, 75 Talavera Rd, North Ryde NSW 2113, Australia
[d] Faculty of Medicine and Health, The University of Sydney, Science Rd, Camperdown NSW 2006, Australia
[e] Greater Sydney Area HEMS, NSW Ambulance, 33 Nancy Ellis Leebold Drive, Bankstown Airport NSW 2200, Australia
[f] NSW Ambulance, Locked bag 105, Rozelle NSW 2039, Australia
[g] System Financial Performance and Deputy CFO, NSW Ministry of Health; UTS Business School, Sydney, Australia
[h] NSW Institute of Trauma and Injury Management (ITIM), Agency for Clinical Innovation, Level 4/67 Albert Ave, Chatswood NSW 2067, Australia
[i] The Children's Hospital at Westmead, Locked Bag 4001, Westmead NSW 2145, Australia

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ABSTRACT

Background: Information about children treated in New South Wales (NSW), Australia following major injury has been limited to those treated at trauma centres using mortality as the main outcome measure, restricting assessment of the effectiveness of the Trauma System. This study sought to describe the detailed characteristics as well as functional and psychosocial health outcomes of all children suffering major injury in NSW.

Methods: A longitudinal study was conducted between July 2015 and November 2017 and included children < 16 years requiring intensive care or an injury severity score (ISS) ≥ 9 treated in NSW or who died following injury. Children were identified through the three NSW Paediatric Trauma Centres (PTC), the NSW Trauma Registry, NSW Aeromedical Retrieval Registry (AirMaestro) and the National Coronial Information System (NCIS). Health-related quality of life (HRQoL) outcomes for children treated at the three PTCs were collected at baseline, 6 and 12 months using the Paediatric Quality of Life inventory (PedsQL 4.0) and EuroQol five-dimensional EQ-5D-Y.

Results: There were 625 children, with a median (interquartile range) age of 7 (2–13) years and 71.7% were male. Around half were injured in major cities (51.2%). The median (IQR) injury severity score (ISS) was 10 (9–17). Twelve-month HRQoL measured by PedsQL remained below baseline for psychosocial health. Treatment costs increased with injury severity (p=<0.001) and polytrauma (p=<0.001). No survival benefit was demonstrated between PTC versus non-PTC definitive care. Injured females and children from rural / remote NSW were overrepresented in the deceased.

Conclusion: Children treated in NSW following major injury have reduced quality of life and in particular, reduced emotional well-being at 12 months post-injury. Improved psychosocial care and outpatient follow-up is required to minimise the long-term emotional impact of injury on the child.

Background

In Australia, injury remains the leading cause of death and disability in children, accounting for more potential life years lost than cancer and heart disease combined [1]. There were over half a million paediatric presentations to Australian emergency

* Corresponding author at: Susan Wakil School of Nursing and Midwifery, The University of Sydney, MO2, 88 Mallett St, Camperdown NSW 2006, Australia.
E-mail address: Belinda.kennedy@sydney.edu.au (B. Kennedy).

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departments following injury or poisoning between 2017 and 2018 [2].

Depending on the severity of injury and distance to the nearest Paediatric Trauma Centre (PTC), in New South Wales (NSW), Australia, children with major injuries may receive initial care and stabilisation measures prehospital, at a regional hospital or an adult trauma centre (ATC), before being transferred to a PTC for specialised acute, diagnostic and/or definitive care, including post-discharge follow-up [3]. In 2010, a retrospective review of 1138 severely injured children using data from the NSW Trauma Registry, children who received definitive treatment at a PTC were between 3 and 6 times more likely to survive than if they were treated at an ATC [3]. A repeat study in 2017 had similar findings [4]. The reasons for the finding of a survival benefit at a PTC were unclear.

Information about children sustaining major injury in NSW remains restricted to those treated at a designated trauma centres, with only minimum data available. This does not completely represent the incidence of major injury in children hospitalised in NSW, nor the acute impact on the health system. Further, the majority of injury outcomes in paediatrics focus on mortality as an outcome measure. This does not aid in our understanding of how care received may influence long-term health-related outcomes [5]. Injury is known to significantly impact quality of life across multiple domains, including physical, emotional and psychosocial health [6], for the patient and their family. This study sought to describe the characteristics, functional and psychosocial health service outcomes of children experiencing major injury in NSW.

Methods

This longitudinal study was conducted between July 2015 and November 2017 and included children < 16 years requiring intensive care (ICU) or an injury severity score (ISS) ≥ 9 treated in NSW or who died following injury, identified between July 2015 and September 2016. Injuries with 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.

Setting

NSW is the most populous state in Australia encompassing an area of around 800,000 km^2 and at June 2015 there were 1.42 million children under 15 years of age residing in NSW [7]. There are three designated PTCs in NSW, all located on the Eastern seaboard in metropolitan areas. Pre-hospital care is delivered and governed by NSW Ambulance, with transport decisions governed by the pre-hospital trauma (T1) protocol [8]. At the time of the study the protocol did not mandate transport of all injured children to a PTC, while transport to a PTC was directed as preferred destination, paramedic crews were not to bypass an adult trauma centre [9].

Identification of injured children

Children were identified through the three NSW PTCs, the NSW Trauma Registry, NSW Aeromedical Retrieval Registry (AirMaestro, Avinet, Australia) and National Coronial Information System (NCIS) to ensure as complete cohort capture as possible. For logistic reasons, only children who were treated at a PTC were eligible for the longitudinal phase of the study that required enrolment and informed parental consent. Data available from each source varied and are summarised in Table 1.

NSW Paediatric Trauma Centres

Children admitted to a NSW PTC were identified by each hospital's trauma coordinator, a secure online notification was completed to notify the research team of a case for review. The definitive care facility was defined as the final destination for acute treatment related to injury. Data collection at the three PTC was undertaken by three nurses experienced in trauma data collection. Both Sydney Children's Hospital at Randwick (SCHR) and The Children's Hospital at Westmead (CHW) had more than one nurse undertaking data collection. Inter-rater reliability using percent agreement was completed on 42 records (10%) randomly selected at both sites between all data collectors at the site, with 83.1% agreement demonstrated [10].

NSW Trauma Registry

The NSW Trauma Registry (Collector) is maintained by NSW Institute of Trauma and Injury Management (ITIM). Designated trauma hospitals enter and manage data mandated for the NSW Trauma Minimum Data set. The minimum data set criteria include all patients of any age admitted to a NSW Trauma service within seven days of injury with an injury severity score > 12; admitted to an ICU, or died in hospital following injury. NSW ITIM queried Collector for eligible cases based on age and an extract of the minimum data set [11], with hospitals de-identified were provided. Date of birth was provided when permitted by the collecting trauma centre. Probabilistic linkage was conducted on data received from Collector and the PTCs using age (years), gender, date of injury, residential postcode and mechanism of injury. Where 1:1 link was established, records were considered to be a link, the remaining records were manually reviewed, using additional variables, such as Abbreviated Injury Scale (AIS) injury descriptors, location of injury and date of birth where available, were required to confirm linkage.

Medical retrieval

The NSW Aeromedical Retrieval Registry (AirMaestro) is managed by NSW Ambulance. All patients who require treatment from an Aeromedical Retrieval Service have a minimum electronic dataset including patient demographic, mechanism and details of injury, interventions and treatment information. The NSW 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 with removal of those that did not meeting study inclusion.

National Coronial Information System

The National Coronial Information System (NCIS) is a national database, managed by the Victorian Department of Justice and Community Safety, recording data on deaths reported to a coroner in Australia and New Zealand. The research team conducted searches of the NCIS database in November 2017 to identify child injury deaths. The data base was searched for children in deceased in NSW aged < 16 years as a result of external causes. Due to limited identifying details, and small number of records, record linkage was conducted manually with other data sources using; the date (month/year) injury, age, residential postcode, mechanism of injury and location of death.

For records not identified through a PTC, that were duplicated in one of the other three data sources, the record providing the greatest clinical detail related to the child's journey was retained.

Treatment costs

A data extract from the Activity Based Funding (ABF) database was provided by the NSW Ministry of Health (MoH) to determine inpatient health care costs. The child's date of birth, sex, medical record number, health facility, date of hospital admission and discharge for each facility in which the child received treatment were

Table 1
Methods of potential participant identification and data collected.

Method of identification	Trauma centre	Trauma registry	Medical retrieval registry	Coronial data
Time frame post injury	24–48 h	12–18 months	12–18 months	12 –18 months
Medical record review - Full	Post discharge	Not possible	Delayed/ Not Possible	Not possible
Baseline PedQL and EQ-5D-Y	Inpatient – during first two weeks	Not possible	Not possible	N/A
6 month PedQL and EQ-5D-Y	6 months post injury	Not possible	Not possible	N/A
12 month PedQL and EQ-5D-Y	12 months post injury	Not possible	Not possible	N/A

Fig. 1. Identification of records for inclusion. 1 26 identified to as transferred to another acute facility. 2 19 cases, one case two MRU records.

provided to the NSW MoH. Inpatient cost data were only available for cases identified through a PTC, as there was insufficient information for linkage to cost data through the other data sources. Four hundred and forty-three PTC records (90%) were linked with ABF data, including cost data for all health facilities attended from injury to discharge from the PTC. Raw unadjusted costs were used to report inpatient health care costs. Where cases were identified to be transported by emergency services to a health facility, prehospital transport costs were calculated according to NSW MoH Policy Directive- Ambulance Service Charges [12] applicable to the study period 2015–2016.

Health related quality of life (HRQoL) outcomes

HRQoL outcomes of children treated at the three PTCs were collected prospectively by parent proxy at baseline, 6 and 12 months using the Paediatric Quality of Life inventory (PedsQL 4.0) and EuroQol five-dimensional EQ-5D-Y. Both instruments are validated for proxy measures [13,14]. Parents were recruited by trauma nurse coordinators during admission or post- discharge as part of follow-up. When recruitment was conducted post-discharge, baseline measures were collected retrospectively.

The PedsQL is designed to measure health dimensions: physical, emotional, social and school functioning and generates summary scores for psychosocial health (emotional, social and school functioning), physical health and a total scale score, a computed measure of all health dimensions [15]. EQ-5D-Y includes an EQ visual analogue scale (VAS) that rates health on scale 0–100 from the “worst health” to “best health” imagined and includes a measure of five dimensions: mobility, looking after myself, performing usual activities, experiencing pain or discomfort and feeling worried, sad or unhappy. Response on the five dimensions is measured in three levels: no problems, some problems and a lot of problems [16]. To obtain HRQoL outcomes of children whose parents did not participate in the follow-up phone calls, the EQ-5D was determined from the outpatient clinic medical records (where there was sufficient information) by two nurses, otherwise it was recorded as missing.

Eighty-eight parents consented to participate and completed both the PedsQL and the EQ-5D-Y baseline measure, with 64 (72.7%) and 75 (85.2%) completing the six and 12-month follow-up, respectively. The six month follow-up for an additional 140 children and 12-month follow-up for an additional 104 children were determined from assessments conducted and documented at outpatient follow-up appointments by medical and/or allied health staff, with sufficient detail available for one or more of the domains as measured by EQ-5D-Y.

Ethical consideration

Ethical approval was obtained through NSW Population and Health Services Research Ethics committee (HREC /15 /CIPHS /6) and the Justice Human Research Ethics Committee, Victoria (CF/15/18354).

Data analysis

Analyses were performed using SPSS v25 [17] (IBM, USA), descriptive statistics were reported using counts and percentages for categorical variables. Continuous variables were tested for normality using Kolmogorov-Smirnov test. Where data were non-normal, non-parametric test were used, otherwise we used parametric methods. Although the sample sizes are large enough to justify the use of parametric methods throughout, we used more conservative non-parametric methods in the presence of non-normality. Median and interquartile range (IQR) or range (where appropriate) were reported for non-normal continuous variables, while mean and standard deviation (SD) were reported for normally distributed data. Association was tested using chi-square for categorical variables. For non-normal data, differences between group were tested using Mann-Whitney *U* (MW) or Kruskal-Wallis (KW) tests. Paired *t*-test were used to compare 6- and 12-month outcomes with baseline measures for HRQoL continuous variables, as these measures were normally distributed. Cochran's Q test was used to examine the association between the three time points and problem status as measured by EQ-5D-Y. McNemar's test was used for pair-wise comparisons when an overall significant association was found. Results were considered significant at an alpha level of 0.05.

Injury severity and mortality

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]. Data related to injury severity were only available for records identified through the PTCs or the NSW Trauma Registry. For the replication of the survival benefit analyses of the 2013 and 2017 studies, cases were selected based on NSW Trauma Registry criteria.

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 (i) major city, (ii) inner regional, and (iii) outer regional/ remote/very remote. Where injury occurred outside NSW, or injury location was unknown, this was recorded separately.

Socioeconomic disadvantage

A measure of socioeconomic disadvantage were assigned using the Socio-Economic Indexes for Areas (SEIFA) [22], using the postcode of residence available from the data sources. The index consists of measures that reflect relative disadvantage, a low score relatively greater disadvantage and high score lack of disadvantage. The index values partitioned into quintiles from most disadvantaged (i.e. 1) to least disadvantaged (i.e. 5). Children identified through NSW Medical Retrieval registry were excluded as residential postcode was not available.

Table 2
Characteristics of study population.

	Cohort (n = 625)
Age (years)	
Median (IQR)	7 (2 – 13)
Age group[a]	n (%)
Less than 1 year	80 (12.8%)
1–5	204 (32.6%)
6–10	119 (19.0%)
11–15	221 (35.4%)
Gender[a]	
Female	176 (28.2%)
Male	448 (71.7%)
Injury location	
Major city	320 (51.2%)
Inner regional	115 (18.4%)
Outer regional/remote/ very remote	104 (16.6%)
Outside NSW/ unknown	86 (13.8%)
Injury type	
Blunt	507 (81.1%)
Penetrating	12 (1.9%)
Other	101 (16.2%)
Unknown	5 (0.8%)
Socioeconomic disadvantage[b]	n = 612
1- Lowest most disadvantaged	131 (21.4%)
2- Second most disadvantaged	112 (18.3%)
3 -Middle	120 (19.6%)
4- Second least disadvantaged	126 (20.6%)
5- Highest least disadvantaged	123 (20.1%)
Outcomes[c]	
Survived	566 (90.6%)
Deceased	58 (9.3%)
Unknown	1 (0.2%)
Injury Severity Score (ISS)[d]	n = 583
Median (IQR)	10 (9 - 17)
New Injury Severity Score (NISS)	
Median (IQR)	13 (9 - 20)
ICU admission	166 (28.5%)
Polytrauma	130 (22.3%)
Head injuries AIS > 2	181 (31%)
Length of Stay (days)	
Overall	n = 520
Median (IQR)	4 (1 - 9)
Survived to hospital discharge	n = 499
Median (IQR)	4 (2 - 9)

[a]Age/ gender not recorded for one record.
[b]One child overseas visitor and MRU data excluded, no residential postcode.
[c]Outcome for children identified through Trauma Registry known at the time of discharge from trauma service.
[d]NCIS and MRU data excluded from analysis ISS, NISS, ICU admission, Polytrauma, ICU admission and LOS as data not available.

Results

Patent characteristics

There were 625 children in the cohort (Fig. 1). The median (IQR) age was 7 (2–13) years, children aged 1- 5 years (32.6%) and 11–15 years (35.4%) each accounted for around one-third of children sustaining injuries. More than half of the children sustained their injuries in major cities (51.2%), and the majority of the injured were male (71.7%). The median (IQR) ISS was 10 (9–17), more than half (n = 348, 59.7%) the children sustained an ISS < 12, 188 (32.2%) had an ISS 12–25, and the remainder had an ISS > 25 (n = 47, 8.1%). The median (IQR) NISS was 13 (9–20), with the NISS for 275 (47.2%) of children < 12, 229 (39.3%) were 12–25 and 79 (13.6%) had a NISS >25.The majority of children (90.6%) survived, with a median (IQR) length of stay (LOS) of 4 (2–9) days, for children who survived to hospital discharge, and one third (28.5%) required ICU admission, with 181 (31.0%) sustaining a severe head injury and 130 (22.3%) had polytrauma. (Table 2)

Injury mechanism

Injury occurred most frequently as a result of falls in 219 (35%) of cases, with almost half (n = 109, 49.8%) classified as low level falls, i.e. < 1 m. Falls accounted for the largest number of injuries across all age groups, where other mechanisms varied with age (Fig. 2). Transport-related incidents (i.e. motor vehicle, motorcycle, pedestrian) were accounted for 138 (22.1%) of injuries. A greater proportion of falls occurred in major city regions (p = 0.001), with motor bike collisions (p<0.001), motor vehicle collisions (p = 0.025) and incident involving cyclist/ scooters/ skateboards (p = 0.045) demonstrating greater proportions of injuries occurring in inner regional and outer regional/ remote areas (Fig. 3). The time of day injury occurred was documented in 512 records. For records where times were available, most injuries occurred between 0700- 1900 hrs, with a greater proportion

Fig. 2. Injury mechanism/activity of severely injured children in NSW per age group. *Other injury includes: crush/caught between objects, struck by object; asphyxiation; choking; explosion; electrical injury.

Fig. 3. Injury mechanism and location of injury. 1 $\chi2$ tests of independence were conducted to examine the association between each of the MOI categories with the three regions using a series of 3 × 2 contingency tables (ie. Assault vs all other MOI categories by the 3 regions; Burns vs all other MOI categories by the 3 regions etc.). 2 MVC- motor vehicle collision, MBC- motor bike collision. 3 Other injury includes: crush/caught between objects, struck by object; asphyxiation; choking; explosion; electrical injury.

(n = 280, 54.6%) occurring during the afternoon/ early evening between 1300 hrs and 1859 hrs, and almost a third (n = 145, 28.3%) between 0700 hrs and 1259 hrs. More children were injured on the weekend with 216 (38%) injured Saturday/ Sunday compared to weekdays and 149 (22.7%) of children were injured during school holiday periods.

Mortality

Comparison made are based on cases with an ISS > 12, ICU admission or deceased following injury. Fifty-eight (9.3%) children died, injured as a result of transport-related incidents (n = 17), drowning (n = 10), assault (n = 3) or burns (n = 3). There was sig-

Table 3
Survival outcome for children meeting inclusion criteria NSW Trauma Registry[a].

	Deceased (n = 58)	Survived (n = 266)	Test statistic[c]	Df	p-value
Age					
Median (IQR)	6 (1–13)	10 (3–14)	MW=6516.5		0.1
Sex			χ^2 = 4.99	1	0.03
Male	31 (14.2%)	188 (85.5%)			
Female	26 (25.0%)	78 (75.0%)			
Injury location			χ^2 = 7.18	3	0.07
Major city	27 (18.4%)	120 (81.6%)			
Inner regional	9 (15.3%)	50 (84.7%)			
Outer regional/remote	20 (25.0%)	60 (75.0%)			
Outside NSW/unknown	2 (5.3%)	36 (94.7%)			
ISS[b]					
Median (IQR)	25 (25–33)	16 (13–22)	MW=1147		<0.001
NISS[b]					
Median (IQR)	25 (25–41)	17 (16–26)	MW=1257.5		<0.001
Polytrauma[b]			χ^2 = 61.8	1	<0.001
Yes	7 (3.7%)	184 (96.3%)			
No	51 (38.3%)	82 (61.7%)			
Head injury AIS > 2[b]			χ^2 = 0	1	1.0
Yes	9 (7.6%)	110 (92.4%)			
No	13 (7.7%)	156 (92.3%)			
ICU admission[b]			χ^2 = 0	1	0.94
Yes	12 (7.2%)	154 (92.8%)			
No	10 (8.2%)	112 (91.8%)			
Hospital LOS (days)[b]					
Median (IQR)	0 (0–3)	7 (3–16)	MW=864.5		<0.001
PTC[a]			χ^2 = 0	1	1.0
PTC	18 (8.5%)	194 (91.5%)			
Non-PTC	4 (7.8%)	47 (92.2%)			

[a]Age, sex and injury location reports all deaths, all other analysis include only in hospital deaths with cases as per NSW Trauma Registry criteria.
[b]MRU and NCIS data excluded from analysis as data not available.
[c]In the case of 2 × 2 tables, Continuity Correction $\chi 2$ results are reported.

nificant relationship between gender and outcome, with a greater proportion of females deceased (25.0%) compared to males (14.2%), $\chi 2(1)=4.985$, p = 0.026. A greater proportion of those living in outer regional/ remote areas were deceased (25.0%), when compared to those injured in major city (18.4%) and inner regional (15.3%) areas, however the relationship was not statistically significant (Table 3). Deceased children had a higher median (IQR) ISS when compared with those who survived, 25 (25–33) versus 16 (13–22) (MW=1147, p<0.001). There was no difference in severe head injury or ICU admission between children that survived or died, but there were more children with polytrauma in the cohort that survived ($\chi 2(1)=61.8$, p <0.001). There was no difference detected in mortality between those where definitive care was provided at a PTC versus an adult or regional trauma centre ($\chi 2(1)=0$, p = 1.00).

Health-related quality of life

PedsQL and EQ-5D-Y were completed via parent proxy for 88 at baseline, 64 at six months and 75 at 12 months. HRQoL as measured by PedsQL for the children followed up by parent proxy, mean summary score showed a decline at six months, with improvement at 12-months, although children only reached baseline in the physical health summary score. Paired t-test demonstrated a significant decrease at six months in both the total PedsQL score (t_{62}=2.3, p = 0.024) and the psychosocial health score (t_{62}=2.5, p = 0.014), with the change from baseline to 12 months remaining significant for the psychosocial health score (t_{72}=2.3, p = 0.023) (Table 4).

The EQVAS rated out of 100, demonstrated a decline from baseline at both six- and twelve-months post injury. The mean (SD) parent proxy rating of health at baseline was 93.9 (8.0) compared to 85.1 (13.0) and 84.7 (19.0), at six and twelve months respectively. The EQ VAS demonstrated a significant change from baseline to both six months and twelve-month scores. From baseline to six months, the mean (SD) difference in the EQVAS score 8.9 (14.0) lower than baseline (t_{63}=5.1, p<0.001), and for the twelve month score the mean (SD) difference was 9.6 (18.8) lower than baseline (t_{73}=4.4, p<0.001).

For the 58 children EQ-5D-Y whose dimensions were measured by parent proxy at all three time points, there were no significant changes in the EQ-5D-0Y dimensions across three time points except the doing usual activities dimension (Cochran's Q = 17.62 df=2, p<0.001). Results of the pair-wise comparisons suggested that significant changes were observed between baseline and 6 months in activity with 91% exhibited no problem at baseline but reduced to only 62% at 6 months. However, a reversed direction of change was observed between 6 months and 12 months with 62% exhibited no problem at 6 months but increased to 83% at 12 months. The parent proxy results for EQ-5D-Y are available in supplementary file 1.

The EQ-5D-Y assessed the impact of injury through both parent proxy and review based assessments from outpatient follow up by medical and allied health staff, this provided EQ-5D-Y data for 88 from baseline measures, 204 at six months and 179 at 12 months. The EQ-5D-Y dimensions showed a greater proportion of children in the samples with problems at 6- and 12-months, as demonstrated in Fig. 4 a smaller proportion of the sample for each domain report a lot of problems compared to those reporting some problems.

For the children where twelve-month outcomes were measured with EQ-5D-Y, there was no significant relationship between SEIFA and those who had problems versus no problems at 12-months on the domains of mobility, activity and emotion. There was a significant relationship between SEIFA and the domains of pain (p = 0.028) and selfcare (p = 0.021) (Table 5). There was no sta-

Table 4
PedsQL score measured baseline, 6 and 12-months post injury, and paired *t*-test results.

	n	Total score Mean (SD)			n	Physical health Mean (SD)			n	Mean (SD)		
Baseline	86	84.0 (15.7)			87	84.3 (23.9)			86	84.0 (15.9)		
6 month	64	76.2 (19.9)			64	77.1 (25.5)			64	76.1 (21.0)		
12 month	74	82.4 (17.6)			75	85.6 (18.9)			74	80.4 (18.7)		
Paired *t*-Test	n	Total score Mean difference (SD)	*t*-test	P	n	Physical health Mean difference (SD)	*t*-test	P	n	Psychosocial health Mean difference (SD)	*t*-test	P
Baseline – 6 months	63	6.6 (22.5)	t_{62}=2.3	0.024	63	6.8 (31.1)	t_{62}=1.7	0.089	63	6.5 (20.5)	t_{62}=2.5	0.014
6- 12 months	58	−5.8 (11.9)	t_{57}=−3.7	<0.001	58	−8.6 (17.1)	t_{57}=−3.9	<0.001	58	−3.9 (12.1)	t_{57}=−2.5	0.016
Baseline – 12 months	73	2.7 (19.2)	t_{72}=1.2	0.233	74	−0.4 (27.5)	t_{73}=−0.1	0.899	73	4.8 (17.6)	t_{72}=2.3	0.023

tistically significant relationship found between children reporting problems and injury descriptors (ISS/NISS/ Polytrauma / head injury AIS >2). There was no difference in between in socioeconomic status of those with 12-month outcome data versus those without ($\chi 2$ =1.247, p = 0.870). The group with 12-month data had a higher median ISS, 13 vs 9 (U = 5631, p<0.0001).

Treatment cost

The total cost of care for children receiving definitive care at a NSW PTC over the 15 months of the study exceeded AUD$16.5 million (Table 6). The median treatment cost for children 11–15 years was more than children <1 year (p = 0.006) and 1–5years (p=<0.001). The median treatment costs were greater for children who required inter-hospital transfer (AUD$15.39 vs $12.01 K), however this was not significant (MW=21,934, p = 0.065). Treatment costs were higher with a higher ISS (p=<0.001) and in the presence of polytrauma (p=<0.001). There was no association with increased treatment costs and severe head injury (MW=18,568, p = 0.192). The cost range is reported in Table 6.

Discussion

This study presents an overview of the characteristics of children who sustained major injury in NSW. Females and children from rural/ remote Australia were overrepresented in the deceased cohort and there was no association between death and location of definitive care treatment. This study demonstrated that injured children treated in NSW suffered from problems related to psychosocial health (i.e. emotional, social and school functioning) at 12-months post-injury. Acute treatment costs exceeded AUD$16.8 million with females and children with multiple body regions injured generating higher individual treatment costs.

The majority of injured children were male (71.7%), a slightly higher proportion than that reported by other Australian sources [23,24]. There were a greater proportion of children injured in the toddler and teenage years, not dissimilar to other reports [25]. Higher injury rates are known to be attributed to the developmental ages of the child with younger children more prone to injury without the ability to recognise and respond to risk and older children as they gain greater independence, influenced by their environment and social pressures with greater risk taking behaviour [23]. More than half of injured children were from middle and lower socioeconomic groups, similar to previous reports [25]. This finding is not unique to Australia, and has been attributed to lower levels of education of caregivers and knowledge regarding safety and/or resources to provide necessary safety equipment [26]. Taking into account differences in child injury characteristics by age and social determinants in the development of injury prevention strategies would assist to address this inequity.

Mortality

Females and children injured in rural and remote areas are overrepresented among children who died following injury. Females represent one-third of the injured child cohort, yet nearly half the deceased. Similarly, children injured in outer regional/remote NSW represent 16.6% of the overall injury cohort, but 25.0% of the deceased. These findings are not unique to NSW, with the 10 year review of childhood injury in Australia demonstrating that children that reside in rural/ regional Australia are twice as likely to die from their injuries as their metropolitan counterparts [24]. The tyranny of distance is frequently described, with the increased time taken to reach definitive care, as likely to contribute to potential adverse consequences. Further investigation is required to establish whether there is any difference

Fig. 4. Proportion of sample with problems according to EQ-5D-Y. EQ-5D-Y sample $n = 88$ at baseline, $n = 204$ six month, $n = 179$ twelve months.

Table 5
Relationship socioeconomic disadvantage with 12-month problems.

	Problem *n* (%)	No problem n (%)	Test stats	df	*p* value
Mobility			$\chi^2 = 2.08$	4	0.72
1 (lowest most)	7 (22.6%)	29 (20.3%)			
2	5 (16.1%)	22 (15.4%)			
3	8 (25.8%)	26 (18.2%)			
4	7 (22.6%)	33 (23.1%)			
5 (highest least)	4 (12.9%)	33 (23.1%)			
Selfcare			$\chi^2 = 11.21$	*	0.02
1 (lowest most)	7 (26.9%)	8 (10.3%)			
2	3 (11.5%)	16 (20.5%)			
3	8 (30.8%)	11 (14.1%)			
4	6 (23.1%)	20 (25.6%)			
5 (highest least)	2 (7.7%)	23 (29.5%)			
Usual activities			$\chi^2 = 4.86$	4	0.30
1 (lowest most)	9 (23.1%)	16 (15.1%)			
2	7 (17.9%)	17 (16.0%)			
3	10 (25.6%)	17 (16.0%)			
4	7 (17.9%)	28 (26.4%)			
5 (highest least)	6 (15.4%)	28 (26.4%)			
Pain/ discomfort			$\chi^2 = 10.86$	4	0.028
1 (lowest most)	6 (18.2%)	15 (15.0%)			
2	7 (21.2%)	15 (15.0%)			
3	9 (27.3%)	17 (17.0%)			
4	10 (30.3%)	22 (22.0%)			
5 (highest least)	1 (3.0%)	31 (31.0%)			
Emotion			$\chi^2 = 1.78$	4	0.776
1 (lowest most)	6 (17.1%)	6 (9.0%)			
2	6 (17.1%)	11 (16.4%)			
3	7 (20.0%)	14 (20.9%)			
4	9 (25.7%)	18 (26.9%)			
5 (highest least)	7 (20.0%)	18 (26.9%)			

*Fisher's Exact Test results reported due to more than 20% of expected count less than 5.

in the characteristics, treatment or time taken to reach definitive care when compared to those who survive following injury in regional/remote areas. Injury prevention measures in rural/regional Australia require enhancement and priority, as does access to definitive trauma care, which was highlighted as a priority need in 2019 by NSW trauma professionals [27].

This study did not demonstrate a survival benefit for children who received definitive care at non-PTCs versus PTCs. The peer-review of deaths during the study period did not find any preventable deaths [28]. These findings are in contrast to earlier work by Mitchell et al. [3,4] who demonstrated a survival benefit for children with an ISS>15 if treated at a NSW PTC. Mitchell and colleagues study, however, was conducted over a six-year period, used a different definition of definitive care (i.e. defined as where the child spent the greatest amount of time), and solely using data from the NSW Trauma Registry. Further, they were not able to account for selection bias as some children may have been conveyed to the nearest trauma centre due to life-threating injuries, which may or may not have been a PTC. Although the current study used the same injury characteristics criteria, the smaller total population may have influenced the result. A replicate analysis using NSW Trauma Registry is in-progress.

Treatment costs

Increased acute treatment costs are associated with multiple injured body regions, higher injury severity scores, being female and/or being aged 11–15 years. These findings are consistent with existing literature [24]. This study did not demonstrate the doubling of treatment costs incurred by children requiring inter-

Table 6
Cost (in K dollars[a]) according to age, sex, inter-hospital transfer, injury severity and body region injured, survival.

Characteristic		Costs linked	Median (range)	Total	Test stat[a]	df	*p* value
Gender					MW=18,807		0.379
	Female	125	16.24 (1.3–1048.5)	6182.17			
	Male	318	12.65 (0.5–900.5)	10,669.80			
Age group					KW=26.78	3	<0.001
	< 1 year	50	9.37 (0.5–250.5)	1384.17			
	1 - 5	168	10.04 (1.3–900.5)	4224.82			
	6 - 10	91	15.93 (1.7–1048.5)	3860.50			
	11 - 15	134	18.69 (1.3–691.4)	7382.48	11–15 vs 1–5 <1 vs 11–15		<0.001 0.006
Transfers					MW=21,934		0.065
	IHT[b]	206	15.39 (1.4–525.0)	6781.31			
	No IHT	237	12.01 (0.5–1048.5)	10,070.66			
ISS[c]					KW=73.99	2	<0.001
	<9	15	18.65 (8.3–70.5)	323.56			
	9 - 12	286	10.11 (0.5–298.9)	4905.44	9–12 vs >12		<0.001
	>12	142	28.32 (1.3–1048.5)	11,622.97			
Body regions injured					KW=28.19	2	<0.001
	Isolated	251	10.59 (0.5–274.0)	4993.48	1 vs 2 1 vs ≥3		0.001 <0.001
	Two	98	17.32 (1.4–525.0)	5544.57			
	≥ Three	94	22.14 (1.4–1048.5)	6313.92			
Head Injury – AIS[d] > 2					MW=18,568		0.192
	No	315	14.34 (0.5–900.5)	11,473.59			
	Yes	128	11.58 (1.3–1048.5)	5378.38			
Outcome					MW=3403		0.692
	Deceased	15	18.9 (1.3–508.8)	818.41			
	Survived	428	13.04 (0.5–1048.5)	16,033.56			

[a]K dollars = $1000. Test statistics with multiple comparisons when appropriate,.
[b]IHT- Inter Hospital Transfer.
[c]ISS- Injury Severity Score.
[d]AIS- Abbreviated Injury Scale.

hospital transfer of other NSW research [29], or, with major head injury. However, these costs include pre-hospital ambulance transport, which other local research does not. The pre-hospital costs perhaps offset the interhospital transport costs which are included in hospital treatment costs. These costs do not represent the true financial cost of injury such as rehabilitation post-discharge or the costs to caregivers, eg time off work, parking, travel [26]. It is important to consider that health budgets are calculated in average costs and this analysis was completed using non-parametric tests due to the abnormal distribution of the data, in some instances the average costs are higher than the reported median costs.

Twelve-month outcomes

Children sustaining major injury in NSW reported a sustained decline in quality of life, particularly psychosocial outcomes. These findings are reflective of similar work in Victoria, Australia [13,30]. The exception was physical health score measured by PedsQL. That there was no relationship found between children with problems and age or injury characteristics requires further investigation. These measures are important to aid in the understanding of injury impact and should be routinely incorporated in ongoing follow-up by service providers, not only as a measure, but as a risk screen for intervention. The association with injury and mental health is well known, yet remains a poorly resourced and frequently neglected component of paediatric inpatient trauma care [31]. During the process of medical record review there was often insufficient information in the record to assess this element of care, raising the question as to whether it is being considered by treating teams. Addressing mental health in conjunction with physical health in injured children would enable early intervention where needed to address the psychological impact of injury [31,32]. Further research is required to determine whether aspects of treatment may influence the quality of life of injured children.

Limitations

While all efforts were made to capture children meeting study inclusion, the number of children captured is potentially underreported. This is due to the lengthy time period required to conduct a coronial investigation and NSW Trauma registry minimum data requirements, children with an ISS 9–12 remaining at an adult or regional trauma service for definitive care were potentially not captured. The 12-month HRQoL outcomes were unable to be determined for children not treated at a PTC, there was 12-month data available for 179 children which represented 38% of children eligible for follow up. A planned collection of 12-month health outcome data on all patients in the NSW Trauma Registry commencing in 2020 should address this gap.

Conclusion

A reduced quality of life was reported by children treated for major injury in NSW, especially emotional well-being at 12-months post-injury. Improved psychosocial care and outpatient follow-up is required to minimise the long-term emotional impact of injury. A co-ordinated child injury prevention strategy for NSW is required. This should target prevention measures to groups that remain overrepresented, particularly children from rural/ remote NSW and lower socio-economic backgrounds.

Declaration of Competing Interest

The authors declare no conflict 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.2020.04.030.

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