Influence of early childhood burns on school performance: an Australian population study

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ABSTRACT

Objectives To determine the influence of burn injuries on childhood performance in national standardised curriculum-based school tests.

Design Birth and health records of 977 children who were hospitalised with a burn injury between 2000 and 2006 in the state of New South Wales, Australia, were linked to performance scores in the National Assessment Program: Literacy and Numeracy test, a compulsory nationwide curriculum-based test (CBT) and compared with children who were not hospitalised for burns and who were matched for birth year, gender, gestation and socioeconomic status.

Main outcome measures Test scores in years 3 (ages 8–9), 5 (ages 10–11) and 7 (ages 13–14) in numeracy, writing, reading, spelling, grammar and punctuation.

Results Mean age at first burn injury was 28 months (median: 20, range: 0–140). Children with burns were significantly more likely to have younger mothers (28.5 vs 29.6 years) (P<0.001), be indigenous (OR 2.5 (95% CI 2.1 to 3.1)) (P<0.001) and have siblings (OR 1.2 (95% CI 1.1 to 1.4)) (P<0.001). They were also less likely to meet national minimum standards in most domains of testing until year 5, even after adjustment for parental education levels, parental smoking, maternal age and indigenous status. Each 10% increase in total body surface area burnt was associated with a decrease in year 5 scores by 37.0% in numeracy and 71.9% in writing.

Conclusions Most childhood burn injuries occur before the start of formal schooling. Children who are hospitalised for burns perform more poorly in CBT even after accounting for family and socioeconomic disadvantage. Rehabilitation of children with burn injuries must address school performance to decrease any long-term negative societal impact of burns.

What is already known on this topic?

- Burn injuries are more common in children with relative socioeconomic disadvantage.
- Children with relative socioeconomic disadvantage also have burn injuries that lead to poorer outcomes, including school performance.

What this study adds?

- Burns in childhood are associated with poorer performance in curriculum-based tests up to at least 5 years after the injury.
- Severe and more extensive burns increase the risk of poor school outcomes.
- Children with burn injuries should be supported even after the burns have physically healed.

INTRODUCTION

Burns are a frequent and serious cause of injury in children.[1–3] In Australia, at least 1% of children below 5 years of age will experience a burn injury and over half will be injured seriously enough to be affected in their daily lives.[4] Some children need to be hospitalised, sometimes for prolonged periods. Unfortunately, hospitalisation of any form may increase the risk of adverse psychosocial and learning sequelae, as children are removed from normal daily activities and interaction with families and peers.[5]

Burns are now an uncommon direct cause of death in developed countries.[1] The long-term sequelae of burn survivors are therefore of paramount importance.[1–3] Recovery may often require multiple subsequent admissions for wound dressings, reparative operations and other related procedures. For children, this may lead to considerable psychosocial consequences as hospitalisation, regardless of duration, isolates them from normal interactions with family and peers at school. Further, these effects may extend into adulthood.[1–5]

Previous data show that adult survivors of childhood burns are at an increased risk of mental and physical problems, including depression, anxiety disorders, substance abuse, suicidal attempts, arthritis, fractures and respiratory morbidities[6] which all have the potential to impair quality of life for the patient as well as their families and society.[6]

The causes of poor adult outcomes after childhood burn injury remain uncertain. Any form of burn injury may prevent regular school attendance, a critical contributor to school performance.[5] In turn, poor academic outcomes increase the risk of poor adult functioning, physical health, psychological dysfunction and social maladjustment.[5–7] The effects of school failure are also far reaching and can extend for generations.[8] Early identification of children at risk of school failure for intervention and support may therefore considerably mitigate the detriments of school failure even until the third decade of life.[7]

Children may start school several years after a burn injury and may be physically healthy at school entry. Providing a rationale for long-term follow-up, particularly for psychosocial sequelae

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in children without physical health problems, is difficult in any resource-challenged environment without evidence of need.

In this study, we sought to determine if childhood burn injuries are associated with poorer performance in standardised curriculum-based tests (CBT) by examining linked health and education data for all children hospitalised for a burn injury in the state of New South Wales (NSW) in Australia between 2000 and 2006. We hypothesised that burn injuries sustained during childhood would worsen performance in CBT and that the magnitude of school failure would correlate to the severity of the burn.

METHODS

Study design

This was a population linkage study using routinely collected data from health and educational records for all children born between 2000 and 2006 in the state of NSW, Australia, and who were hospitalised for a burn injury in this period.

Databases and patient selection

The databases used for this study were:

1. The *Perinatal Data Collection (PDC)* providing prenatal, delivery and postnatal (to hospital discharge) data for mothers and their infants registered in NSW who were either born alive or dead of at least 20 weeks' gestation or at a minimum birth weight of 400 g.
2. The *Admitted Patients Data Collection (APDC)* provides information on all episodes of care to NSW residents in public, private, psychiatric and repatriation facilities in NSW and within Australia. Each episode of care was categorised according to the International Statistical Classification of Diseases and Related Health Problems 10th Revision-Australian Modification (ICD-10-AM) with the trauma codes T20–T98 defining the burn injury and its characteristics (see table 1).[3]

Table 1 International Statistical Classification of Diseases and Related Health Problems 10th Revision-Australian Modification (ICD-10-AM) diagnostic codes correlating to burn injuries within the Admitted Patients Data Collection (APDC)

T20–25	Burns of external surface specified by site
T26–28	Burns confined to eye and internal organs
T29–32	Burns of multiple and unspecified body regions
T90–98	Injury and other consequences from burns
Total body surface area (TBSA) of burn Burn injuries were classified according to TBSA, according to the ICD-10-AM trauma codes T31.0–31.9.	1=<10% 2=10%–19% 3=20%–29% 4=30%–39% 5=40%–49% 6=50%–59% 7=60%–69% 8=70%–79% 9=80%–89% 10=90%–99%
Degree of burn injury Another measure of burn severity, related to burn thickness. Classified by ICD-10-AM trauma codes into first, second and third-degree burns	0=unspecified degree 1=first-degree burn 2=second-degree burn 3=third-degree burn
Burn injury with sequelae Sequelae of burns derived from ICD codes: T95.0, 95.1, 95.2, 95.3, 95.4, 95.8, 95.9	1=with sequelae 0=without sequelae

3. The *Registry of Births, Deaths and Marriages* and the *Australian Coordinating Registry Cause of Death Unit Record File*, containing ICD-10 codes for causes of all deaths in NSW that do not require a coronial inquiry from 1997.
4. The *National Assessment Plan for Literacy and Numeracy (NAPLAN)*. This is a CBT that commenced in 2008 and is completed by all Australian children in year levels 3, 5, 7 and 9. Since year 9 NAPLAN results were not available at the time, this study analysed the results of year 3, 5 and 7 NAPLAN tests. Approximately 1 000 000 Australian children sit these assessments in each year level, with performance assessed in five domains—grammar and punctuation, reading, spelling, writing and numeracy.[8–11] Australian schools are divided into primary school, comprising years kindergarten through year 6, and secondary school comprising years 7–12. The dispersion of NAPLAN assessments across a child's primary and secondary schooling in years 3 (ages 7–9), 5 (ages 9–11) and 7 (ages 11–13) enables longitudinal assessment of their academic progress. Information retrieved for this study includes parental education levels, school sector, attendance of exams and raw NAPLAN scores. These are scored out of 100 for each domain, translated into bands which are then used to determine whether the student performed below the national minimum standard (NMS). All scores are graded according to the same scale across year levels. The NMS is the minimum band above which all normal children in Australia are expected to achieve. Failure to achieve the NMS indicates that a child will have difficulties in progressing to the next level of schooling without assistance.[8–11] The NAPLAN is compulsory for children in all Australian schools. The tests are conducted on the same day in May each year and the results are released on the same day in September of the same year.

Linkage

The Centre for Health Record Linkage,[12] a dedicated record linkage facility affiliated with the NSW Ministry of Health, performed the data linkage required for this study. Each patient record was deidentified and assigned a unique project-specific person number, which enabled researchers to correctly link deidentified patient health and education records across the multiple data sets within the project. Linkage rates for NSW children without burns to a NAPLAN record were higher (877 833 of 1 105 338, 79.4%) than for children with burns (977 of 1556, 62.8%) or to matched controls (3692 of 6200, 59.5%, $P<0.001$).

Patient selection

Children with birth dates from January 2000 to December 2006 were eligible to sit NAPLAN up to 2011. Children born after 2006 would have been too young to have sat for the NAPLAN within the period of this study and APDC diagnoses were only available from July 2000. Three groups of children were identified and compared.[1] The burn injury cohort consisted of children registered in the PDC in the designated time period who were also registered in the APDC with an ICD-10-AM diagnosis correlating to a burn injury up to the year 2011. Children included in this cohort may have had a burn injury as the primary reason for admission, or as a secondary or tertiary diagnosis. The hospital burn admission criteria include all burn injuries >5% total body surface area (TBSA), any burn injury to special sites, associated with an inhalational burn or due to chemical or electrical exposure. In addition, burns with a TBSA <5% in

children would also be admitted if there was a suspicion of non-accidental injury, if the child has multiple comorbidities or other trauma, or if there are concerns of the child's social situation or compliance with dressings. More severe TBSA burns would be transferred to specialised burns unit.[2] The children with burns were matched in a 4:1 ratio with children who were born in the same time period and also registered in the APDC, but not with a burn injury for gender, Socio-Economic Index For Area and gestational age. This means that the control population was children who had been hospitalised for reasons other than burn injuries.[3] The rest of the NSW population excluded children who died before reaching an eligible age to sit the NAPLAN (including perinatal deaths) or who sustained a burn injury after they had sat for at least one NAPLAN test. This provided us with a second control population that had neither suffered a burn injury nor required an admission to hospital (online supplementary appendix A).

Statistical analysis

Comparisons of categorical data were conducted with χ^2 analyses for the baseline characteristics or Fisher's exact test for samples with <5 subjects. Percentages with ORs and 95% CIs were expressed for proportions, means (SD) and medians (ranges) for continuous data in the baseline characteristics. Analyses of variance for unbalanced data were conducted on NAPLAN scores, expressed as difference of means. Univariate logistic regression analyses and a multiple binary logistic regression model with backward elimination investigated the impact of burn injury on scoring below NMS when controlling for other confounders. Burn injury was the primary independent variable. Others included attendance at a school in a major city, attending a government school, parental school education level and parental education beyond schooling years, indigenous status, smoking during pregnancy, mental and behavioural comorbidities (as defined by ICD-10-AM codes F00–F98), previous pregnancies and maternal age (1–8, see table 2). Estimates of association were reported as ORs with two-sided 95% CIs.[6] A Hosmer-Lemeshow goodness-of-fit test[6] was conducted on the year 3 analysis to confirm if this model appropriately fit the data.

Table 2 Baseline maternal and infant characteristics

Variable	Burns (%) n=1556	Matched controls (%) n=6200	P value
Maternal characteristics			
Age	28.5 (6.0)	29.6 (5.6)	<0.001
Indigenous	176 (11.3)	258 (4.5)	<0.001
Multiparous	994 (63.9)	3662 (59.1)	<0.001
Smoked during pregnancy	406 (26.5)	1061 (17.5)	<0.001
Vaginal delivery	1042 (67.0)	3790 (61.1)	<0.001
Maternal diabetes	8 (0.5)	4 (0.6)	0.49
Gestational diabetes	63 (4.1)	289 (4.7)	0.31
Hypertension	5 (0.3)	44 (0.7)	0.08
Immigrant	665 (42.7)	2781 (44.9)	0.14
Rural	534 (34.2)	1978 (31.9)	0.07
Birth weight (g)	3361.4	3381.9	0.15
Infant characteristics			
Mean gestational age (weeks)	39	39	0.58
Preterm (<37 weeks)	124 (8.0)	488 (7.9)	0.92
Admission into an NICU	275 (17.7)	1126 (18.2)	0.66

NICU, neonatal intensive care unit.

Linear regression models served to analyse associations between time duration after a burn injury in years, percentage burn TBSA, months follow-up in hospital and NAPLAN scaled scores. Estimates of association were reported with SEs and t-values. Statistical significance was calculated at P<0.05 using the SAS V.9.4 statistical software.

RESULTS

Up to 1 119 440 paediatric patients were registered in the NSW PDC between July 2000 and December 2006. Of these, 7041 were stillbirths and 3085 died within the neonatal period (<29 days of age), leaving a total of 1 108 513 survivors. Of these, 1556 were admitted to a NSW hospital with a burn injury before the age of 13.

Maternal characteristics

Maternal characteristics are summarised in table 2. Mothers of children with burns were significantly younger than control mothers, twice as likely to be indigenous, more likely to have smoked during pregnancy and be multiparous (P<0.001).

Characteristics of children with burns

The median age at the first burn injury was 20 months (range: 0–140). Most (76.0%) patients were younger than 5 years of age when they sustained a burn injury. The majority of patients (87.5%) had <10% TBSA burnt. Others (5.4%, 83) had >20% and (7.1%, 111) had between 10% and 20% TBSA burnt. Most children (40.9%, 673) sustained deep partial thickness burns while 9.7% (151) had a full thickness burn. Only 1.0% of patients were burned in more than two regions. The most commonly burnt regions were the hand and wrist (680, 43.7%). This was followed by trunk (422, 27.1%), hip and lower limb (421, 27.1%) and shoulder and upper hand (392, 25.2%). Children with burns spent a median of 8 days in hospital for each episode of care.

Length of stay and hospitalisations

Children with burn injuries experienced a higher accumulated time in hospital than the matched controls. Total length of stay (LOS) for burns in children was 15 339 days (mean 9.86, median 8) compared with 35 250 days (mean 5.66, median 6) for controls (P<0.001). The mean LOS per admission for control patients (M: 3.58, SD: 6.53) was actually slightly higher than for children with burn injuries (M: 3.27, SD: 7.02), t(2.39), P=0.0168.

Mortality

Seven (0.5%) of the 1556 children with burns died in hospital (compared with 18 of 6200 controls (0.3%, OR 1.55, 95% CI 0.65 to 3.70, P=0.32)). Three deaths were directly attributable to the cause of the burn (a fire, each child was aged 1–2 years), three died from an unclear cause and one death was attributed to a burn injury caused by a motor vehicle accident.

NAPLAN RESULTS

Significantly more children with burns were absent from a test (2.6% vs 0.5%, P<0.001) compared with matched controls, although test absences decreased from year 3 (3.7%) to year 7 (1.6%) in the burns cohort. Mean test scores for children with burn injuries were significantly lower than either controls or the rest of the children of NSW (P<0.05) in every test domain but this difference decreased with age (see table 3). The year 7 mean scores show the least significance in difference between means. Only one significantly lower mean was found

Table 3 Differences in mean test scores for children with burns, matched controls and rest of NSW population

	Burns versus controls (95% CI)	P value	Burns versus rest of NSW (95% CI)	P value	df between groups	df within groups	F value	P value
Year 3								
Grammar	−29.00 (−36.10 to −21.79)	<0.001	−36.11 (−42.50 to −29.70)	<0.001	2	485 951	70.52	<0.001
Reading	−27.70 (−34.20 to −21.09)	<0.001	−33.40 (−39.20 to 27.52)	<0.001	2	485 339	69.43	<0.001
Spelling	−25.50 (−31.50 to −19.40)	<0.001	−30.89 (-36.28 to −25.49)	<0.001	2	485 951	70.07	<0.001
Writing	−16.90 (−22.01 to −11.80)	<0.001	−24.80 (−29.40 to −20.30)	<0.001	2	485 294	78.50	<0.001
Numeracy	−19.60 (−25.40 to −13.80)	<0.001	−25.40 (−30.60 to −20.30)	<0.001	2	484 990	56.21	<0.001
Year 5								
Grammar	−26.20 (−33.90 to −18.50)	<0.001	−33.40 (−40.30 to −26.60)	<0.001	2	477 705	54.21	<0.001
Reading	−18.80 (−25.80 to −11.80)	<0.001	−26.10 (−32.40 to −20.00)	<0.001	2	477 165	43.31	<0.001
Spelling	−22.40 (−28.90 to −15.90)	<0.001	−26.20 (−32.00 to 20.50)	<0.001	2	477 705	42.92	<0.001
Writing	−18.60 (−24.70 to −12.50)	<0.001	−30.90 (−36.30 to −25.40)	<0.001	2	477 024	98.13	<0.001
Numeracy	−16.30 (−23.10 to −9.50)	<0.001	−22.20 (−28.20 to −16.20)		2	475 480	32.79	<0.001
Year 7								
Grammar	−13.40 (−24.0 to −2.90)	0.01	−17.00 (−26.40 to −7.70)	<0.001	2	462 674	7.43	<0.001
Reading	−8.70 (−17.90 to −0.50)	0.07	−15.60 (−23.80 to −7.45)	<0.001	2	461 380	12.12	<0.001
Spelling	−12.50 (−21.80 to −3.20)	0.01	−14.40 (−22.70 to −6.20)	<0.001	2	462 674	6.28	<0.001
Writing	−17.30 (−27.20 to −7.30)	<0.001	−33.80 (−42.60 to −24.90)	<0.001	2	462 148	52.97	<0.001
Numeracy	− 14.10 (−24.90 to −3.30)	0.01	−13.80 (−23.40 to −4.240)	0.01	2	462 704	4.01	<0.05

NSW, New South Wales.

in numeracy results of children with burn injuries compared with controls. The difference in means between burn injuries and controls (average of 13.2 points) was less significant than the difference in means between burn injuries and the rest of the NSW population (average of 18.9 points, P<0.01, table 4).

Factors associated with failure to reach NMS

Factors associated with poor school performance were examined using univariate and then multivariate logistic regression to determine the relationship between a burn injury and other factors with failure to meet NMS (table 5). The influence of burn injuries was only significant in year 3 across all domains of testing (OR 1.41, 95% CI 1.18 to 1.68, online supplementary appendix B). Factors increasing risk of not meeting NMS that persisted until high school included: schooling in a government (public) facility, having a multiparous mother or a mother who smoked during pregnancy and being indigenous (see tables 3 and 4). The year 7 multivariable regression showed the most significant associations between prenatal factors such as smoking during pregnancy (OR 2.09, 95% CI 1.50 to 2.90) and indigenous status (OR 2.65, 95% CI 1.50 to 2.91). Conversely, the lower scholastic performance observed in children with burn injuries appeared to be ameliorated in those attending a metropolitan school or with a mother over 35 years of age.

Table 4 ANOVA analysis comparing mean scores of burns, matched controls and rest of NSW population

	Burns versus controls (95% CI)	P value	Burns versus rest of NSW (95% CI)	P value	df between groups	df within groups	F value	P value
Year 3								
Grammar	−29 (−36.1 to 21.79)	<0.001	−36.11 (−42.5 to 29.7)	<0.001	2	485 951	70.52	<0.001
Reading	−27.7 (−34.2 to 21.09)	<0.001	−33.4 (−39.20 to 27.52)	<0.001	2	485 339	69.43	<0.001
Spelling	−25.5 (−31.5 to 19.4)	<0.001	−30.89 (−36.28 to 25.49)	<0.001	2	485 951	70.07	<0.001
Writing	−16.9 (−22.01 to 1.8)	<0.001	−24.8 (−29.4 to 20.3)	<0.001	2	485 294	78.5	<0.001
Numeracy	−19.6 (−25.4 to 13.8)	<0.001	−25.4 (−30.6 to 20.3)	<0.001	2	484 990	56.21	<0.001
Year 5								
Grammar	−26.2 (−33.9 to 18.5)	<0.001	−33.4 (−40.3 to −26.6)	<0.001	2	477 705	54.21	<0.001
Reading	−18.8 (−25.8 to 11.8)	<0.001	−26.1 (−32.4 to −20.0)	<0.0001	2	477 165	43.31	<0.001
Spelling	−22.4 (−28.9 to 15.9)	<0.001	−26.2 (−32.0 to −20.5)	<0.0001	2	477 705	42.92	<0.001
Writing	−18.6 (−24.7 to 12.5)	<0.001	−30.9 (−36.3 to −25.4)	<0.0001	2	477 024	98.13	<0.001
Numeracy	−16.3 (−23.1 to 9.5)	<0.001	−22.2 (−28.2 to −16.2)	<0.001	2	475 480	32.79	<0.001
Year 7								
Grammar	−13.4 (−24.0 to −2.9)	0.0123	−17 (−26.4 to −7.7)	0.0004	2	462 674	7.43	0.0006
Reading	−8.7 (−17.9 to −0.5)	0.0626	−15.6 (−23.8 to −7.45)	0.0002	2	461 380	12.12	<0.0001
Spelling	−12.5 (−21.8 to −3.2)	0.0082	−14.4 (−22.7 to −6.2)	0.0006	2	462 674	6.28	0.0019
Writing	−17.3 (−27.2 to −7.3)	0.0007	−33.8 (−42.6 to −24.9)	<0.0001	2	462 148	52.97	<0.0001
Numeracy	−14.1 (−24.9 to −3.3)	0.0103	−13.8 (−23.4 to −4.24)	0.014	2	462 704	4.01	0.0182

ANOVA, analysis of variance; NSW, New South Wales.

Table 5 Associations with failure to reach national minimum standards in year levels 3, 5 and 7

	Univariate analysis			Multivariate analysis		
Association	**SE**	**OR (95% CI)**	**P value**	**SE**	**OR (95% CI)**	**P value**
Year 3						
Burn injury	0.08	1.76 (1.49 to 2.07)	<0.001	0.09	1.41 (1.18 to 1.68)	<0.001
City school	0.08	0.73 (0.63 to 0.85)	<0.001	0.09	0.93 (0.79 to 1.11)	0.42
Government school	0.09	1.95 (1.63 to 2.34)	<0.001	0.10	1.61 (1.32 to 1.97)	<0.001
Parent with high school education	0.08	0.42 (0.36 to 0.49)	<0.001	0.09	0.61 (0.51 to 0.73)	<0.001
Previous pregnancy	0.08	1.33 (1.14 to 1.55)	<0.001	0.09	1.39 (1.16 to 1.67)	<0.001
Smoking during pregnancy	0.16	3.95 (2.89 to 5.39)	<0.001	0.09	1.76 (1.46 to 2.12)	<0.001
Indigenous status	0.08	2.79 (2.37 to 3.29)	<0.001	0.17	2.00 (1.42 to 2.78)	<0.001
Mother >35 years old	0.01	0.94 (0.93 to 0.95)	<0.001	0.01	0.96 (0.94 to 0.97)	<0.001
Year 5						
Burn injury	0.10	1.49 (1.23 to 1.79)	<0.001	0.11	1.18 (0.96 to 1.45)	0.12
City school	0.09	0.65 (0.55 to 0.78)	<0.001	0.10	0.83 (0.68 to 1.01)	0.06
Government school	0.11	2.35 (1.90 to 2.89)	<0.001	0.12	1.85 (1.46 to 2.37)	<0.001
Parent with high school education	0.09	0.45 (0.38 to 0.53)	<0.001	0.11	0.62 (0.51 to 0.76)	<0.001
Previous pregnancy	0.09	1.48 (1.24 to 1.76)	<0.001	0.11	1.62 (1.32 to 2.00)	<0.001
Smoking during pregnancy	0.10	2.76 (2.29 to 3.34)	<0.001	0.11	1.69 (1.36 to 2.11)	<0.001
Indigenous status	0.16	5.30 (3.85 to 7.31)	<0.001	0.18	1.85 (1.56 to 2.34)	<0.001
Mother >35 years old	0.01	0.94 (0.93 to 0.96)	<0.001	0.01	0.95 (0.93 to 0.97)	<0.001
Year 7						
Burn injury	0.14	1.34 (1.03 to 1.75)	<0.05	0.14	1.13 (0.84 to 1.54)	0.42
City school	0.13	0.59 (0.46 to 0.76)	<0.001	0.16	0.80 (0.59 to 1.08)	0.15
Government school	0.14	2.75 (2.10 to 3.61)	<0.001	0.15	2.24 (1.63 to 3.09)	<0.001
Parent with high school education	0.12	0.46 (0.36 to 0.58)	<0.001	0.18	0.65 (0.48 to 0.88)	<0.05
Previous pregnancy	0.12	1.30 (1.02 to 1.65)	<0.05	0.16	1.41 (1.04 to 1.92)	<0.05
Smoking during pregnancy	0.14	3.27 (2.50 to 4.28)	<0.001	0.17	2.09 (1.50 to 2.91)	<0.001
Indigenous status	0.25	5.00 (3.08 to 8.11)	<0.001	0.27	2.65 (1.55 to 4.50)	<0.001
Mother >35 years old	0.01	0.95 (0.93 to 0.97)	<0.001	0.01	0.98 (0.96 to 1.01)	0.21

Effects of burns and hospitalisation on test scores

Linear regression was used on the cohort with burn injuries alone to analyse the effect of duration between time of burn and NAPLAN assessment, number of follow-up hospitalisations and severity of TBSA on NAPLAN scores (table 6). In regard to duration of time since burn injury, the most significant results (P<0.001) were shown in year 5, where NAPLAN scores were increased an average of 4.8 points for each year following the burn injury, showing that as the duration of time since the burn injury lengthened, the NAPLAN scores improved.

Linear regression also demonstrated that for every added month of hospitalisation for children with burns, year 3 NAPLAN scores decreased in spelling (t-value: −2.37) and writing (t-value: −2.43) by 0.2 points (P<0.05). With every 10% increase in TBSA burn severity, year 5 domains showed large decreases ranging from 37 points in numeracy (t-value: −3.42) to 71.9 points in writing (t-value: −6.00).

DISCUSSION

This is the first study to objectively link school performance with childhood burn injury. We have demonstrated a clear disparity in school performance between children with and without burns, even after controlling for socioeconomic and gender differences. The differences were most prominent in primary school but persisted even for older children. We also found that the negative effect of burns on school performance increased with the severity of burns and with the age at which the burns were sustained, both findings which would tend to support this association. More extensive burns and a shorter duration between time of burn injury and time of test had worse outcomes.

There are, of course, mitigating circumstances towards a long-term outcome such as school performance. Indeed, there is a well-documented significant association between socioeconomic and family disparity to the risk of burn injuries.[9–14] This further highlights the need for support of any child with a burn injury as the factors that increase the risk of burns are also similar to those increasing the risk of poor academic outcomes.[9–14] Follow-up may be difficult in this cohort due to the time difference between the burn injury and the start of school for the child: the median age of burns in children in our study was 20 months, about 2.5 years before starting school for most Australian children. The improvement of NAPLAN scores as time since burn injury increased does highlight the acute nature of burn injuries and suggests that the concentration of impacts manifests earlier in a child's life after the initial incident. Therefore, a child's development postburn injury is amenable to improvement and this improvement may be facilitated by better rehabilitation. In addition, there was some evidence that the adverse impact of the burn injury might be reduced if the children attended a metropolitan school or if the mother was over 35 years of age. These findings may reflect easier access to medical care and improved financial resources typically associated with a more mature family unit.

The association between TBSA severity and poorer academic outcomes in year 5 suggests that the trauma of the burn injury exerts an independent risk in affecting school performance. It is well documented that increase in severity of the burn increases

Table 6 Linear regression on effects of years after burn injury, months follow-up in hospital and burn severity by TBSA on mean NAPLAN scores

Domain	Estimate	SE	t-value	P value
Effect of increase in years after burn injury, by year on NAPLAN average performance				
Year 3				
Grammar and punctuation	2.81	1.34	2.11	<0.05
Reading	1.56	1.28	1.22	0.22
Spelling	2.48	1.18	2.10	<0.05
Writing	0.8	1.11	0.72	0.47
Numeracy	1.41	1.07	1.32	0.19
Year 5				
Grammar and punctuation	5.36	1.18	4.53	<0.001
Reading	4.11	1.07	3.84	<0.001
Spelling	5.34	1.15	4.65	<0.001
Writing	5.14	1.17	4.40	<0.001
Numeracy	4.13	1.06	3.89	<0.001
Year 7				
Grammar and punctuation	0.90	1.80	0.50	0.6168
Reading	0.79	1.41	0.56	0.5786
Spelling	2.47	1.51	1.64	0.1020
Writing	0.99	1.59	0.62	0.5349
Numeracy	0.77	1.48	0.52	0.6044
Effect of increased follow-up in hospitalisation, by month on NAPLAN average performance				
Year 3				
Grammar and punctuation	−0.16	0.10	−1.62	0.11
Reading	−0.05	0.10	−0.52	0.61
Spelling	−0.21	0.09	−2.37	<0.05
Writing	−0.20	0.08	−2.43	<0.05
Numeracy				
Year 5				
Grammar and punctuation	0.00	0.09	0.01	0.99
Reading	−0.04	0.08	−0.50	0.62
Spelling	0.07	0.09	0.82	0.41
Writing	−0.06	0.09	−0.67	0.51
Numeracy				
Year 7				
Grammar and punctuation	−0.11	0.10	−1.05	0.30
Reading	−0.15	0.08	−1.76	0.08
Spelling	−0.06	0.09	−0.65	0.51
Writing	−0.1368	0.09	−1.48	0.14
Numeracy				
Effect of increase in TBSA by 10% on NAPLAN average performance				
Year 3				
Grammar and punctuation	8.63	15.93	−0.54	0.59
Reading	−26.08	14.99	−1.74	0.08
Spelling	−29.84	14.17	−2.11	<0.05
Writing	−8.04	12.94	−0.62	0.53
Numeracy	−12.4	12.6	−0.98	0.32
Year 5				
Grammar and punctuation	−50.04	12.53	−4.00	<0.001
Reading	−34.56	11.16	−3.10	<0.05
Spelling	−47.61	11.22	−4.24	<0.001
Writing	−71.89	11.98	−6.00	<0.001
Numeracy	−37.01	10.81	−3.42	<0.001
Year 7				
Grammar and punctuation	0.38	4.31	0.09	0.93
Reading				
Spelling	−3.54	3.51	−1.01	0.31
Writing	11.23	4.18	2.69	<0.05
Numeracy	−1.87	3.59	−0.52	0.60
Rates of burn severity by TBSA in burn injury cohort				
TBSA (%)	Rate (%)			
<10	1362 (87.5)			
10–19	132 (8.5)			
20–29	36 (2.3)			
30–39	14 (0.9)			
40–49	8 (0.5)			
50–59	1 (0.1)			
60–69	0			
70–79	0			
80–89	1 (0.1)			
90–99	2 (0.2)			

NAPLAN, National Assessment Plan for Literacy and Numeracy; TBSA, total body surface area.

the risk of complications including further admissions, infections, scarring and surgeries.[15–17] These factors may perhaps explain the association between the burn severity and academic outcomes.

Previous studies using self-assessment tools such as parent[18] or healthcare professional[16] surveys have found similar negative outcomes on academic outcomes but to date, and to our knowledge, there are no other published data on objective educational outcomes for children after a burn injury.

The association between burn injuries and educational outcomes is complex and is most likely intertwined with socioeconomic and family influences as well as health issues according to the current literature.[9–14] Children with burns may need repeated hospitalisations[1] and this disrupts the sequence of learning and peer interaction. Indeed, data show that academic performance is related to intelligence and school attendance.[17 19–21] Early identification (eg, from the time of the burn injury) to provide support for the children may have far-reaching ramifications, even into subsequent generations.[7]

One of the strengths of our study lies in the high linkage rates between burn injury admissions and education data. We obtained data from all three Australian school sectors (Catholic, government and independent), while previous studies linking only government schools were able to achieve linkage rates of only 56%.[22] The reasons for failure to link NAPLAN results to certain children cannot be determined from this study. Linkage rates are decreased if the identifiers are weak (eg, multiple name and address changes), but children may also move or not turn up for a test due to illness or parental objection (although this is not frequent in NSW). We found that matched children without burns had similar linkage rates to the rest of the children in NSW, suggesting that the burn injury itself was a significant association in lower linkage rates, perhaps due to higher rates of non-attendance for the test. This may in fact underestimate the poor academic outcomes of children with burn injuries as non-attendance of tests may be an indicator of long-standing school disruptions, although the exact reason for the lower linkage rate cannot be known.

Unfortunately, we did not have data on school attendance: both this and other factors should be examined in future studies

to better determine the mechanism by which burn injuries and subsequent disruptions may be associated with children failing to achieve their academic potential. Our study, nevertheless, shows that the long-term outcomes of any child admitted into hospital for burn injuries must not be neglected. The repercussions of an early life injury may not be appreciable until long after it has occurred. Other important factors that could potentially be explored in future studies include psychosocial sequelae, family support needs and the success of school reintegration programmes in order to clarify the mechanism by which burn injuries could contribute to poorer academic outcomes. This is a vital step to recognise as poor school outcomes will have devastating effects on both a personal and societal level, with important cost implications.[2,3] This flags the importance for clinicians in primary healthcare settings to identify children at increased risk of burn injuries and with more tailored prevention, intervention strategies and rehabilitation programmes improve the long-term outcomes of these children.

This project has identified several risk factors and associations that contribute to the impact of burns on a child's quality of life. More detailed prospective studies which delve into each of these risk factors may provide additional information on the question of the mechanism by which burn injuries affect long-term outcomes. Since academic performance influences a child's confidence, professional and social participation later in life, this places a great priority on clinicians to seek more efficient rehabilitation strategies with paediatric patients with burns. Some protective factors that could be explored in future research include ensuring support for family, psychosocial interventions and school rehabilitation interventions that span primary and secondary schools.

CONCLUSION

Our study has demonstrated an association between burn injuries and poorer academic outcomes. More severe burn injuries were associated with worse school outcomes, although as the time since the burn injury increased, school outcomes also improved. While it may not be possible for the children to return to school in a timely fashion because of their injuries, strategies could be put in place to minimise the children's displacement from mainstream learning and regular interaction with their peers. Future research into the psychosocial, family and health implications of burn injuries might elucidate the complex association between the burn injury and poorer academic outcomes. A better understanding of this association would provide potential targeted solutions to facilitate improved educational outcomes for both the child and their family well beyond completion of any physical treatment of the burn injury.

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