



Original research

Incidence, costs, and temporal trends of sports injury-related hospitalisations in Australian children over a 10-year period: A nationwide population-based cohort study

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ABSTRACT

Objectives: To quantify and describe the incidence, cost, and temporal trends of sports injury-related hospitalisations in Australian children over a 10-year period.

Design: Retrospective population-based cohort study.

Methods: This study used linked hospitalisation and mortality data of children aged ≤ 16 years who were hospitalised for sports-related injury in Australia from 1 July 2002 to 30 June 2012. Age-standardised incidence rates were calculated with 95% confidence intervals (CI). Negative binomial regression was used to examine change in temporal trends in incidence rates.

Results: There were 130,167 sports injury-related hospitalisations during the 10-year study period. The overall annual incidence rate was 281.0 (95%CI: 279.5, 282.6) per 100,000 population. Males and older children were more frequently hospitalised than their female and younger counterparts. The most common sports activities resulting in hospitalisation were team ball sports (43.1%) and wheeled non-motor sport (22.3%). There was no significant annual decline in the overall incidence rate during the 10-year study period (-1.0% [95%CI: -3.0% , 1.0%]). The estimated total hospital treatment cost was \$396 million, with an estimated mean cost per injured child of \$3058.

Conclusions: There has been no significant decline in sports injury-related hospitalisation rates among Australian children during 2002–03 to 2011–12. This may suggest that sports injury prevention initiatives in Australia to date have been inadequate to produce population-level reduction in sports injury-related hospitalisations. It is recommended that a national injury prevention strategy to reduce the burden of sports injuries among Australian children is developed and implemented.

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1. Introduction

Participation in sport and active recreation is widely encouraged for general health and wellbeing, especially to prevent illnesses related to obesity and a sedentary lifestyle.^{1,2} Although the benefits of regular physical activity are undisputed, participation in sport and active recreation is not without risk, and injury is a common adverse outcome.^{3,4} Notwithstanding the increasing recognition of the public health burden of sports injuries, there is very limited high-quality population-based data on incidence and costs of sports injury among Australian children.⁵

Decision makers need relevant information to prioritise and develop policy. In the absence of good quality evidence about the magnitude and impact of the sports injury problem in Australia, it is unsurprising that there is no national child sports injury prevention strategy currently in place. There have been some policy attempts in the past,^{6,7} but without a sustained and coordinated national strategy efforts to prevent and mitigate the sports injury problem are less likely to have population-level effects.⁸

To evaluate the potential impact of sports injury prevention strategies it is essential to identify and quantify temporal changes in injury incidence and costs. Population-based studies examining temporal trends in sports injury in Australia to date have relied on state-wide data only.^{5,9} One study of sport and leisure injuries among all ages in New South Wales found no significant decline in hospitalisations during the five-year period from 2003–04 to 2007–08.⁹ Another study of sport injuries among children aged ≤ 14

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years from Victoria revealed a significant decline in hospitalisations, but a large increase in Emergency Department presentations during the seven-year period from 2004 to 2010.⁵ The national burden of sports injury, however, remains unclear and there is a need for a population-based study examining nationwide trends in sports-related injury among Australian children. This study aims to quantify and describe the incidence, cost, and temporal trends of sports injury-related hospitalisations in Australian children aged ≤ 16 years over a 10-year period.

2. Methods

This retrospective population-based cohort study used linked hospitalisation and mortality records of Australian children aged ≤ 16 years who were hospitalised for a sports-related injury during 1 July 2002 to 30 June 2012. Ethical approval was provided by the Australian Institute of Health and Welfare and jurisdiction-based ethics committees.

The National Hospital Morbidity Database and jurisdiction-based hospitalisation data collections were used to collect hospitalisation record information from all Australian public and private hospital patient admissions. However, data collection from the Australian Capital Territory (ACT) was limited to 1 July 2004 to 30 June 2012. Diagnoses, external cause, and procedure codes in the hospitalisation data were classified using the International Classification of Diseases, 10th Revision, Australian Modification (ICD-10-AM). ICD-10-AM principal diagnosis codes S00–T78 (injuries) and external cause codes U50–U71 (sporting activities) were used to identify sports injury-related hospital admissions (Supplementary Appendix A).

The Australian Institute of Health and Welfare probabilistically linked the National Death Index mortality data with the hospitalisation records. This enabled the identification of mortality post-hospital discharge. The Western Australian hospitalisation and mortality records were probabilistically linked by the Western Australia Data Linkage Branch. Tasmanian hospitalisation records were linked using a unique patient identifier. Tasmanian hospitalisation records contained mortality post-discharge data.

The International Classification of Disease Injury Severity Score (ICISS) was used to estimate injury severity. The ICISS is derived by multiplying the probability of survival for each injury diagnosis using survival risk ratios.¹⁰ Injury severity was defined as minor (>0.99), moderate (0.941–0.99) or serious (<0.941) injury.¹¹ Chronic health conditions for children (i.e. conditions that last 12-months, require ongoing medical specialist health care and/or equipment, and limit the child's self-care, independence and social interactions) were identified.¹² Children were categorised as having none or ≥ 1 chronic health conditions.

The Australian Statistical Geographical Standard defines remoteness based on distance to service centres.¹³ The five categories of remoteness were collapsed into two categories: rural (i.e. very remote, remote, outer regional, and inner regional) and urban (i.e. major cities). A measure of socioeconomic status was assigned to each hospitalisation using the Index of Relative Socioeconomic Disadvantage¹⁴ and residential postcode. Socioeconomic disadvantage was partitioned into quintiles from most (i.e. 1) to least disadvantaged (i.e. 5).

Hospital costs were estimated using the Australian Refined-Diagnosis Related Groups (AR-DRGs), episode of care type (e.g. acute, rehabilitation) and length of stay. Estimates of hospital costs were used to determine the average daily cost per AR-DRG,¹⁵ which was multiplied by the episode of care length of stay up to 120 days, then a flat rate of \$200 per day was applied thereafter.¹⁶ The Australian Capital Territory and Tasmanian data for 2002–03

and 2003–04 were missing and were therefore not included in the calculations of costs. All costs are in 2009–10 Australian dollars.

All analyses were performed using SAS version 9.4 (SAS Institute, Inc., Cary, NC). All episodes of care related to a hospital stay were linked to form a period of care (i.e. all episodes of care from hospital admission until discharge from the health system). The Australian Bureau of Statistics population estimates for each State and Territory were used to obtain the number of young people aged ≤ 16 years. The Australian residential population at 30 June 2001 was used as the standard population to calculate age-standardised incidence rates, as recommended by the Australian Bureau of Statistics and the Australian Institute of Health and Welfare.¹⁷ All age-standardised incidence rates were calculated with 95% confidence intervals (CI). Negative binomial regression was used to examine percent change in the annual incidence of sports injury-related hospitalisations, adjusting for age group (i.e. 0–5 years, 6–10 years, and 11–16 years) and sex and using the log of the population as an offset. Because the data prior to 1 July 2004 from the ACT were not available, all data from the ACT were excluded from the incidence and trend analyses. Thirty-day mortality and 28-day readmission were calculated from the date of admission for the index sports injury-related hospitalisation.

3. Results

There were 130,167 sports injury-related hospitalisations of Australian children aged ≤ 16 years during the 10-year study period. The majority of hospitalisations occurred among male children (76.7%), children aged 11–16 years (72.6%), and children residing in urban locations (70.1%) (Table 1). About one-third (35.0%) of injuries were of moderate or serious severity, and there were 103 deaths within 30 days of hospital admission.

Team ball sports (43.1%) and wheeled non-motor sport (22.3%) accounted for almost two thirds of hospitalisations (see Supplementary Appendix B for more details). Compared to females, males had noticeably higher proportions of hospitalisations related to team ball sports (48.6% versus 25.0%) and wheeled motor sports (8.0% versus 3.0%), but lower proportions of hospitalisations related to equestrian activities (0.9% versus 13.0%) and acrobatic sports (1.2% versus 6.7%). These differences between males and females were observed across the age groups, although the overall proportions of hospitalisations by sports activity varied by age group. For instance, team ball sports accounted for only 8.6% of hospitalisations among children aged 0–5 years, but 50.3% of hospitalisations among children aged 11–16 years.

The elbow and forearm (31.9%) and head (20.2%) were the most frequently injured body regions, while fracture (63.1%) was the most common type of injury (see Supplementary Appendix C for more details). The proportion of head injuries was higher among males (21.2%) than females (16.7%), and the gender disparity was observed across all age groups. The proportion of injuries to the elbow and forearm was higher for females (36.2%) than males (30.7%), but the difference was observed among children aged 0–5 years and 6–10 years only. In regard to types of injury, the proportion of injuries to internal organs was higher among males (10.0%) than females (6.9%), and the gender disparity was observed across all age groups. The proportion of dislocations, sprains, and strains was lower for females than males among children aged 0–5 years (1.4% versus 2.2%) and 6–10 years (2.4% versus 3.4%), but higher among children aged 11–16 years (12.3% versus 7.2%).

The overall average annual incidence rate during the 10-year study period was 281.0 (95%CI: 279.5, 282.6) per 100,000 population. The average annual incidence rate in male children (419.7 [95%CI: 417.1, 422.4] per 100,000 population) was more than three times that of female children (134.8 [95%CI: 133.2, 136.3] per

Table 1

Characteristics and health outcomes of children aged ≤ 16 years with a sports injury-related hospitalisation, by sex and age group, linked hospitalisation and mortality data, Australia, 1 July 2002 to 30 June 2012.^{a,b,c,d,e}

Characteristic	0–5 years (n = 5930) No. (%)		6–10 years (n = 29,764) No. (%)		11–16 years (n = 94,464) No. (%)	
	Male (n = 3706) No. (%)	Female (n = 2232) No. (%)	Male (n = 19,282) No. (%)	Female (n = 10,482) No. (%)	Male (n = 76,906) No. (%)	Female (n = 17,558) No. (%)
Location of residence						
Urban	2636 (71.1)	1546 (69.3)	13,681 (71.0)	7320 (69.8)	54,216 (70.5)	11,892 (67.7)
Rural	1051 (28.4)	666 (29.8)	5492 (28.5)	3106 (29.6)	22,228 (28.9)	5559 (31.7)
Socioeconomic status						
1 (most disadvantaged)	651 (17.6)	361 (16.2)	3206 (16.6)	1616 (15.4)	12,422 (16.2)	2722 (15.5)
2	680 (18.4)	414 (18.6)	3776 (19.6)	2059 (19.6)	15,415 (20.0)	3607 (20.5)
3	829 (22.4)	489 (21.9)	3994 (20.7)	2192 (20.9)	16,506 (21.5)	3715 (21.2)
4	710 (19.2)	459 (20.6)	3768 (19.5)	2078 (19.8)	14,922 (19.4)	3399 (19.4)
5 (least disadvantaged)	808 (21.8)	485 (21.7)	4377 (22.7)	2445 (23.3)	16,971 (22.1)	3958 (22.5)
Chronic health conditions						
None	3673 (99.1)	2224 (99.6)	19,131 (99.2)	10,418 (99.4)	76,379 (99.3)	17,420 (99.2)
≥ 1	33 (0.9)	8 (0.4)	151 (0.8)	64 (0.6)	527 (0.7)	138 (0.8)
Injury severity						
Minor	2193 (59.2)	1481 (66.4)	12,778 (66.3)	7819 (74.6)	48,561 (63.1)	11,812 (67.3)
Moderate	1167 (31.5)	571 (25.6)	5414 (28.1)	2220 (21.2)	22,776 (29.6)	4785 (27.3)
Serious	346 (9.3)	180 (8.1)	1090 (5.7)	443 (4.2)	5569 (7.2)	961 (5.5)
Health outcomes						
30-day mortality	6 (0.2)	#	16 (0.1)	#	58 (0.1)	16 (0.1)
28-day readmission	305 (8.2)	199 (8.9)	1653 (8.6)	884 (8.4)	5758 (7.5)	1113 (6.3)

^a Data from Australian Capital Territory only available from 1 July 2004.

^b Sex was missing for 1 child.

^c Location of residence was missing for 773 children.

^d Socio-Economic Indexes for Areas (SEIFA) was missing for 1132 children.

^e # refers to cell size <5.

100,000 population). The average annual incidence rate in children aged 11–16 years (565.3 [95%CI: 561.7, 569.0] per 100,000 population) was more than twice that of children aged 6–10 years (220.2 [95%CI: 217.7, 222.7] per 100,000 population) and more than an order of magnitude higher than that of children aged 0–5 years (36.8 [95%CI: 35.9, 37.8] per 100,000 population).

There was no significant annual decline in the overall incidence rate during the 10-year study period (–1.0% [95%CI: –3.0%, 1.0%]; $P=0.302$). Fig. 1 depicts the trends in annual incidence rates by sex. There were no marked differences in trends observed for male and female children. There were slight declines in annual incidence rates for both male children (–0.5% [95%CI: –1.2%, 0.2%]; $P=0.160$) and female children (–1.0% [95%CI: –2.0%, –0.1%]; $P=0.028$); however, the decline was significant among female children only. Fig. 2 depicts the trends in annual incidence rates by age group. There were noticeable differences in trends observed for younger and older age groups. There were significant declines in annual incidence rates for children aged 0–5 years (–1.7% [95%CI: –2.6%, –0.8%]; $P<0.001$) and 6–10 years (–2.2% [95%CI: –2.9%, –1.6%]; $P<0.001$), whereas a significant increase in annual incidence rates was observed for children aged 11–16 years (1.2% [95%CI: 0.7%, 1.6%]; $P<0.001$).

The estimated total hospital treatment cost for Australian children with sports injuries was \$396 million over the 10-year study period, with an estimated mean cost per injured child of \$3058. The estimated mean cost per injured child was higher for males (\$3146) than females (\$2767), and for children aged 11–16 years (\$3222) than children aged 0–5 years (\$2632) and 6–10 years (\$2620). Wheeled motor sports injuries had the highest estimated cost per injured child (\$5471), while team ball sports had the highest estimated total costs per year (\$14.9 million) (See Supplementary Appendix D for more details).

4. Discussion

This is the first study to report nationwide trends in sports injury-related hospitalisations among Australian children over a 10-year period. It reveals that there has been no significant decline

in the overall sports injury-related hospitalisation rate during 2002–03 to 2011–12; however, there are diverging trends among different age groups. This study also demonstrates that child sports injury is a prevalent and costly population health problem, and that the burden varies by sex and age. Consequently, the findings of this study have implications for future child sports injury prevention strategies and efforts in Australia.

During the 10-year study period, the overall annual incidence rate of child sports injury-related hospitalisations remained relatively stable around 280 per 100,000 population. In the context of widespread interest in and multiple efforts to prevent child sports injuries, this lack of decline in hospitalisation rates is disappointing. It is unlikely that factors such as changes in ICD-10-AM coding practices and hospital admission policies have influenced the observed hospitalisation rates in this study.⁹ A more likely explanation is that child sports injury prevention efforts in Australia to date have been either wanting in real-world effectiveness or inadequately implemented to have had any discernible impact at the population-level. Alternatively, child sports injury prevention efforts may actually have been working, but the expected decline in hospitalisation rates has been offset by increasing sport participation.

To determine the most likely explanation it would have been useful to examine hospitalisation rates adjusted for sport participation in the study population. Unfortunately, there are very limited population data available of sports participation among Australian children. As a supplement to their Labour Force Survey, the Australian Bureau of Statistics (ABS) have conducted a Children's Participation in Cultural and Leisure Activities survey.¹⁸ However, the ABS survey was limited to children aged 5–14 years and was only conducted at three-year intervals between 2000 and 2012.¹⁸ Hence, for the purposes of the present study the ABS survey data were not suitable as denominator data, and hospitalisation rates were therefore calculated per resident population only. It is worth noting, however, that the ABS survey data indicate that the proportion of Australian children aged 5–14 years participating in organised sport outside of school hours decreased from 63% in 2006¹⁹ and 2009²⁰ to 60% in 2012.²¹ This apparent decrease in child sport participation suggests that the most likely explanation

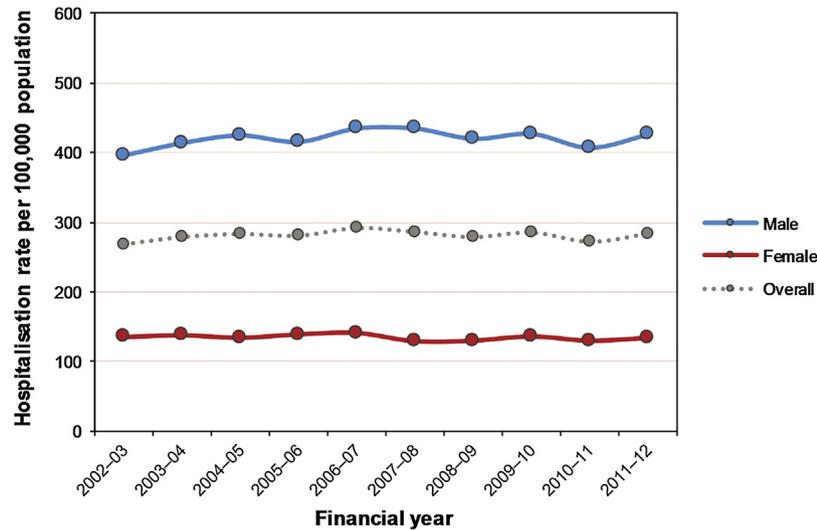


Fig. 1. Trends in sports injury-related hospitalisation rates for children aged ≤ 16 years by sex, linked hospitalisation and mortality data, Australia, 1 July 2002 to 30 June 2012^{a,b}.

^aExcludes data from the Australian Capital Territory.

^bSex was missing for 1 child, who was excluded from rate calculations.

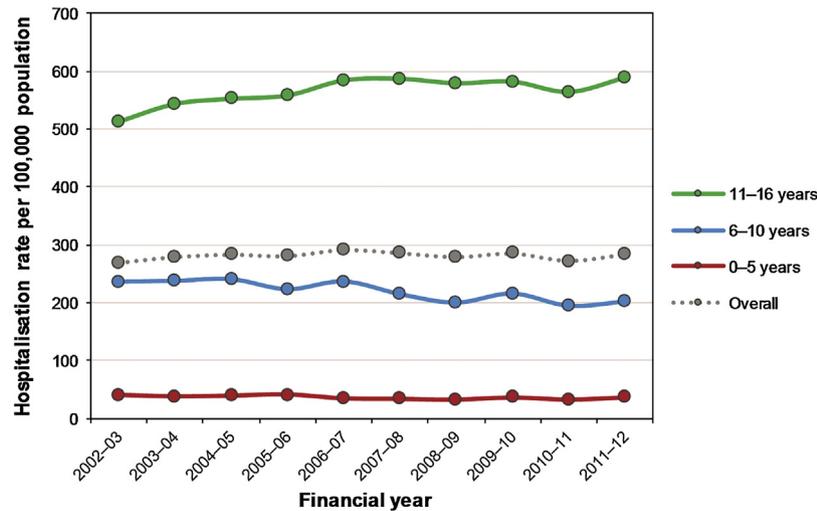


Fig. 2. Trends in sports injury-related hospitalisation rates for children aged ≤ 16 years by age group, linked hospitalisation and mortality data, Australia, 1 July 2002 to 30 June 2012^{a,b}.

^aExcludes data from the Australian Capital Territory.

^bSex was missing for 1 child, who was excluded from rate calculations.

for the lack of decline in hospitalisation rates is that child sports injury prevention initiatives in Australia have been either inadequate or ineffective at the population-level. In any event, to enable more accurate estimates of child sports injury trends, it is highly recommended that good quality estimates of sports participation among Australian children is captured and made available in future. Fortunately, the Australian Sports Commission has recognised this need, and with their annual AusPlay survey, which was introduced in October 2015, comprehensive national sports participation data from all ages has been available in Australia since December 2016.¹⁸

Although the overall sports injury-related hospitalisation rate remained stable during the 10-year study period, there were noticeable differences in trends among different age groups. That is, the hospitalisation rate among younger children declined, on average, approximately 2% per year, while it increased more than 1% per year among children aged 11–16 years. The reason for these diverging trends is unclear, but may be related to differential changes over time in injury prevention initiatives and/or sports participa-

tion. Again, better quality data on child sport participation would be needed to elucidate the underlying causes of the diverging trends in sports injury-related hospitalisation rates observed in this study.

Consistent with previous studies of sports injury-related hospitalisations in Australia,^{9,22,23} this study found that males and adolescents presented to hospital three times more frequently than their female and younger child counterparts. This study, moreover, revealed important differences in the burden and pattern of sports injury across sex and age groups. For instance, males were more frequently hospitalised for injury related to team ball sports and wheeled motor sports, while females had higher proportions hospitalisations related to equestrian activities and acrobatic sports. Importantly, not only were these gender differences observed across all age groups, they became more accentuated in older age groups. These findings suggest that it may be appropriate to develop and implement targeted child sports injury prevention strategies from very early ages. In particular prevention initiatives targeting team ball sports and wheeled non-motor sport would be

vital to significantly reduce the overall burden of child sports injury at the population-level in Australia.

With an estimated total hospital treatment cost of almost \$40 million each year, child sports injury is a significant public health issue in Australia. Indeed, a previous study of child injury in Victoria reported that the total treatment costs of sports injury-related hospitalisations is more than 2.5 times greater than that of hospital-treated road traffic injury.⁵ There is a clear need for a concerted and coordinated national strategy for preventing sports injury among Australian children. The experience with the Accident Compensation Corporation system in New Zealand over the past 30 years suggests that national sports injury prevention programs can be cost effective if supported and managed systematically by government.²⁴ It is essential that key stakeholder groups (e.g. health and sport government agencies, peak sports governing bodies, sports medicine professional bodies, and injury prevention experts) come together and jointly develop and implement safety policies and programs to reduce the burden of sports injury among Australian children.

There were several limitations to this research. Information on sport injury-related hospitalisations in the Australian Capital Territory prior to 1 July 2004 was not available. Valid AR-DRG classification was not available for the Australian Capital Territory and Tasmania data during 2002–03 and 2003–04, which has resulted in the under-enumeration of total hospital treatment costs. In addition, 20.4% of hospital records from Victoria were not able to be linked, which has resulted in under-enumeration of sports injury-related hospitalisations and treatment costs. Because there was no available information about the number of Australian children participating in sports over the whole study period, only incidence rates per resident population were calculated in this study. It is also worth pointing out that this study does not capture the full picture of sports injuries in Australian children because many sports injuries not represented in hospitalisation data. It has been estimated that for each sports injury-related hospitalisation, there are approximately 11 presentations to Emergency Departments and 12 visits to primary care physicians.²⁵

5. Conclusion

There has been no significant decline in sports injury-related hospitalisation rates among Australian children aged ≤ 16 years during 2002–03 to 2011–12. This may suggest that sports injury prevention initiatives in Australia to date have been inadequate to produce population-level reduction in sports injury-related hospitalisations. To provide more comprehensive evaluations of population-level impacts of sports injury prevention efforts, it is recommended that future studies incorporate good quality child sports participation data and estimate sports participation-based injury rates. It is recommended that a national injury prevention strategy to reduce the burden of sports injuries among Australian children is developed and implemented.

Practical implications

- Approximately 13,000 Australian children aged ≤ 16 years are hospitalised with a sports-related injury each year, with an estimated hospital treatment cost of almost \$40 million.
- Overall, there has been no significant decline in annual sports injury-related hospitalisation rates among Australian children aged ≤ 16 years over the 10-year period from 2002–03 to 2011–12.
- There are noticeable differences in trends across age groups, with decreasing rates for young children (0–5 and 6–10 years) and increasing rates for older children (11–16 years).

- There is a need to develop and implement a targeted national injury prevention strategy to reduce the burden of sports injuries among Australian children.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.jsams.2018.07.010>.

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