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Incidence, Trends, and Seasonality of Paediatric Injury-Related Emergency Department Presentations at a Large Level 1 Paediatric Trauma Centre in Australia

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Abstract: This retrospective cohort study aimed to examine the characteristics, incidence, temporal trends, and seasonality of paediatric injury-related Emergency Department (ED) presentations at a large metropolitan paediatric hospital. It included children aged ≤15 years who presented to the ED at The Children's Hospital at Westmead, Sydney Australia, with a principal diagnosis of injury during the ten-year period from 1 January 2010 to 31 December 2019. Descriptive statistics were used to describe the characteristics of the cohort and the distribution of ED presentations by mode of arrival, triage category, discharge status, injury diagnosis. Negative binomial regression was used to examine percentage change in annual incidence. Seasonality was examined with Seasonal and Trend decomposition using Loess (STL). There were 134,484 (59.7% male children) paediatric injury-related ED presentations during the ten-year period, of which 23,224 (17.3%) were admitted to hospital. Head injury accounted for more than one-quarter (26.8%) of ED presentations. The average annual increase in incidence was more pronounced during the first five years (5.6% [95%CI 4.1% to 7.1%]) than in the last five years (0.8% [95%CI 0.2% to 1.5%]). The monthly incidence of ED presentations had a bimodal distribution with peaks during autumn (March–May) and spring (October–November) seasons. The mean number of ED presentations per day was higher on weekends (40.8 ± 0.3) than weekdays (35.3 ± 0.8). During 2010 to 2019, there was a significant increase in the annual incidence of injury-related ED presentations for children aged ≤15 years, with head injury accounting for more than one-quarter of the ED presentations. The incidence of paediatric injury-related ED presentations was higher during autumn and spring seasons and at weekends. These data will inform health resource planning and priority-setting and advocacy for child injury prevention strategies in Australia.

Keywords: injury; trauma; incidence; seasonality

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1. Introduction

Injury is a leading cause of hospitalisation, long-term disability, and death among children worldwide [1–4]. In Australia, injury is the leading cause of death for children aged 1 to 16 years [5], with about 1 in 67 children admitted to hospital for injury every year [6]. Previous research has reported no significant decline in the annual incidence of injury-related hospitalisations in Australian children between 2002 and 2012 [6]; however, it remains unclear whether this trend persisted during the subsequent decade.

The societal burden of paediatric injuries is very large. In Australia, the direct hospital treatment costs of child injury-related hospitalisations alone are estimated to be in excess of A$200 million [6]. Beyond the initial trauma, an injured child may experience ongoing physical limitations, chronic pain, and psychological issues, such as post-traumatic stress disorder [7]. Furthermore, paediatric injuries can have considerable impact on families, including parents being at increased risk of developing mental and emotional distress [8–10].

Current epidemiological data on paediatric injury is essential for quantifying the burden of injury and associated costs, monitoring injury trends, determining health resource planning, priority-setting of injury prevention strategies, and for evaluating the impact of injury prevention measures [6,11]. It is envisaged that continued improvements in prehospital care, trauma management, and advocacy for effective child injury prevention measures, will lead to future gains in reducing the burden and improving health outcomes of paediatric injury [1,12,13]. This study aimed to examine the characteristics, incidence, temporal trends, and seasonality of injury-related paediatric Emergency Department (ED) presentations at a large metropolitan paediatric hospital in Sydney, Australia, during the ten-year period from 2010 to 2019.

2. Materials and Methods

2.1. Study Design and Population

This is a retrospective cohort study of children aged ≤15 years who presented to the ED at The Children's Hospital at Westmead (CHW), Sydney, New South Wales, Australia, with a principal diagnosis of injury during the ten-year period from 1 January 2010 to 31 December 2019. The CHW is the largest paediatric centre in New South Wales, with an estimated 29,000 hospital admissions, 51,000 ED presentations, and 960,000 outpatient occasions annually. Injury-related ED presentations were identified using International Classification of Diseases, 10th Revision, Australian Modification principal diagnosis codes for injury (ICD-10-AM: S00-T78) [14]. Ethical approval was provided by the Sydney Children's Hospitals Network Human Research Ethics Executive Committee (reference number: 2020/ETH00083).

2.2. Data Sources

Data were obtained from the CHW ED information system. The ED presentation data included information on patient demographics (i.e., sex, age, and residential postcode), arrival and departure dates and times, mode of arrival, triage category, departure status, and principal diagnosis.

A measure of socioeconomic disadvantage was mapped to the residential postcode for each child using the Index of Relative Socioeconomic Disadvantage (IRSD) [15]. The IRSD is derived from Australian population census data about the economic and social conditions of people and households within an area (e.g., household income, education, employment, and occupation). Lower IRSD scores indicate greater socioeconomic disadvantage, and all areas are ranked from lowest to highest score and categorised into quintiles.

Each ED presentation was assigned an International Classification of Injury Severity Score (ICISS) using previously validated survival rate ratios for a paediatric population [16,17]. The ICISS was categorised as serious injury (ICISS $\leq$ 0.98), moderate injury (ICISS 0.98–0.99), and minor injury (ICISS $\geq$ 0.99) [16].

2.3. Data Analysis

Descriptive statistics were used to present the characteristics of the cohort and the distribution of ED presentations by mode of arrival, triage category, discharge status, injury diagnosis. Negative binomial regression was used to examine percentage change in annual incidence. Seasonality was examined with Seasonal and Trend decomposition using Loess (STL) and the methods for computing measures of trend and seasonal strength described by Hyndman and Athanasopoulos [18]. The values for trend and seasonal strength can range from 0 to 1, with higher values indicating stronger evidence of trend or seasonality. All of

the analyses were conducted using R version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria) and the *forecast* and *tsfeatures* packages.

3. Results

A total of 134,484 children aged ≤15 years presented to the ED at CHW for injury during the ten-year period from 2010 to 2019. Of these, 59.7% were male children, 45.0% were children aged 1–5 years, and 85.6% arrived by private car (Table 1). Figure 1 depicts the distribution of injuries by sex and age. With regards to severity, 88.8% of the injuries were minor, 10.3% were moderate, and 0.9% were serious. A total of 17.3% of children were admitted to hospital, and 13 children died. The most common types of injury were head injuries (26.8%), elbow and forearm injuries (15.2%), and wrist and hand injuries (10.5%) (Table 2).

Table 1. Characteristics of paediatric injury-related ED presentations, 1 January 2010 to 31 December 2019 (*N* = 134,484).

Characteristic	*N* (%)
Sex	
Male	80,297 (59.7)
Female	54,187 (40.3)
Age group	
0 years	7852 (5.4)
1–5 years	60,550 (45.0)
6–10 years	33,824 (25.2)
11–15 years	32,258 (24.0)
Socioeconomic disadvantage [1]	
1 (most disadvantaged)	32,812 (24.6)
2	11,018 (8.3)
3	17,963 (13.5)
4	32,649 (24.5)
5 (least disadvantaged)	38,744 (29.1)
Mode of arrival	
Private car	115,079 (85.6)
Ambulance	17,885 (13.3)
Walk-in	563 (0.4)
Public transport	428 (0.3)
Hospital transport	335 (0.2)
Other	194 (0.1)
Triage category [2]	
Less urgent condition	18,706 (13.9)
Potentially serious condition	88,379 (65.7)
Potentially life-threatening condition	22,772 (16.9)
Imminently life-threatening condition	3342 (2.5)
Immediately life-threatening condition	1283 (1.0)
Injury severity	
Minor (ICISS > 0.99) [3]	119,376 (88.8)
Moderate (ICISS 0.98–0.99) [3]	13,904 (10.3)
Serious (ICISS < 0.98) [3]	1204 (0.9)
Departure status	
Discharged	110,185 (81.9)
Admitted	23,224 (17.3)
Departed	876 (0.7)
Transferred	186 (0.1)
Died	13 (0.0)

[1] Socioeconomic status was missing for *n* = 1298 children. [2] Triage category was missing for *n* = 2 children. [3] ICISS: International Classification of Injury Severity Score.

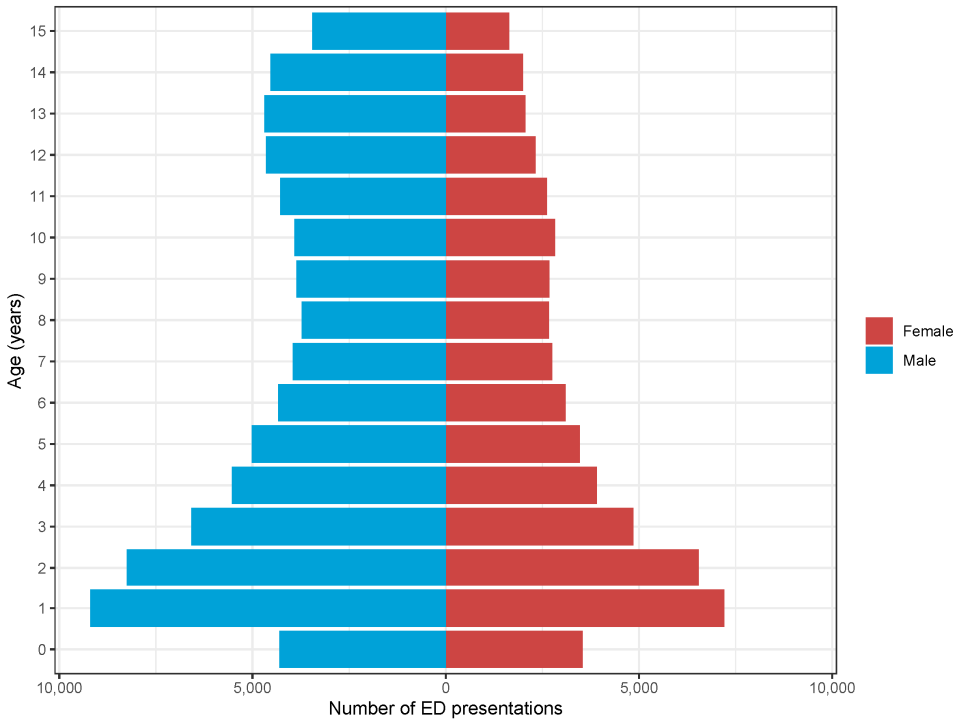

Figure 1. Distribution of paediatric injury-related ED presentations by sex and age, 1 January 2010 to 31 December 2019 (*N* = 134,484).

Table 2. Frequencies and proportions of paediatric injury-related ED presentations, 1 January 2010 to 31 December 2019 (*N* = 134,484).

Diagnosis	*N* (%)
Injuries to the head (S00-S09)	36,034 (26.8)
Superficial injury of head (S00) [1]	2878 (2.1)
Open wound of head (S01) [1]	13,243 (9.9)
Fracture of skull and facial bones (S02) [1]	4207 (3.1)
Dislocation, sprain, and strain of joints and ligaments of head (S03) [1]	41 (0.0)
Injury of eye and orbit (S05) [1]	2297 (1.7)
Intracranial injury (S06) [1]	2259 (1.7)
Other and unspecified injuries of head (S09) [1]	10,990 (8.2)
Injuries to the neck (S10-S19)	665 (0.5)
Injuries to the thorax (S20-S29)	158 (0.1)
Injuries to the abdomen, lower back, lumbar spine and pelvis (S30-S39)	937 (0.7)
Injuries to the shoulder and upper arm (S40-S49)	9568 (7.1)
Injuries to the elbow and forearm (S50-S59)	20,502 (15.2)
Injuries to the wrist and hand (S60-S69)	14,155 (10.5)
Injuries to the hip and thigh (S70-S79)	1448 (1.1)
Injuries to the knee and lower leg (S80-S89)	8871 (6.6)
Injuries to the ankle and foot (S90-S99)	5895 (4.4)
Injuries involving multiple body regions (T00-T07)	390 (0.3)
Injuries to unspecified part of trunk, limb or body region (T08-T14)	13,486 (10.0)
Effects of foreign body entering through natural orifice (T15-T19)	7518 (5.6)
Burns (T20-T31)	5031 (3.7)
Poisoning by drugs, medicaments and biological substances (T36-T50)	834 (0.6)
Toxic effects of substances chiefly nonmedicinal as to source (T51-T65)	950 (0.7)
Other and unspecified effects of external causes (T66-T78)	5334 (4.0)
Certain early complications of trauma (T79)	85 (0.1)
Complications of surgical and medical care (T80-T89)	2623 (2.0)

[1] Individual diagnosis codes under the S00-S09 diagnosis block.

The mean annual incidence of paediatric injury-related ED presentations was 13,448 (95%CI 13,222 to 13,678). The average annual increase in incidence was 2.5% (95%CI 1.6% to 3.4%) during the ten-year study period, with the average annual increase in incidence being more pronounced during the first five years (5.6% [95%CI 4.1% to 7.1%]) than in the last five years (0.8% [95%CI 0.2% to 1.5%]) (Figure 2).

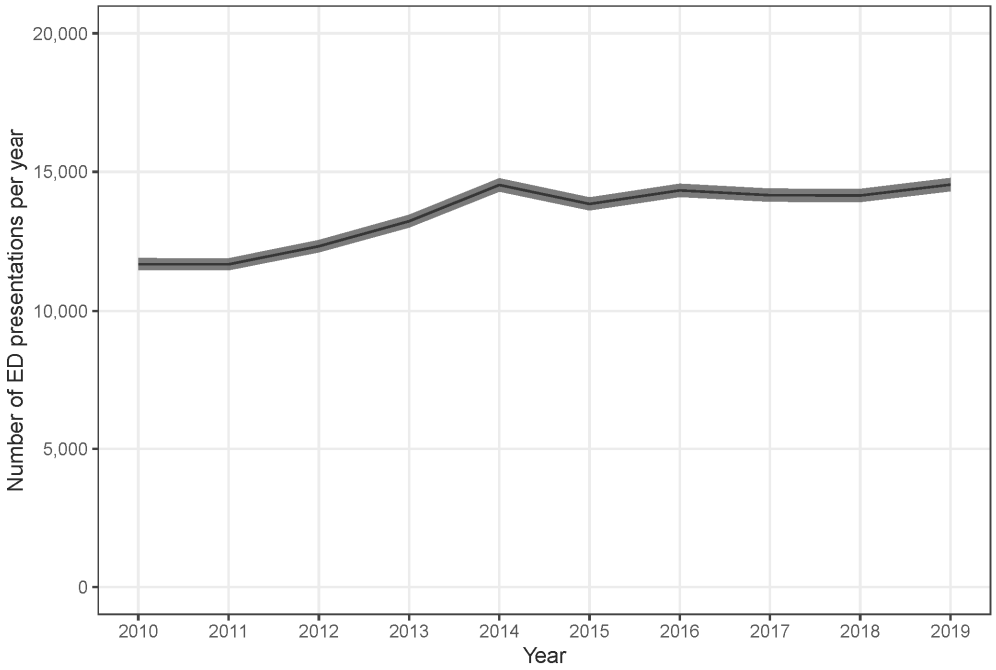

Figure 2. Annual incidence of paediatric injury-related ED presentations, 1 January 2010 to 31 December 2019 (N = 134,484).

Figure 3 shows the mean number of paediatric injury-related ED presentations by month of the year (A), by day of the week (B), and by hour of the day (C). Decomposition of monthly incidence revealed a clear trend over time (strength: 0.835) and seasonality (strength: 0.741), with peaks during March–May and October–November and troughs during June–September and December–January (Figure 4). The mean number of paediatric injury-related ED presentations per day was higher on weekends (40.8 $\pm$ 0.3) than weekdays (35.3 $\pm$ 0.8). There was a clear diurnal pattern, with the mean number of paediatric injury-related ED presentations per hour rising from less than 0.3 during 01:00 to 06:59, to about 1.5–2.1 during 07:00 to 13:59, and to about 2.6–3.0 during 14:00 to 20:59, before declining precipitously during 21:00 to 00:59.

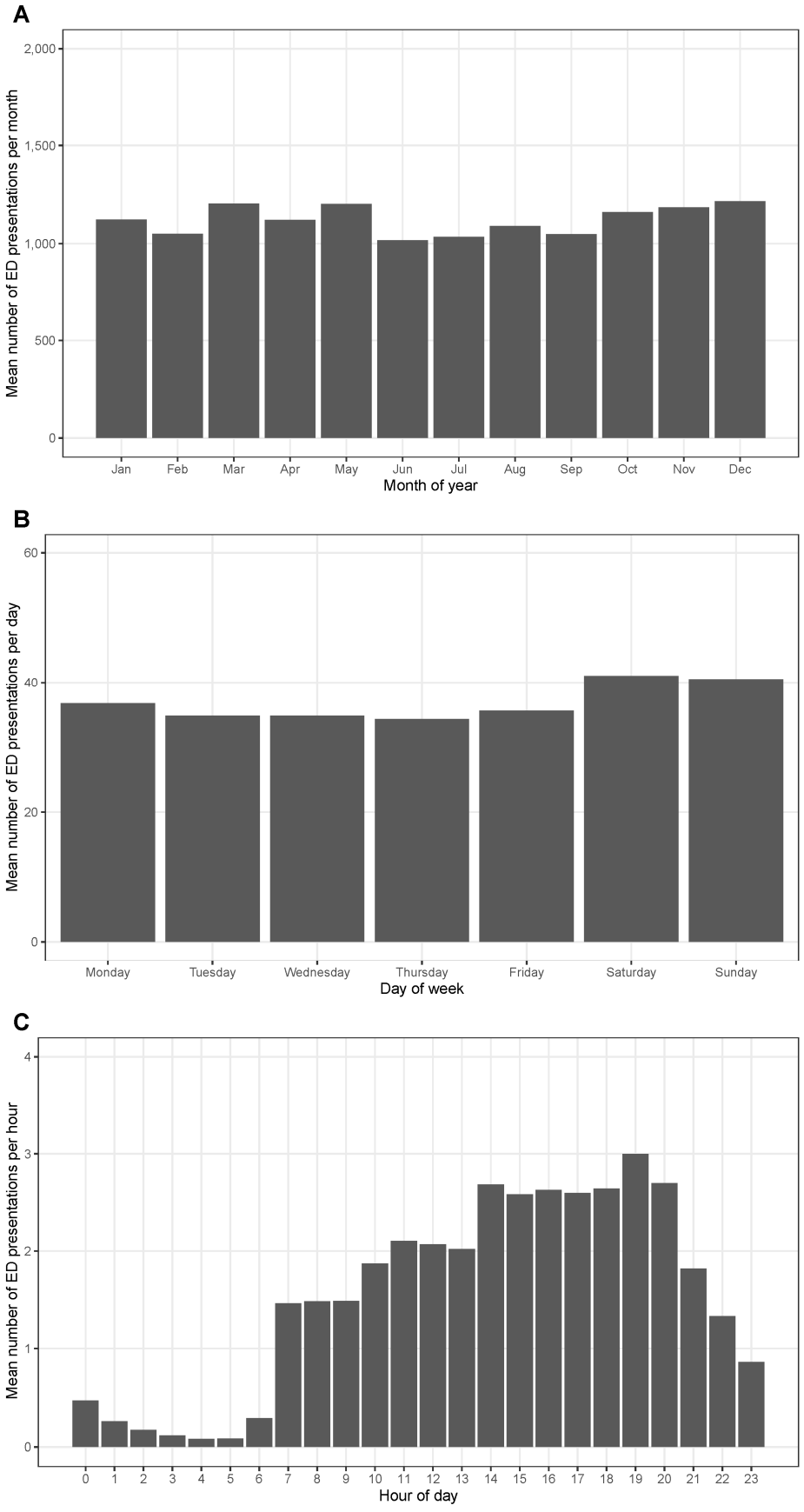

Figure 3. Mean number of paediatric injury-related ED presentations by month of year (**A**), day of week (**B**), and time of day (**C**).

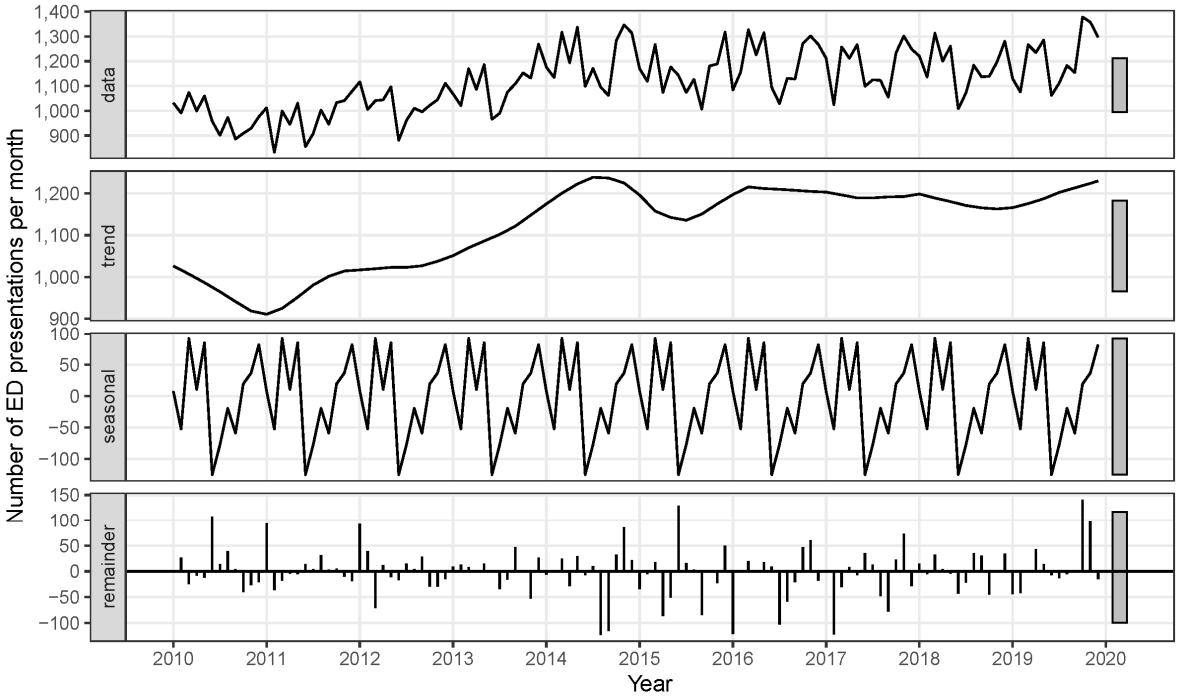

Figure 4. Seasonal and trend decomposition of paediatric injury-related ED presentation data.

4. Discussion

This study provides much-needed data on recent trends in paediatric injury-related ED presentations in Australia. During the ten-year period from 2010 to 2019, there was a significant increase in the annual incidence of injury-related ED presentations for children aged ≤15 years. It found head injury was the most common type of injury, accounting for more than one-quarter of paediatric injury-related ED presentations. The data also displayed clear patterns in the incidence of paediatric injury-related ED presentations, including diurnal, weekly, and seasonal variations.

The annual incidence of paediatric ED presentations increased by 5.6% per year during 2010 to 2014, before subsiding during 2015 to 2019. There are very limited data examining recent trends of paediatric injury in Australia to which we can compare our findings, with little nationwide data post-2012 and statewide data post-2017 [6,19–21]. Nonetheless, all of these investigations agree that there has been no reduction in paediatric injury in recent decades. This lack of decline is disappointing considering that injury prevention has been designated as a national public health priority area in Australia for more than two decades [22]. Unfortunately, Australia's most recent national injury prevention strategy expired in 2014 [23], and although a new national strategy is currently under development (consultations closed in July 2020) [24], it is yet to be delivered at the time of this writing. With injury continuing to represent a substantial burden to the Australian community (i.e., 7.6% of total health expenditure) [25], the development of a national injury prevention strategy is long overdue.

Head injury accounted for more than one-quarter (26.8%) of paediatric injury-related ED presentations. This finding aligns with previous research showing that head injury comprised 23.9% of injury-related hospitalisations among Australian children [6,26]. Although data on mechanism of injury were not available for this study, previous research have highlighted that falls and road trauma were the most common mechanisms of head injury in children (i.e., 45.2% and 16.0%, respectively) [26]. In particular, falls from furniture or while being carried for children <1 year, falls at playgrounds for children aged 6–10 years, and road trauma for children aged 11–16 years, which suggests the need for greater awareness of falls prevention and road safety among children and their caregivers [26–28].

There was clear seasonal variation in the monthly incidence of paediatric injury-related ED presentations, with a bimodal distribution with peaks during March–May and October–November, which corresponds to autumn and spring, respectively. Previous studies have reported mixed findings on seasonal variation in the incidence of paediatric injuries. Similarly to the present study, Zacay and colleagues [29] observed a bimodal distribution of paediatric orthopaedic trauma in Israel, with peaks during spring and autumn. In contrast, both Agar and colleagues [30] and Livingston and colleagues [31] observed a unimodal distribution of paediatric orthopaedic trauma presentations in Turkey and the United States, respectively. While Agar and colleagues [30] reported the incidence peaking during June–July (summer), Livingston and colleagues [31] observed the highest incidence during September (autumn). The mixed findings across the studies are likely related to differences in local context and climate because the incidence of paediatric trauma is linked to weather (i.e., temperature, precipitation, hours of sunshine) [30–32]. In addition to seasonal variation, this study observed that there were, on average, about 15% more paediatric injury-related ED presentations per day on weekends than on weekdays. Although Agar and colleagues [30] found a higher incidence of paediatric orthopaedic trauma presentations during weekdays, the majority of studies concur that the incidence of paediatric trauma is usually higher on weekend than weekdays [31,32]. The above findings regarding variations by month of year and day of week may have implications for resource planning for trauma care provision and injury prevention plans.

The main strengths of this study include its large dataset and its application of advanced analytic methods for computing measures of trend and seasonality. The generalisability of the findings in this study may be limited because the data were obtained from a single hospital only, albeit one of the largest paediatric Level 1 trauma centres in Australia. Unfortunately, no specific denominator data on children aged $\leq$15 years were available for the CHW catchment area, which precluded calculation of age- and sex-adjusted incidence rates of paediatric injury-related ED presentations. Local government areas within the CHW catchment area have experienced significant general population growth (approximately 2% per annum [33]) during the study period, which may partly account for the observed trend of increasing incidence of paediatric injury-related ED presentations. The data source for this study did not contain ICD-10-AM coded data on external causes of injury, which precluded any analysis exploring injury mechanisms of the paediatric injury-related ED presentations.

5. Conclusions

There was a significant increase in the annual incidence of injury-related ED presentations for children aged $\leq$15 years during 2010 to 2019, with head injury accounting for more than one-quarter of the ED presentations. The incidence of paediatric injury-related ED presentations is higher during autumn and spring seasons, at weekends, and during afternoon and evenings. These data will inform health resource planning and priority-setting and advocacy for child injury prevention strategies in Australia.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Sydney Children's Hospitals Network Human Research Ethics Executive Committee (reference number: 2020/ETH00083).

Informed Consent Statement: Patient consent was waived because it involved a secondary analysis of administrative data, which could not practicably be carried out without a waiver of consent.

Data Availability Statement: The data used in this study are available at reasonable request from The Children's Hospital at Westmead, Sydney, Australia, subject to obtaining relevant ethics and governance approvals required by the hospital.

Conflicts of Interest: The authors declare no conflict of interest.

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