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Original research

Epidemiology of hospital-treated cricket injuries sustained by women from 2002–2003 to 2013–2014 in Victoria, Australia

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ABSTRACT

Objectives: To present the first comprehensive epidemiological profile of hospital-treated injuries sustained by female cricketers from 2002–2003 to 2013–2014 in Victoria, Australia.
Design: Analysis of routinely collected hospital data (detailed case-series).
Methods: A retrospective analysis of hospital-treatment data associated with cricket injuries sustained by women between 1 July 2002 and 30 June 2014, inclusive were extracted from databases held by the Victorian Injury Surveillance Unit in Australia.
Results: Over the 12-year period, 668 cases were treated in Victoria. Of these, 547 were emergency department (ED)-presentations. There were 121 hospital-admissions, of which, the length of stay was <2 days for 78.5% cases. All cases were treated and released, and no fatalities were reported. The 10–14 year age group most frequently presented to ED (19.9%) and were most commonly admitted to hospital (16.5% of the total admissions). Fractures were the most common cause of hospital-admissions (47.1%) but only accounted for 17.2% of the ED-presentations. Dislocations, sprains and strains, were the most common (36.4%) cause of ED-presentations. The head was the most commonly injured anatomical location (27.8% of ED-presentations and 28.1% of hospital-admissions), followed by the wrist and hand (27.8% ED-presentations and 17.4% hospital-admissions).
Conclusions: These findings provide the first overview of the nature of injuries requiring hospital attendance in female cricketers, and a foundation to inform the development of targeted injury prevention programs for female cricketers.

Practical implications

- Players aged 10–14 years were most frequently sought treatment from a hospital and correspond with the female cricket participation figures. The higher frequency of hospital-presentations might be because young players have less, and more varied game skill levels compared to adult players and should be a focus for development of prevention strategies.
- The high incidence of head injuries is a concern and maybe indicative of the need to make players more aware of the Cricket Australia's concussion and head trauma policy across all matches and use of protective equipment as well as skill development to minimise the injury risk.
- The high incidence of joint-related injuries reported in this study is a concern and may be indicative of the need to develop targeted, cricket-specific, neuromuscular injury prevention programs for the women's form of the game.
- There was a relatively high incidence of fractures in female players who are in their adolescence and young adulthood. Therefore, it is important that future studies examine causative factors associated with the risk and type of fractures in this age group, with subsequent implementation and evaluation of injury prevention strategies.

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1. Background

Cricket has the highest participation rate of any sport in Australia[1] and is experiencing an increase in popularity among women. Injury surveillance data from Australian Emergency Departments (EDs), combining both males and females, have previously ranked cricket as one of the top ten sports associated with sport injury[2,3] with the head (44.2%), upper (33.9%) and lower extremity (15.5%) injuries being the most frequent.[2] These rankings are likely to be inaccurate because, in general, sports with the highest number of participants have the highest frequency of hospital-treated injuries unless the participation data is adjusted for. In 2003, self-reported data from a community-based survey, cricket was ranked as the sport with the highest rate of injuries per 1000 participants (242 injuries per 1000 participants).[3]

Women's cricket is growing at the national and international level. In the 2016–2017 season, 27.5% Australian cricket participants were female[4] which then increased to 30% in the 2017–2018 season.[5] Therefore, it is important to understand the extent and types of injuries sustained by female players to inform and underpin targeted injury prevention strategies. Most of our present understanding of women's cricket injuries is limited,[6,7] with only a few studies describing injuries presenting for treatment in a hospital.[2,3] Most of the available injury data for cricket in Australia is pooled across both sexes together, and to date there have been no comprehensive studies of injuries for a well-defined population of recreational female cricketers in the peer-review literature. Therefore, this study aims to present the first comprehensive epidemiological profile of hospital-treated injuries sustained by female cricketers from 2002–2003 to 2013–2014 in Victoria, Australia.

2. Methods

De-identified hospital-treatment data on injuries sustained by female cricketers were obtained from Victoria, Australia, for the period 1 July 2002–30 June 2014, inclusive. The Victorian Injury Surveillance Unit (VISU) which is funded by the Victorian Department of Health[8] manages the injury-specific subsets of two hospital based databases, namely the Victorian Emergency Minimum Dataset (VEMD: ED-presentations) and the Victorian Admitted Episodes Dataset (VAED: hospital-admissions). The VEMD records data on all ED-presentations to the 39 public hospitals providing a 24-h ED service with 100% coverage of all cases that present at a public hospital EDs in Victoria.[9] It is estimated that 6% of all ED-presentations in Australia are to a private hospitals and not recorded in the VEMD.[10,11] Therefore, it is likely that the VEMD data covers approximately 94% of all EDs in Victoria. The data is coded using the VEMD user manual 16th edition.[12] Each de-identified unit record represents the first ED-presentation for an injury.

Upon our request, VISU extracted data on all of the cases of women's cricket injuries from the VEMD and VAED from 1 July 2002 and 30 June 2014, inclusive. The variables relevant to identifying cricket-related injury cases within the VEMD database were:

- a primary diagnosis of an injury or additional diagnoses relating to an injury; and
- a description of the injury event and/or the activity at the time of the injury indicating cricket was selected.

Then the 250-character narratives were searched to extract data from the VEMD using the following criteria:

- the code for the activity at the time of sustaining the injury was cricket; and/or
- the description of the injury indicated that the person was playing cricket; and/or
- the narrative mentioned that the injured person was engaged in a cricket-related activity when injured.

The VAED records relate to all hospital-admissions to private and public hospitals, rehabilitation centres, extended care facilities and day procedure centres across Victoria; therefore, there is 100% coverage of all hospital-admissions across the state of Victoria. The injury cases recorded on the VAED are coded to the external causes chapter of the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM).[13] Each record represents an entire episode of care, rather than a single injury incident. Thus, replication can occur if patients are transferred within and between hospitals for various care episodes in relation to one injury. Where possible, VISU excluded transfers and re-admission cases from all reports/standard data output provided to the authors to minimise the impact of this potential over-counting of incident cases.

Cases were selected if the place of occurrence of the injury was an athletic/sporting area, a place of recreation or a school environment. We wanted to investigate cricket injuries sustained by participating in the formal format of the game. Therefore, cases from the VAED database were included if they were coded to ICD-10-AM activity code U51.1 (Cricket) AND had one of the following location codes: sports and athletic areas: Y92.30: sporting grounds (outdoor); Y92.31: sporting hall (indoor); Y92.38: other specified sports and athletic area; and Y92.39: sporting and athletic area (unspecified).[13] However, despite out best efforts, if a family played recreational cricket at an oval and then needed treatment from a hospital, then this scenario is likely to be included in the dataset because it will come under sports and athletic areas: Y92.30: sporting grounds (outdoor). The inability to separate out formal from informal sport is a known limitation of this type of data.[14,15] Data were provided by VISU in a standard output format (Appendix A in Supplementary material).

The total state-specific participation figures (formal participation in programs and competitions) were extracted from the National Cricket Census from the 2002–03 to 2013–14 seasons for Victoria. This enabled the calculation of participant-adjusted incidence rates per 1000 participants.

Participant-adjusted annual incidence rates were calculated for ED-presentations, hospital-admissions and for overall hospital-treated cases (i.e. ED-presentations and hospital-admissions) using the following formula:[16]

$$\textit{Incidence rate per } 1000 \textit{ participants} = \frac{\textit{number of cases}}{\textit{number of participants}} \times 1000$$

The annual frequency of hospital-treated cases was calculated by summing the ED-presentation and hospital-admission cases for each financial year/season. The length of hospital stay is a proxy indicator of the severity of the hospitalised injury cases in the VAED.[2,3] The proportion of cases admitted to a hospital ward (VAED data) following an ED-presentation (VEMD data) was therefore used to infer the severity of injury cases. The length of stay (VAED data) was also used as an indication of the severity of the hospitalised injury cases. However, there is a possibility that admission to a hospital and length of stay may reflect complexity of treatment rather than severity of the injury. Further, it should be noted that the selected cases from the VEMD represent ED-presentations only, and the selected cases from VAED include hospital-admissions and only counted once in the VISU data. The VAED is an episode-of-care database, not an injured person database. For this reason, additional exclusions were undertaken by VISU before data provision,

to minimise the likelihood of a single patient being represented in both subsets of data. The VISU provided ED-presentation data excluded cases that were subsequently and/or directly admitted to hospital. It was therefore restricted to patients attending the ED for the first time or patients transferred within and between hospitals. Identifiable subsequent, or additional, admissions to the same hospital within 30 days were excluded, to minimise double counting of a single injury. However, it should be noted that the VAED data represents the number of cases transferred from EDs as well as other admissions such as routine surgery. Therefore, the data might overestimate the ED to hospital-admission ratio.

Given the small number of annual cases reported in the VISU datasets, a graphical analysis was used to demonstrate the trends in both annual counts and participation-adjusted rates over time and the coefficient of determination (r^2) of a straight-line trend was calculated using Excel® (Microsoft Office Excel 2013). The r^2 is a key output of regression analysis and interpreted as the proportion of dependent variable variation that is explained by the independent variable in a linear model. The r^2 indicates how well the data fit a given statistical model, in this case a straight-line trend. A value of zero indicates that the line does not fit the data, whereas a value of 1 indicates that the regression line fits the data perfectly. It should be noted that the trend line was fitted to annual injury rates adjusted to annual participation.

Ethics approval for the project was obtained through the Federation University Human Ethics Committee (Project no C15-004 and C16-001).

3. Results

Over the 12-year period analysed, 668 cases (ED-presentations = 547 cases and hospital-admissions = 121 cases) of women's cricket injuries were treated in Victorian hospitals. Overall, just under one in five (18.1%) of all cases were admitted to hospital. The length of stay for 78.5% (n = 95) cases was <2 days; for the remaining 21.5% (n = 26) of cases, the length of stay was between 2 and 30 days. The ratio of ED-presentations to admitted cases was 4.5:1.

No fatalities were reported. The overall participation-adjusted injury rate was 1.5 ED-presentations per 1000 participants (95% CI 0.9–3.9) and 0.3 hospital-admissions per 1000 participants (95% CI 0.8–1.5), respectively (Appendix B in Supplementary material). The r^2 value of 0.80 (95% CI 0.76–0.84) indicates a linear trend is a reasonable fit to the data, thereby demonstrating a decline in overall participant-adjusted cricket injuries over 12-years in Victoria (Fig. 1).

The 10–14-year age group was identified as the most frequent to attend (Appendix C in Supplementary material). Fractures were the most common cause of hospital-admissions (n = 57, 47.1%) but only accounted for 17.2% (n = 94) of the ED-presentations over the 12-year period. The most common nature of the ED-presentations was dislocations, sprains and strains 36.4% (n = 199) (Fig. 2). The most common anatomical location of the main injury was the head (27.8%, n = 152 in ED-presentations; 28.1%, n = 34 in hospital-admissions). This was followed by wrist and hand injuries (27.8%, n = 158 in ED-presentations; 17.4%, n = 21 hospital-admissions) (Fig. 3). The most common cause of injury was being hit/struck/crushed by a ball or a bat. These mechanisms accounted for 63.8% (n = 349) of ED-presentations and 44.7% (n = 54) of hospital-admissions (Appendix D in Supplementary material).

4. Discussion

Cricket is a sport that is played around the world. To our knowledge, this is the first study to describe the frequency, nature, anatomical location and injury mechanisms of hospital-treated injuries sustained by female cricketers in any country. This study used hospital presentation data from Victoria because this is the only Australian state to have close to 100% coverage of data pertaining to cricket injuries treated in a hospital.

The overall participation-adjusted injury rate of hospital presentations was 1.9 per 1000 participants (95% CI 0.8–4.5). The overall trend of participation-adjusted injury rate showed a decline in Victoria for the 12-year period, based on the yearly injury rates and the 95% CI. The reasons for this decline are not known. Although it is not formally reported within the peer-review literature, it is possible that Cricket Australia and its regional associations could have implemented specific existing injury prevention programs that could have contributed to the reduction in injury rates. It is also possible that more female players sought treatment outside of a hospital, such as through allied health professionals and general practitioners, in the latter part of the 12-year period. This lack of clarity further highlights the need for a comprehensive injury surveillance program specific to women, to definitively evaluate the causes and injury trends over time.

Almost a fifth of all cricket-related hospital presentations were severe enough to require the injured person to be admitted to hospital. In the majority of these cases, the patient stayed in hospital for <2 days. People with the most severe injuries are likely to be admitted to a hospital; therefore, hospital admission following an ED-presentation can be used as a proxy indication of injury severity. In 2003, self-reported data from a community-based survey reported a conversion rate of 11:1 for ED-presentations to hospital-admissions for all sports injuries in La Trobe Valley, Victoria.[3] In comparison, the ratio of 4.5:1 in this study of cricket injuries indicates relatively more severe injuries. It is important to note that hospital admission could reflect complexity of treatment rather than severity of the injury. For example, if a person requires prophylactic intravenous antibiotics, then they need to be admitted to a hospital to receive this treatment compared to a person with an anterior cruciate ligament injury who may be discharged from an ED with a brace and analgesia. For this reason, it is possible that the data presentation could be an overestimation of the true injury severity. Since the first International Conference on Concussion in Sport in 2001,[17] concern and awareness regarding concussion has risen. It is possible that more conservative management and time required to exclude other conditions might be another reason for the difference in increased ED-presentations to hospital-admissions conversion rate relating to concussion in our study compared to the study from 2003.[3]

Players aged 10–14-years were most frequently associated with presentations to a hospital setting for treatment. These findings correspond with the female cricket participation figures, where 13–18-year-olds represent the second-largest female player population in Victoria and across Australia, behind 5–12-year olds.[1] Our findings are also consistent with the literature on team bat-or-stick sport injuries, where 95% players presenting to EDs in the United States between 1990 and 2003 were aged 10–18-years (both sexes).[18] The majority of lacrosse injuries (59%) presenting to Canadian EDs from 2007 to 2010 were also in the age group of 10–14-years (both sexes).[19] The higher frequency of hospital-presentations might be because young players have less and more varied game skill levels compared to adult players.

Typically, both fielding and batting involve sudden bursts of running, sliding, diving and lunging. These mechanisms likely explain the high frequency of dislocations, strains and sprains reported in our study. The findings are consistent with existing evidence for cricket injuries (data for sex not separated) at the recreational level[2,3] and other team bat-or-stick sports for female players[18] and for both sexes.[19] Joint sprains have been reported as being common in elite women's cricket.[7] Such injuries can adversely affect play-

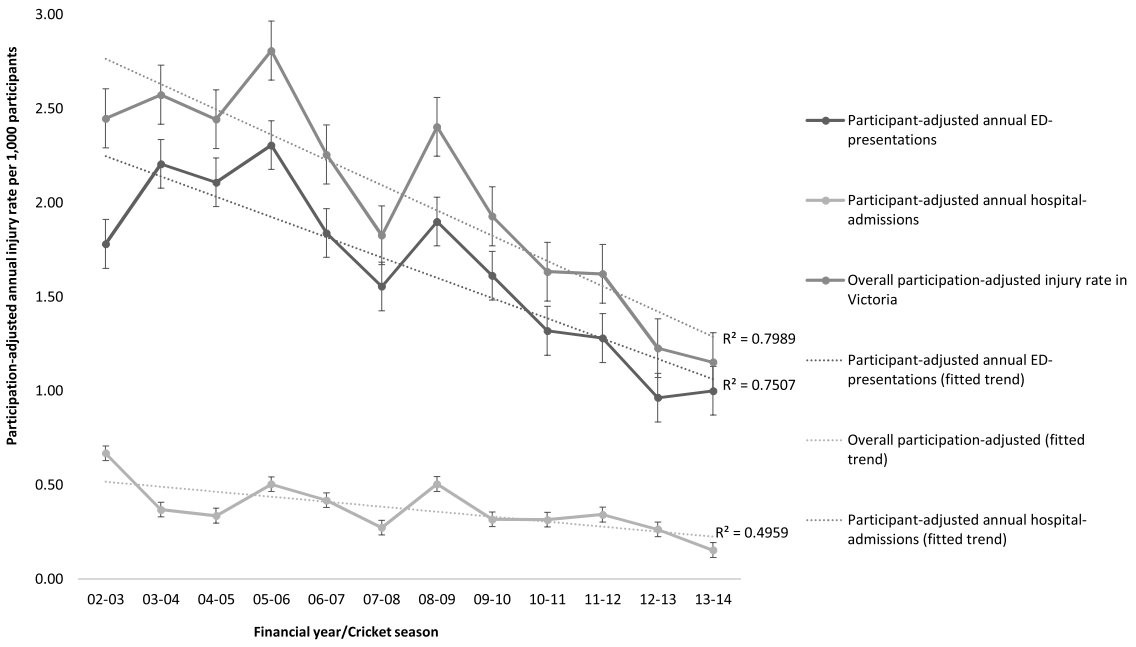

Fig. 1. The trends in participation-adjusted annual hospital-treated injury rates in female cricketers in Victoria from 1 July 2002 and 30 June 2014, inclusive. r^2 = coefficient of determination.

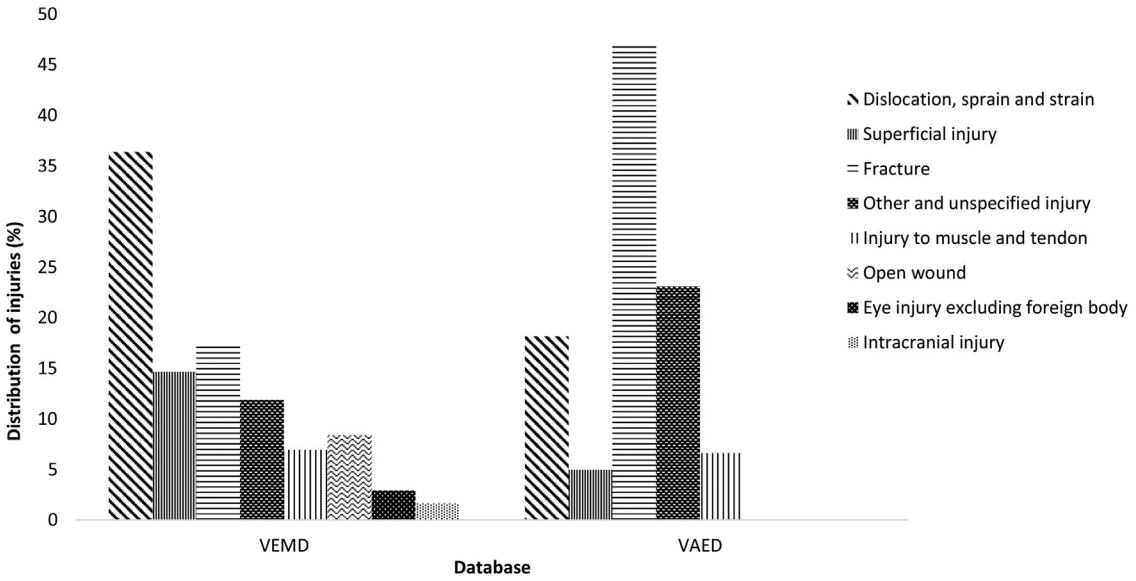

Fig. 2. Victorian ED-presentations and hospital admissions of female cricket injuries from 1 July 2002 and 30 June 2014, inclusive; grouped by the nature of the main injury. VEMD = Victorian Emergency Minimum Dataset (ED-presentations); VAED = Victorian Admitted Episodes Dataset (hospital admissions).

ers' welfare throughout their lifespan as injuries to the joint can be associated with early joint osteoarthritis.[20,21] Targeted neuromuscular injury prevention programs have been found to be effective in preventing joint and ligament injuries female athletes in other sports.[22] The high incidence of joint-related injuries reported in this study is a concern and may be indicative of the need to develop targeted, cricket-specific, neuromuscular injury prevention programs for the women's form of the game.

Several Australian studies (data not separated for sex) of cricket injuries have reported fractures as being commonly treated within EDs[2,3] or general practitioner clinics[3] and associated hospital-admissions.[3] We found fractures to be the second-most common diagnosis for ED-presentations and the most common cause of hospital-admission. This is partly expected because fractures are an acute traumatic injury and more likely to present to an ED and then require hospital-admission/surgery than other injuries. Therefore, a peak in counts from the admissions database was expected compared to the database with only ED-presentations. Fractures were also common in sports similar to cricket such as field-hockey and lacrosse,[23] with more female players seeking treatment in a ED than males in the United States.[18] Previous studies indicate that female players may be more vulnerable than males to fractures.[24] The majority of hospital presentations with fractures, were in females aged in their adolescence or young adulthood. Given that a significant proportion of Australian female cricket participants are in their adolescence and young adulthood,[1] it is important that future studies examine causative factors associated with the risk and type of fractures in this age group, with subsequent implementation and evaluation of injury prevention strategies.

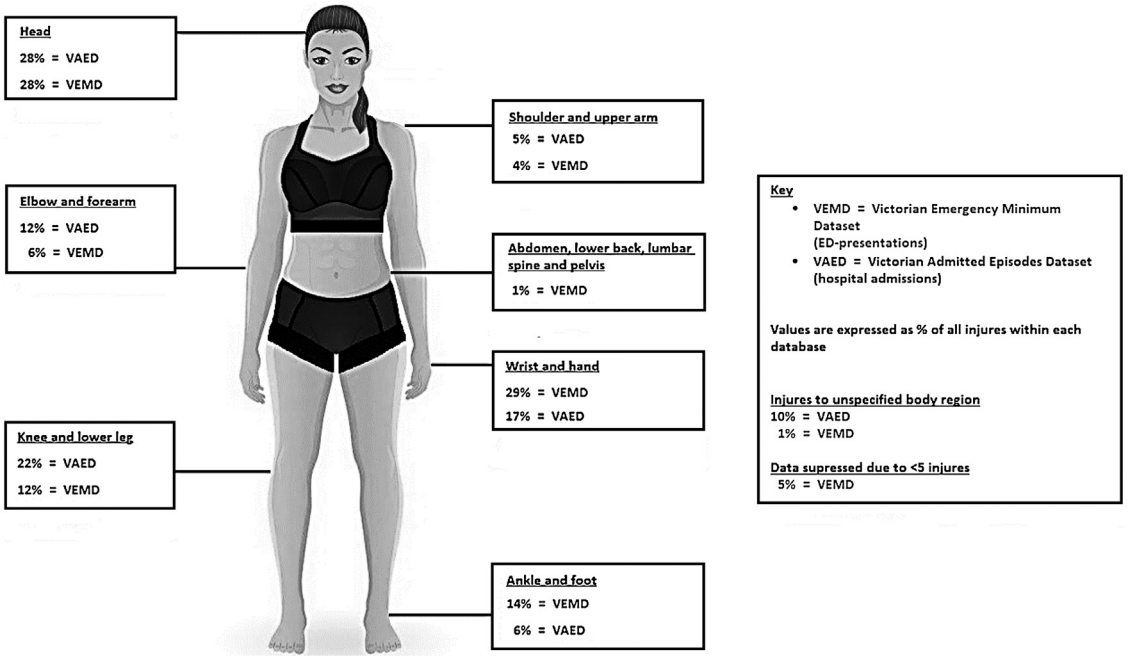

Fig. 3. Victorian ED-presentations and hospital admissions of female cricket injuries from 1 July 2002 and 30 June 2014, inclusive, inclusive; grouped by anatomical location of the main injury.

In contrast to elite level women's cricket,[7] we found head injuries to be the most common cause of hospital presentations in community level women's cricket and our findings concur with self-assessed worst injury in female cricketers.[25] This could be due to differences in skill levels where elite players have superior technical skills and inconsistent use of helmets. Importantly, no fatalities were reported in this study or within the recent cricket literature from Australia.[2,3,26] A Victorian study of hospital-admissions found concussions were associated with cricket; however, between 2002–03 and 2010–11 inclusive, a trend for decreased hospital-admissions for concussion among cricketers was seen.[27] Encouragingly, since the data period reported here, an updated concussion and head trauma policy across all matches has been sanctioned by Cricket Australia and introduced for the 2015–2016 season.[28] Further research using hospital presentation data could be used to extend the data series reported in this paper and to allow for an ecological evaluation of the impact of the concussion policy on hospital-treated injuries.

Impact-related injuries were common in recreational cricket players[29] and the current findings concur. Being hit/struck/crushed and ball-related injuries were the most common mechanisms leading to hospital presentation. In contrast, injuries relating to bowling delivery and insidious mechanisms were common in elite female cricketers[7] and likely to be underrepresented in an acute traumatic dataset such as hospital presentation data. Previous studies have also demonstrated that ball/puck-related injuries were the most common reason for female lacrosse and field-hockey players to seek treatment in an ED.[18] Leather cricket balls can be propelled toward a batter at high speeds, particularly from a fast bowler. Therefore, when a batter faces a pace bowler, it is mandatory to wear a helmet in games and in practice.[28] However, other players such as fielders are unlikely to wear helmets and potentially more vulnerable to head injury. Due to the nature of the summary data, it was not possible to identify which playing positions sustained more impact injuries.

Routinely collected hospital admission data serves as a potentially rich source of information, the findings are subject to inherent limitations associated with such databases. By default, those seeking treatment within a hospital setting are more likely to have sustained a severe acute traumatic injury than a gradual onset injury.[3] Data are therefore biased towards acute traumatic injuries and probably under-represent the true magnitude of cricket injuries. Identification of specific cricket injury cases were dependent upon the quality of the data provided. Detailed data collection by health professionals was not always evident because the VEMD data were collected from busy EDs. It is estimated that, due to inadequate coding, approximately one-third of the sports injuries presenting to an ED are missed.[14] Further, a validation study found the VEMD dataset to be reliable and valid with a 82.5% mean capture rate of ED-presentations in Victoria.[30] For this reason, it can be estimated that the VEMD covers approximately 85–95% of all Victorian ED-presentations. Based on the data request, certain case selection criteria were adapted prior to the provision of the data to be used for analysis in this study. This means that some cases may have been excluded from the data provided, potentially leading to an under-representation of the true magnitude of cricket injuries in women.

As a result of significant changes to the Victorian Hospital Admission Policy in July 2012,[31] if a patient received their entire care within a designated ED or urgent care centre, they were no longer eligible to be recorded as a hospital admission, irrespective of the amount of time spent in the hospital. Consequently, the hospital-admission cases for the 1 July 2013–30 June 2014 financial year (cricket season) were reduced. For this reason, caution should be exercised when interpreting the changes in hospital-admissions, and the ratio of ED-presentations to admissions, during this period compared with previous years.

One of the major advantages of the hospital presentation data used for study is that the stability of both VISU data sets allow changes over time to be monitored with some confidence. Additionally, the hospital admission data are the largest, most comprehensive and consistently recorded cricket injury data available at the recreational level in Australia.[2,3] For this reason, future injury surveillance in women's cricket would benefit from inclusion of injuries presented to hospitals, and these should be supplemented

with data from other treatment sources to provide a more comprehensive picture of injuries across Australia.

5. Conclusion

One in five hospital-presentations for cricket-related injury in females were severe enough to require hospital-admission, most cases staying in hospital for <2 days. Players aged 10–14-years were most frequently sought treatment from a hospital and correspond with the female cricket participation figures. Dislocations, sprains and fractures were the most common types of injuries and the head, wrist and hand were the most injured anatomical location. These findings provide the first overview of the nature of injuries requiring hospital attendance in female cricketers and provide a foundation to inform the development of targeted injury prevention programs for female cricketers.

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Contributorship

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jsams.2019.07.010.

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