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# The incidence and burden of hospital-treated sports-related injury in people aged 15+ years in Victoria, Australia, 2004–2010: a future epidemic of osteoarthritis?

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*Objectives:* Previous sports injury is a known risk factor for subsequent osteoarthritis (OA), but population-based rates of sports injury are unknown. The aims of this study were to: (1) describe the trends in the population incidence and burden of all hospital-treated sports injury in Victoria, Australia in adults aged 15+ years; (2) determine the incidence of lower limb and knee injuries; and (3) quantify their population health burden as average direct hospital costs per injury and lengths of stay.
*Methods:* Health sector data relating to adults aged 15+ years, for 2004–2010 inclusive, was extracted from the Victorian Admitted Episodes Dataset (VAED) and Victorian Emergency Minimum Dataset (VEMD). Data relating to sports injuries were identified using activity codes in each dataset Trends in injury frequency and rates were determined, and economic burden was calculated.
*Results:* The overall annual rate of hospital treated sports injuries increased by 24% ($P = 0.001$), and lower limb injuries by 26% ($P = 0.001$) over the 7 years. The associated accumulated economic burden was $265 million for all sports injuries and $110 million for lower limb injuries over the 7-years.
*Conclusions:* The findings of this study show a significant increase in sports injuries in the state of Victoria, Australia over a 7-year period. As previous sports injury is a risk factor for the development of OA, the future incidence of OA will escalate, placing an even greater burden on health care systems. Population-wide preventative strategies that reduce the risk of sports injury are urgently required in order to reduce the future burden of OA.


## Introduction

Participation in sports is a common way for adults to take part in the regular physical activity that is considered to be important for the health of individuals and society. Physical inactivity is associated with adverse health outcomes, including type-2 diabetes, cardiovascular disease (CVD), stroke, depression and certain cancers[1], and is estimated to be the fourth leading cause of mortality worldwide[1]. Physical activity through participation in sport is of great benefit to individuals and society by reducing the likelihood of lifestyle diseases and the associated public health burden. However, any benefit has the potential to be diminished by the risk of participants sustaining a musculoskeletal sports injury, which can then lead to other future adverse long-term health outcomes such as osteoarthritis (OA)[2–4].

Epidemiological studies that have used field- or team-based injury surveillance methods consistently report injuries to the lower-limb as the most common body region injured, particularly in team ball sports[5,6]. Lower limb sports injuries are also the most commonly reported in case series studies based in sports medicine or musculoskeletal clinical studies[7]. Despite these figures, the rate of sports-related injury, including lower-limb musculoskeletal

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injuries, in the general population remains unreported, but widespread anecdotal opinion is that it is rising. There is an urgent need to monitor trends in sports injuries at the population level to help guide policy development and for priority setting[8], This is particularly important since prior injury is a well-recognised precursor to joint OA[3,9,10]. There is a strong possibility that an increasing incidence of sports injuries, especially to the lower limbs, could result in an increasingly larger future burden of OA in the population, with a corresponding increase in health service delivery and musculoskeletal ill-health burden in future years.

The cost burden to society of sports injury and specifically lower limb injuries sustained during sport is currently unknown. In contrast, the community burden of OA and associated surgery has been previously reported[11–13]. While direct heath care costs are often reported, indirect health care costs may be eight times greater than direct costs, indicating that the true burden of OA is underestimated[10]. In the United States, the direct insurer-borne cost of medical treatment for OA has been estimated to be $185 billion per annum[12]. This estimate does not account for the indirect costs of the disease which include absenteeism, loss of productivity, early retirement and premature death[11]. The cost of arthritic disease in Australia is estimated to be $24 billion per annum[11], affecting one in eight adults[12]. In addition, OA is an independent predictor of increased risk of CVD, whereby people undergoing total joint replacement are 26% more likely to have CVD than people with no OA[14]. The worldwide number of years lost to disability (YLDs) for OA is the fastest growing, being second only to that for mental and behavioural disorders.[12]

It is clear that OA already places a large burden on health care systems. Any increase in the incidence of joint-related sports injuries is likely to further increase this burden. In order to implement preventive strategies and related health policy to reduce the risk and consequent burden of sports injuries, it is vital to understand the magnitude and impact of the problem now[15]. Therefore a greater understanding of the rate and burden of sports injury, and lower-limb related sports injury more specifically, is urgently required if a potential future epidemic of OA is to be avoided.

The aims of this study were to: (1) describe the trends in the population incidence and burden of all hospital treated sports injury in Victoria in adults aged 15+ years; (2) specifically determine the incidence of lower limb and knee injuries; and (3) quantify the population health burden of these injuries in terms of the average direct hospital costs per injury and length of stay for hospitalised cases.

## Methods

### *Data sources for the identification of sports injuries*

The Victorian Admitted Episodes Dataset (VAED) provides a complete dataset of all hospital episodes of care in the state of Victoria, Australia. The population of Victoria, Australia was 5,821,300 at March 2014[16]. All residents of Victoria have access to hospital based health care through both state-funded and privately funded institutions in metropolitan, regional and rural centres.

Health sector data, routinely collected for the calendar years 2004–2010 inclusive, were extracted from the following datasets. Data were extracted for people aged 15+ years only because corresponding population-level sports participation rate data were only available for this age range on an annual basis. Sports injury cases were selected as follows:

i. **The number of hospital admissions** was extracted from the VAED, which includes all admissions to public and private hospitals in Victoria. The VAED is coded to the International Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modifications (ICD-10-AM)[17], which has included 200 ‘activity codes’ for identifying specific types of sport/leisure activity in which the person was participating at the time of injury since 2002[18,19]. Sports injury cases were identified if the activity when injured was recorded as a sport (ICD-10-AM activity code in the range U50–U71). For all analyses, cases were further restricted to only those with a principal diagnosis of injury (ICD-10-AM diagnosis code S00–T98).
ii. **The number of emergency department (ED)** presentations was extracted from the Victorian Emergency Minimum Dataset (VEMD), which includes ED presentations to 38 Victorian public hospitals with 24 h EDs. The VEMD injury surveillance items are based on the National Injury Surveillance Data Dictionary (NISDD)[20]. The start year was chosen as 2004 because a consistent number of hospitals has contributed to the VEMD since January 2004. Sports injury cases were selected if the activity field was coded to sport (activity code = S).

Data relating to all injuries of the lower limb were identified using the ICD-10-AM diagnosis codes S70–S99, which include injuries to the hip, thigh, knee, lower leg, ankle, foot and toes. “Knee and lower leg injuries” (a subset of all lower limb injuries) were specifically identified by the codes S80–S89; “dislocation, sprain or strain of the joints and ligaments of the knee” were identified using the code S83. Data for sports injuries that were not treated in a hospital setting (for example: injuries that were treated by a primary care general practitioner or sports physiotherapist) were not included.

### *Calculation of incidence rates and trends*

Sport participation numbers were obtained from the annual *Exercise*, *Recreation and Sport Surveys* (ERASS) covering the 2004–2010 years[21]. The ERASS collects information on the frequency, duration, nature and type of activities in which persons aged 15+ years participated in for exercise, recreation or sport during the previous 12 months. Incidence rates were calculated as incidence density, as the number of new injuries during a given time period in relation to the person time at risk during this time period. Incident cases of injury were included when cases were aged 15 years or above, were assigned an ICD-10-AM diagnosis code within the range S00–T98 (injury); and had activity codes U50–U71 for hospital admissions (sports-related) or activity code of “sport” for ED admissions. Rates of injury were then calculated using the specific number of incident cases injuries in each year as the numerator, and the number of sports participants (calculated from the annual ERASS) for the specific year as the denominator. The rates were then expressed as a number per 100,000 sports participants.

### *Measures of the burden of injury*

The burden of sports-related injury was expressed as the economic burden (direct hospital costs) and the number of hospital bed days. The economic burden of injury was estimated as the year-specific average cost per Australian Refined Diagnosis Related Group (AR-DRG) for each hospital admission. To calculate the economic burden, the average Victorian cost for that specific AR-DRG diagnosis (for the relevant year of admission) was applied to each hospital admission (based on the admission's AR-DRG). The component costs included in the National Hospital Costs Data Collection (NHCDC) DRG based cost estimates[22] include a separately reported cost for the ED component of a hospital admission. The average cost for the ED component of all admissions was applied to each ED presentation. The cost of knee and lower leg injury cases, all lower limb injury cases and the cost of overall sports injury cases were reported as direct hospital costs (in Australian dollars) for the 7-year period.

For the frequency analysis of incident cases, re-admissions and transfers within and between hospitals were excluded to avoid over counting. For the calculations of direct hospital costs and hospital bed days all re-admissions and transfers within and between hospitals were included to determine a true estimate of the burden of injury. Return ED visits and presentations subsequently admitted to hospital were excluded from the case frequency analyses to avoid double counting of incident injury cases, as they are presumed to be included in the admissions data.

### *Data analyses*

The term hospital-treated injury refers to the sum of hospital admissions and hospital ED presentations. The annual number and rate of hospital-treated sports injuries was calculated as (1) an overall figure; (2) for all lower limb injuries: (3) for knee and lower leg injuries; and (4) for knee injuries specifically. Annual rates were computed using year-specific participation numbers as the denominator.

The injury rates were calculated as incidence density rates. Trends were modelled on the annual rates to assess changes over the whole time period. Trends in injury frequency and rates (per 100,000 participants aged 15+ years) over the 7-year period were determined using a log-linear regression model of the data assuming a negative binomial distribution of cases, given that there was over-dispersion in the data. The statistics relating to the trend curves, slope and intercept, estimated annual percentage change, estimated overall change, 95% confidence intervals around these estimated changes and the *P*-value were calculated using the regression model in SAS® 9.2. A trend was considered statistically significant if the p-value of the slope of the regression line was less than 0.05.

## Results

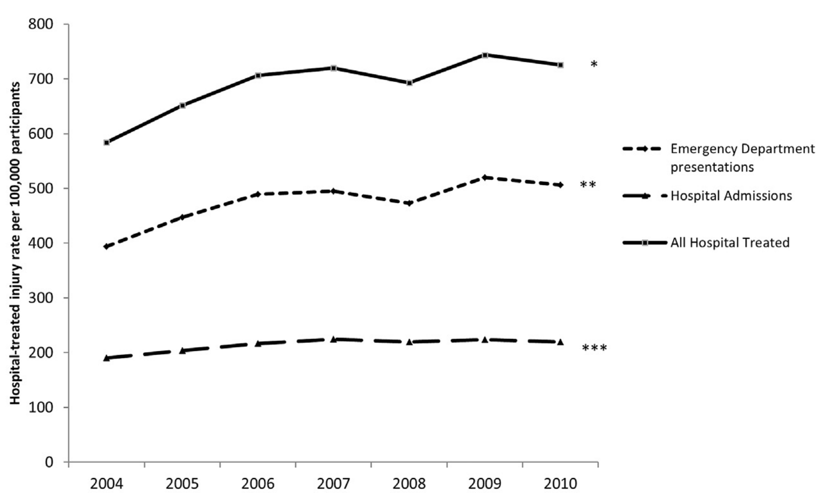
Between January 2004 and December 2010 there were 165,496 hospital-treated sports injuries in people aged 15+ years in Victoria. Of these, 59,399 (35.9% of all sports injury cases) were lower limb injuries, 29,430 (17.8%) were injuries to the knee and lower leg and 11,749 (7.1%) were knee dislocations, strains and sprains. Figure 1 shows that the rate of all hospital-treated sport injury, per 100,000 adult participants, increased by statistical significance by 24% over the 7-year period. The rate of ED admissions for sports injuries increased by 28% over the 7-year period, while the rate for hospital admissions only increased by 16% over the same period.

Table I summarises the frequency, direct hospital costs and hospital bed days (admissions only) for all hospital-treated (admissions and ED presentations) sports injuries as well as lower limb injury and knee and lower leg sports injuries. The estimated direct hospital costs of hospital-treated sports injury was $265million overall, with an average cost per injury of $1,510. Overall, the estimated total cost of knee and lower leg sports injury was less than a third of the total sports injury costs, but the per-injury average cost was 1.5 times higher. Overall, hospital-treated sports injury accounted for 143,947 hospital bed days; of these 26.5% were associated with lower limb injuries and 12.4% specifically to knee and lower leg injuries.

Table II shows the year-specific frequency and rate (per 100,000 participants) of hospital-treated sports injuries, sports-related lower limb injuries and sports related knee and lower leg injuries in the period 2004–2010. The frequency of hospital-treated sports injuries for all groups increased by statistical significance by 37% over the 7-years. The hospital-treated injury rate per 100,000 participants only increased significantly in the lower limb and overall sports injuries groups.

## Discussion

This study is the first to describe trends in the population health burden of all sports injuries, and more specifically lower limb injuries, based on acute care presentations and admissions to hospitals. In the state of Victoria, Australia between 2004 and 2010, the number of hospital-treated sports injuries in people aged 15+ years increased by 37% over the 7-year period, with a corresponding 39% increase in the number of lower limb injuries. After adjustment for




**Legend:** *Overall rate increase of 24% (95% confidence interval 9% to 41%) (p=0.001) for all hospital treated sports injuries; average annual increase in rate 3.1% (1.2 to 5.0%). **Overall rate increase of 28% (95% confidence interval 10% to 47%) (p=0.001) for emergency department admissions for sports injuries; average annual increase in rate 3.6% (1.3 to 5.7%). ***Overall rate increase of 16% (95% confidence interval 5% to 29%) (p=0.004) for hospital admissions for sports injuries; average annual increase in rate 2.2% (0.6 to 3.7%).

**Fig. 1.** Trends in annual participation-adjusted rate of hospital treated sports injuries (per 100,000 Victorians aged 15+ years participating in sports) during 2004 and 2010,victoria, Australia.

**Table I**
The healthcare burden of hospital-treated sports injury – overall, all lower limb injuries, and knee and lower leg injuries in people aged 15+ years, Victoria, Australia 2004–2010

| Frequency | N | % |
|---|---|---|
| Knee/lower leg injuries | 29,430 | *17.8* |
| Lower limb injuries | 59,399 | *35.9* |
| All sports injuries | 165,496 | *100.0%* |
| Direct hospital costs | $AUD | *Mean per case ($AUD)* |
| Knee/lower leg injuries | $82,200,173 | *$2,273* |
| Lower limb injuries | $110,264,776 | *$1,856* |
| All sports injuries | $265,161,850 | *$1,510* |
| Hospital bed days (admissions only) | Total (N) | *Mean per case* |
| Knee/lower leg injuries | 17,837 | *0.6* |
| Lower limb injuries | 38,210 | *0.6* |
| All sports injuries | 143,937 | *2.4* |

N = number; $AUD – Australian dollars (calculated August 2013).

changes in concurrent sports participation changes over the same period, there was still a statistically significant increase in sports injury rates, albeit at a lower level of 24% over the 7-years. Our previous research has also reported an increase in the rate of hospital-treated sports injuries in children in the same geographic region over the same period[15]. Assuming a direct correlation between sports injury rates and the subsequent development of OA, it could be expected that this could lead to an increase in the population-level incidence of sports-related OA cases in the next decade or two. This has direct implications for the planning of health services to deal with more OA patients in the future. Strategies targeted to reduce the incidence of these sports injuries are therefore urgently required.

This study confirms that sports injuries place a substantial burden on the current health delivery system of Victoria, in terms of their direct costs and accumulated length of stay in hospital. The increasing trends in the numbers of all sports injuries, all lower limb injuries and knee injuries more specifically, indicates that in real terms, more people are now at risk of developing future ill-health, such as OA, as a result of such injuries. With more people being encouraged to take up an active lifestyle for health reasons, there is potential for the rate of sports injuries to increase further. Already, the rate of occurrence of all sports injuries, and those to the lower limb overall, appears to be over and above changes in participation rates. This information is essential for prioritising sports injury prevention by government health agencies and other bodies[8,23]. Moreover, these trends could be reversed in the future through the implementation of validated injury prevention programs in community sports groups at the individual, group and organisational level.[24,25]

OA is associated with reduced physical activity, daily activity and quality of life. It contributes directly to reduced productivity due to increased rates of absenteeism and presenteeism, poor physical function, and fatigue secondary to sleep disturbance[26]. As OA is a progressive disease often seen secondary to sports injury, and the population is continuing to age, it is also becoming an increasing cost burden in western society[27]. Therefore, the increase in sports injuries in adults reported in this study, even after adjustment for participation is of grave concern, given the likelihood of progression to OA in adults who sustain a sports injury. Importantly, many of these individuals will only be aged between 25 and 45 years at the time of OA development[10], when occupational and family demands are at their greatest[12]. The direct (medical care) and indirect (impact on work, reduced quality-of-life and reduced physical activity) costs to society of this future OA epidemic will be substantial. A large epidemic of OA and associated conditions several years from now that will compound the public health burden of musculoskeletal conditions to the Australian population is likely. It is therefore imperative that health policy makers focus on strategies to prevent sports injury and enable safe participation in physical activity.

Adequate physical activity is considered to be vital in reducing risk of mortality[28], as well as reducing the likelihood of lifestyle disease onset such as type 2 diabetes, CVD and depression[1]. For many adults, participation in sport provides the intensity of activity necessary to meet these guidelines in an enjoyable, group based environment. Studies have shown that participation in organised team sports, such as soccer, provides superior cardiovascular benefits to moderate intensity running[29] in untrained adults, increase bone health and reduce falls risk[30]. Yet these benefits can be diminished when participants undertaking sport sustain an injury, which ultimately results in OA. Any reduction in population-level participation in sport and physical activity will lead to an increased burden on health care systems. This increased burden will be 2-fold if it is because of a sports injury that needs hospital treatment that then leads to OA requiring treatment in 10-years' time.

It is clear from our findings that prevention of sports injuries is of great importance. Safe participation in sport depends on appropriate, evidence-based injury prevention programs being implemented at all levels of sport[2]. Injury prevention strategies to reduce the incidence of lower limb injuries in sport have been

**Table II**
Trend in frequency of hospital treated sports injury – all sports injuries, all lower limb injuries, all knee/lower leg injuries and knee dislocations, strains and sprains in people aged 15+ years, Victoria, Australia 2004–2010†

| Type of sports injury | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | Total (N) | Overall % change in frequency (95% confidence intervals) (*P*) |
|---|---|---|---|---|---|---|---|---|---|
| **Knee dislocations, strains and sprains** | | | | | | | | | |
| Frequency | 1,310 | 1,633 | 1,766 | 1,741 | 1,646 | 1,773 | 1,880 | 11,749 | 33 (7–62) ($P = 0.008$)* |
| Rate per 100,000 participants | 38.8 | 48.0 | 53.8 | 53.4 | 47.4 | 50.0 | 51.5 | | 20 (−8–54) ($P = 0.166$) |
| **All knee/lower leg** | | | | | | | | | |
| Frequency | 3,568 | 4,039 | 4,238 | 4,320 | 4,189 | 4,479 | 4,597 | 29,430 | 27 (13–40) ($P < 0.001$)* |
| Rate per 100,000 participants | 105.6 | 118.7 | 129.1 | 132.4 | 120.7 | 126.2 | 126.0 | | 15 (−4–36) ($P = 0.108$) |
| **All lower limb** | | | | | | | | | |
| Frequency | 6,969 | 7,902 | 8,383 | 8,606 | 8,483 | 9,437 | 9,619 | 59,399 | 39 (25–53) ($P < 0.001$)* |
| Rate per 100,000 participants | 206.3 | 232.2 | 255.4 | 263.8 | 244.4 | 265.9 | 263.7 | | 26 (7–46) ($P = 0.004$)* |
| **All sports injuries** | | | | | | | | | |
| Frequency | 19,741 | 22,167 | 23,188 | 23,491 | 24,047 | 26,397 | 26,465 | 165,496 | 37 (26–48) ($P < 0.001$)* |
| Rate per 100,000 participants | 584.3 | 651.5 | 706.3 | 720.0 | 692.7 | 743.8 | 725.5 | | 24 (9–41) ($P = 0.001$)* |

* = statistically significant trend over the 7-years ($P < 0.05$).
† Data takes into account changes in the number of participants, as the rates are calculated on the basis of the year specific numerator and denominator data.

reported previously, and include programs which incorporate pre-season and during-season exercise programs focussing on muscle strength, motor control, movement retraining, agility training and proprioception[31,32]. In addition, programs which focus on rule changes to improve safety[2], improving attitude and motivation to correct poor technique and education of the benefits of injury prevention can be beneficial[33]. Such programs with high efficacy have been introduced in sports such as soccer[34]. However community-based injury prevention programs with excellent efficacy may suffer very low levels of compliance, dissemination and widespread adoption if no consideration is given how to implement them properly[35,36]. If injury prevention strategies are to successfully reduce the population incidence of sports injuries, co-operation between researchers, clinicians and policy-makers is vital.[8,37–39]

The current study has a number of strengths. Notably, this is the first population-based study of trends in sports injury rates among adults and the direct cost of such injuries. The VAED encompasses every hospital in the state of Victoria, allowing a comprehensive and complete population-based dataset to determine the rate of sports injury admissions. However, there are also some limitations to this study. Firstly, the identification of injury in the VEMD and VAED may be unreliable due to data quality issues, that could lead to an underestimation of sports injury cases[19]. Secondly, a large number of sports injuries do not present at hospitals, and are instead managed by general practitioners, sports physicians and sports physiotherapists through primary referral. These cases could not be captured using the data collection methods of this study. This is likely to result in a large underestimation of the number of sports injuries, and the subsequent burden. In addition, the cases included in this study were largely acute, traumatic cases requiring hospital treatment. Therefore it is unclear whether the increases seen in this study are largely limited to sports injuries that require hospital treatment, or if there is also an increase in sports injuries that do not require hospital treatment. Further population-based studies are required to examine sports injuries not treated in the hospital setting. During 2008, participation rates in sport were reported differently, resulting in increased sporting participation numbers for that year, and so impacted upon the denominator used in the ratio calculation, resulting in a lower injury rate per 100,000 participants for that year. This most likely has resulted in under-reporting of injury rates for that year. Furthermore, the data presented here do not include admissions for elective surgery (e.g., Anterior cruciate ligament (ACL) reconstruction surgery). If patients delay such surgery, they would not be included in this dataset as it includes only acute episodes of care. The impact of this is that our figures of the overall burden of sports injuries are likely to underestimate the true burden, because they include acute, largely traumatic, cases only. Taken together, this suggests that our findings are a very conservative estimate, and the overall burden of sports injury is likely to be much greater than reported within the current study. Finally, the findings of this study refer to the population of the state of Victoria, Australia. These findings may not be generalizable to other populations in Australia, or to other countries. Future studies should examine population rates of sports injuries in other populations to provide additional information regarding the true burden of sports injuries across diverse populations.

In conclusion, the current study presents the population-level participation-adjusted rate of adult sports injuries and knee-specific sports injuries, and their burden to the health care delivery system, and cost in Victoria, Australia over 7-years. During 2004–2010, after adjusting for changes in sports participation rates, the overall rate of sports injuries requiring hospital treatment increased by 24%, whilst lower limb increased by 26% over this time. The associated economic burden was substantial; being $265 million for all sports injuries in people aged 15+ years and $110 million for hospital treatment of acute lower limb injuries over the 7-years. Importantly, this is likely to be a conservative estimate of the rate of such injury as it only includes injuries treated in hospital and in acute care. As previous injury is an important risk factor[10] for the development of OA between five and 15 years post injury, these findings suggest that in the coming decade, the societal cost of OA will escalate, placing an even greater burden on health care systems. Population-wide preventative strategies that reduce the risk of sports injury are urgently required in order to reduce the future burden of OA and associated diseases on health care systems.

## Author contributions

Caroline Finch contributed to and critically commented on the design of the study and analyses plan; analysed and interpreted the data; drafted, critically revised and wrote the manuscript.

Joanne Kemp contributed to and critically commented on the design of the study; interpreted the data; drafted, critically revised and wrote the manuscript.

Angela Clapperton contributed to and critically commented on the design of the study; undertook data analysis; drafted, critically revised and wrote the manuscript.

## Competing interest statement

The authors have no conflict of interest and this manuscript has not been submitted elsewhere. There are no industry affiliations to declare.

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