

Bicycling injuries and mortality in Victoria, 2001–2006

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The number of bicyclists in Victoria is increasing,¹⁻³ and cycling is the fourth most popular physical activity for Australians over the age of 16 years.² Bicycle sales have outnumbered car sales for the past 9 years⁴ but, as there is no bicycle registration in Australia, the number of people who own and ride bicycles is largely unknown. Further, the data on cycling participation rates are available for selected years only.⁵

Despite the increasing number of bicyclists in Victoria, the number of reported bicycle casualty accidents does not seem to have changed substantially between 2002 and 2007.⁶ Controversy about the requirement for all cyclists to wear helmets continues,⁷ but the 1990 legislation making helmets compulsory for bicyclists in Victoria was associated with a decrease in non-fatal head injuries and fatalities.⁸⁻¹⁰ Several authors have called for more comprehensive strategies to prevent serious bicycle injuries, including separation of bicyclists from motor vehicle lanes and greater regulation of bicyclists' behaviour and interaction with other road users.¹¹⁻¹⁴

There is a paucity of epidemiological data describing bicycle-related injury trends in Australia. We investigated the incidence of bicycle-related injuries in the Victorian population over a 5-year period (2001–2006) to inform prevention strategies.

METHODS

Setting

The state of Victoria has a population of over 5 million people, accounting for 24% of all Australians. Most of the population is concentrated in one large metropolitan area with 3.8 million people.¹⁵

Study design

Data on bicycle-related injury were extracted from four datasets for the period July 2001 – June 2006. Emergency department (ED) presentations were identified using the Victorian Emergency Minimum Dataset, and hospital admissions were extracted from the Victorian Admitted Episodes Data Set. Bicycle-related major trauma cases were identified in the Victorian State Trauma Registry, and deaths were extracted from the National Coroners Information System.

ABSTRACT

Objective: To investigate the incidence of bicycling injuries and bicycle injury characteristics in the Victorian population.

Design: Review of prospectively collected data.

Setting: Bicycling injury data were extracted from four datasets for the period July 2001 to June 2006: (i) emergency department (ED) presentations from the Victorian Emergency Minimum Dataset; (ii) hospital admissions from the Victorian Admitted Episodes Data Set; (iii) major trauma cases from the Victorian State Trauma Registry (VSTR); and (iv) deaths from the National Coroners Information System.

Main outcome measures: The profile and incidence of bicycling injuries across the datasets and years.

Results: In the 5 years, 25 920 bicycle-related ED presentations were recorded, 10 552 bicyclists were admitted to hospital, 298 bicycling injuries were classified as major trauma (VSTR), and there were 47 bicycling fatalities. From 2001 to 2006, the incidence of bicycle-related ED presentations (incidence rate ratio [IRR] = 1.42; 95% CI, 1.37–1.48), hospital admissions (IRR = 1.16; 95% CI, 1.09–1.23) and major trauma (IRR = 1.76; 95% CI, 1.22–2.55) increased significantly. Most of those injured were males, aged < 35 years, with road-related injuries. Patients classified as having major trauma had a significantly higher incidence of trunk and head/face/neck injuries compared with those presenting to an ED or admitted to hospital.

Conclusion: The incidence of serious bicycling injury has risen over recent years, highlighting the need for targeted prevention programs. Accurate data on cycling participation, use of injury prevention strategies, and injury profiles would assist in reducing bicycle-related injury.

MJA 2009; 190: 353–356

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Victorian Emergency Minimum Dataset (VEMD)

Data on all patients who presented to the EDs of Victorian public hospitals after a bicycle-related injury were obtained from the VEMD. It has been estimated that more than 80% of ED presentations in the state are captured by the VEMD, and it has been found to be a reliable and valid database.¹⁶ Patients were included if a cause of injury was riding a bicycle or if a description of the injury event indicated a bicycle was involved. Only those not admitted to hospitals were included. Summary tables for the VEMD were provided by Monash University Accident Research Centre (ie, we did not use the raw data).

Victorian Admitted Episodes Data Set (VAED)

Data on all patients who were admitted to a Victorian public or private hospital after a bicycle-related injury were obtained from the VAED. The VAED contains data about all hospital admissions in Victoria.¹⁷ Patients

were selected if the external cause-of-injury code was in the range V10–V19, referring to a bicyclist. As with the VEMD, summary tables for the VAED were provided by Monash University Accident Research Centre and we did not use raw data.

Victorian State Trauma Registry (VSTR)

The VSTR is a statewide population-based trauma registry which includes prospectively collected data on all hospitalised major trauma patients in Victoria. The inclusion criteria for the VSTR have been described previously and include any of the following: death due to injury, an Injury Severity Score > 15, urgent surgery, and an intensive care unit stay longer than 24 hours requiring mechanical ventilation.¹⁸ The VSTR provides high-quality data as a result of its quality assurance policy including, among other things, date and time validation checks built into the web-based database.¹⁹ Demographic data, injury event details, clinical observations, management and outcomes were extracted for analysis.

National Coroners Information System (NCIS)

Data on patients who died from a bicycle-related injury were obtained from the NCIS. This registry contains a record of every death reported to a participating coroner in Australia. "Closed cases" (ie, those finalised by the coroner, even if some data were missing) in Victoria, when death was due to external causes and the mode of transport was a bicycle, were extracted. A cross-check between the VSTR and the NCIS ensured that deaths were only counted once.

Overlapping data

The VAED, the VSTR and the NCIS provide overlapping data. In the VEMD and the VAED, multiple admissions due to transfer were not able to be accounted for because of lack of a unique health system identifier.

Analysis

Population estimates for Victoria were obtained from the Australian Bureau of Statistics.¹⁵ Descriptive statistics were used to summarise the profiles of ED presentations, hospital admissions, major trauma cases and deaths. We reported categorical data as percentages and 95% confidence intervals (CIs). For the coroners data, exact binomial CIs were calculated because of the small sample size. Continuous data were reported as median and interquartile range. Population-based incidence rates (95% CIs) were calculated for each 12-month period, based on the total population at the end of June 2002, 2003, 2004, 2005 and 2006. A Poisson regression model was used to test for a dose-response effect of increasing incidence over the 5 years by assuming a linear increase in the logarithm of the rate with increasing years.

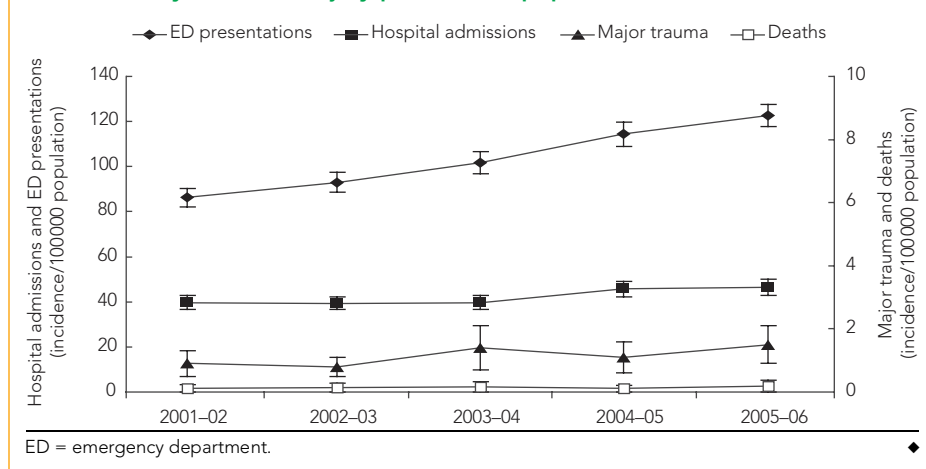
Ethics approval

Ethics approval for use of the VSTR was granted by all participating institutions and the Standing Committee on Ethics in Research Involving Humans at Monash University; and access to the NCIS was approved through the ethics process of the NCIS. As mentioned, data from the VAED and the VEMD, which were obtained from the Monash University Accident Research Centre, were de-identified.

RESULTS

Overall, for the 5-year period, bicycle-related injuries resulted in 25 920 ED presentations

1 Rate of bicycle-related injury per 100 000 population (2001–2006)



and 10 552 hospital admissions; and there were 298 major trauma cases and 47 bicycle-related fatalities. Of the major trauma cases (VSTR), 18 (6%) died in hospital, whereas 19 deaths were noted by the coroners. Thus, one death was missing from the VSTR.

Incidence of bicycle-related injury

The incidence of bicycle-related injury increased over the 5-year period (Box 1): bicycle-related ED presentations rose from 86 to 122 per 100 000 population (incidence rate ratio [IRR]=1.42; 95% CI, 1.37–1.48; $P<0.001$); and bicycle-related hospital admissions rose from 40 to 46 per 100 000 population (IRR=1.16; 95% CI, 1.09–1.23; $P<0.001$). Data from the VSTR are consistent with this trend: bicycle-related major trauma cases increased from 1.0 per 100 000 population in 2001 to 1.5 per 100 000 population in 2006 (IRR=1.76; 95% CI, 1.22–2.55; $P=0.002$). A 37% rise in bicycle-related deaths was observed, although this increase in incidence was not significant (IRR=1.58; 95% CI, 0.57–4.34; $P=0.375$).

Age and sex of cyclists injured

Irrespective of the data source, most patients injured in bicycle-related incidents were male and most were aged under 35 years (Box 2). Bicycle fatalities were more evenly distributed across the age groups, but 55% of fatally injured cyclists were aged over 35 years.

Place and time of injury

Most severe injuries occurred on streets or highways, but almost half of the less severe cases occurred elsewhere (Box 2). Bicycle-related major trauma most commonly occurred on a Sunday, and usually between

1:00 pm and 4:00 pm. Most fatal injuries occurred between 5:00 am and 8:00 am and 5:00 pm and 8:00 pm, which are peak traffic periods.

Body regions injured

For ED presentations and hospital admissions, the most commonly injured body region was the extremities (73% [95% CI, 72.4%–73.6%] and 58% [95% CI, 57.1%–58.9%], respectively). Of the major trauma cases, 220 (74%) sustained multiple injuries; the most commonly injured body regions were the trunk (51%; 95% CI, 45.3%–56.7%) and head/face/neck (44%; 95% CI, 38.3%–49.7%). The percentage of trunk and head/face/neck injuries in major trauma cases was significantly higher than for ED presentations (21%; 95% CI, 20.5%–21.5%) and hospital admissions (29%; 95% CI, 28.1%–29.9%).

Most deaths involved a head injury (33; 70%), and 22 cyclists (47%) sustained multiple injuries; in 19 cases (40%) data regarding injuries were incomplete. Of the 47 fatalities referred to the coroner, 20 bicyclists (42%) wore helmets, three (6%) wore helmets and reflective clothing, and seven (15%) did not wear a helmet, but one of the seven without helmets wore reflective clothing. For 17 cases (36%), the report was incomplete with respect to protective equipment.

DISCUSSION

Our population-based study found that ED presentations and hospital admissions for bicycle injuries increased significantly from 2001 to 2006. There was also a marked increase in cyclists sustaining major trauma. Our findings of an average of about 5200 ED

2 Distribution of bicyclists injured (95% CIs) according to sex, age, place and activity at the time of injury, by data source

	Emergency department (VEMD) (n = 25 920)	Hospital admissions (VAED) (n = 10 552)	Major trauma (VSTR) (n = 298)	Coroners reports (NCIS) (n = 47)
Sex				
Male	77% (76.5%–77.5%)	80% (79.2%–80.8%)	88% (84.3%–91.7%)	89% (76.9%–96.4%)
Age				
< 15 years	46% (45.4%–46.6%)	37% (36.1%–37.9%)	19% (14.4%–23.5%)	15% (6.2%–28.3%)
15–24 years	21% (20.5%–21.5%)	18% (17.3%–18.7%)	22% (17.3%–26.7%)	13% (4.8%–25.7%)
25–34 years	15% (14.6%–15.4%)	15% (14.3%–15.7%)	17% (12.7%–21.3%)	17% (7.6%–30.8%)
35–44 years	9% (8.7%–9.3%)	12% (11.4%–12.6%)	11% (7.4%–14.6%)	15% (6.2%–28.3%)
45–54 years	5% (4.7%–5.3%)	10% (9.4%–10.6%)	17% (12.7%–21.3%)	15% (6.2%–28.3%)
55–64 years	2.6% (2.4%–2.8%)	5% (4.6%–5.4%)	8% (4.9%–11.1%)	13% (4.8%–25.7%)
65–74 years	1% (0.9%–1.1%)	2% (1.7%–2.3%)	5% (2.5%–7.5%)	8% (2.4%–20.4%)
75+ years	0.4% (0.3%–0.5%)	1% (0.8%–1.2%)	1% (0.0–2.1%)	4% (0.5%–14.5%)
Place				
Home	20% (19.5%–20.5%)	3% (2.7%–3.3%)	3% (1.0%–5.0%)	—
Athletic or sports area	3% (2.8%–3.2%)	4% (3.6%–4.4%)	4% (1.7%–6.3%)	5% (0.6%–15.8%)*
Street or highway	51% (50.4%–51.6%)	41% (40.1%–41.9%)	82% (77.5%–86.5%)	95% (84.2%–99.4%)*
Place of recreation	10% (9.6%–10.4%)	—	5% (2.4%–7.6%)	—
Other specified	9% (8.7%–9.3%)	6% (5.5%–6.5%)	6% (3.2%–8.8%)	—
Unspecified place	7% (6.7%–7.3%)	46% (45.0%–47.0%)	—	—
Activity				
Sport/active recreation	7% (6.7%–7.3%)	34% (33.1%–34.9%)	26% (20.6%–31.4%)	—
Leisure	71% (70.4%–71.6%)	4% (3.6%–4.4%)	41% (35.0%–47.0%)	—
Other specified†	14% (13.6%–14.4%)	25% (24.2%–25.8%)	33% (27.2%–38.8%)	—
Unspecified activity	8% (7.7%–8.3%)	37% (36.1%–37.9%)	—	—

VEMD = Victorian Emergency Minimum Dataset. VAED = Victorian Admitted Episodes Data Set. VSTR = Victorian State Trauma Registry. NCIS = National Coroners Information System. * Percentages were calculated for the 43 cases with available data. † "Other specified" includes: vital activity, resting, sleeping or eating; being nursed, cared for, education; working for income; other work; as well as many other smaller groups. ◆

presentations a year for bicycle injuries (just over half from road collisions), contrasts with Victoria's probably under-reported road-crash data, showing about 1200 bicycle casualty accidents per year.⁶ On the other hand, our use of hospital-based data, excluding injuries treated by general practitioners, may have underestimated the burden of bicycle injuries.

Consistent with previous reports,^{11,20,21} injured bicycle riders were predominantly young men, but the relative burden of major trauma cases and fatalities seemed to increase with age. In the major trauma and fatality groups, head injuries were the most common injury, consistent with previous studies.^{12,19,20,22}

Wearing an approved safety helmet substantially reduces the risk of serious head injury in cyclists who fall or are involved in collisions with motor vehicles.^{10,12,23} A prospective study of 1710 bicycle casualties in Victoria, 1987–1989, before the introduction of compulsory helmet wearing, found that the 21% wearing an approved helmet

had overall at least a 39% reduced risk of head injury and significantly less frequent severe head injuries.¹⁰ Recent anecdotal evidence suggests less compliance with helmet laws. However, of the 30 cyclists with a fatal injury for whom coronial data were available, 23 (77%) wore a helmet, a proportion consistent with a 1994 Victorian survey of helmet wearing.⁸ Updated statistics on helmet-law compliance are needed. Injuries to the extremities, although not life-threatening, were common among ED and hospital presentations and often involved long-term morbidity,²⁴ so strategies to target these injuries are also needed.

Most serious injuries occur on streets or highways.²⁵ Separation of bicyclists from cars results in fewer injuries.^{11,13,14} Our study presents data on when (VSTR) and where (all datasets) most collisions occurred, and could be used as a guide to where designated bicycle paths should be provided, and then their utility and impact on cyclists' safety could be monitored. However, geographical, economic (and political) consider-

ations often hinder provision of cycle paths. An alternative solution — restricting access for bicycle riders to major roads with high-speed vehicles, especially in peak periods — may not be well received by cyclists.

Research is needed on alcohol use by cyclists.^{11,21} Davidson found that over 60% of cyclists injured at night had consumed alcohol.¹¹ As bicycle-related crashes may not always be reported to police,^{26,27} blood-alcohol tests may not be performed and the role of alcohol use in accidents ignored.

There is a need for greater community awareness of cyclists. Motorists need to be educated about safely sharing the road, and cyclists informed about potentially risky behaviours. The numerous bike organisations across Victoria could convey messages to their members, but bicyclists most at risk may not be members of these organisations. Indeed, most bicyclists are involved in non-organised cycling activities.⁵

As 55% of the fatally injured cyclists were aged over 35 years, education and prevention strategies should target this age group.

RESEARCH

In overseas studies,²⁸ and Australian studies before helmet wearing was made compulsory,^{8,29,30} prevention strategies emphasised the importance of helmet-wearing. In Australia, further data are needed to identify factors other than helmet-wearing that contribute to preventing cycling injuries. These might include cycling skills and training in cycle riding, bicycle design, clothing, bicycle-path engineering, education of motorists, and other factors. Establishment of a reliable registry of bicycle participants would assist in understanding and improving cyclists' road safety.

A major limitation of our study was the lack of data on participation rates or change in participation rates over time. With no valid estimates of the number of people riding bicycles and the time spent riding, it was not possible to calculate incidence of cycling injuries using actual time at-risk or number of people cycling as the denominator. We had to use the entire population instead. Clearly, this provides a broad estimate only and is likely to underestimate the incidence of cycling injury.

Bicycle accidents causing minor injuries are likely to be under-reported,^{12,26} and minor injuries would be dealt with by GPs. As no GP registry for such injuries exists, these data were not included. Thus, another important limitation is that not all minor injuries were included.

A final limitation is that it is not possible to identify readmissions from the VAED and the VEMD due to a lack of a unique identifier for patients in the health system.

Presentations to EDs and hospitals for bicycle injuries appear to have increased significantly over the 5-year period 2001–2006. Accurate data regarding participation in cycling, use of injury prevention strategies, and injury profile would assist in lowering injury rates in this cohort.

ACKNOWLEDGEMENTS

The VSTR is a Department of Human Services and Victorian Trauma Foundation funded and approved initiative. Belinda Gabbe is supported by a Career Development Award (465103) from the National Health and Medical Research Council (NHMRC). We thank Andrew Hannaford and Sue McLellan for their assistance with extracting data from the VSTR and the NCIS.

COMPETING INTERESTS

None identified.

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(Received 25 Aug 2008, accepted 10 Dec 2008) □