Incidence, severity and correlates of bicycling injuries in a sample of cyclists in Queensland, Australia

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ABSTRACT

Bicycle injuries, particularly those resulting from single bicycle crashes, are underreported in both police and hospital records. Data on cyclist characteristics and crash circumstances are also often lacking. As a result, the ability to develop comprehensive injury prevention policies is hampered. The aim of this study was to examine the incidence, severity, cyclist characteristics, and crash circumstances associated with cycling injuries in a sample of cyclists in Queensland, Australia. A cross-sectional study of Queensland cyclists was conducted in 2009. Respondents (n=2056) completed an online survey about their cycling experiences, including cycling injuries. Logistic regression modelling was used to examine the associations between demographic and cycling behaviour variables with experiencing cycling injuries in the past year, and, separately, with serious cycling injuries requiring a trip to a hospital. Twenty-seven percent of respondents (n=545) reported injuries, and 6% (n=114) reported serious injuries. In multivariable modelling, reporting an injury was more likely for respondents who had cycled <5 years, compared to ≥10 years ($p<0.005$); cycled for competition ($p=0.01$); or experienced harassment from motor vehicle occupants ($p<0.001$). There were no gender differences in injury incidence, and respondents who cycled for transport did not have an increased risk of injury. Reporting a serious injury was more likely for those whose injury involved other road users ($p<0.03$). Along with environmental and behavioural approaches for reducing collisions and near-collisions with motor vehicles, interventions that improve the design and maintenance of cycling infrastructure, increase cyclists' skills, and encourage safe cycling behaviours and bicycle maintenance will also be important for reducing the overall incidence of cycling injuries.

Keywords: Bicycle, Injury, Cyclist characteristics, Crash circumstances, Prevention

1. Introduction

Relative to motor vehicle occupants, cyclists in Australia are over-represented in traffic crash casualties. They account for 14.6% of serious injuries in road based traffic crashes yet comprise less than one percent of kilometers travelled (Henley and Harrison, 2009). For the period 2000 to 2007, serious injury rates for Australian cyclists increased by 47%, while for all other road user groups (motorcycles aside) rates either remained steady or declined (Henley and Harrison, 2009). Similarly, for the same time period, total road crash fatalities decreased by 12%, but bicyclist fatalities showed a small increasing trend (Henley and Harrison, 2009). Similar trends have recently been reported in New Zealand (Tin Tin et al., 2010).

International comparisons indicate that Australian cyclists experience a greater risk of injury than cyclists in a number of other developed countries. The cyclist injury rate in Melbourne in 2008, 12.4 serious injuries per 10 million km[1], compares unfavourably with cyclist injury rates in The Netherlands (1.4 serious injuries per 10 million km), Denmark (1.7), Germany (4.7) and the UK (6.0) (Garrard et al., 2010; Pucher and Buehler, 2008). Substantially lower cyclist fatality and injury rates in The Netherlands, Germany and Denmark have been attributed to better cycling infrastructure; national cycling education, skills and promotion programs; widespread traffic calming; and driver licensing and road safety systems that place greater responsibility on drivers for the safety of cyclists and pedestrians (Bassett et al., 2008; Christie et al., 2007; Fedtke, 2003). Australia has implemented few of these bicycle safety measures.

Although cyclists comprise a relatively high and increasing proportion of serious injuries among road users in Australia, little is known about the incidence of cycling injuries among cyclists and about the causes of these cycling injuries. What is known comes from police crash reports and hospital datasets. Police crash reports include only a relatively small proportion of the serious cyclist injuries treated in Australian hospitals (Richardson, 2009; Sikic et al., 2009), and hospital datasets, in turn, exclude injuries treated by general practitioners and other health care providers (Sikic et al., 2009). Because few cycling injuries are investigated, little is known about the causes of bicycle injuries. Furthermore, hospital and police-based injury data do not include cyclists' exposure to injury risk (e.g., frequency of cycling or distance cycled), and thus analysis of such data cannot control for exposure.

[1] Police-reported serious injuries, Greater Melbourne Metropolitan Area. The hospital-reported injury rate was substantially higher; at 31.5 serious injuries per 10 million km. National data for Australia are unavailable.

Police and hospital databases also rarely include non-serious injuries, making non-serious injuries a neglected area of research. The societal costs of non-serious injuries is likely to be high due to their high incidence; however, their absence from research makes it impossible to develop effective policy interventions aimed at reducing the overall burden of injury attributable to cycling trauma (Veisten et al., 2007).

There is also limited and inconsistent evidence on the impact of demographic factors on cycling injuries. Most studies show higher injury counts for young to middle-aged cyclists and for males (Boufous et al., 2010; Henley and Harrison, 2009; Watson and Cameron, 2006), but this pattern is not consistently evident in the small number of studies that have examined injury rates based on exposure to injury risk. A year-long study of adult bicycle commuters in the Portland, OR, metropolitan area found no differences in injury rates (per 100,000 miles commuted) for age, gender, safety practices or experience levels (Hoffman et al., 2010). In a New Zealand study, children and adolescents were found to be at highest risk (Tin Tin et al., 2010). In the UK, the risk of a cyclist being killed or seriously injured (per million km travelled) was reported to be highest for young cyclists aged 10-15 years, followed by a decline in risk for young and middle-aged cyclists, but rising again for older cyclists (70+ years) (Knowles et al., 2009).

Demographic factors may also impact the severity of a cycling injury. In the US, Lustenberger et al. (2010) reported an increased incidence of severe or critical trauma with age: 20.3% for cyclists aged ≤ 14 years, increasing to 38.2% for cyclists aged > 65 years. A study in Hong Kong reported more bicycle injuries among children, but more serious injuries for adults, a pattern the authors attributed to greater exposure to motor vehicle traffic among adult cyclists (Yeung et al., 2009). In the UK study by Knowles et al. (2009), males were more likely than females to be injured, and the relative risk for males increased with injury severity. To better inform policy interventions, further research is required to clarify socio-demographic injury risk profiles for cyclists.

This study addresses these gaps in cycling injury research. Cyclist surveys provide an opportunity to obtain information about cycling injuries, including injury severity (including minor injuries), and cycling patterns, which are currently unavailable from police and hospital records. The aim of the study was to examine the incidence, severity, and correlates of cycling injuries, and separately, serious cycling injuries requiring a trip to a hospital, in a sample of Queensland cyclists.

2. Method

2.1. Sampling and study protocol

An online survey was used to collect data on characteristics, behaviours, and experiences of cyclists in Queensland, Australia. The sample was drawn from the adult membership (aged ≥18 years) database of Bicycle Queensland (BQ), a state-wide community group that advocates for better cycling facilities and safety and promotes cycling for recreation and transport.

Between 29 October and 6 November 2009, BQ sent email invitations, with a link to the survey, to the 'primary member' of member households. All adult members of the household were encouraged to participate. Before sending invitations, BQ encouraged participation via its mail-delivered and online member newsletters. One week after the final invitations were sent, BQ sent reminder emails. To further encourage participation, respondents could enter into prize draws to win bicycle accessories from local bicycle shops and receive a newsletter of the study findings.

Of 4469 households invited to participate, 2085 responded. This 46.6% response rate is higher than typically found for online surveys (Garrard et al., 2006; Manfreda et al., 2008). The households that participated included 2356 individual respondents, and of these respondents, those who reported that they cycled less than monthly (n=180) or that their residence was not in Queensland (n=120) were excluded from analysis, leaving 2056 respondents available for inclusion in this analysis.

2.2. Items

2.2.1. Outcome Variable

Respondents reported the number of 'cycling accidents causing injury' they had experienced in the previous 12 months. Responses were dichotomized (none; ≥1). Based on qualitative data collected on injuries, injuries that did not result in a fall to the ground (e.g., muscle pull) were not deemed to be injuries for these analyses.

2.2.2. Demographic characteristics

Respondents were asked standard demographic questions (age, gender, educational level, home postcode). Home postcodes were used to determine socio-economic indexes for areas (SEIFA). This measure uses 2006 Census variables to assess the relative socio-economic advantage or disadvantage of Australian geographic areas, and for this study, the area within which respondents lived (Australian Bureau of Statistics, 2008). Areas are divided into deciles with higher deciles representing greater advantage.

2.2.3. Cycling patterns

Respondents reported the length of time they had been cycling as an adult (weeks, months, years), their cycling frequency (5–7 days/week, to never in the last year), and the purposes of their cycling (recreation [just for fun or exercise], competition, transport [as a means of getting to and from places]).

2.2.4. Cycling harassment

Respondents reported whether, while cycling, they had experienced intentional harassment from motorists or their passengers in the last 12 months (yes/no).

2.2.5. Causes of cycling injuries

Respondents who reported cycling injuries were asked to describe the cause of their most severe cycling injury in the last 12 months. Exclusive response options were collision with a moving vehicle; another type of collision with a motor vehicle (e.g., an opened door of a vehicle); collision with another cyclist; collision with a pedestrian; swerving to avoid a vehicle; hitting an object on the road or path (e.g., the curb, a pothole); skidding on a wet surface; falling off; and other, for which they described the cause.

2.2.6. Treatment for and reporting of cycling injuries

Respondents who reported a cycling injury stated all the treatments they sought for their most severe cycling injury in the last 12 months. Response options were: no consultation with a health professional; consultation with a general practitioner; consultation with an allied health practitioner; trip to a hospital emergency department; and admittance to a hospital. Respondents could report more than one treatment. If the injury required hospital admittance, they reported the number of nights they had spent in the hospital. They also had the option of selecting "other" and describing their main treatment. Last, they were asked whether the crash that caused their injury was reported to the police (yes/no).

2.2.7. Qualitative description of the most sever cycling injury

Respondents were asked to further describe their most severe cycling injury in the previous 12 months. An open-ended response format was used.

2.3. Statistical analysis

Two of the authors (KCH, SS) jointly reviewed and coded the qualitative data collected from respondents who described the cause of their most severe injury; described the treatment they sought for their most severe injury, or provided further details about their most severe injury in the open-ended item. The qualitative data were used to place participants into injury cause and injury treatment categories already defined in the survey, to expand those categories, and to create new categories. KH subsequently reviewed the initial coding, collapsed some themes and merged others in consultation with the other authors. Most new themes were coded as subcategories under the categories already included in the survey although a few themes became new categories because they did not fit within existing categories.

All quantitative analyses were conducted with STATA/SE 10.1 (StataCorp, College Station, Texas). Missing data were imputed using the hotdeck procedure in STATA that uses all other available data in the dataset to impute a value for categorical variables. The survey (svy) command was used to account for clustering of respondents within households (StataCorp, 2007). Descriptive statistics were generated for all quantitative study variables, and incidence of cycling injuries was computed across categories of each quantitative variable. Logistic regression models were computed to examine possible correlates of incurring a cycling injury. Correlates examined were demographic characteristics, cycling patterns, and cycling harassment. Associations between cycling injuries and correlates were first examined in bivariate models. Variables that were significantly associated with injury were then entered into a multivariable model. Age and gender were maintained in the multivariable model given their previous associations with cycling injuries (Knowles et al., 2009). Among respondents who reported a cycling injury, the same modelling was used except the outcome variable was incurring a serious cycling injury, and the reported cause of the injury was included as a possible correlate. A serious injury was defined as an injury that required treatment at a hospital (trip to a hospital emergency room and/or admittance to a hospital). For this final analysis, cause of injury was collapsed into incident with a vehicle; incident with another cyclist, a pedestrian or animal; incident with an object on or off road; a mountain bike injury, and falling off.

3. Results

Respondent characteristics are shown in Tables 1 and 2. Twenty-seven percent of respondents (n=545) reported one or more cycling injuries in the previous year, with a total of 752 injuries reported. Most respondents who reported being injured reported one injury (n=405; 74.3% of those injured), but few of these respondents (n=50; 9.2%) indicated that their most severe cycling injury was reported to police.

Based on the qualitative data, the list of injury causes was expanded to include additional causes of collisions and near-collisions (hitting an animal, swerving to avoid a pedestrian or animal, swerving to avoid an object in the road) and specific causes of falling off (difficulty unclipping from cleats; mechanical failure causing a fall). Given the number of respondents who reported off-road mountain biking injuries, a category for these injuries was added. Skidding on a wet surface was expanded to include skidding on any surface. As shown in Table 3, the most commonly reported injuries involved crashing with or avoiding a crash with an object on the road or path, and skidding (38.0% of all injuries, and 34.2% of serious injuries). Collision or swerving to avoid a collision with a motor vehicle was responsible for 18.2% of all injuries and 29.0% of serious injuries.

Treatments used for the most severe injury are described in Table 4. Based on respondents' qualitative descriptions of their treatments, no consultation with a health professional was expanded to include minor first aid treatment, such as that provided at a cycling event, and consultation with a general practitioner was expanded to include other medical professionals, including nurses, medical specialists, or paramedics. In total, 114 respondents required a trip to a hospital (20.9% of those injured reported going to a hospital emergency department and/or being admitted to the hospital). Of 96 who went to the hospital emergency room, only 18 were later admitted. Another 18 indicated that they were admitted to hospital without first going to the emergency department. For the 36 who were admitted, hospital stays ranged from <1 day to 30 days with most spending >1 day (69.4% of those admitted, n=11).

In multivariable modelling (Table 5), age was not associated with overall injury but was associated with serious injury: cyclists aged 18-34 years were less likely to report a serious injury than those aged 45-54 years. Measures of cycling patterns were associated with injury. Compared to respondents who had cycled ≥10 years as adults, those who had cycled ≤5 years were more likely to report a cycling injury, but not a serious injury. Respondents who cycled ≤4 days per week were less likely to incur an injury or a serious injury compared to those who cycled 5-7 days per week. Cycling for competition and experiencing harassment while cycling were both associated with having an injury, but not with having a serious injury. Gender, cycling for recreation, and cycling for transport were not significantly associated with overall injury or with a serious injury. Last, the circumstances of the injury was associated with having a serious injury: respondents who reported that their injury was due to an incident with an animal, a pedestrian, another cyclist or a motor vehicle were more likely to report a serious injury than respondents who reported the cause to be falling off their bicycle.

4. Discussion

This study of regular cyclists showed the incidence of a cycling injury over one year to be 27%. While this percentage seems high, it does include a high proportion of minor injuries that did not require treatment from a health professional (49% of all injuries). Injuries that are generally classified as serious (treated and discharged on the day from a hospital or admittance to a hospital) were less common (6.6%), and the incidence of such injuries was similar to the 12-month incidence of serious cycling injuries (5%) reported in Portland, OR, for a sample of commuter cyclists (Hoffman et al., 2010).

One third of injuries involved colliding with, or attempting to avoid a collision with, another road/path user (e.g., motor vehicles, cyclists, pedestrians, animals). The finding that interactions involving a motor vehicle increased the likelihood of receiving a serious injury supports previous studies showing that crashes involving motor vehicles lead to the most serious cyclist injuries (Richardson, 2009; Sikic et al., 2009; Watson and Cameron, 2006). Our findings also indicate that interactions with other road and path users contribute to serious injury risk. Thus, findings from this study support the need for a continued focus on cycling safety improvements that reduce hazardous cyclist/driver interactions, including the provision of separate bicycle facilities (Lusk et al., 2011), and the results also support the need for safety measures that reduce hazardous interactions with other road/path users, particularly on sidewalks and multi-use trails (Reynolds et al., 2009).

Most injuries (67%) did not result from interactions with motor vehicles, pedestrians, animals, or other cyclists (i.e., were non-collision). These injuries resulted from hazardous road or path conditions, falling off, or mountain biking crashes. These injuries, however, were less likely to be serious (see Table 5). The high rate of non-collision injuries indicates that additional actions aimed at improving the design and maintenance of cycling infrastructure, increasing cyclists' skills, encouraging safe cycling behaviour and bicycle maintenance are required to reduce the overall incidence of cycling injuries. As Veisten et al. (2007) demonstrated, a relatively large number of non-serious, but frequent, bicycle crashes can make a substantial contribution to the overall burden of bicycle injuries. Further, neglect of these injuries and their causes can curtail the effectiveness of injury prevention efforts.

Understanding the demographic factors that contribute to cycling injuries can also assist in planning interventions to improve cycling safety. Studies of cycling injuries that use hospital data (Henley and Harrison, 2009; Sikic et al., 2009) or police crash reports (Watson and Cameron, 2006) typically do not account for demographic differences in cycling participation. In particular, these data are not able to determine to what extent the substantially higher proportion of injuries reported previously for men (Sikic et al., 2009;

Watson and Cameron, 2006) is due to men cycling more than women. The current study found that, after adjusting for other demographic characteristics and for cycling patterns, men were not significantly more likely than women to have a cycling injury or a serious cycling injury. This is consistent with the findings of Hoffman et al. (2010) for adult commuter cyclists in Portland, OR. In contrast, a comprehensive analysis of cycling injuries in the UK, which controlled for gender differences in cycling exposure, found that men were over-represented in cyclist casualties, particularly fatal casualties (Knowles et al., 2009). However, the study included children, who are often over-represented in cycling-related injuries. The authors suggested that higher levels of 'impulsive' behaviour among boys may contribute to the over-representation of males in cycling injuries (Knowles et al., 2009).

Consistent with the above findings, and not unexpectedly, greater cycling exposure (cycling more days/week) was associated with increased likelihood of having any type of injury or having a serious injury. The consistently documented higher injury rates for men in hospital and police-based studies (Richardson, 2009; Sikic et al., 2009; Watson and Cameron, 2006) may therefore be partly due to cycling exposure, at least for adult males.

Except for the reduced likelihood of the youngest cyclists (aged 18-34 years) having a serious injury, relative to cyclists aged 45-54 years, our findings indicated no significant impact of age on cycling injuries in multivariable modelling. To date, the evidence supporting an association between age and injury (for adult cyclists) has been inconsistent, with results varying by injury severity, injury data source, and selection of covariates (Hoffman et al., 2010; Knowles et al., 2009).

The least experienced cyclists (i.e., those who had ridden for ≤5 years) were the most likely to be injured, but were not significantly more likely to be seriously injured. Given that a high proportion of non-serious injuries were for non-collision incidents (e.g., falling off), it appears that inexperience has a greater impact on these than on the more serious collision-related injuries. Interestingly, those who experienced harassment from motor vehicle drivers or passengers were more likely to have an injury (but not of a serious injury). Whether the harassment reported was directly associated with the injury is not known. Little research has been conducted into cyclists' experiences of harassment or the associations between harassment and injury. However, it may be that particular cycling routes or cyclist behaviour predisposes cyclists to both injury and harassment.

Cycling for competition was associated with an increased likelihood of reporting an injury, but cycling for transport was not. People who cycle for competition may cycle at higher speeds (e.g., during on-road 'training') or in different locations than those who cycle for transport. Interestingly, competitive cyclists did not have an increased likelihood of having a serious injury. Given that serious cyclist injuries are more likely to involve a motor vehicle (Watson and Cameron, 2006), it may be that people who cycle and train for competition are more likely to ride in groups and possibly experience more, but less serious, collisions with other cyclists. O'Connor and Brown (2010) describe how a pseudo-competitive style of high-speed bunch cycling occurs in considerable numbers at many on-road locations in Victoria, Australia.

This survey study indicates that hospital records and police crash reports (the sources of most research studies of cycling injuries) capture only a small, albeit more serious, fraction of total cycling injuries (Richardson, 2009; Sikic et al., 2009) and are thus only capturing the 'tip of the injury iceberg'. They are consequently unable to capture the total contribution of cycling injuries to the overall burden of injury for cyclists. This study also documents under-reporting to police of cyclist injuries involving a collision with a motor vehicle, despite state rules requiring road users, including motorists and cyclists, to report traffic crash injuries to police and for police to file traffic crash reports (Queensland Government, 2009; Queensland Government, 2010). While 74 respondents were injured as a result of a collision with a motor vehicle and a further 25 were injured swerving to avoid a motor vehicle (Table 3), only 50 injured cyclists reported their injury crash to police. This finding may be explained in part by the perceived negative experiences cyclists have with police. In an open-ended question, five respondents reported negative dealings with police, most notably that they felt police did not act when cyclists reported an injury. Further investigation is needed to understand why cycling injuries are under-reported to and by police.

This study contributes to two current deficits in cycling injury research: the incidence of, and factors related to, non-serious injuries and the influences of cyclist characteristics and crash circumstances on serious and non-serious injuries. While offering some advantages over injury analysis based on hospital or police data, the study also has limitations. One study limitation is the sample selection bias due to the use of online survey data from members of a bicycle community and advocacy group. Caution is therefore warranted in generalizing our findings to the general population of Australian, or Queensland, cyclists. Comparisons with data on Australian cyclists (Australian Sports Commission, 2010) indicate that our sample had fewer young adults (13.5% aged 18-34 years versus 31.8% nationally), more middle-aged adults (60.5% aged 34 to 54 years versus 50.6% nationally) and slightly fewer females cyclists (27% versus 33%), suggesting that our findings are biased towards middle-aged adults and slightly biased towards men. Notably, the age differences partially reflect the inclusion of cyclists aged 15-17 years in the Australian data whereas our sample included adults aged 18+ years. Our sample also tended to be of relatively high socio-economic status. While 33% of the sample did not have a university degree, only 16% lived in disadvantaged areas. Although we are unaware of other data on the socio-economic status of cyclists in Australia for comparison, findings from a study in Western Australia indicate that the willingness to walk or bicycle for short trips, instead of taking a car, increases with increasing education level (Milligan et al., 2007), suggesting a possible socio-economic gradient in utility cycling.

Only cyclists who had cycled on average at least monthly for the past year were included in our analysis. It is possible that very severely injured cyclists who no longer cycled were omitted because they did not meet the eligibility criteria or because they are no longer were members of a cycling group. Recall biases was also possible: respondents may have forgotten to report minor injuries or thought that such injuries were too minor to report. Other limitations include the cross-sectional design, which did not allow for causality to be determined, and the collection of descriptive data on only respondents' most severe injuries, which limited our ability to describe causes of some of the less severe injuries. However, most respondents who reported injuries reported one injury (74%), and, therefore, our descriptions reflect most of the injuries. Last, although our response rate (47%) is quite good for an online survey (Garrard et al., 2006; Manfreda et al., 2008) and is similar to response rates found for some large population-based studies in Australia that have used mailed surveys (Brown et al., 1999; Giles-Corti et al., 2008) or CATI surveys (Mummery et al., 2008), it is low. Thus, our findings may not be generalizable to all BQ members.

5. Conclusions

These findings indicate a relatively high incidence of bicycling injuries in a sample of cyclists in Queensland, Australia, the majority of which are non-serious injuries. Nevertheless, the high frequency of non-serious injuries, the over-representation and increasing incidence of serious cycling injuries in road traffic crash casualties, and the substantially higher rates of cycling injuries in low-cycling countries such as Australia compared with a number of European and Asian countries indicates the need for preventive action. Many countries and cities now have sustainable transport policies that foster a shift from motor vehicle use to bicycling for transport. There are multiple health, transport, environmental and community livability benefits associated with cycling for transport, and it would be unfortunate if these benefits were to be diluted by an increase in cycling injuries.

International experience demonstrates that cycling can be made safer, both for children (Christie et al., 2007) and adults (Pucher and Buehler, 2008). Environmental and behavioural measures (targeting both cyclists and drivers) aimed at reducing collisions and near-collisions will be important for reducing the overall incidence of cycling injuries. In addition, interventions that improve the design and maintenance of cycling infrastructure, increase cyclists' skills, and encourage safe cycling behaviours and bicycle maintenance are needed.

Acknowledgements

Dr. Heesch was supported by a NHMRC program grant in physical activity and health (ID#301200) at The University of Queensland, School of Human Movement Studies. Dr. Sahlqvist was supported by funds from the Engineering and Physical Sciences Research Committee at the Medical Research Council, Epidemiology Unit. We would like to thank the staff at Bicycle Queensland for their assistance with development of the questionnaire and study design, recruitment of their members, and collection of incentives for the prize draws. We would like to give a special thank you to Andrew Demack of Bicycle Queensland, whose enthusiasm for the study and input into the development and implementation of the survey benefited the study greatly. Special thanks also to the Bicycle Queensland members who took the time to complete the online survey for this study.

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Table 1
Characteristics of the sample (n=2056).[a]

Characteristics	n	% of total sample
Age, years		
18-34	274	13.3
35-44	536	26.1
45-54	706	34.3
55-64	393	19.1
65+	147	7.2
Gender		
Male	1,470	71.5
Female	586	28.5
Education		
No tertiary degree	286	13.9
Trade/apprenticeship or certificate/diploma	397	19.3
Undergraduate degree	713	34.6
Postgraduate university degree	660	32.1
SEIFA		
Decile 10 (most advantaged)	575	28.0
Decile 9	608	29.6
Decile 8	349	17.0
Decile 7	195	9.4
Deciles 1-6 (most disadvantaged)	329	16.0
Years of cycling as an adult		
10+ years	859	41.8
5 - < 10	454	22.1
2 - < 5	503	24.4
0 - < 2	240	11.7
Cycling frequency		
5-7 days/week	496	24.1
3-4 days/week	820	39.9
1-2 days/week	601	29.2
At least once/month	139	6.8
Cycle for recreation		
No	194	9.4
Yes	1,862	90.6
Cycle for transport		
No	846	41.1
Yes	1,210	58.9
Cycle for competition		

No	1,690	82.2
Yes	366	17.8
Harassment while cycling		
No	486	23.6
Yes	1,570	76.4

[a] Adjusted for clustering by household.

Table 2

Percentage of respondents within each characteristic category who reported a cycling injury and, separately, those who reported a serious injury. [a]

Characteristics	Reported injury n=545		Reported serious injury n=114	
	n	%	n	%
Age, years				
18-34	80	29.2	8	2.9
35-44	134	25.0	28	5.2
45-54	201	28.5	44	6.2
55-64	102	26.0	28	7.1
65+	28	19.0	6	4.1
Gender				
Male	401	27.3	89	6.1
Female	144	24.6	25	4.3
Education				
No tertiary degree	73	25.5	17	5.9
Trade/apprenticeship or certificate/diploma	97	24.4	20	5.0
Undergraduate degree	201	28.2	34	4.8
Postgraduate university degree	174	26.4	43	6.5
SEIFA				
Decile 10 (most advantaged)	159	27.7	38	6.6
Decile 9	156	25.7	29	4.8
Decile 8	104	29.8	23	6.6
Decile 7	40	20.5	4	2.1
Deciles 1-6 (most disadvantaged)	86	26.1	20	6.1
Years of cycling as an adult				
10+ years	204	23.7	50	5.8
5 - < 10	115	26.5	30	7.1
2 - < 5	153	30.4	22	4.4
0 - < 2	73	30.4	12	5.0
Cycle frequency				
5-7 days/week	172	34.7	51	10.3
3-4 days/week	221	27.0	39	4.8
1-2 days/week	138	23.0	23	3.8
At least once/month	14	10.1	1	0.7
Cycle for Recreation				
No	46	23.7	11	5.7
Yes	499	26.8	103	5.5
Cycle for Transport				
No	211	24.9	38	4.5
Yes	334	27.6	76	6.3
Cycle for Competition				
No	413	24.4	90	5.3

Yes	132	36.1	24	6.6
Harassment while cycling				
No	85	17.5	19	3.9
Yes	460	29.3	95	6.1

[a] Adjusted for clustering by household.

Table 3

Main cause of the most severe cycling injury in the previous 12 months, using quantitative and qualitative data. [a]

Categories of causes and specific causes reported	Respondents reporting an injury n=545		Respondents reporting a serious injury n=114	
	n	%	n	%
Collision or avoidance of a collision with a motor vehicle [b] (Total)	99	18.2	33	29.0
Collision with a moving motor vehicle	62	11.4	24	21.1
Other collision with a motor vehicle (most with an opened door)	12	2.2	3	2.6
Swerving to avoid a motor vehicle	25	4.6	6	5.3
Collision or avoidance of a collision with another cyclist, a pedestrian or an animal (Total)	86	15.8	24	21.0
Collision with another cyclist [c]	58	10.6	19	16.6
Collision with pedestrian	13	2.3	3	2.6
Collision with animal (e.g., dog, cat, wallaby)	7	1.3	2	1.8
Swerve to avoid cyclist or pedestrian [c]	7	1.3	0	0.0
Swerve to avoid animal	1	0.2	0	0.0
Crash or avoidance of a crash with an object on the road or path; [d] skidding (Total)	207	38.0	39	34.2
Hitting an object on the road or path	101	18.5	21	18.4
Swerving to avoid objective on the road or path (e.g., cracked or uneven pavement, tree branches across path, potholes)	10	1.8	1	0.9
Skidding (due mainly to wet but also dirt, gravel, or oily surfaces)	96	17.6	17	14.9
Falling off [e] (Total)	111	20.4	13	11.4
Unable to unclip out of cleat	19	3.5	0	0.0
Mechanical failure (e.g., flat tyre, poorly adjusted handle bars or seat)	7	1.3	3	2.6
Other/reason not provided	85	15.6	10	8.8
Off-road mountain biking injury	41	7.5	5	4.4
Cause not given	1	0.22	0	0.0

[a] Adjusted for clustering by household. Percentages do not necessarily sum to 100% due to rounding error. Qualitative data were used to revise the categories.

[b] Cyclists tended to report that these injuries were due to the vehicle driver being unaware of the cyclist's presence.

[c] These injuries tended to be falls that occurred while cycling in groups, such as occurs when a cyclist in front suddenly breaks, causing following cyclists to collide or swerve to collide

[d] Most cyclists who reported these injuries described the cause of the injury as the presence of hazards on paths due to poor path maintenance.

[e] Reasons for falling off varied with most reported to be the inability to unclip out of cleats when wanting to stop suddenly, such as when a street-light changed to red, or a mechanical problem.

Table 4

Treatments reported for the most severe cycling injury in the previous 12 months (n=545). [a]

Treatment	N	%
No consultation with a health professional or only first aid	267	49.0
Consultation with medical professional (e.g., general practitioner, nurse, medical specialist)	145	26.6
Consultation with allied health practitioner (e.g., physiotherapist, chiropractor)	88	16.2
Trip to a hospital emergency department [b]	96	17.6
Admitted to a hospital [b]	36	6.6

[a] Adjusted for clustering by household. Respondents could select more than one treatment (only the first category was exclusive). Qualitative data were used to revise the categories.

[b] 114 respondents in total reported making a trip to a hospital emergency department and/or admitted).

Table 5
Correlates of cycling injuries, and separately of severe cycling injuries. [a]

	Injury				Serious injury [b]			
Variables	**UNADJUSTED OR (95% CI)**		**ADJUSTED [c] OR (95% CI)**		**UNADJUSTED OR (95% CI)**		**ADJUSTED [c] OR (95% CI)**	
Age, years								
18-34	1.04	0.76-1.41	0.94	0.68-1.30	**0.40**	**0.18-0.90**	**0.33**	**0.14-0.78**
35-44	0.84	0.65-1.08	0.80	0.62-1.05	0.99	0.58-1.70	0.99	0.55-1.78
45-54 (ref)	1.00		1.00		1.00		1.00	
55-64	0.88	0.67-1.16	0.98	0.73-1.30	1.31	0.75-2.29	1.32	0.72-2.41
65+	**0.59**	**0.38-0.92**	0.68	0.42-1.08	0.95	0.36-2.51	1.06	0.42-2.69
Gender								
Male	1.00		1.00		1.00		1.00	
Female	0.87	0.70-1.08	0.93	0.74-1.18	0.77	0.47-1.27	0.94	0.54-1.61
Years of cycling as an adult								
10+ years	1.00		1.00		1.00		1.00	
5 - < 10	1.09	0.84-1.42	1.12	0.86-1.48	1.09	0.641.84	1.14	0.64-2.04
2 - < 5	**1.40**	**1.10-1.79**	**1.58**	**1.22-2.06**	**0.54**	**0.31-0.93**	0.62	0.34-1.15
0 - < 2	**1.40**	**1.02-1.93**	**1.77**	**1.26-2.50**	0.62	0.31-1.25	0.86	0.40-1.86
Cycle frequency								
5-7 days/week	1.00		1.00		1.00		1.00	
3-4 days/week	**0.70**	**0.55-0.88**	**0.71**	**0.55-0.91**	**0.51**	**0.32-0.82**	**0.51**	**0.30-0.85**
1-2 days/week	**0.56**	**0.43-0.73**	**0.60**	**0.45-0.80**	**0.47**	**0.27-0.83**	**0.50**	**0.26-0.97**
At least once/month [b]	**0.21**	**0.12-0.38**	**0.25**	**0.14-0.46**				
Cycle for recreation								
No	1.00		1.00		1.00		1.00	
Yes	1.18	0.83-1.67	1.26	0.88-1.80	0.82	0.40-1.69	0.93	0.42-2.07
Cycle for transport								
No	1.00		1.00		1.00		1.00	
Yes	1.15	0.94-1.40	1.09	0.86-1.37	1.28	0.83-1.98	1.02	0.61-1.71
Cycle for competition								
No	1.00		1.00		1.00		1.00	
Yes	**1.74**	**1.37-2.21**	**1.53**	**1.19-1.97**	0.77	0.47-1.28	0.78	0.44-1.39
Harassment while cycling								
No	1.00		1.00		1.00		1.00	

Yes	**1.96**	**1.51-2.53**	**1.75**	**1.33-2.30**	0.85	0.48-1.49	0.76	0.42-1.38
Cause of injury [d]								
Falling off					1.00		1.00	
Motor vehicle					**3.85**	**1.87-7.91**	**4.01**	**1.81-8.87**
Cyclist/ pedestrian/ animal					**2.68**	**1.25-5.74**	**2.53**	**1.17-5.51**
Object in road or skidding					1.73	0.88-3.41	1.82	0.90-3.71
Off-road mountain bike					1.00	0.33-3.03	1.08	0.33-3.57

[a] Adjusted for clustering by household. Only variables included in multivariable modelling are included here. The first category is the referent except where stated otherwise. Bold signifies significant results (p<0.05).

[b] Serious injuries were those for which treatment included a trip to a hospital emergency department and/or hospital admission in the previous 12 months. The analysis sample was limited to data from respondents who reported a cycling injury. Respondent who did not report the cause of their injury (n=1) or cycled less than weekly (n=14, only one of which reported a trip to a hospital) were excluded due to small cell sizes.

[c] Adjusted for all other variables in the table.

[d] Cause of injury was only included in the analysis of serious cycling injuries.