Helmet use and bicycle-related trauma in patients presenting to an acute hospital in Singapore

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ABSTRACT

Introduction: To describe the relationship between bicycle helmet use and injury pattern sustained by patients presenting to an emergency department (ED) in Singapore for bicycle-related trauma.

Methods: Data was collected from all individuals treated for bicycle-related trauma between September 1, 2004 and May 31, 2005 using a closed-ended questionnaire.

Results: 160 bicyclists with mean age of 34.4 years (range 10 to 89 years) were surveyed. Among them, 80 percent were male and 30.6 percent were non-residents. Helmets were worn by 10.6 percent of the patients. Alcohol was clinically detected in 11.3 percent of bicyclists. There was no difference in bicycle helmet use between Singaporeans and non-residents (p-value is 0.275). However, compared to younger bicyclists, bicyclists aged 30 years or older (p-value is less than 0.05), and compared to recreational or sport bicyclists, those who commute by bicycle, tended not to wear helmets (p-value is less than 0.01). Compared to Singaporeans (p-value is less than 0.05), non-residents and bicyclists aged 30 years or older (p-value is 0.011) believed that helmets did not protect against head injury. Comparing the helmeted group with the non-helmeted group, injury patterns by body region were: head injury 5.9 percent versus 40.0 percent (p-value is less than 0.01); facial injury 5.9 percent versus 37.1 percent (p-value is less than 0.05). Not wearing a helmet, being hit by a motor vehicle and age were significantly associated with higher injury severity scores, after adjusting for several potential confounding factors.

Conclusion: Bicycle helmet use was low in our sample of injured patients. When worn, protection against injury was demonstrated. A campaign to promote use of bicycle helmets should be targeted at non-residents and older bicyclists. Authorities should consider compulsory helmet laws for bicyclists and expanding anti-drunk driving campaigns to target alcohol-intoxicated bicyclists.

Keywords: bicycling, head injury, helmets, multiple injuries

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INTRODUCTION

Singapore has 3,164 km of roads and the majority of road-users commute by car, motorcycle or public buses. At present, there are no compulsory helmet laws for bicyclists, in contradiction to compulsory helmet laws for motorcyclists, which have been in place for more than 30 years in Singapore. There are also no designated bicycle lanes in Singapore. Bicyclists who share the roads with these motor vehicles form a small but extremely vulnerable group. Less than 1% of Singaporeans use the bicycle for regular travel but this is on the rise with the growing number of cycling enthusiasts. In addition, there are approximately 450,000 non-resident unskilled or semiskilled work-permit holders in Singapore and bicycles are used by them, primarily as a mode of transport. In Singapore, bicyclists are prohibited from riding on expressways and pedestrian pavements but they are allowed to ride on all other roads without a licence. In addition, there are several park connectors and off-road tracks on the island for adventure cyclists.

Traffic trends provided by the traffic police[1] reported that cyclist fatalities rose 29% (12 to 17) from 2001 to 2003, while reported non-fatal injuries rose 10% (319 to 354) from 2000 to 2003. We believe that this is the tip of the iceberg as the majority of bicycle crashes are not reported to the police and the injured present directly at healthcare facilities. Internationally, the prevalence of bicycle helmet use has been reported to be between 0% and 21.3%[2-6] in areas that have not received interventions designed to increase bicycle helmet use. This is despite the

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evidence that helmets reduce the risk of head injury by up to 88%, and reduce the risk of facial injury by 65% for bicyclists of all ages[7]. We postulate that the prevalence of helmet use is low among local bicyclists. In this study, we aimed to examine the usage, attitudes, beliefs and barriers towards helmet use, and the injury pattern among patients presenting to the emergency department (ED) for bicycle-related injuries.

METHODS

This study was conducted at the ED of a 1,000-bed tertiary public adult hospital. The annual census of its ED in 2004 was 137,100. The hospital is located in the centre of the island-state of Singapore, close to housing estates and the central business district. The ambulance service, run by the Singapore Civil Defence Force (SCDF), operates on a "zoning" system under which trauma patients are brought to the nearest public hospital from the crash scene. From September 1, 2004 to May 31, 2005, all consecutive patients with bicycle injuries who presented to the ED were identified at triage and enrolled in the study. All the ED doctors and nurses were briefed about the study and on the use of the questionnaire. Verbal consent was obtained from the participants. The same doctor who provided care for the patient administered the interview with the patient or a suitable surrogate. The hospital's trauma registry records were cross-referenced to identify bicyclists with major trauma who were brought directly by the paramedics into the resuscitation room, bypassing triage. This study was approved by the hospital ethics committee.

Using a closed-ended questionnaire, the following data were collected: (1) demographics, (2) mode of arrival, (3) whether a bicycle helmet was worn and if not, the reason, (4) injury nature and region, (5) mechanism and (6) reason for bicycle use, (7) alcohol consumption (a history of alcohol consumption before sustaining injury or the presence of alcohol on the patient's breath was classified as clinically-detectable recent alcohol consumption), (8) location of bicycle injury, and (9) disposition. Injury severity score (ISS) was calculated based on abbreviated injury scale 1990 version (AIS-90), update 98. Logarithmic transformation was performed on ISS and age due to skewed distribution. Continuous data was analysed using Student's t test. Categorical data were analysed by the chi-square test and Fisher exact test when the sample was small. Multiple linear regression was applied with log (ISS) as the dependent variable and log (age), mechanism of accident, helmet use, sex, ethnicity, nationality, alcohol intoxication and purpose of bicycle use as the independent variables. Statistical calculations were performed with STATA 8.0 for Windows (College Station, TX, USA). A p-value equal or less than 0.05 was considered to be significant (two tailed).

RESULTS

160 patients attended the ED for bicycle-related trauma between September 1, 2004 and May 31, 2005. There were 131 male and 29 female patients with median ages of 30 and 32 years, respectively. 64% were Chinese, 13.8% were Malay, 13.8% were Indian, and 8.1% were from other races. The median age for recreational and sport bicyclists was 22 years, compared with 41 years for commuter bicyclists ($p<0.01$). Alcohol was clinically detected in 11.3% of bicycle crashes. Alcohol consumption did not correlate with nationality, race, helmet-wearing, body region injured, ISS or disposition status, but it was more common in males ($p=0.045$) and with increasing age ($p=0.014$). 22% of bicycle crashes occurred on pedestrian footpaths, 65% on roads, 6% at intersections, and 7% on "off-road" tracks. 46% of bicyclists self-skidded, 45% were hit by a motor vehicle, and 9% fell due to other reasons (e.g. equipment failure, chased by an animal, foot caught in the wheel). There were no crashes involving motorised bicycles in our study. The breakdown in injury pattern by body region was: 36.3% of patients sustained a head injury (14.4% had either a skull fracture or intracranial haemorrhage or both), 33.8% had a facial injury, 74.4% had limb injuries, and 19.4% truncal injuries. Three (1.9%) patients died, 60 (37.5%) were admitted to hospital, and 97 (60.6%) were discharged from the ED.

Bicycle helmets were worn by 10.6% of our cohort of patients. Significantly more bicyclists aged 30 years and older did not wear helmets ($p=0.04$). Helmet use did not correlate with sex or nationality (Table I). Comparing recreational bicyclists and commuting bicyclists, more recreational bicyclists wore helmets ($p<0.01$). 54% of patients who believed that helmets protect against head injury did not actually wear one at the time of the crash (Table I). 42% of patients did not believe that helmets protect against injury. Significantly more patients aged 30 years and above did not believe that helmets protect against injury, compared with those below 30 years ($p=0.011$). The reasons cited for not wearing a helmet were that: it was troublesome (67.4%), unnecessary (15.6%), inability to afford it (9.2%), and that it was ugly (7.8%). Significantly more non-residents stated that they could not afford a bicycle helmet, while Singaporeans cited the other reasons ($p<0.01$).

Table I. Characteristics of injured bicyclists presenting to ED by helmet use.

Variables	Helmet use		p-value[1]
	Wore helmet (n=17)	Did not wear helmet (n=143)	
Age (in years)			
Mean (SD)	27.6 (11.1)	35.1 (17.1)	NS
Median	24	32	
Range	17 - 49	10-89	
Sex - male	14 (82.4%)	117 (81.8%)	NS
Race			
Chinese	10 (58.8%)	93 (65.0%)	<0.05
Malay	6 (35.3%)	16 (11.2%)	
Indian	1 (5.9%)	21 (14.7%)	
Others	0	13 (9.1%)	
Nationality			
Singaporean	14 (82.4%)	97 (67.8%)	NS
Non-residents	3 (17.7%)	46 (32.2%)	
Alcohol involvement	0	18 (12.6%)	NS
Believes helmets protect	15 (88.2%)	76 (53.5%)	<0.01
Previously involved in bicycle crash	5 (29.4%)	19 (14.8%)	NS
Bicycle use			
Recreation/sport	14 (82.4%)	52 (36.4%)	<0.01
Transport	3 (17.7%)	91 (63.4%)	

[1] Statistical comparisons were made between helmet use and non-use groups by t-test (for mean), chi-square test and Fisher exact test (for proportion).

NS: not significant

Table II. Characteristics of injured bicyclists presenting to ED by nationality.

Variables (n=111)	Nationality		p-value[1]
	Singaporean (n=49)	Non-residents	
Age (in years)			
Mean (SD)	35.9 (18.7)	30.9 (10.5)	NS
Median	36	28	
Range	10-89	15-66	
Sex - male	92 (82.9%)	39 (79.6%)	NS
Race			
Chinese	81 (73.0%)	22 (44.9%)	<0.01
Malay	20 (18.0%)	2 (4.1%)	
Indian	9 (8.1%)	13(26.5%)	
Others	1 (0.9%)	12 (24.5%)	
Helmet worn			
Yes	14 (12.6%)	3 (6.1%)	NS
Alcohol involvement	11 (9.9%)	7 (14.3%)	NS
Believes helmets protect	70 (63.6%)	21 (42.9%)	<0.05
Previously involved in bicycle crash	11 (9.9%)	13 (26.5%)	<0.01
Arrival mode			
Self	45 (40.5%)	19 (38.8%)	<0.01
Family	23 (20.7%)	2 (4.1%)	
Ambulance	43 (38.7%)	28 (57.1%)	
Bicycle use			
Recreation/ sport	58 (52.3%)	8 (16.3%)	<0.01
Transport	53 (47.8 %)	41 (83.7%)	
Mechanism of injury			
Self-skidded	59 (53.2%)	15 (30.6%)	<0.01
Hit by vehicle	40 (36.0%)	32 (65.3%)	
Others	11 (10.8%)	2 (4.1%)	
Location of crash			
Footpath	31(27.9%)	4 (8.2%)	<0.01
Road	66 (59.5%)	38 (77.6%)	
Cross junction	4 (3.6%)	5(10.2%)	
Off-road/track	10 (9.0%)	2 (4.1%)	

[1] Statistical comparisons were made between Singaporean and non-resident groups by t-test (for mean), chi-square test and Fisher exact test (for proportion).

NS: not significant

Non-residents made up 30.6% (49) of the injured bicyclists. Non-residents used their bicycles mainly for transportation (Table II). There was no difference in prevalence of helmet-wearing compared with Singaporeans. Significantly fewer non-residents believed that helmets protect against head injury ($p<0.05$) and they were more likely to have been involved in a previous bicycle crash ($p=0.008$). They were more likely to have been injured while riding on the road ($p=0.006$), being involved in a collision with a vehicle ($p=0.004$) and being brought to hospital by ambulance ($p<0.01$). There was no statistical difference between Singaporeans and non-residents in terms of injury outcomes and disposition status.

Helmet use was significantly related with fewer cases of head injury and facial injury ($p=0.006$), and lower mean ISS ($p=0.026$) (Table III). However, there was only borderline significance between helmet use and discharge status ($p=0.052$). Multiple linear regression with ISS as the dependent variable showed statistically significant association with helmet use, age and being hit by a motor vehicle, while sex, race, nationality, alcohol use and purpose of bicycle usage showed no significant relationship with ISS (Table IV).

DISCUSSION

It has been reported that head injuries occur in 31%-65% of bicycle crashes[2,3,8-11] and 70%-86%

Table III. Injury and disposition of bicyclists by helmet use.

Outcomes	Helmet use		p-value[1]
	Wore helmet (n=17)	Did not wear helmet (n=143)	
Sustained head injury	1 (5.9%)	57 (40.0%)	<0.01
Soft tissue	1 (100.0%)	34 (59.6%)	
Skull fracture	0	9 (15.8%)	
Intracranial bleed	0	14 (24.6%)	
Sustained facial injury	1 (5.9%)	53 (37.1%)	<0.05
Soft tissue	1 (100.0%)	42 (79.2%)	
Fracture	0	11 (20.8%)	
Sustained limb injury	15 (88.4%)	104 (72.3%)	NS
Soft tissue	11 (73.3%)	64 (61.5%)	
Fracture	4 (26.7%)	40 (38.5%)	
Sustained trunk injury	3 (17.7%)	28 (19.6%)	NS
Injury severity score mean (SD)	4.0 (2.5%)	8.9 (8.8%)	<0.05
Disposition			
Discharged	14 (82.4%)	83 (64.8%)	NS
General ward	3 (17.7%)	42 (29.4%)	
High dependency	0	4 (2.8%)	
ICU	0	11 (7.7%)	
Death	0	3 (2.1%)	

[1] Statistical comparisons were made between helmet use and non-use groups by t-test (for mean), chi-square test and Fisher exact test (for proportion).

NS: not significant

Table IV. Adjusted odds-ratios (OR) and 95% confidence intervals (CI) of various variables for injury severity score (ISS†) in 160 patients presenting to ED.

Co-variates	OR	95% CI	p-value
Helmet worn	0.538	0.339 to 0.856	0.009
Age†	1.570	1.142 to 2.158	0.006
Collision with motor vehicle versus other mechanisms	1.610	1.189 to 2.181	0.002
Male	1.191	0.829 to 1.711	0.340
Indian versus Chinese	0.748	0.513 to 1.093	0.133
Malay versus Chinese	0.964	0.642 to 1.448	0.859
Non-residents	1.089	0.763 to 1.553	0.639
Bicycle use - recreational versus transportation	1.073	0.743 to 1.550	0.706
Alcohol intoxicated	1.149	0.736 to 1.793	0.537

† ISS and age were logarithmically transformed due to skewed distribution.

of deaths due to bicycle crashes are from head injuries[11-13]. In our sample population, 36.3% of patients had head injuries. The majority of these patients (60%) had minor soft tissue injuries (e.g. lacerations, abrasions, haematomas) and was discharged from the ED. Conceivably, these patients may have completely avoided injury if a helmet had been worn. Though only 8.8% of all the patients sustained intracranial haemorrhage, it is well-known that such cases have prolonged recovery and persistent sequelae[14-16], with high direct and indirect costs due to healthcare and work-loss disability[17]. Three patients (all of whom did not wear helmets) who had severe head injury, died.

A meta-analysis of 16 studies on the efficacy of bicycle helmets reported that the summary odds-ratio estimate was 0.40 (95% CI 0.29 to 0.55) for head injury, 0.42 (95% CI 0.26 to 0.67) for brain injury, 0.53 (95% CI 0.39 to 0.73) for facial injury, 0.27 (95% CI 0.10 to 0.71) for fatal injury, indicating a statistically-significant protective effect of bicycle helmets[18]. Odds-ratio of bicycle helmets efficacy against head injury in our study was 0.14 but it was not statistically significant due to the small sample size and hence was not presented.

Compulsory helmet laws for all bicyclists have been passed in countries such as Australia, New Zealand and Finland. Some jurisdictions in the United States have similar laws for youth bicyclists. In New Zealand, a decrease by 18.7% in head injuries was attributed to its helmet law [19]. Grant and Rutner estimated that youth helmet laws reduced fatalities by about 15% in the United States[20]. With the implementation of youth helmet laws, no evidence of spillover effects (to adults) or substitution effects (youths choosing other methods of transportation) was found. It has been shown that bicycle helmet laws in combination with informational and educational activities lead to significantly higher helmet use compared to non-compulsory measures alone[21].

Critics of bicycle helmet legislation cite evidence that such laws actually discourages cycling, and that the number of bicyclists in Australia decreased after such laws were implemented[22]. In addition, Robinson queried if the observed fall in number of head injured cyclists after implementation of helmet laws in Victoria, Australia may have been due to other major road safety initiatives (directed at speeding and drunk-driving), which were introduced at the same time as the helmet law[22]. It has also been argued that helmeted cyclists may increase their risk-taking behaviour, influenced by a greater sense of security, and be more prone to crash, a phenomenon known as "risk compensation"[23]. Thompson et al counter-

argued that they have not found any evidence to support risk compensation and that the "fundamental issue is whether or not when bicycle riders crash and hit their heads they are benefited by wearing a helmet[7]."

Bicycle helmet usage was 10.6% among our sample of injured patients. Patients who did not wear helmets were more likely to be commuter bicyclists rather than recreational or sport bicyclists. Non-resident work permit holders were more likely to use bicycles as a means of commuting. Non-residents and Singaporeans alike were not inclined to wear bicycle helmets but significantly fewer non-residents believed that helmets protect against injuries. This could reflect their lack of exposure to safety education in their native countries. Singaporean bicyclists aged ≥30 years were less likely to believe that helmets protect against injury and were less likely to wear helmets, reflecting a possible deficiency in safety education in this age group. A large number of patients (54%) stated that they believed that helmets protect against injury but were not actually wearing one when they were involved in the bicycle crash, possibly reflecting an "It won't happen to me" attitude.

Educational efforts regarding bicycle helmets should be directed particularly at non-resident work-permit holders and older bicyclists. Perhaps employers of non-resident workers should consider helmet rebates for those who cycle to work, as "cost" was a frequent reason cited for not wearing bicycle helmets. Our findings that younger bicyclists tended to be the ones who wore helmets contrasts with other studies which found the lowest rate of bicycle helmet use to be among teenagers[24,25]. In our study, younger bicyclists tended to cycle for recreation and sport. It was reported that modelling after helmet-use patterns of parents and peers influences helmet use[24]. The high profile use of helmets during bicycle sporting events broadcast by the media could have influenced their positive attitude and behaviour towards safety equipment.

Cycling while intoxicated is associated with a greater risk of injury to the head or face and the rider is less likely to have worn a helmet[26]. It has been estimated that the odds of injury for bicyclists with blood alcohol content ≥0.10 g/dL is more than ten times that of their sober counterparts[27]. The proportion of bicyclists with clinically-detectable recent alcohol consumption in our sample was 11.3%. All of these patients did not wear a helmet and 44% of these intoxicated patients were involved in a collision with a motor vehicle. This is similar to findings by Spaite et al[28] who found alcohol to be a contributing factor in about 8% of bicycling injuries treated in the ED. It was also concluded that consumption of alcohol is highly associated with greater injury severity, longer hospitalisation, and higher healthcare costs.

Several jurisdictions in the United States have mandated that drunk bicycling is a separate violation punishable with sanctions such as driving licence revocation. From 1986 to 1999, local studies, albeit using different sampling methods, have reported a decreasing trend in alcohol-related motorcycle and motor vehicle crashes from 10% to 0.9%[29-31]. It is apparent from the high proportion of alcohol-intoxicated bicyclists in our study that drunk-driving campaigns conducted by the traffic police should be expanded to target this group of road users as well.

Selection bias may be present as neither patients with minor injuries who never came to the ED, nor patients who died at the scene of the crash, would have been captured in our data. This was a single centre study in an adult ED, hence our sample population consisted mainly of teenagers and adults. In a previous one-year review of injuries among children aged 12 and below in 1999 in Singapore, it was estimated that bicycle injuries accounted for 5.9% of children involved in road traffic accidents[32]. Possibly due to our small sample size, no statistical significance was found between helmet wearing and discharge status, though it approached statistical significance. Despite our small sample size over the study period, compelling evidence is provided to support the fact that bicycle helmets can protect against head and facial injuries and more needs to be done to encourage bicycle helmet use among all cyclists in Singapore.

69% of the patients were injured while cycling on the road while 42% were knocked down by a motor vehicle. Rivara et al[33] reported an odds-ratio of 4.6 for serious injury (ISS >8) among bicyclists knocked down by a motor vehicle. Our study also found that in addition to age and not wearing a helmet, being hit by a motor vehicle was an independent factor associated with an increased ISS. Prevention of serious bicycle injuries cannot be accomplished through helmet use alone; it may require physical separation of bicyclists from motor vehicles by demarcation of bicycle lanes in high-use areas and educating motorists about sharing the road with bicyclists[34]. To date, the Ministry of Transport of Singapore has decided against bicycle lanes, citing land scarcity and the relatively small number of bicyclists compared to other road users[35]. As the number of cyclists grows, this position may need to be revisited.

In conclusion, our study shows that wearing a helmet is associated with fewer head and facial injuries and lower ISS after a bicycle crash. The

proportion of patients in our study cohort who wore bicycle helmets was low. Public awareness campaigns targeting adult and non-resident bicyclists, together with compulsory helmet laws, should increase the rate of helmet use, thus decreasing head and facial injuries in a crash. Anti-drink-driving campaigns should be expanded to target alcohol-intoxicated bicyclists.

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