Risk of Head, Facial and Neck Injury in Bicycle and Motorcycle Crashes in relation to Helmet Use

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Abstract

Recent rises in bicycle and motorcycle use have been met with concern over their impact on road safety. This has been coupled with the recognition that helmet effectiveness needs to be reviewed. Little recent research has been performed on helmet performance in real accidents and related injury risks in Australia. A retrospective study was undertaken at a major trauma centre in Sydney to examine the general profile of injuries and the risk of head, facial and neck injury with helmet use. The results of a sample of 214 casualties collected over a 12 month period showed that sixty (28%) riders sustained a head, face and neck injury, with 59 (27.6%) having suffered concussion. The cyclists had a mean age of 31 ± 13 years (range, 3 - 64 years). Of the 214 casualties, 21% of riders did not wear a helmet at the time of the crash. Wearing a helmet significantly lowered the risk of head, facial and neck injuries (Odds ratio = 0.2, 95% CI 0.1 to 0.43). Attempt was made to examine whether injury reduction was the same across all levels of impact by controlling the levels of injury severity. The logistic regression analysis only showed that helmet use significantly lowered the risk of minor to moderate head trauma. This study is part of a major prospective crash investigation study examining the performance of current bicycle and motorcycle helmets.

Key words

Helmet effectiveness, head injury, bicycle, motorcycle.

Introduction

In Australia it is mandatory for bicyclists and motorcyclists to wear a Standards Australia approved helmet whilst riding. Nevertheless, head injury remains the most significant cause of death for both bicyclists and motorcyclists [1, 2]. In 2005 and 2006, road crashes involving two-wheeled vehicles resulted in the highest rates of serious injury [3]. Internationally, there are research and policy activities around helmet use related to helmet wearing laws, helmet promotion, helmet usability, injuries in on and off road riding, risk taking behaviour, and optimisation of helmet effectiveness for both pedal and motorcyclists. This is due in part to an increasing financial burden that arises from injury and death in motorcycle crashes in the developed world and the recognition that helmets present a cost effective injury intervention in all societies; with regards to the former, it was observed in the USA that the motorcycle fatalities had doubled between 1997 and 2005 [4, 5].

Previous studies have found a significant reduction in the risk of head and brain injury for helmet wearers as compared to non-wearers [6-14]. A recent systematic review of motorcycle helmets estimated that helmets reduced the risk of head injury by 72% compared to non use [15]. However, these studies did not indicate whether the injury risk reduction was the same across the various levels of impact severity. The protection afforded by a helmet varies depending on the severity of the impact, and whether the impact is within the requirements of the relevant standard. Analyses of motorcycle helmet performance in real world crashes has identified the need to improve helmet function, especially the ability of the helmet to reduce impact forces [16]. Thus, helmet performance and safety in real world crashes warrants further investigation.

In this retrospective study, injury patterns and morbidity risk for helmeted and unhelmeted bicycle and motorcycle casualties treated at a public hospital were reviewed. The main aim of this study was to determine whether injury reduction associated with helmet use was similar across various levels of impact

severity. Additionally, the relative risks of a diminished level of consciousness (Glasgow Coma Score, GCS) and hospital admission for helmeted versus unhelmeted cyclists were examined.

Methods

Data Source

The study population was bicyclists and motorcyclists who sought medical treatment at St. George Public Hospital (SGPH), New South Wales, from 1 June 2008 to 1 June 2009. SGPH is the level 1 trauma centre for the south eastern area of Sydney, extending to Milton on the south coast of NSW. Data were collected from the SGPH trauma registry, which provides comprehensive physiological data, injury descriptions and coding for each patient. Injuries are coded according to the Abbreviated Injury Scale (AIS), 2005 Revision [17]. The overall injury severity for each rider was measured using both the Injury Severity Score (ISS) and the New ISS. Crash-related information, helmet use, and patient demographic information stored in the data registry were obtained from a number of sources, including ambulance case sheets, in-patient medical records, and patient interviews.

Ethical approval was received from the human research ethics committees of both the NSW Department of Health and the South Eastern Sydney Illawarra Health Service before conducting this study.

Analysis

The strength of univariate and bivariate associations between selected demographical characteristics, patient outcomes and helmet use were evaluated by chi-square tests. Odds ratios (OR) and 95% confidence intervals (CI) from logistic regression were used to estimate relative risks of injury for helmeted and unhelmeted riders. A p value of ≤ 0.05 was considered significant. Statistical analyses were performed using SPSS statistical package, version 17.

Results

During the 12 month study period, a total of 214 patients presented to the St George Hospital Trauma Centre as a result of bicycle and motorcycle involved crashes.

Demographics

Of the 214 presenting cyclists, 195 (91.1%) were male and 19 (8.9%) were female. The age of patients ranged from 3 to 64 years, with the mean (± S.D.) ages of males and females of 32.4 (±13.2) and 23.8 (±11.2) years, respectively. Twenty-two (10.3%) patients were 16 years or younger; 92 (43.0%) patients were aged 17–30 years; 96 (44.8%) were aged 31–59 years and 4 (1.9%) patients were aged 60 years or older (Table 1). Of the 214 patients, 45 (21%) were not wearing a helmet at the time of the crash. There was a significantly lower proportion of pedal cyclists wearing a helmet compared to motorcyclists. Amongst those patients who sought medical treatment, approximately 10% were female cyclists.

Table 1: Age distribution of pedal- and motor-cyclists presenting to hospital

Characteristic	Pedal cyclists (n = 84)	Motorcyclists (n = 130)	p-value
Age Group (%)			<0.0001
≤ 16	22.6	2.3	
17 - 30	22.6	56.1	
31 - 59	51.2	40.8	
≥ 60	3.6	0.8	
% Female	14.3	5.4	0.025
% Helmet Worn	64.3	88.5	<0.0001

In-hospital assessment and injury outcomes related to helmet use

Almost all patients with bicycle and motorcycle related injuries presented with external injuries such as abrasions, contusions and lacerations. Other than superficial injuries, limb injuries were most common,

followed by head injury (Table 2). Twenty-seven (12.6%) riders experienced some brief loss of consciousness and 32 (15%) riders suffered cerebral concussion (AIS 2005 Revision). Of the 32 cyclists who suffered concussion, 23 (71.8%) were helmeted. A total of 7 (3%) crash victims (5 helmeted) sustained serious to critical head injuries (AIS ≥ 4).

Five (2.3%) patients sustained severe traumatic brain injury with a GCS of less than 9 on admission, while another 5 (2.3%) patients presented with moderate head injury (GCS 9-13). No significant differences between GCS scores were observed for helmeted and unhelmeted patients.

Brain CT was performed on admission in 83 (38.8%) cases, and 6 (7.2 %) revealed the presence of skull fracture with brain contusion, haemorrhage or haematoma. Surgery was required immediately in four of the six patients.

Mean ISSs were, on average, slightly worse for the unhelmeted rider. Likewise, unhelmeted riders were more likely to report head injury, of any severity, as the principal complaint. Helmeted patients were more likely than unhelmeted to suffer injuries to the extremities.

Fifteen patients required intensive care, with a length of stay (LOS) in ICU of up to 19 days. Seventeen patients required high dependency care, with a mean HDU stay of 5 days (range 1 to 9 days). Although not statistically significant, unhelmeted patients were more likely than helmeted patients to require a longer stay in hospital or in the ICU.

Table 2: Hospital treatment and outcomes of injuries sustained

In-Hospital Assessment	Helmet (n=169)	No Helmet (n = 45)	*p*-value
Mean Admission GCS	14.6	14.2	> 0.05 (NS)
CT Head scan (%)	33.7	57.8	0.003
Mean ISS at discharge	6.9	9.4	> 0.05 (NS)
Location of Main Injury (%)			0.024
Head	19.5	46.7	
Face	3.6	4.4	
Thorax	11.2	11.1	
Abdomen	3.0	2.2	
Spine	7.7	6.7	
Upper Extremity	26.6	17.8	
Lower Extremity	27.2	11.1	
External	1.2	0	
Discharged to (%)			0.032
Home	37.3	22.2	
Ward	48.5	55.6	
Intensive Care Unit (ICU)	4.7	15.6	
High Dependency Unit (HDU)	8.9	4.4	
Other Acute Hospital	0.6	2.2	
Mean Hospital LOS (days)	7.0	8.2	> 0.05 (NS)
Mean ICU stay (days)	6.6	10.1	> 0.05 (NS)
Mean HDU stay (days)	4.7	4.6	> 0.05 (NS)

Logistic regression analysis related to helmet use

Table 3 presents a regression analysis of helmet use in relation to age group, in-hospital assessment and injury outcome. It was found that helmeted rider has an 80% reduction in head, facial or neck injuries of any severity than unhelmeted rider. Helmeted riders had a 69% reduction in receiving severe to critical injury (MAIS ≥ 4) compared to unhelmeted riders. Generally, CT scans are performed as a routine procedure for patients with suspected head injury. Head CT scans were significantly more common for unhelmeted cyclists.

Teenage cyclists were three times less likely to wear a helmet than young adults, and four and a half times less likely than older adults. The likelihood of arriving at the trauma centre with a GCS less than 9 was assessed for helmeted and unhelmeted cyclists, however the differences in the level of head trauma as reflected in the GCS did not reach statistical significance.

Table 3: Results of multiple logistic regression analyses related to helmet use

Variables	Helmet Use		Odds Ratio (95% CI)	*p*-value for differences in OR
	Yes	No		
Head, face and neck injuries				
No (Reference)	104	11	1	
Yes	65	34	0.20 (0.1-0.43)	< 0.0001
Age				
≤ 16 (Reference)	12	10	1	
17 - 30	72	20	3.00 (1.13-7.95)	0.027
> 30	85	15	4.72 (1.73-12.87)	0.002
AIS (All body regions)				
≤ 3 (Reference)	160	38	1	
≥ 4	9	7	0.31 (0.11-0.87)	0.027
Admission GCS				
< 9 (Reference)	4	1	1	
≥ 9	165	44	0.94 (0.10-8.6)	> 0.05
Head CT				
No (Reference)	112	19	1	
Yes	57	26	0.37 (0.19-0.73)	0.004
ISS at discharge				
≤ 15 (Reference)	150	37	1	
≥ 16	19	8	0.59 (0.24-1.44)	> 0.05

Helmet use and head and spine injury severity

Further analyses were performed by controlling the overall injury severity associated with helmet use. Patients were categorised by severity of head injury (AIS ≥ 4), cervical spine fracture, and LOC or concussion. Table 4 presents the results of logistic regression modelling. The analysis indicated that helmet use was only significantly associated with reduced odds of minor to moderate head injury.

Table 4: Helmet use related to head trauma and cervical spine fracture

Injuries		Helmet Use (%)		Odds ratio	*p*-value
		Yes	No		
Severe head trauma (AIS ≥ 4)	No	164 (76.7)	43 (20.1)	Reference	
	Yes	5 (2.3)	2 (0.9)	0.90 (0.11-7.35)	> 0.05
Cervical Spine Fracture	No	166 (77.5)	41 (19.2)	Reference	
	Yes	3 (1.4)	4 (1.9)	0.21 (0.03-1.33)	> 0.05
LOC or concussion	No	132 (61.7)	23 (10.7)	Reference	
	Yes	37 (17.3)	22 (10.3)	0.30 (0.15-0.60)	0.001

Discussion

The study estimated that the risk of head, face and neck injuries among helmeted pedal and motor cyclists was 80% less than for an unhelmeted cyclists (OR=0.2, 95% CI 0.1-0.43). The OR was statistically significant and consistent with previously reported findings [6, 12-15, 18] that helmets do offer some

level of protection to the user and reduces the severity of head injury. The 80% level of reduction is consistent with the 72% reported by Liu et al in their systematic review [15].

It is well known that protection varies depending on the severity of the impact and whether the impact is within the specifications of the standard. Attempts were therefore made to examine the effectiveness of helmet in reducing injury risk and prevent head and neck injuries by controlling the levels of injury severity. The logistic regression analysis showed that helmet use significantly lowered the risk of minor to moderate head trauma (Table 4). The odds of sustaining serious to severe head trauma were not significantly different for helmet wearers than non-wearers.

Seventeen percent of helmeted riders experienced LOC or concussion (Table 4). This observation indicates the need to acquire an in-depth understanding of the mechanism of these injuries and the role of a helmet, despite the overall reduction in head, face and neck injury risk.

Despite the low incidence of cervical fracture or injuries (3.3%), it is a routine procedure for all unconscious patients and in-patients who are conscious and alert with neck pain and associated muscle spasm as a result of a road accident to have an x-ray and/or CT scan of the cervical spine. Thirty-seven (17.3%) of the patients had the radiologic assessment of the cervical spine using X-ray, 25 (11.7%) using CT scan, and 9 (4%) using both X-ray and CT-scan. However, these assessments produced 94% false-negatives. A guideline or diagnostic protocol is deemed necessary to be established to assist medical officers in assessing cervical spine fracture potential among pedal and motor cycle crash victims.

This study found that the OR for helmet use amongst this population varied with age; the youngest group (age $\leq$ 16) were less likely to wear a helmet (Table 3). This finding is consistent with previous studies where younger pedal and motor cyclists tended not to wear helmets while they were riding [19-22]. In the USA, it was reported that in 2007, 85% of high school students rarely or never wore a helmet whilst riding a bicycle [23]. Younger riders are also more likely to sustain head, face and neck injuries than older cyclists. The OR for head, face and neck injuries associated with age and helmet use were: 0.15 (95% CI 0.07 to 0.33, $p < 0.001$) for age 17 to 30 years and 0.32 for age > 30 years (95% CI 0.15 to 0.65, $p = 0.002$). More needs to be learnt about why young cyclists do not wear a helmet when it is mandatory and, based on those findings, interventions are required to increase the proportion of helmeted cyclists.

This study may have suffered from several limitations. The difference in crash circumstances or crash severity between helmet users and non-users were not captured in the trauma registry. Therefore, analysis by controlling injury severity as a measure of impact severity might inherit the limitation as previously reported [18, 24]. Data captured from a trauma registry excludes those helmeted pedal and motor cyclist who have had a helmet impact but were not injured. Similarly, the trauma registry would have excluded those who died at the scene of the crash. New subject groups which include the non-injury and fatal crashes are needed to remove these limitations. In our larger crash study, we are seeking a cohort of injured and uninjured cyclists in order to address this issue.

It has been reported that helmet fit is an important factor associated with risk of head and brain injury; well-fitting helmets were reported to significantly reduce the risk of head injury [25]. Helmet users whose helmets fitted well or poorly fitted could not be ascertained in this study, and the state of helmet fit, wearing patterns and head coverage that may influence the likelihood and severity of injuries [26] remains to be examined.

Conclusions

The study confirmed that helmet wearing offers a substantial benefit to the cyclist through a reduction in the risk of head, face and neck injuries. Unfortunately, it was observed that some cyclists, especially adolescents, were less likely to wear a helmet and thus exposed themselves to avoidable injury risks.

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