

Increased Risk of Death or Disability in Unhelmeted Wisconsin Motorcyclists

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ABSTRACT

Objective: The purpose of this study is to investigate the relationships among motorcycle rider helmet, alcohol use and the full spectrum of health outcomes following crashes.

Methods: Data from the National Highway Traffic Safety Administration-sponsored Crash Outcome Data Evaluation System (CODES) for Wisconsin, 2002, were used to study 2462 motorcycle crash victims. Logistic regression models were used to assess the relationship of helmet and alcohol use with outcomes.

Results: Compared to helmeted motorcycle riders, unhelmeted riders were more likely to require inpatient hospitalization (Relative Risk Ratio [RRR]=1.4; 95% confidence interval [CI]:1.1-1.8) or die (RR=1.9, 95% CI:1.0-3.7) but equally likely to be treated in emergency departments. Injury patterns differed by helmet use. Unhelmeted riders were more likely to suffer injuries of the head (odds ratio [OR]=2.3, 95% CI:1.5-3.3) or face (OR=3.0, 95% CI:2.1-4.2) than helmeted riders. No difference was observed in other injuries, including spine/neck injuries. Reported alcohol use was more prevalent among patients who were inpatients or died, and was associated with higher likelihood of not wearing a helmet (OR=7.0, 95% CI:4.8-12.9).

Conclusion: Motorcycle riders who are inpatients or die in a crash are less likely to be helmeted and more likely to sustain head or face injuries. Alcohol use is associated with unhelmeted riding and increased risk of poor outcomes. These findings support policy and educational efforts promoting helmet use, which seek to decrease these tragedies.

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INTRODUCTION

Motorcycle riding has been gaining popularity in recent years.^{1,2} Motorcycle crashes account for a disproportionate, and increasing, share of motor vehicle-related morbidity and mortality in the United States.² Since 1997, each year's injuries and deaths have exceeded those of the preceding year.² Such rises in casualties among motorcycle riders may be due to a nationwide decrease in helmet use (from 71% to 58%) in recent years,² which is occurring despite the widely known effectiveness of helmets in preventing traumatic head and brain injuries.³⁻⁸

Most studies of motorcycle crash outcomes have focused on death, long-term disability, or inpatient hospitalization. There has been a paucity of data on motorcycle riders involved in crashes who did not require treatment or were treated only in hospital emergency departments (EDs) and discharged. However, the Crash Outcome Data Evaluation System (CODES) provides information on motorcyclists involved in police-reported crashes who required medical treatment as well as those who were never treated in a medical facility. CODES merges information on motor vehicle crashes from police records with hospital discharge data, allowing assessment of the full spectrum of injury outcomes. In 2002, Wisconsin CODES added information on patients seen in the ED as well as all inpatient units. We believe this is the first study of motorcycle crashes to utilize this information, resulting in a more complete understanding of these events and the injuries and outcomes of motorcycle crash victims.

A more thorough study of injuries sustained by motorcycle riders is useful for further examination of anecdotal and unpublished claims among motorcycle riders regarding helmet use.¹¹ Though some of the claims of danger such as decreased visual field and increased neck and spine injuries with helmet use have been largely refuted by the scientific community,¹² this study may be useful for confirming previous studies that suggest that helmet use is not associated with other injuries.

Previous studies and surveys have shown the presence of alcohol to be increased in fatal crashes and asso-

ciated with lower rates of helmet use.^{2,13} This study examines the relationship between alcohol use and helmet use in a general population of crash victims and specifically considers the effects of alcohol and helmet usage on outcomes of both fatal and non-fatal crashes.

SUBJECTS AND METHODS

Database

This study used the Wisconsin Crash Outcome Data Evaluation System (CODES) database. CODES links information about each motor vehicle crash from multiple sources into 1 database. In Wisconsin, CODES preparation and maintenance is a multi-agency effort in which police records from the Wisconsin Department of Transportation (WisDOT) and hospital records and death certificates from the Department of Health and Family Services (DHFS) are linked and analyzed at the Center for Health Systems Research and Analysis. In 2002, DHFS began collecting ED discharge data for inclusion. Funding is provided by the National Highway Transportation Safety Administration (NHTSA).

Study Population

We analyzed all motorcycle crashes in the Wisconsin CODES database for 2002. Of the 341,481 subjects involved in motor vehicle crashes, 2829 were involved in motorcycle crashes. This classification includes both standard motorcycles (~96%) and mopeds (~4%). Due to missing critical variables, 367 cases were excluded. The final number of subjects included in the study was 2462.

Study Measures

For each crash, data were collected on age, sex, median income, hospital charges, length of hospital stay, posted speed limit, helmet use, alcohol use, ejection off of motorcycle, manner of collision, collision location (urban/rural and intersection/non-intersection), vehicle damage, discharge status from hospital, Maximum Abbreviated Injury Severity (MAIS, described in detail below), body region injured (MAIS>0), and multi-region injury. Distributions of these characteristics were compiled and compared for each treatment/outcome group.

The discharge diagnoses were used to determine the Abbreviated Injury Scale (AIS) scores using ICDMAP-90 Software (©1998 Johns Hopkins University & Tri-Analytics, Inc.). The AIS divides injuries into 9 body region categories (head, face, neck, thorax, abdomen, spine, upper extremity, lower extremity, and external/other) and gives each injury a score based on severity, from 0 to 6 (no injury to unsurvivable, respectively). The MAIS designates the most severe injury in each of the regions.

For this analysis, all body regions were used; neck injuries (n=1) were combined with spine injuries due to small numbers. Median income variable was obtained from the US Census Bureau using ZIP codes from the original dataset.

Statistical Analysis

Subjects were divided into 4 different groups for analysis: 1) No treatment—riders in crashes that made a police report but were not treated in a hospital or related medical facility; 2) ED—riders who were treated in the ED and discharged; 3) Inpatient—riders who were treated in the ED, were admitted as an inpatient and later discharged; 4) Died—riders who died at the crash scene and were not seen at the hospital, or riders who were transported to the hospital and died within 30 days of the crash.

Using STATA Version 8 software, multinomial logistic regression models were used to estimate the risk of placement into one of the groups based on helmet use, with Group 1 (no hospital treatment/survived) as the referent group, adjusting for age, alcohol use, speed limit, and vehicle damage. Binomial logistic regression was applied to examine the effect of helmet use on the risk of sustaining various regional injuries among hospital-treated subjects, adjusting for age, alcohol and injury severity with no treatment as the referent group. Statistical significance was defined as $P < 0.05$ (2 tails).

RESULTS

Motorcycle Riders in Crashes

A total of 2462 motorcycle riders (drivers and passengers) were involved in reported motorcycle crashes in Wisconsin in 2002. The involved riders were predominantly male (81.3%), with a mean age of 37.1(±12.7) years. The majority of crashes occurred in rural areas (54.4%). Only 29.1% of the involved riders wore helmets; helmet use was unknown in 8.7%.

Alcohol Use in Crashes

Significant differences in alcohol use were seen between helmeted, unhelmeted and unknown helmet use groups (2.5%, 15.7%, 9.8%, respectively; $P < 0.01$). Alcohol-related crash victims were, as a group, significantly more likely to be unhelmeted compared to those not using alcohol (Odds Ratio [OR]=7.0, 95% Confidence Interval [CI]: 4.8-12.9).

Rider Outcomes

The 4 outcome groups had significant differences (Table 1). Nearly 60% of riders were seen in the ED for injuries (of some severity), and over 20% of riders required inpatient care. Age among outcome groups varied, with the average age increasing with progressively more severe

Table 1. Selected Characteristics of Occupants, Motorcycle and Crash by Treatment Location and Outcome*

Treatment Location Outcome	No Treatment Survived (n=971)	ED Survived (n=952)	Inpatient Survived (n=462)	All Locations Died† (n=77)	Total‡ (n=2462)
Variable	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age (yr)	36.4 (12.6)	36.7 (12.5)	38.7 (12.7)	43.4 (13.7)	37.1 (12.7)
Median Income (US \$/yr)	46,574.2 (11980.5)	46,322.2 (10997)	46,410.4 (11336.1)	47,058.9 (16401.1)	46,461.6 (11651.7)
Hospital Charge (US \$)	NA	1319.8 (1763.3)	27,948.8 (37556.6)	18,890.1 (17484.4)	10,216.6 (24757.7)
Length of Stay (day)	NA	NA	5.9 (7.6)	2.5 (3.5)	5.8 (7.5)
Speed Limit (mph)	39.7 (13.2)	40.2 (13.1)	43.3 (13.0)	48.4 (10.2)	40.8 (13.2)
Variable	Percent	Percent	Percent	Percent	Percent
Sex					
Male	82.8	79.2	82.0	83.1	81.3
Alcohol Use					
Yes	7.3	10.3	17.3	39.0	11.3
Helmet Use					
Helmet	30.2	30.8	25.5	18.2	29.2
No Helmet	58.8	61.3	68.2	76.7	62.1
Unknown	11.0	7.9	6.3	5.2	8.7
Urban Class					
Rural	50.9	52.6	61.3	79.2	54.4
Ejected					
Ejected	45.2	67.1	78.6	93.5	61.5
Not Ejected	40.4	22.6	12.3	3.9	27.1
Unknown	14.4	10.3	9.1	2.6	11.5
Manner of Collision					
No Collision	51.2	56.6	60.0	45.5	54.8
Rear End	17.2	10.9	8.2	1.3	12.6
Angle	17.9	22.7	22.7	32.5	21.1
Other	8.9	8.0	7.6	19.5	8.6
Unknown	4.8	1.8	1.5	1.3	2.9
Vehicle Damage					
Minor	35.8	29.7	19.9	11.7	29.7
Moderate	37.9	41.2	35.7	29.9	28.5
Severe	16.4	21.3	38.3	52.0	23.5
Unknown	9.9	7.8	6.1	6.5	8.3

*No Treatment Survived = Crash reported to police but not treated in hospital or medical facility; ED Survived = Treated and released from emergency department; Inpatient Survived = Admitted to inpatient unit and released; All Locations Died = Died at the scene of the crash or in the hospital or ED within 30 days of the crash; NA = Data not available for these variables.

† Died includes hospital death and scene death. Hospital charge include only hospital death patients (n=32). Length of Stay includes only inpatient death patients (n=19).

‡Total includes all crash victims. Hospital charge includes only treated patients (n=1446). Length of Stay includes only inpatients (n=481).

outcomes: no treatment (36.4 years), ED (36.7 years), inpatient (38.7 years), and death (43.4 years) ($P<0.01$). The percentage of riders who were unhelmeted also varied with increasing severity in the outcome groups, from 59%, to 61%, to 68%, to 77%, respectively ($P<0.01$); as did alcohol use, increasing from 7.3%, to 10.3%, to 17.3%, to 39.0%, respectively ($P<0.01$) (Figure 1).

Table 1 shows other characteristics among the treat-

ment groups considered in this analysis. More severe crashes (those requiring treatment beyond ED or resulting in death) occurred in rural areas, when the rider was thrown from the motorcycle or when severe damage to the vehicle occurred. Most crashes were not the result of a collision with another vehicle but occurred when the motorcycle “wiped out” or crashed without involvement of another vehicle.

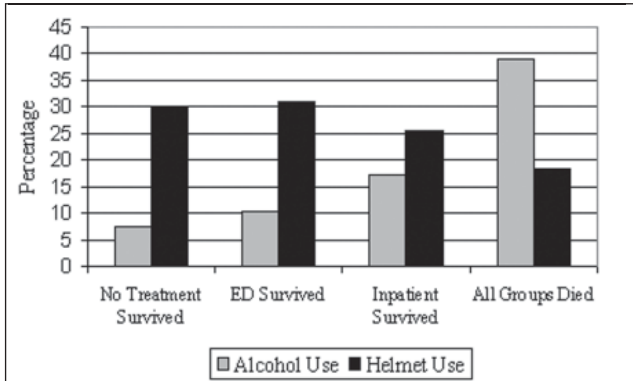


Figure 1. Helmet and alcohol use by treatment/outcome group.

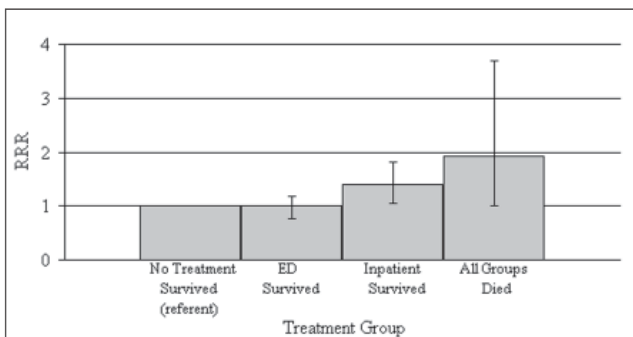


Figure 2. Relative risk ratio of helmet nonuse for treatment/outcome groups.

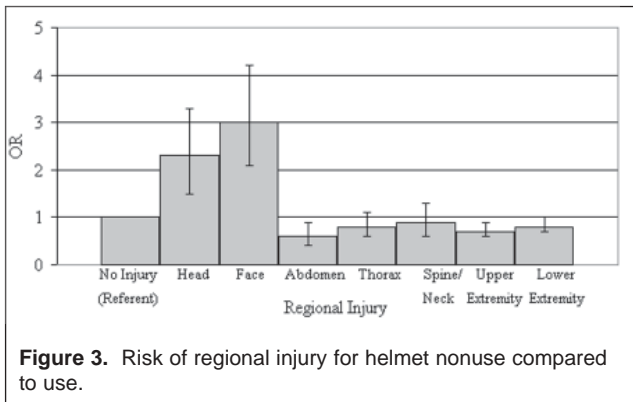


Figure 3. Risk of regional injury for helmet nonuse compared to use.

While riders without helmets were as likely as helmeted riders to be seen in the ED (Relative Risk Ratio [RRR]= 1.0; 95% CI: 0.82-1.23), unhelmeted riders were more likely to require inpatient care (RRR =1.4; 95% CI: 1.1-1.8) or die (RRR =1.9; 95% CI: 1.0-3.7) compared to helmeted riders, adjusting for age, alcohol use, speed limit, and vehicle damage (Figure 2).

Body Region Affected

The 4 outcome groups reflect the overall injury severity, as the mean MAIS score for most body regions increased from ED to inpatient to death groups (Table 2). The

mean MAIS of head injuries was significantly higher in the inpatient (1.03) and death (2.44) groups than the ED group (0.13) ($P<0.01$). Additionally, the mean MAIS of thorax injuries was significantly higher in the inpatient (0.8) and death (1.25) groups compared to the ED group (0.1) ($P<0.01$). Among outcome groups, a majority of those who died (53.1%) suffered a brain injury. The number of riders suffering thorax injuries also increased with outcome group, with 40.6% of those who died sustaining thorax injuries. Additionally, riders with multiple body regions injured increased between the ED and the inpatient groups, especially those with at least 2 body regions injured (ED 49.8%, inpatient 70.2%).

Riders without helmets were significantly more likely to suffer injuries of the head (OR=2.3; 95% CI: 1.5-3.3) and face (OR=2.9; 95% CI: 2.1-4.2) compared to helmeted riders (Figure 3). The likelihood of neck and spine, thorax, lower extremity, and other external injuries was the same whether the victim was helmeted or unhelmeted. Spine and neck injuries showed no increased risk with helmet use (OR=0.9; 95% CI: 0.6-1.3). Helmet nonuse was associated with a slightly decreased risk of abdominal and upper extremity injuries.

Riders without helmets more frequently were discharged to a medical facility for further care (20.7%) or died (3.7%), compared to helmeted riders, of whom 16.5% were discharged to a medical facility and 2.5% died. Medical facilities included nursing homes or hospices.

DISCUSSION

Our study confirms that, compared to other motor vehicles, motorcycles are a higher-risk means of transportation and recreation. Nearly 60% of motorcycle crashes result in visits to the ED, and over 20% required further inpatient care or resulted in death. This contrasts with studies showing that only 20% of passenger car crashes result in any injury or death.²

The 2002 CODES database permits assessment of the full spectrum of outcomes experienced by motorcycle crash victims. Compared to those who wore helmets, Wisconsin motorcycle riders who did not wear helmets were significantly more likely to require inpatient treatment or to die either at the hospital or at the scene. Only the group treated in the ED and released had similar rates of injury regardless of helmet use. It is likely that helmet use exerted a protective effect against both death and serious injury requiring hospitalization, while helmets did not protect against less severe injuries requiring minimal ED treatment.

Helmet use and nonuse were associated with different injury patterns. The risk of head and face injuries

Table 2. Regional Injuries of Treated Occupants by Treatment Location and Outcome*

Treatment Location Outcome	Emergency Dept Survived (n=952)	Inpatient Survived (n=462)	ED or Inpatient Died (n=32)
Variable	Mean (SD)	Mean (SD)	Mean (SD)
Max Abbreviated Injury Scale Score for a Body Region			
Head	0.13 (0.5)	1.03 (1.63)	2.44 (2.44)
Face	0.19 (0.41)	0.28 (0.55)	0.22 (0.49)
Thorax	0.1 (0.40)	0.8 (1.34)	1.25 (1.57)
Abdomen	0.05 (0.22)	0.25 (0.77)	0.42 (0.92)
Spine/Neck	0.10 (0.34)	0.26 (0.74)	0.06 (0.35)
Upper Extremity	0.55 (0.75)	0.74 (0.94)	0.22 (0.71)
Lower Extremity	0.45 (0.65)	1.02 (1.17)	1.03 (1.31)
External, Burns, Other	0.41 (0.49)	0.17 (0.38)	0.06 (0.25)
	Percent	Percent	Percent
Body Region Injured†			
Head	7.8	33.6	53.1
Face	18.3	23.6	18.8
Thorax	7.0	28.6	40.6
Abdomen	4.7	11.7	21.9
Spine/Neck	9.0	12.6	1.3
Upper Extremity	40.3	42.4	9.4
Lower Extremity	36.1	49.1	43.8
External, Burns, Other	41.1	16.2	6.3
Multi-Region Injury‡			
0	2.2	1.7	NA
>=1	97.8	98.3	NA
>=2	49.8	70.2	NA
>=3	14.5	39.5	NA
>=4	2.3	9.4	NA
5	0.0	0.7	NA

*Emergency Department Survived = Treated and released from Emergency Department (ED); Inpatient Survived = Admitted to inpatient unit and released; ED or Inpatient Died = Died in the hospital or ED within 30 days of the crash; NA = Data not available for these variables.
 † Maximum Abbreviated Injury Scale score>0
 ‡ Maximum Abbreviated Injury Scale score>0, number of body regions injured.

was lower in those who wore helmets. We did not find that helmet use was associated with any increased risk of spine or neck injuries, which had been suggested previously. However, our findings indicated that helmet nonuse exerted a slight protective effect on abdominal and upper extremity injuries. Future analyses that consider injuries sustained by an individual in multiple body regions will help to clarify this finding.

Findings show both an increased need for inpatient care and rate of death among riders without helmets, primarily due to head injuries. Head injuries were frequent—found in 33.6% of inpatients and 53.1% of riders who died, and riders without helmets were more likely to sustain head injuries than helmeted riders. Examination of discharge status of patients from the hospital showed that a higher proportion of unhelmeted victims were discharged to a nursing home or other health care facility.

While a detailed analysis of post-hospitalization costs is beyond the scope of this study, these results indicate that helmets are responsible for preventing the types of head injuries that result in death or further care, and the corresponding greater costs.

Wearing helmets is beneficial not only for riders' post-hospitalization quality of life, but also for society thanks to decreased health care costs associated with motorcycle crashes.⁸⁻¹⁰ According to NHTSA, \$13.2 billion was saved in crash-related costs between 1984 and 1999 simply from helmet use, and \$11.1 billion more could have been saved if all motorcycle riders had worn helmets.²

Our study documents the association of alcohol with fatal crashes and not wearing helmets in Wisconsin. It also extends to the relationship of alcohol use, helmet use, and crash severity to non-fatal events. As crash severity increased, the percentage of helmeted riders dropped

dramatically, while the percentage of alcohol use rose significantly. Alcohol was also associated with helmet nonuse. This relationship suggests that alcohol may be a factor in the decision not to wear a helmet as well as affecting driver's performance, a combination that impacts the risk, outcome, and severity of the crash.

Several limitations should be considered in interpreting these findings. The group that required no treatment in a hospital or medical facility may be underestimated in this analysis because minor crashes are often not reported to police but handled privately by individuals involved. Further, the database does not include motorcycle riders with no identifying information or those who were transported out of state for treatment. We believe these represent a relatively small number of people and would not significantly affect this analysis.

Helmet laws in other states have been shown to increase helmet use to nearly 100%, compared to 34%-54% in states without laws,² and to significantly drop the rates of injury and death among motorcycle riders.¹⁴⁻¹⁷ Currently, Wisconsin has no such law requiring helmet use for motorcycle riders over age 17.

Our findings strongly suggest that increased helmet use would significantly reduce the number of crash victims suffering severe injuries and death, and would dramatically change the pattern of injury related to motorcycle crashes. This would not only benefit the victims and their quality of life, but would positively impact society through decreased health care costs associated with motorcycle crashes. In addition, a mandatory helmet law would enable officers to detain unhelmeted motorcycle riders who, according to our study, are more likely to be involved in alcohol-related crashes, thereby decreasing the number of intoxicated riders on the roads and potentially reducing the total number of crashes.

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