

MOTORCYCLE INJURIES IN OHIO



CENTER *for* INJURY
RESEARCH & POLICY

*The Research Institute
at Nationwide Children's Hospital*

EXECUTIVE SUMMARY

The Problem

Motorcycle-related fatalities and fatality rates have been increasing rapidly during the past decade nationally. Research has shown that excessive speed and alcohol use is related to motorcycle fatalities, whereas helmet use is effective at reducing fatalities. However, a comprehensive understanding of motorcycle injuries in Ohio is needed.

Study Goals

The purpose of this study was to describe the nature of motorcycle crash-related injuries in Ohio. This study assessed the influence of various risk (e.g., speed, alcohol use) and protective (e.g., helmet use) factors associated with the outcome of individuals who sustain motorcycle crash-related injuries in Ohio.

Methodology

This investigation used two probabilistically-linked statewide databases, the Ohio crash database and the Ohio emergency department and inpatient hospital database, for the years 2005 through 2007. Any individual riding a motorcycle at the time of the crash was included in our study. Injury (yes/no) and death information was obtained from a combination of crash report and hospital records, and therefore available for all motorcycle riders. However, hospital care information (e.g., injury type, severity, discharge status, and hospital charges) was only available for injured riders who linked to a hospital record.

Key Findings

From 2005 through 2007, there were 15,467 motorcycle riders involved in a crash in Ohio—79.3% experienced an injury and 440 died at the scene or after arrival to the hospital. Of the injured motorcycle riders, 83.6% were male, but 92.0% of rider deaths were male. Suspected alcohol use was reported for 50.9% of motorcyclists who died. Riders with known or suspected alcohol use had 9.50 times greater odds of death than

riders without known or suspected use. Most (91.3%) motorcyclists who received hospital care had an injury severity score (ISS) indicating mild or moderate injuries ($ISS < 16$), but 725 (8.7%) experienced more serious injuries ($ISS \geq 16$). The odds of having a high ISS ($ISS \geq 16$) increased with increasing age of the injured motorcyclist. At any given age the odds of high ISS were 1.15 times greater than the odds of someone 10 years younger. There were 1,561 injured riders who sustained a motorcycle crash-related TBI, and 73.2% were not wearing a helmet at the time of the crash. Among riders in a single-vehicle crash, unhelmeted riders had 2.42 times greater odds of TBI than helmeted riders, whereas among riders in a multiple-vehicle crash, unhelmeted riders had 1.51 times greater odds of TBI than helmeted riders. This indicates helmets were 59% effective in single-vehicle crashes but 34% effective in multiple-vehicle crashes. The average hospital LOS was 1.37 days among all non-fatal injuries and 3.25 days among non-fatal TBI injuries. During 2005 through 2007, \$113,055,115 was spent on hospital care for motorcycle-related injuries in Ohio, which equals an average of \$37,685,038 annually. When riders exceeded the speed limit or had a speed-related crash as reported by the police officer, hospital charges increased by 24% compared with riders who were not speeding or did not have a speed-related crash. Helmet use decreased hospital charges, but the percent decrease depended on the age of the motorcycle rider (11% decrease among 50 year-olds, but 25% decrease among 20 year-olds).

Conclusion

This study demonstrates that motorcycle crash-related injury and death is a serious and frequent public health problem in Ohio. We recommend increases in educational efforts to reduce alcohol consumption and speed among motorcycle riders, as well as to convey the importance of helmet use among all motorcycle riders. We support legislative action to institute a law for all riders requiring use of a helmet at all times while operating or riding a motorcycle in Ohio.

TABLE OF CONTENTS

	PAGE
CONTENTS	
Executive Summary	3
List of Figures	5
List of Tables	5
Background	7
Data Considerations	8
Motorcycle Crashes in Ohio	11
<i>Crash Details</i>	14
<i>Behavioral Considerations</i>	18
<i>Risk of Death</i>	20
<i>Hospital Care</i>	21
<i>Economic Impact</i>	27
Key Findings	30
Conclusions	32
Acknowledgements	32
References	33
Ohio CODES Program at the Center for Injury Research and Policy	35

LIST OF FIGURES

	PAGE
Figure 1	Motorcycle Rider Age by Gender, Ohio 2005-2007 11
Figure 2	Number of Injuries by County, Ohio 2005-2007 12
Figure 3	Percent of Injuries by Month of Crash, Ohio 2005-2007 13
Figure 4	Percent of Injuries for Injury Status by Ejection Status, Ohio 2005-2007 15
Figure 5	Percent of Injuries for Injury Status by Light Conditions, Ohio 2005-2007 16
Figure 6	Percent of Injuries for Injury Status by Road Contour, Ohio 2005-2007 18
Figure 7	Percent of Helmet Use by Motorcycle Rider Age Group, Ohio 2005-2007 19
Figure 8	Body Region Injured for Motorcycle Riders Receiving Hospital Care, Ohio 2005-2007 21
Figure 9	Type of Injury for Motorcycle Riders Receiving Hospital Care, Ohio 2005-2007 22
Figure 10	Length of Hospital Stay by TBI Severity for Motorcycle Riders Receiving Hospital Care, Ohio 2005-2007 24
Figure 11	Percent of Helmet Use by TBI Status and Hospital Discharge Disposition, Ohio 2005-2007 26
Figure 12	Median Emergency Department Charges by TBI Severity, Ohio 2005-2007 28
Figure 13	Median Inpatient Charges by TBI Severity, Ohio 2005-2007 28

LIST OF TABLES

	PAGE
Table 1	Motorcycle Rider Injury and Death by Region, Ohio 2005-2007 12
Table 2	Number of Injuries by Time of Crash, Ohio 2005-2007 13
Table 3	Injury Status by Manner of Collision, Ohio 2005-2007 14
Table 4	Injury Status by First Sequence of Events, Ohio 2005-2007 14
Table 5	Injury Status by Weather Conditions, Ohio 2005-2007 16
Table 6	Injury Status by Posted Speed Limit, Ohio 2005-2007 17
Table 7	Injury Status by Motorcycle Rider Age Group, Ohio 2005-2007 18
Table 8	Injury Status by Helmet Use, Ohio 2005-2007 19
Table 9	Injury Status by Driver Contributing Action, Ohio 2005-2007 20
Table 10	TBI Severity by Helmet Use, Ohio 2005-2007 23
Table 11	Maximum AIS for Head/Face Region by Helmet Use, Ohio 2005-2007 23
Table 12	Hospital Charges by Helmet Use for All Motorcycle Riders Receiving Hospital Care, Ohio 2005-2007 27
Table 13	Hospital Charges by Helmet Use for Motorcycle Riders Receiving Hospital Care for a TBI, Ohio 2005-2007 27



INTRODUCTION

Injury is among the most compelling public health problems facing our state and nation. In 2007, unintentional motor vehicle traffic injuries were the second leading cause of unintentional injury death among all ages in Ohio,¹ and the first leading cause among all ages nationally.² Motorcyclists were approximately 37 times more likely to die and 9 times more likely to be injured than occupants of passenger cars per vehicle mile driven in 2007.³ Since 1996, motorcycle registrations have seen a dramatic increase,⁴ making motorcycle crashes an important focal point for prevention strategies to reduce traffic-related injuries and death. This study describes the medical and economic impact of motorcycle injuries in Ohio, with the long-term goal of preventing motorcycle crash-related morbidity and mortality in Ohio.

BACKGROUND

Motorcycle-related fatalities and fatality rates have been increasing rapidly during the past decade nationally. Motorcyclist deaths increased by more than 110% from 1996 to 2005. Increases in motorcycle registrations (61%) and vehicle miles of travel (8.6%) played only a minor role in the observed increase; the motorcycle fatality rate increased by 94% during this ten-year period.⁴ The number of motorcyclist deaths increased another 5% from 2005 to 2006, 7% from 2006 to 2007, and 2% from 2007 to 2008, totaling 5,290 deaths and another 96,000 non-fatal injuries nationally among motorcyclists in 2008.^{3, 5-6} In 2007, motorcycles represented 3% of registered vehicles and

contributed 0.4% of all vehicle miles of travel, but motorcyclists were approximately 37 times more likely to die and 9 times more likely to be injured than occupants of passenger cars per vehicle mile driven in 2007.³

Excessive speed was involved in 35% of motorcyclist deaths, compared with 23% of deaths to passenger car drivers in 2008.³ Alcohol also plays an important role in motorcycle-related fatalities. In 2008, 29% of motorcyclists who died had a blood alcohol concentration (BAC) of .08 g/dL or greater, which was a higher percentage than any other category of motor vehicle driver. Motorcycle operators with BACs of .08 or greater killed in crashes had lower helmet use rates (46%) than those who had no detectable alcohol (66%).³

Brain injury is the leading cause of death in motorcycle crashes.⁷ Motorcycle helmets are estimated to be 37% effective in preventing motorcycle crash-related fatalities, and 33-48% effective in preventing brain injuries.⁷⁻⁸ In 2008, an estimated 1,829 motorcyclist lives were saved by helmets, and another 823 lives could have been saved if there had been universal helmet use by motorcycle operators.³ According to the National Occupant Protection Use Survey (NOPUS), motorcycle helmet use was estimated at 67% in 2009.⁹ Hospital costs of motorcycle crash-related injuries are higher among unhelmeted operators, and these costs are less likely to be covered by insurance. An estimated \$1.3 billion was saved in hospital costs in 2002 alone due to motorcycle helmet use.⁷

This study offers a comprehensive understanding of the breadth and magnitude of the motorcycle-related injury problem in Ohio.

Motorcycle-related fatalities and fatality rates have been increasing rapidly during the past decade nationally.

DATA CONSIDERATIONS

Data Sources

This investigation used two large statewide databases for Ohio. The Ohio Department of Public Safety crash database contains all reported crash incidents that involved an injury event or property damage greater than \$400. The Ohio Hospital Association database includes all emergency department and inpatient admissions reported by the approximately 174 member hospitals. Cases with an injury diagnosis code (ICD-9-CM 800.00-960.00) or external cause of injury code (E800-E999, and V714) in the hospital database were selected for data linkage.

Study Population

The Ohio crash database and Ohio hospital database for the years 2005 through 2007 were probabilistically linked using CODES2000 software¹⁰ to create an extensive new combined research dataset for analysis. This sophisticated probabilistic linkage procedure¹¹⁻¹³ includes multiple imputation of missing links to reduce potential bias in the combined research dataset.¹³ Once the combined dataset was obtained, individuals who had a police crash record indicating they were riding a motorcycle at the time of the crash were selected for inclusion in our study. Non-full size motorcycles were excluded from the study.

Variable Description

Variables in this study were derived from information contained in police reports and/or hospital records. An individual was considered injured if either the police report or hospital record indicated an injury. For motorcycle riders without a linked hospital record, a death was said to occur if the police report indicated a fatality, but for riders with a linked hospital record, a death was said to occur if hospital discharge information indicated a fatality.

Hospital care and economic information was only available for injured motorcycle riders who linked to a hospital record. Barell Matrix classification from injury diagnosis codes (ICD-9-

CM) was used to determine the nature of injury (e.g., fracture) and body region injured (e.g., brain injury, torso).¹⁴ For the classification of traumatic brain injury (TBI), the Barell Matrix describes three TBI severity categories: severe (type1), moderate (type2), and mild (type3). This study also classifies head injury unspecified (ICD-9-CM: 959.01) as a TBI, in accordance with the Center for Disease Control and Prevention's TBI definition,¹⁵ and refers to this group as potential TBI when presenting TBI severity levels. Injury Severity Score (ISS) and Abbreviated Injury Scale (AIS) scores were determined from injury diagnosis codes (ICD-9-CM) using ICDMAP-90 software.¹⁶ AIS describes seven injury severity categories: minor (AIS=1), moderate (AIS=2), serious (AIS=3), severe (AIS=4), critical (AIS=5), unsurvivable (AIS=6), and uninjured (AIS=0). Hospital charges were adjusted for inflation using the consumer price index to 2007 dollar values.¹⁷

Descriptive crash and motorcycle rider information was obtained from the crash report, such as age, speed limit, gender, and helmet use. A crash time between 9 pm and 6 am was defined as a night-time crash. Riding alone was determined from the number of occupants. The variable for type of intersection was used to determine whether the crash occurred at an intersection. The road contour variable was used to determine a curved road. Alcohol suspected included alcohol use or suspected use, which also included riders who had suspected alcohol and drug use. The manner of collision variable was used to determine a single-vehicle crash (i.e., not a collision between two vehicles). An incident was considered speed-related when the unit speed exceeded the posted speed limit, or the contributing circumstance on the crash report indicated "exceeded speed limit" or "unsafe speed." Aggressive driving included contributing circumstances that indicated: "followed too closely," "improper lane change/passing," and "operating erratically/recklessly." Pre-crash driver actions were consolidated into "movement straight," "left/right turn," "passing/lane change," and "other." Crash point of impact was consolidated into "front," "right," "left," and "other," where "left" and "right" include side crashes towards the front and rear. Metropolitan area was determined from crash county and US Department of Agriculture definitions of metropolitan and non-metropolitan counties.¹⁸

Data Analyses

SAS version 9.1 was used to generate descriptive statistics (frequencies, means, medians, ranges), and to conduct logistic and linear regression model analyses to determine the influence of selected risk/protective factors on health outcomes. Our data analytic strategy included multiple imputation of missing values, with analysis conducted on five imputed datasets using the SAS *mianalyze* procedure. All descriptive crash and motorcycle rider variables mentioned above were included as explanatory variables in our regression models, except the type of intersection and aggressive driving, because they were not significantly related to any health outcome. Injury severity was also added as explanatory variable in the model describing hospital charges and hospital length of stay (both models used log-transformed outcome values). Night crash was not included in the model describing death, because of model instability. Because the influence of helmet use may vary depending on another crash factor, our analyses tested for interactions between helmet use and age, as well as helmet use and single/multiple-vehicle crashes. Significantly meaningful adjusted odds ratios (ORs) from our models are presented where appropriate. Unadjusted effectiveness estimates for helmet use were calculated as 1 minus the relative risk (e.g., 1 minus the ratio of death among helmet wearers to non-wearers), and 1 minus the odds ratio for adjusted estimates from logistic regression analyses.⁸ The rates of injury and death were determined using the number of motorcycle vehicle registrations in Ohio during the study period as the denominator.¹⁹⁻²¹

Limitations

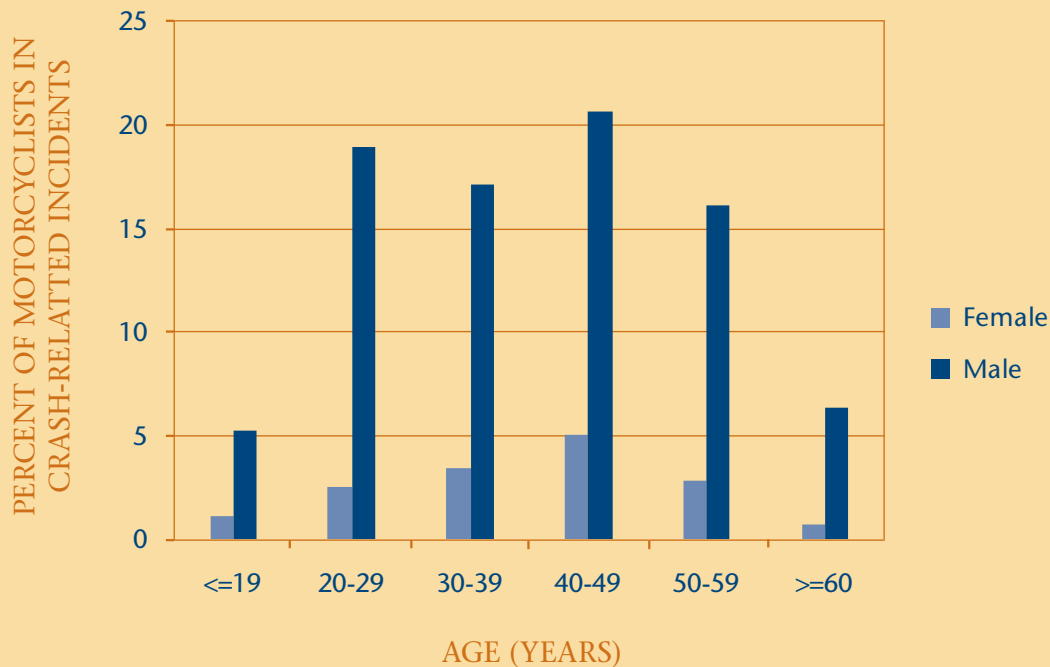
There were some limitations to this research investigation. The crash database included uninjured motorcycle riders, who were not expected to link to a hospital record; however, it is likely there were some injured riders who received hospital care for whom our probabilistic linkage techniques were unable to link their crash and hospital records. Simulated data linkages using parameters that mimic those of the Ohio databases have indicated that we are able to detect 83% of the true links. Our analysis using hospital data only included individuals who had a crash and hospital record link. Further, we were unable to ascertain medical outcome of individuals who sought care at an urgent care center or physician office. Hospital charges in this study represent billed hospital charges, rather than hospital costs, and do not include other hospital-related charges, such as physician fees. Thus, the financial information presented likely underestimates the true economic impact of these injuries. Additionally, our metropolitan area variable would be more precise if obtained directly from the police report; however, this information is not available in Ohio and therefore derived estimates were made based on the county where the crash occurred. Finally, this study assessed crash data involving a motorcycle but did not include motorized bicycles or other non-full-size motorcycles. Including these additional cases would likely show that the injury problem associated with motorized two-wheeled vehicles in Ohio is even greater than the results from this study illustrate.



A gravel road with a yellow center line leads towards a range of mountains under a blue sky with large white clouds. The road is made of dark gravel, and the yellow line is painted in the center. The mountains in the distance are dark and rugged. The sky is a deep blue with large, fluffy white clouds. The overall scene is a wide, open landscape.

*Every week in Ohio, 79
motorcycle riders are injured
and 3 are killed as a result of
a motorcycle crash.*

MOTORCYCLE CRASHES IN OHIO

Figure 1
**Motorcycle Rider Age by Gender,
Ohio 2005-2007**


From 2005 through 2007, there were 15,467 motorcycle riders involved in a crash in Ohio. These motorcyclists were on average 39.6 years of age, and 84.4% of these riders were male (Figure 1). More than three-fourths (79.3%) of these riders experienced an injury, as documented by police crash report or hospital record. For 3,919 motorcycle riders, an injury was documented by the police report but was not linked to any hospital record. The remaining 8,348 injured motorcyclists received emergency department care (6,606 riders) or inpatient hospital care (1,745 riders). There were 440 motorcyclists who died at the scene or after arrival to the hospital.

greatest number of fatalities were: Cuyahoga (33), Lucas (28), Franklin (24), Summit (21), Montgomery (19), Ashtabula (12), Hamilton (11), and Mahoning (11).

The rate of motorcycle crash-related injury and death was calculated using the number of registered motorcycles for 2005 through 2007. The rate of injury was 1.24 injuries per 100 registered motorcycles. The rate of death was 4.45 deaths per 10,000 registered motorcycles.

The Northeast and Southwest regions of Ohio had the largest number of injuries and fatalities (Table 1). There was considerable variation in the number of injuries by county (Figure 2). The counties with the greatest number of injuries were: Franklin (932), Cuyahoga (886), Hamilton (655), Summit (579), Montgomery (508), Lucas (486), Stark (393), and Butler (328). However, the counties with the

Region	Number of Injuries	Number of Deaths
Northwest	1,678	75
Northeast	4,321	157
Central	1,871	60
Southwest	3,022	98
Southeast	1,375	50

Figure 2 | Number of Injuries by County, Ohio 2005-2007



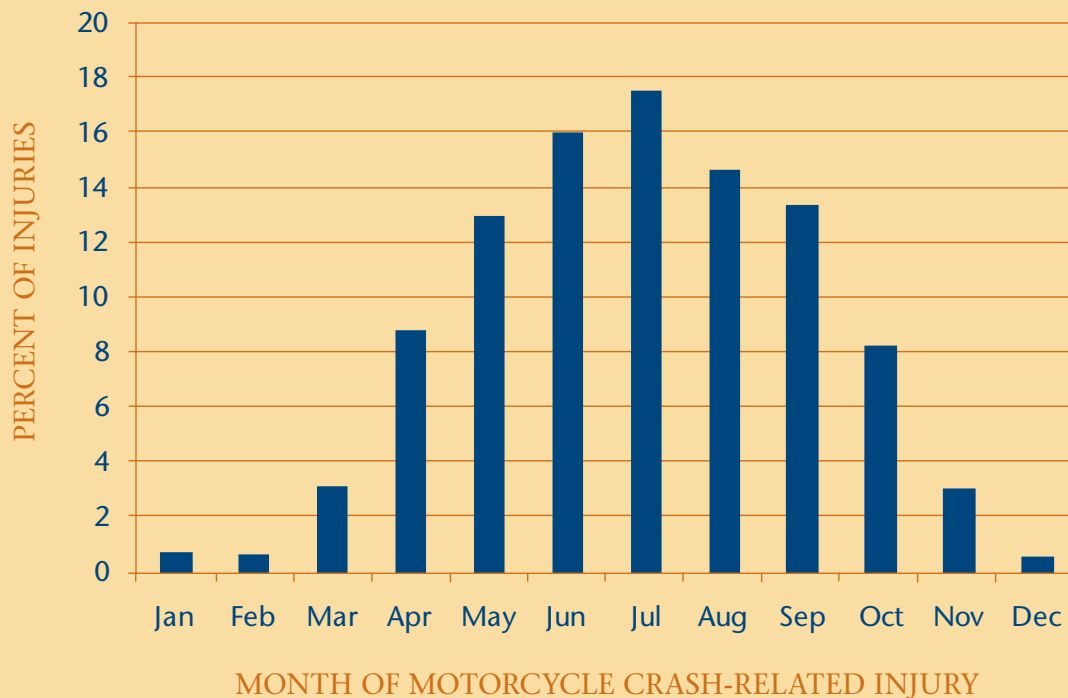
Approximately two-thirds (67.3%) of motorcycle-related injuries occurred from 10 am to 8 pm (Table 2). A larger number of injuries occurred on a Saturday (21.6%) or Sunday (19.8%), than any other day of the week. Almost half (48.1%) of motorcycle-related injuries occurred during the summer months of June, July, and August (Figure 3).

Table 2 | Number of Injuries by Time of Crash, Ohio 2005-2007

Crash Time	Number of Injuries	Percent
12:00 am - 5:59 am	1,039	8.5
6:00 am - 9:59 am	714	5.8
10:00 am - 3:59 pm	3,996	32.6
4:00 pm - 7:59 pm	4,254	34.7
8:00 pm - 11:59 pm	2,264	18.4

Note: Injury determined by police report and/or hospital record.

Figure 3 | Percent of Injuries by Month of Crash, Ohio 2005-2007



Note: Injury determined by police report and/or hospital record.

CRASH DETAILS

Crash records indicated that 12,561 (81.2%) motorcycle riders had a crash that involved contact (i.e., striking and/or struck) with another motorist, non-motorist or object. The primary point of impact on the motorcycle for riders who sustained

an injury was front-center (32.3%), followed by left-impact (28.0%) and right-impact (25.8%). More than half (54.6%) of all fatal and non-fatal injuries did not involve a collision between two vehicles (Table 3). Among injured motorcyclists who collided with a second vehicle (5,565 riders), the primary manner of collision was an angle impact (52.7%)

Table 3 | Injury Status by Manner of Collision, Ohio 2005-2007

Manner of Collision	Death	Non-Fatal Injury, ED/INP care	Non-Fatal Injury, PR only	No Injury
Not Between Two Vehicles	228 (51.9)	4,508 (55.4)	1,966 (53.4)	1,119 (35.0)
Front to Front	37 (8.3)	270 (3.3)	108 (2.9)	68 (2.1)
Angle	125 (28.3)	2,011 (24.7)	793 (21.5)	655 (20.5)
Rear Involved	38 (8.7)	1,017 (12.5)	588 (15.9)	1,079 (33.7)
Sideswipe	12 (2.8)	335 (4.1)	231 (6.3)	279 (8.7)
Note: Values = Number (%). Death determined by police report and/or hospital record; ED/INP care = Emergency Department/Inpatient care; PR only = Police Reported Injury, unlinked to a medical record.				

Most (81.2%) injured motorcycle riders were moving straight prior to the crash event. Some riders were stopped or slowing in traffic (6.1%),

turning left (4.4%), turning right (2.9%), or passing (2.3%). The first item in the sequence of motorcycle crash events is listed in Table 4.

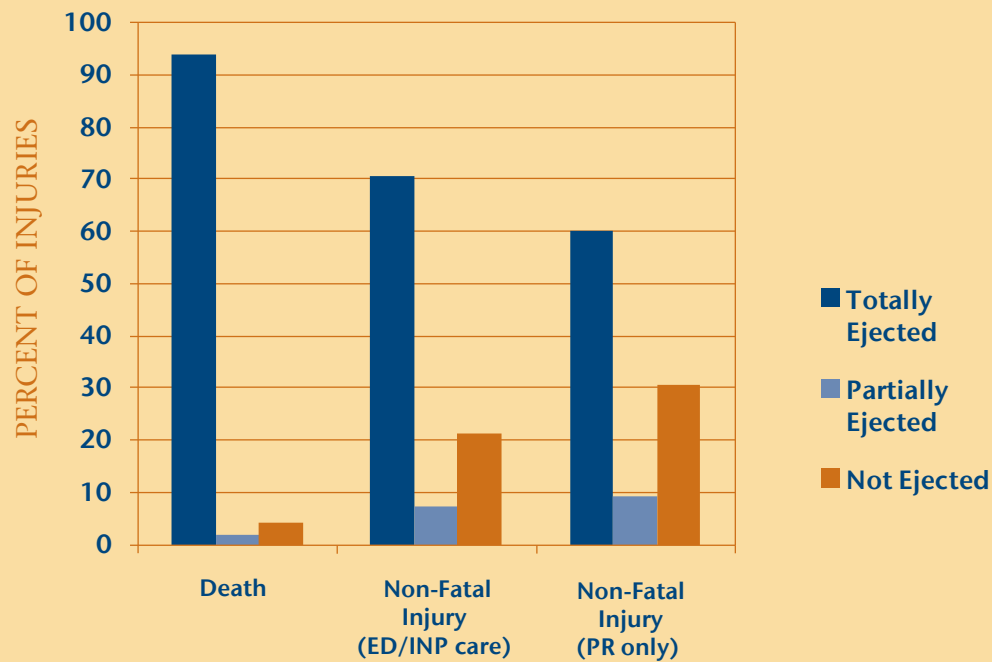
Table 4 | Injury Status by First Sequence of Events, Ohio 2005-2007

First Sequence of Events	Death	Non-Fatal Injury, ED/INP care	Non-Fatal Injury, PR only	No Injury
Motor Vehicle in Transport Collision	170 (38.5)	3,391 (41.6)	1,601 (43.4)	1,994 (62.3)
Animal Collision	18 (4.2)	471 (5.8)	225 (6.1)	140 (4.4)
Ran Off Road, Right	107 (24.3)	1,465 (18.0)	514 (14.0)	234 (7.3)
Ran Off Road, Left	35 (7.9)	436 (5.4)	166 (4.5)	82 (2.5)
Overturn/Rollover	38 (8.7)	961 (11.8)	456 (12.4)	172 (5.4)
Cross Median/ Centerline	33 (7.5)	267 (3.3)	121 (3.3)	54 (1.7)
Other	39 (8.9)	1,150 (14.1)	603 (16.3)	524 (16.4)
Note: Values = Number (%). Death determined by police report and/or hospital record; ED/INP care = Emergency Department/Inpatient care; PR only = Police Reported Injury, unlinked to a medical record.				

There were 8,403 injured motorcycle riders who were totally ejected from the motorcycle during their crash, and 413 (4.9%) of these riders died (Figure 4). Property damage to the motorcycle for riders who died was severe or disabling in 75.7% of

the cases, and 93.1% of the motorcycles were towed from the crash site. However, for non-fatal injuries, severe or disabling motorcycle damage occurred for 43.3% of riders, and 54.9% needed to be towed from the crash site.

Figure 4 | **Percent of Injuries for Injury Status by Ejection Status, Ohio 2005-2007**



Note: Death determined by police report and/or hospital record; ED/INP care = Emergency Department/Inpatient care; PR only = Police Reported Injury, unlinked to a medical record.



Environmental Factors

Motorcycle crashes occurred mostly under clear (79.6%) or cloudy (17.3%) weather conditions. The

distribution was similar among motorcyclists with an injury and non-injury event (Table 5). Most injury occurrences (94.5%) had dry road conditions at the scene of the crash.

Table 5 | Injury Status by Weather Conditions, Ohio 2005-2007

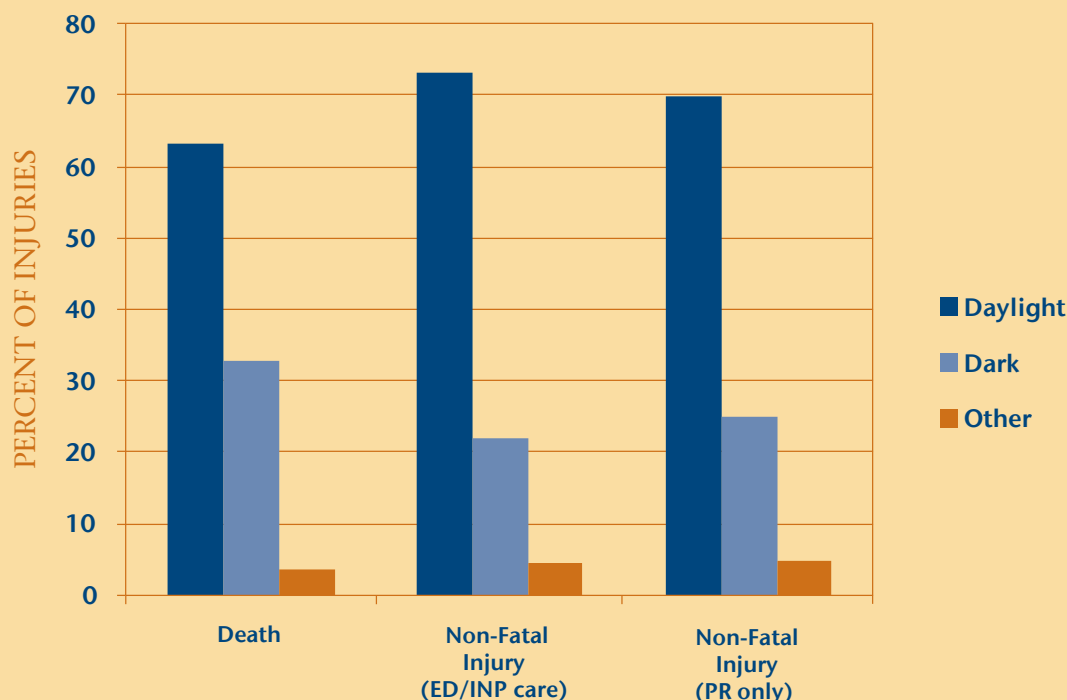
Weather Conditions	Death	Non-Fatal Injury, ED/INP care	Non-Fatal Injury, PR only	No Injury
Clear	342 (77.8)	6,466 (79.4)	2,946 (79.9)	2,552 (79.8)
Cloudy	92 (20.9)	1,441 (17.7)	616 (16.7)	521 (16.3)
Rain	6 (1.3)	190 (2.4)	105 (2.9)	110 (3.4)
Other	0 (0)	44 (0.5)	19 (0.5)	17 (0.5)

Note: Values = Number (%). Death determined by police report and/or hospital record; ED/INP care = Emergency Department/Inpatient care; PR only = Police Reported Injury, unlinked to a medical record.

The majority (72.3%) of motorcycle crashes incidents occurred under daylight conditions; however, a larger percentage of deaths had dark

lighting conditions compared with non-fatal injuries (Figure 5). Roughly 32.8% of motorcycle deaths occurred at dark, representing 145 fatalities.

Figure 5 | Percent of Injuries for Injury Status by Light Conditions, Ohio 2005-2007



Note: Death determined by police report and/or hospital record; ED/INP care = Emergency Department/Inpatient care; PR only = Police Reported Injury, unlinked to a medical record.

Road Elements

Approximately three-fourths (75.7%) of motorcycle crashes occurred in a metropolitan area.

Although the majority of deaths also occurred in a metropolitan area, 31.5% of deaths occurred in a rural area whereas only 24.8% of non-fatal

injuries occurred in a rural area. As shown in Table 6, motorcycle-related injuries occurred most frequently on roadways with posted speeds of 50/55 mph (36.1%) and 30/35 mph (27.6%). Over half (51.4%) of all motorcycle-related deaths occurred on roadways with a posted speed of 50/55 mph.

Table 6 | Injury Status by Posted Speed Limit, Ohio 2005-2007

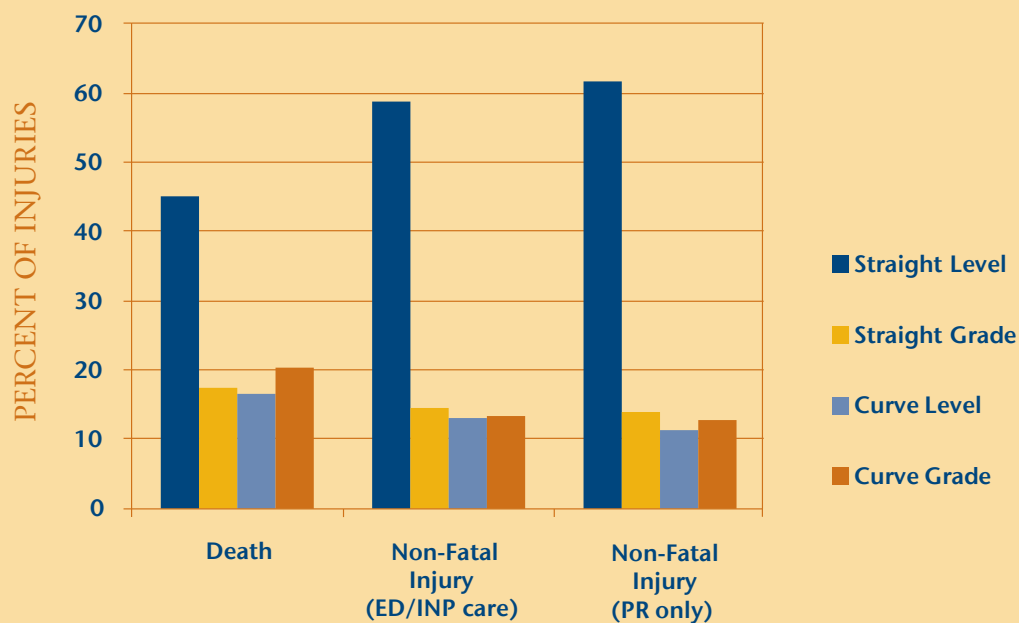
Posted Speed Limit	Death	Non-Fatal Injury, ED/INP care	Non-Fatal Injury, PR only	No Injury
≤ 25 mph	40 (9.2)	1,318 (16.2)	698 (18.9)	801 (25.0)
30/35 mph	84 (19.0)	2,239 (27.5)	1,060 (28.8)	1,085 (33.9)
40/45 mph	58 (13.2)	1,212 (14.9)	478 (12.9)	422 (13.2)
50/55 mph	226 (51.4)	2,960 (36.3)	1,241 (33.7)	763 (23.9)
60/65 mph	32 (7.2)	412 (5.1)	209 (5.7)	129 (4.0)

Note: Values = Number (%). Death determined by police report and/or hospital record; ED/INP care = Emergency Department/Inpatient care; PR only = Police Reported Injury, unlinked to a medical record.

Motorcycle crashes tended to occur on the roadway (82.0%), rather than off the roadway (15.4%) in locations such as the shoulder, median, or roadside. However, 26.8% of motorcycle-related deaths occurred off the roadway. When an injury event occurred at an intersection, four-way intersections were most common (16.3%), followed

by T-intersections (14.0%) and then driveways (7.3%). However, the majority (60.9%) of crash-related motorcycle injuries did not occur at an intersection. Roadways that were straight and level were involved in 59.2% of all injuries and deaths combined, but the percentage varied by injury status (Figure 6).



Figure 6**Percent of Injuries for Injury Status by Road Contour, Ohio 2005-2007**

Note: Death determined by police report and/or hospital record; ED/INP care = Emergency Department/Inpatient care; PR only = Police Reported Injury, unlinked to a medical record.

BEHAVIORAL CONSIDERATIONS

There were 10,258 male motorcycle riders and 2,009 female motorcycle riders who experienced a fatal or non-fatal injury. Male riders comprised 92.0%

of the deaths and 83.3% of non-fatal injuries. The majority of injuries and deaths occurred between 20 and 50 years of age (68.1%), representing 8,353 fatal and non-fatal injuries (Table 7).

Table 7**Injury Status by Motorcycle Rider Age Group, Ohio 2005-2007**

Age Group	Death	Non-Fatal Injury, ED/INP care	Non-Fatal Injury, PR only	No Injury
Less than 20 Years	14 (3.2)	501 (6.1)	258 (7.0)	201 (6.3)
20 to 29 Years	109 (24.8)	1,676 (20.6)	878 (23.8)	648 (20.3)
30 to 39 Years	95 (21.5)	1,684 (20.7)	745 (20.2)	660 (20.6)
40 to 49 Years	92 (20.9)	2,154 (26.5)	919 (24.9)	804 (25.1)
50 to 59 Years	94 (21.4)	1,533 (18.8)	645 (17.5)	662 (20.7)
60 Years and Older	36 (8.2)	593 (7.3)	241 (6.6)	225 (7.0)

Note: Values = Number (%). Death determined by police report and/or hospital record; ED/INP care = Emergency Department/Inpatient care; PR only = Police Reported Injury, unlinked to a medical record.

Of the 12,267 injured motorcycle riders, 7,131 (41.9%) were wearing a helmet at the time of the crash, but helmet use among injured and non-injured riders varied by Ohio Region. Central and Southeast Ohio had the highest percentage of helmet use among riders who experienced a crash

(46.4% and 47.8%, respectively). The lowest helmet use was in Northwest (40.9%), Southwest (40.9%), and Northeast (41.6%) Ohio. Helmet use also varied by motorcyclist age (Figure 7). Only 29.7% of motorcyclists who died were wearing a helmet at the time of the crash (Table 8).

Figure 7 | Percent of Helmet Use by Motorcycle Rider Age Group, Ohio 2005-2007

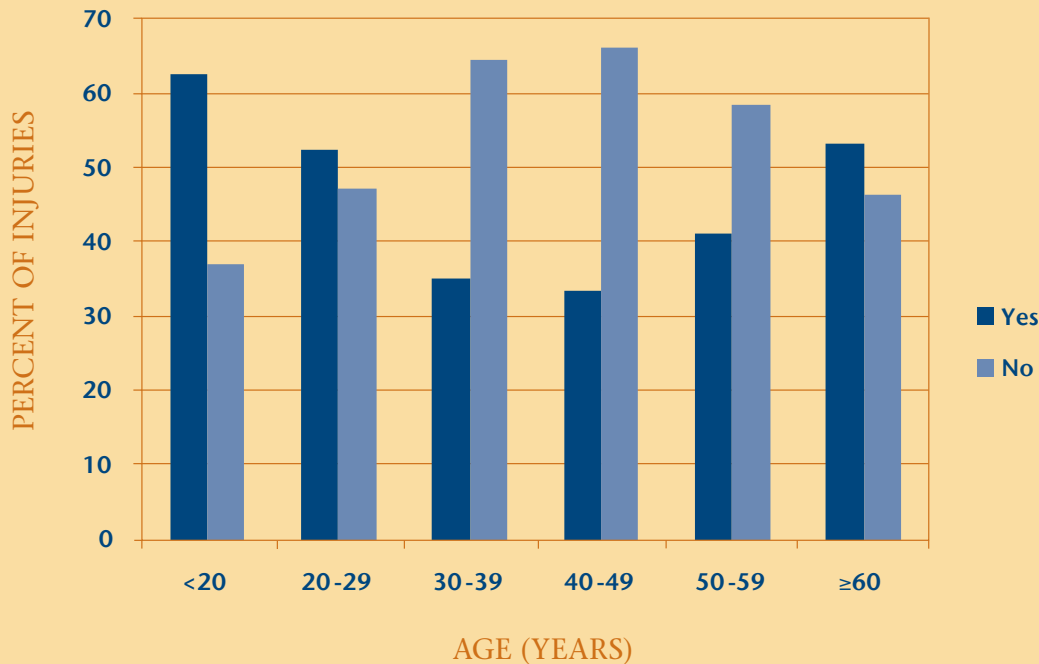


Table 8 | Injury Status by Helmet Use, Ohio 2005-2007

Helmet Use	Death	Non-Fatal Injury, ED/INP care	Non-Fatal Injury, PR only	No Injury
Yes	131 (29.7)	3,420 (42.0)	1,585 (43.0)	1,471 (46.0)
No	309 (70.3)	4,721 (58.0)	2,101 (57.0)	1,729 (54.0)

Note: Values = Number (%). Death determined by police report and/or hospital record; ED/INP care = Emergency Department/Inpatient care; PR only = Police Reported Injury, unlinked to a medical record.

Of the 15,467 motorcycle riders in a crash, 13,660 were driving the motorcycle and the remaining riders were passengers. Accordingly, 23.5% of injured motorcycle riders were accompanied by another rider at the time of the crash. Only 16.6% of riders who sustained an injury resulting in death were on a motorcycle with another rider.

Alcohol use was suspected for 1,749 motorcycle riders involved in a crash. Suspected alcohol use was reported for 50.9% of riders who died, 11.7% of riders with a non-fatal injury who received hospital care, and 9.8% of non-fatal injuries reported by police report but were unlinked to a medical record. Actions of the motorcyclist that contributed

to the crash are presented in Table 9. After excluding riders with no contributing actions, the most frequent contributing circumstances were failure to control (38.2%), speed related factors (14.3%), followed too closely (13.1%), improper

lane change/passing (9.9%), operating erratically/recklessly (6.2%), swerving to avoid (4.3%), failure to yield/stop (4.3%), and driver inattention/fatigue (2.6%).

Table 9 | Injury Status by Driver Contributing Action, Ohio 2005-2007

Driver Contributing Action	Death	Non-Fatal Injury, ED/INP care	Non-Fatal Injury, PR only	No Injury
None	138 (31.5)	3,249 (39.9)	1,547 (42.0)	1,718 (53.7)
Failure to Control	77 (17.5)	2,043 (25.1)	782 (21.2)	464 (14.5)
Speed Related	85 (19.3)	724 (8.9)	351 (9.5)	99 (3.1)
Followed too Closely	19 (4.2)	532 (6.5)	286 (7.8)	317 (9.9)
Improper Lane Change/ Passing	41 (9.4)	490 (6.0)	204 (5.5)	140 (4.4)
Operating Erratically/ Recklessly	33 (7.5)	300 (3.7)	138 (3.7)	76 (2.4)
Swerving to Avoid	5 (1.2)	194 (2.4)	101 (2.8)	76 (2.4)
Failure to Yield/Stop	13 (2.9)	186 (2.3)	75 (2.0)	108 (3.3)
Driver Inattention/ Fatigue	6 (1.4)	131 (1.6)	55 (1.5)	42 (1.3)
Other	23 (5.1)	292 (3.6)	147 (4.0)	160 (5.0)

Note: Values = Number (%). Death determined by police report and/or hospital record; ED/INP care = Emergency Department/Inpatient care; PR only = Police Reported Injury, unlinked to a medical record.

RISK OF DEATH

Risk and protective factors associated with death were assessed among the 15,467 motorcycle riders involved in a crash in Ohio. Unadjusted estimates indicated that helmet use was 43% effective in preventing rider death. Among riders wearing a helmet at the time of the crash, 2.0% died compared with 3.5% of riders not wearing a helmet at the time of the crash. However, this relationship was not statistically significant when adjusting for other factors associated with death.

Adjusted estimates from regression analysis indicated that male riders had greater odds of death (OR = 1.54), as well as riders who rode alone versus with a passenger (OR = 1.69). Riders with known or suspected alcohol use at the time of the crash had 9.50 times greater odds of death than riders without known or suspected alcohol use. Driver pre-crash movement that was straight resulted in significantly greater odds of death when compared to making left/right turns (OR

= 1.91) or other movements (OR = 2.09) such as slowing, stopping, or entering traffic.

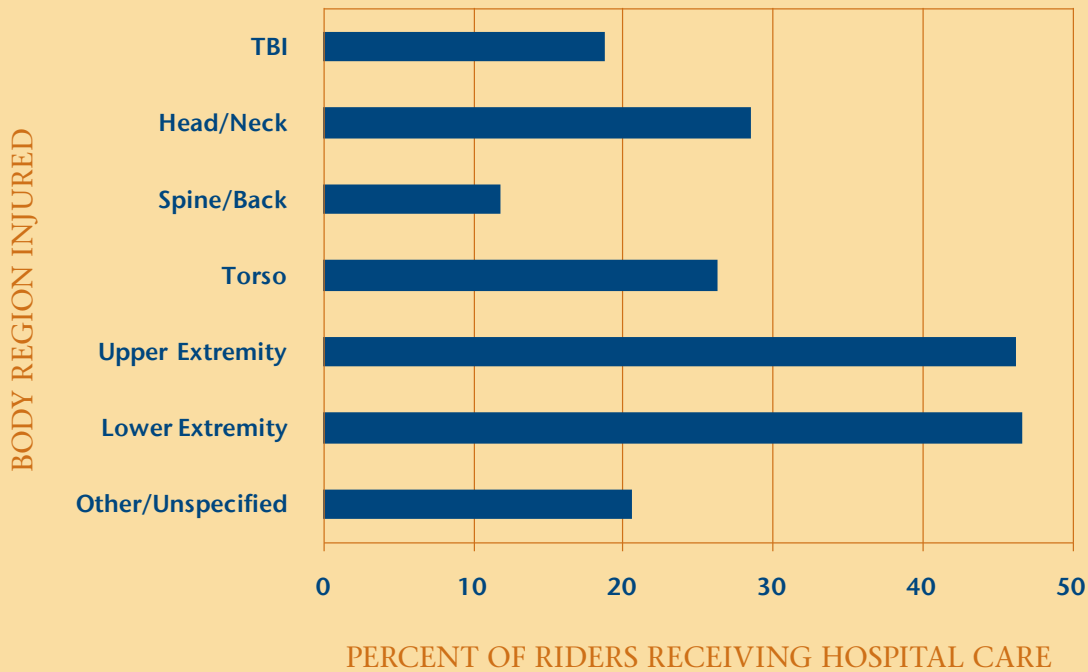
Motorcyclists involved in a multiple-vehicle collision had 2.20 greater odds of death than those in single-vehicle collision. Crashes in a rural area resulted in 1.25 greater odds of death than crashes in an urban area. Speed was a significant factor. On average, a 5 mile per hour increase in speed limit was associated with 1.20 greater odds of death, and when a rider exceeded the speed limit or had a speed-related crash as reported by the police officer, the odds of death increased by 1.52 compared with those who were not speeding or did not have a speed-related crash. Motorcycle crashes occurring on a curved segments of the roadway had 1.39 times greater odds of death than those occurring on straight segments of the roadway. Front impact crashes had greater odds of death than right (OR = 1.68), left (OR = 1.68), or other (OR = 1.51) impact crashes.

HOSPITAL CARE

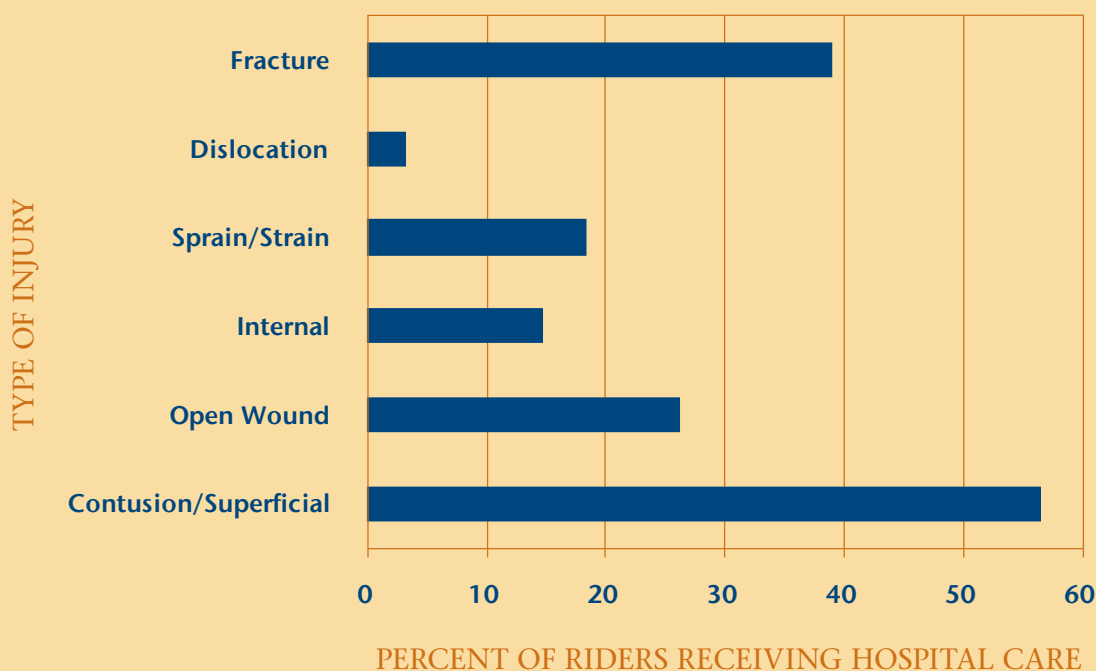
Information on hospital care was available for 8,348 injured motorcycle riders who had a crash report that linked to a medical record. The distributions

of the injured body regions (Figure 8) and the six most frequent types of injuries (Figure 9) are shown below. Riders who experienced multiple injuries are counted separately for each injury.

Figure 8 | Body Region Injured for Motorcycle Riders Receiving Hospital Care, Ohio 2005-2007



Every 36 hours in Ohio a motorcyclist is treated in a hospital for a serious injury.

Figure 9**Type of Injury for Motorcycle Riders Receiving Hospital Care, Ohio 2005-2007**

Injury Severity

The maximum Abbreviated Injury Scale (AIS) over all injuries was determined for each patient and represents the maximum severity score for any injured body region. There were 4,286 (51.3%) motorcyclists who experienced a minor injury, 2,436 (29.2%) who experienced a moderate injury, 820 (9.8%) who experienced a serious injury, 353 (4.2%) who experienced a severe injury, 132 (1.6%) who experienced a critical injury, 39 (0.5%) who experienced an injury rated unsurvivable, and 282 (3.4%) who were rated uninjured.

An Injury Severity Score (ISS) was also calculated for all injured patients receiving hospital care. It provided an overall injury severity estimate for patients and accounted for multiple injuries. Most (91.3%) motorcyclists who received hospital care had an ISS indicating mild or moderate injuries ($ISS < 16$), but 725 (8.7%) experienced more serious injuries ($ISS \geq 16$).

Risk of High ISS

Risk and protective factors associated with high injury severity ($ISS \geq 16$) were assessed among the

8,348 injured riders who had a crash report link to a medical record. Unadjusted estimates indicated that helmet use was 38% effective in preventing high injury severity among riders. Among riders wearing a helmet at the time of the crash, 6.4% had a high ISS compared with 10.3% high ISS among riders not wearing a helmet at the time of the crash.

Adjusted estimates from regression analysis indicated that the effect of helmet use in preventing high ISS was different for riders in a single versus multiple-vehicle crash. Among motorcyclists in a multiple-vehicle crash, unhelmeted riders had 1.06 times greater odds of high ISS than helmeted riders; but among motorcyclists in a single-vehicle crash, unhelmeted riders had 1.77 times greater odds of high ISS than helmeted riders. Thus, in both multiple and single-vehicle crashes helmets reduce the odds of high ISS, but the effectiveness of helmets at preventing a high ISS is less among riders in multiple-vehicle crashes (6% effective) than single-vehicle crashes (43% effective).

On average, for each increase in year of motorcyclist age, the odds of a high ISS increase by 1.014. Thus, the odds of high ISS at any given age is 1.15 times

greater than the odds of someone 10 years younger having high ISS. Riders with known or suspected alcohol use at the time of the crash had 2.52 times greater odds of a high ISS than riders without known or suspected use. When a motorcyclist was passing/making a lane change prior to the crash, the odds of a high ISS was 1.56 times greater than motorcyclists who were moving straight. Frontal impact crashes had greater odds of a high ISS than right (OR = 1.49), left (OR = 1.41), or other (OR = 1.33) impact crashes. Crashes that occurred in an urban area had 1.76 times greater odds of a high ISS than crashes that occurred in a rural area.

Head Injury

There were 1,561 injured riders who sustained a motorcycle crash-related TBI: 493 riders experienced a severe TBI, 573 riders experienced a moderate TBI, 30 riders experienced a mild TBI, and 465 had a potential TBI. Among motorcyclists who sustained a TBI, 1,142 riders (73.2%) were not wearing a helmet at the time of the crash (Table 10). The maximum AIS for the head and face region is presented in Table 11.

Table 10 | TBI Severity by Helmet Use, Ohio 2005-2007

TBI Severity	Helmet Use		
	Yes	No	Total
Severe	108 (3.1)	385 (7.9)	493 (5.9)
Moderate/Mild	192 (5.5)	411 (8.4)	603 (7.2)
Potential	119 (3.4)	346 (7.1)	465 (5.6)
None	3,058 (88.0)	3,729 (76.6)	6,787 (81.3)

Note: Values = Number (%). TBI = Traumatic Brain Injury. Due to the infrequency of Mild TBI, it was combined with Moderate TBI.

Table 11 | Maximum AIS for Head/Face Region by Helmet Use, Ohio 2005-2007

Maximum AIS Head/Face Region	Helmet Use		
	Yes	No	Total
Critical	24 (0.7)	106 (2.2)	130 (1.6)
Severe	56 (1.6)	199 (4.1)	255 (3.0)
Serious	32 (0.9)	108 (2.2)	140 (1.7)
Moderate	141 (4.1)	319 (6.5)	460 (5.5)
Minor	351 (10.1)	1,037 (21.3)	1,388 (16.6)
None	2,873 (82.6)	3,102 (63.7)	5,975 (71.6)

Note: Values = Number (%). Head and Face AIS regions were combined due to the definition of TBI including diagnosis codes from both regions.

Risk of TBI

Risk and protective factors associated with TBI were assessed among the 8,348 injured riders who had a crash report link to a medical record. Unadjusted estimates indicated that helmet use was 49% effective in preventing TBI among riders. Among

riders wearing a helmet at the time of the crash, 12.1% had a TBI compared with 23.4% TBI among riders not wearing a helmet at the time of the crash. Adjusted estimates from regression analysis indicated the effect of helmet use in preventing TBI was different for motorcyclists in a single verses multiple-vehicle crash. Among riders in a

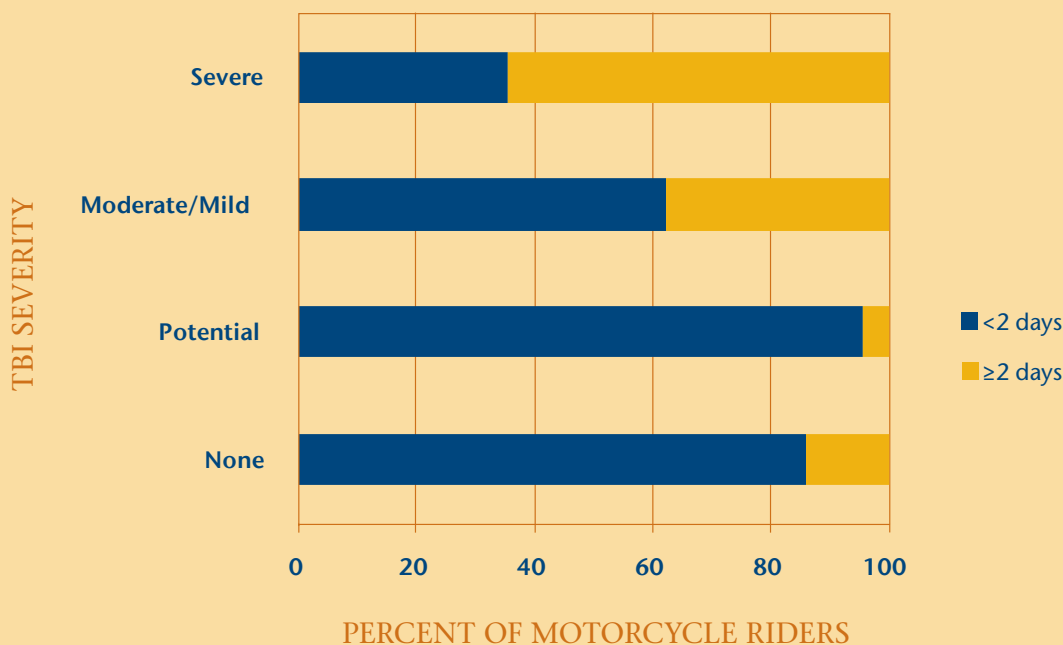
single-vehicle crash, unhelmeted riders had 2.42 times greater odds of TBI than helmeted riders; whereas among riders in a multiple-vehicle crash, unhelmeted riders had 1.51 times greater odds of TBI than helmeted riders. Hence, in both single and multiple-vehicle crashes helmets reduced the odds of TBI, but the effectiveness of helmets at preventing TBI is greater among riders in single-vehicle crashes (59% effective) than multiple-vehicle crashes (34% effective).

The odds of TBI at any age is 1.006 times greater than the odds of a person one year younger. Hence, the odds of TBI at any age is 1.06 times greater than the odds of someone 10 years younger having TBI. Riders with known or suspected alcohol use at the time of the crash had 1.92 times greater odds of TBI than riders without known or suspected use. Frontal impact crashes had greater odds of TBI than right (OR = 1.32), left (OR = 1.32), or other (OR = 1.47) impact crashes.

Length of Hospital Stay

The average length of stay (LOS) in the hospital was calculated for surviving motorcyclists who received hospital care (riders who died were excluded due to shorter hospital stay than their injuries would otherwise indicate). The mean LOS was 1.37 days, with helmeted motorcycle riders experiencing a shorter duration LOS (1.09 days) than unhelmeted riders (1.57 days). Among the 1,561 motorcyclists who sustained a TBI, the mean LOS was 3.25 days. Helmeted motorcycle riders who sustained a TBI had a shorter duration LOS (2.84 days) than unhelmeted riders (3.40 days). There were 1,427 surviving motorcyclists with a LOS ≥ 2 days. Figure 10 shows the percentage of riders who experienced a LOS ≥ 2 days for each level of TBI severity.

Figure 10 | Length of Hospital Stay by TBI Severity for Motorcycle Riders Receiving Hospital Care, Ohio 2005-2007



Note: Fatal injuries are not included.

Risk of Hospital LOS $\geq$ 2 Days

Risk and protective factors associated with a LOS $\geq$ 2 days were assessed among the 8,141 injured riders who had a crash report link to a medical record (fatal injuries were excluded). Unadjusted estimates indicated that helmet use was 22% effective in preventing LOS $\geq$ 2 days among riders. Among riders wearing a helmet at the time of the crash, 15.1% had a LOS $\geq$ 2 days compared with 19.3% LOS $\geq$ 2 days among riders not wearing a helmet at the time of the crash.

Adjusted estimates from regression analysis indicated that unhelmeted motorcyclists had 1.20 times greater odds of LOS $\geq$ 2 days than helmeted motorcyclists. Helmet use was 16% effective in preventing LOS $\geq$ 2 days among riders when taking into account other factors related to a LOS $\geq$ 2 days. On average, for each increase in one year of age, the odds of LOS $\geq$ 2 days increase by 1.018. Thus, the odds of LOS $\geq$ 2 days at any given age is 1.20 times greater than the odds of someone 10 years younger having LOS $\geq$ 2 days. Riders who rode alone versus with a passenger had greater odds of LOS $\geq$ 2 days (OR = 1.21). Driver pre-crash movement that was straight had greater odds of LOS $\geq$ 2 days when compared with other movements, such as slowing, stopping, or entering traffic (OR = 1.74).

Motorcyclists who were involved in a multiple-vehicle collision had 1.21 greater odds of LOS $\geq$ 2 days than those in single-vehicle collision. When a rider exceeded the speed limit or had a speed-related crash as reported by the police officer, the odds of LOS $\geq$ 2 days increased by 1.52 compared with those who were not speeding or did not have a speed-related crash. Crashes in an urban area had 3.32 times greater odds of LOS $\geq$ 2 days than crashes in a rural area. Motorcyclists with a severe injury (ISS $\geq$ 16) had 10.31 times greater odds of LOS $\geq$ 2 days than motorcyclists with a mild/moderate injury (ISS<16).

Factors Affecting Hospital LOS

Adjusted estimates from regression analysis among the 1,656 surviving motorcyclists who had a crash report link to a hospital inpatient record indicated that several factors affect the LOS of inpatient admissions. On average, for each increase in one

year of age, LOS increases by a factor of 1.004 days, or 0.4%. For example, when you increase age from a 20 to 30 year old, LOS would increase an average of 10.0 days. When compared with a single-vehicle crash, multiple-vehicle crashes increased LOS by a factor of 1.16 days, or 16%. When injury severity increased from mild/moderate (ISS<16) to high (ISS $\geq$ 16), LOS increased by a factor of 1.92 days, indicating an increase of 92%.

Discharge Disposition from the Hospital

Almost all (91.2%) of the injured motorcyclists who received hospital care were discharged home. The remaining 738 motorcyclists were discharged to a rehabilitation facility (144 riders), long term care (316 riders), died (206 riders), or left against medical advice (72 riders). The distribution of helmet use by TBI status and discharge status is presented in Figure 11.

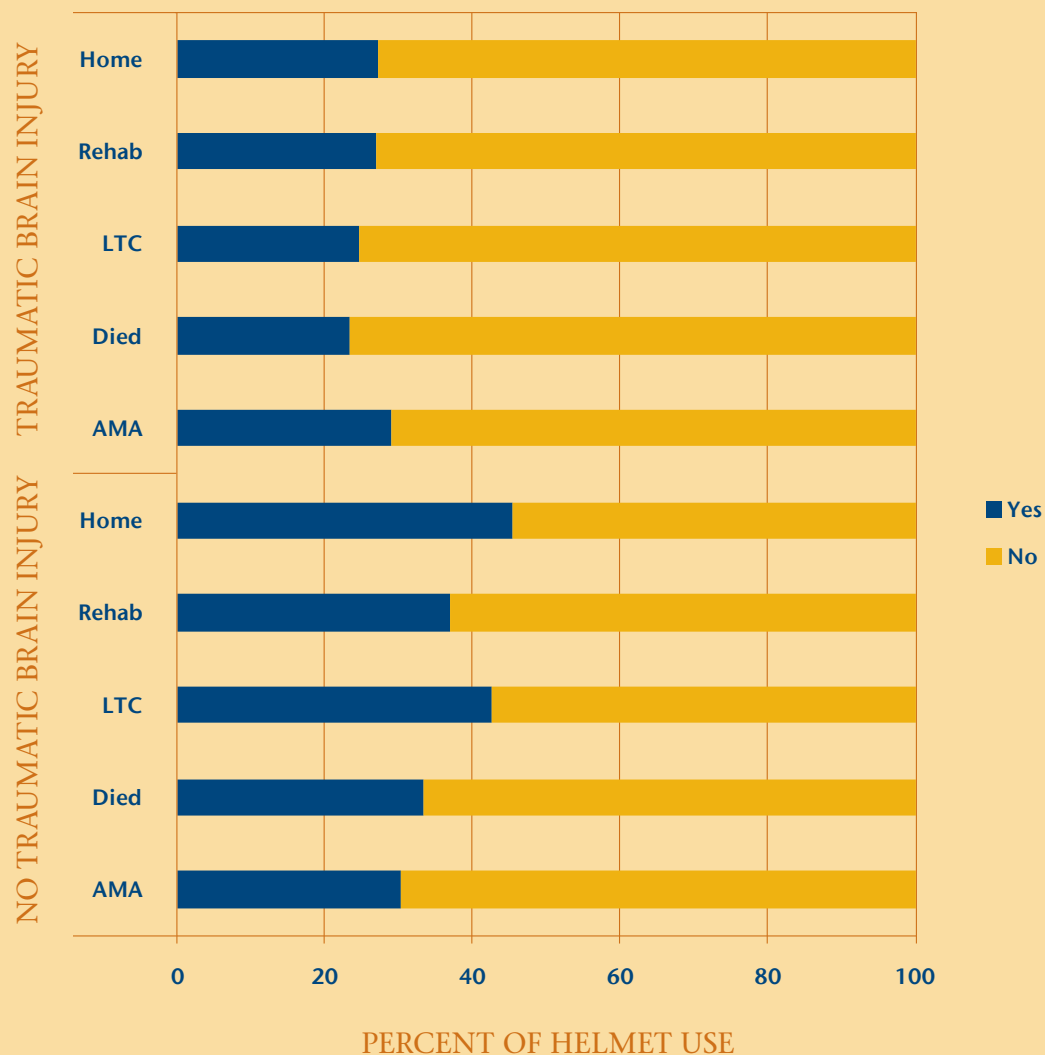
Risk of Rehabilitation

Risk and protective factors associated with discharge to a rehabilitation facility were assessed among the 8,348 injured riders who had a crash report link to a medical record. Unadjusted estimates indicated that helmet use was 34% effective in preventing rehabilitation admission among riders. Among riders wearing a helmet at the time of the crash, 1.3% were admitted to a rehabilitation facility compared with 2.0% admission to rehabilitation among riders not wearing a helmet at the time of the crash. However, this relationship was not statistically significant when accounting for other factors associated with rehabilitation admission.

Adjusted estimates from regression analysis indicated that for each increase in year of age, the odds of admission to a rehabilitation facility increased by 1.015. Thus, the odds of admission to a rehabilitation facility at any given age is 1.16 times greater than the odds of someone 10 years younger having an admission to rehabilitation. Motorcyclists who were involved in a multiple-vehicle collision had 1.60 times greater odds of admission to a rehabilitation facility than those in a single-vehicle collision. Crashes in an urban area had 2.24 times greater odds of admission to a rehabilitation facility than crashes in a rural area.

Figure 11

Percent of Helmet Use by TBI Status and Hospital Discharge Disposition, Ohio 2005-2007



Note: Rehab = Rehabilitation, LTC = Long Term Care, AMA = Against Medical Advice.



ECONOMIC IMPACT

The primary payer covering hospital charges for injured motorcyclists who received hospital care was mainly a private source (65.0%), followed by self pay/uninsured (20.0%), public payer (12.5%), and other (2.5%). Hospital charge data were adjusted for inflation for 2005 and 2006 to be equivalent to 2007 dollars. During 2005 through 2007, \$113,055,115 was spent on hospital care for

motorcycle-related injuries in Ohio, which equals an average of \$37,685,038 annually. Mean hospital charges were \$13,543 (median = \$3,083), with unhelmeted riders accumulating greater hospital charges (mean = \$15,330; median = \$3,447) than helmeted riders (mean = \$11,040; median = \$2,636). Average hospital charges for emergency department and inpatient admission are presented for all motorcyclists who received hospital care in Table 12.

Table 12 | Hospital Charges by Helmet Use for All Motorcycle Riders Receiving Hospital Care, Ohio 2005-2007

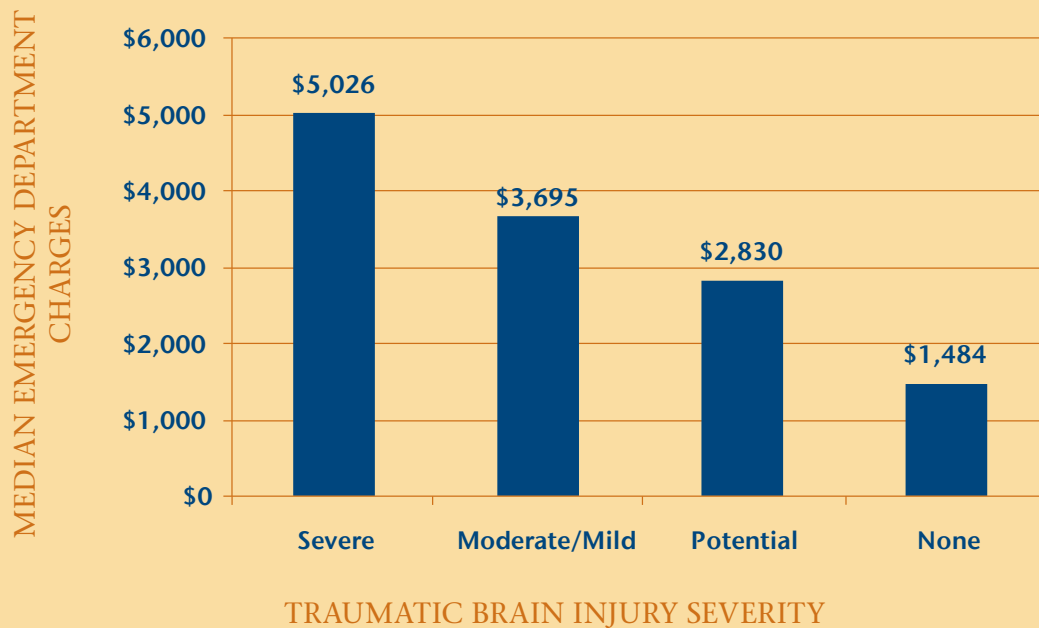
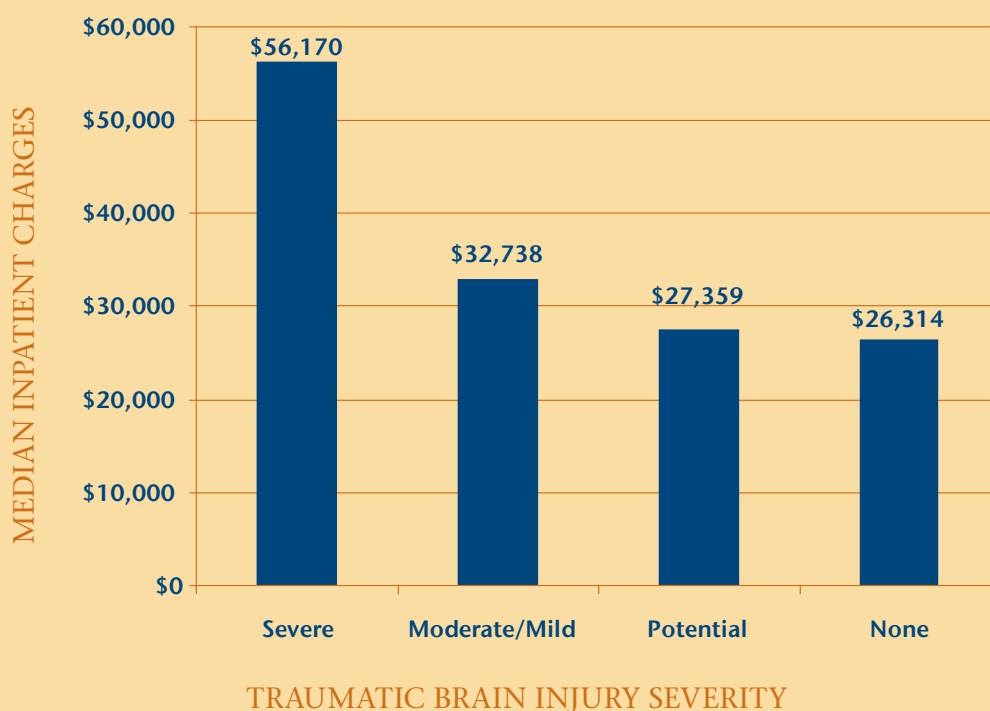
Hospital Care	Helmet Use		
	Yes	No	Total
Emergency Department Care			
Mean	\$2,635	\$3,023	\$2,855
Median	\$1,563	\$1,747	\$1,665
Inpatient Admission			
Mean	\$50,104	\$56,115	\$53,993
Median	\$29,869	\$32,794	\$31,730

Among the 1,561 motorcyclists who sustained a TBI, mean hospital charges were \$33,195 (median = \$9,822). Unhelmeted motorcycle riders who sustained a TBI accumulated greater hospital charges (mean = \$33,463; median = \$10,144) than helmeted riders (mean = \$32,459; median = \$8,996). Average hospital charges for emergency department

and inpatient admission are presented for motorcyclists who received hospital care for a TBI-related injury in Table 13. Riders with a severe TBI incurred the greatest emergency department (Figure 12) and inpatient charges (Figure 13) compared with those with a moderate/mild TBI or no TBI.

Table 13 | Hospital Charges by Helmet Use for Motorcycle Riders Receiving Hospital Care for a TBI, Ohio 2005-2007

Hospital Care	Helmet Use		
	Yes	No	Total
Emergency Department Care			
Mean	\$4,770	\$5,014	\$4,946
Median	\$3,222	\$3,482	\$3,408
Inpatient Admission			
Mean	\$74,222	\$72,484	\$72,932
Median	\$42,299	\$43,973	\$43,536

Figure 12 |**Median Emergency Department Charges by TBI Severity, Ohio 2005-2007****Figure 13** |**Median Inpatient Charges by TBI Severity, Ohio 2005-2007**

Factors Affecting Hospital Charges

Adjusted estimates from regression analysis among the 8,348 injured motorcycle riders who had a crash report link to a medical record indicated that several factors affect hospital charges for injured motorcyclists. Riding alone increased hospital charges by a factor of 1.27 dollars, or 27%, compared with riding with a passenger. When compared with a driver pre-crash movement of a left/right turn, movement in a straight direction increased hospital charges by a factor of 1.14 dollars, or 14%; whereas compared with other driver pre-crash movements, such as slowing, stopping, or entering traffic, movement in a straight direction increased hospital charges by a factor of 1.45 dollars, or 45%.

The influence of helmet use on hospital charges varied depending on age of the motorcyclist. Among motorcycle riders 20 years of age, helmet use decreased hospital charges by a factor of 0.75, or 25%, compared with no helmet use. Among riders 35 years of age, helmet use decreased hospital charges by a factor of 0.82, or 18%, compared with no helmet use, but among 50 year-olds, helmet use decreased hospital charges by a factor of 0.89, or 11%, compared with no helmet use. Thus, as the age of the motorcycle rider increased, the reduction

of hospital charges due to helmet use became less. Among helmeted riders, hospital charges increased by a factor of 1.012 for each increasing year of age, or 1.2%; whereas among unhelmeted riders for each increase in one year of age, hospital charges increased by a factor of 1.007, or 0.7%.

Motorcycle crashes occurring at nighttime increased hospital charges by a factor of 1.14 dollars, or 14%, compared with crashes occurring during the daytime. Crashes on curved segments of the roadway increased hospital charges by a factor of 1.12 dollars, or 12%, compared with crashes on straight segments of the roadway. When riders exceeded the speed limit or had a speed-related crash as reported by the police officer, hospital charges increased by a factor of 1.24 dollars, or 24%, compared with riders who were not speeding or did not have a speed-related crash. When compared with a single-vehicle crash, multiple-vehicle crashes increased hospital charges by a factor of 1.15 dollars, or 15%. Crashes in an urban area increased hospital charges by 1.76 dollars, or 76%, compared with crashes in a rural area. When the severity of a motorcyclist injury increased from mild/moderate (ISS<16) to high (ISS≥16), hospital charges increased by a factor of 7.05, indicating a 605% increase.



KEY FINDINGS

From 2005 through 2007, there were 15,467 motorcycle riders involved in a crash in Ohio, and 79.3% of these riders experienced an injury.

- Of the motorcycle riders who experienced a non-fatal injury, 83.3% were male, whereas 92% of the rider deaths were male.
- Only 23.5% of injured motorcycle riders were accompanied by another rider at the time of the crash.
- Suspected alcohol use was reported for 50.9% of riders who died, and 11.7% of riders with a non-fatal injury who had linked crash and hospital records.
- At the time of the crash, 41.9% of injured motorcycle riders were wearing a helmet, but only 29.7% of riders who died were wearing a helmet.

Death: There were 440 motorcyclists who died at the scene or after arrival to the hospital.

- When a rider exceeded the speed limit or had a speed-related crash, the odds of death increased by 1.52 compared with those who were not speeding or did not have a speed-related crash.
- Motorcyclists involved in a multiple-vehicle collision had 2.20 greater odds of death than those in a single-vehicle collision.
- Riders with known or suspected alcohol use at the time of the crash had 9.50 times greater odds of death than riders without known or suspected alcohol use.

Injury Severity: Most (91.3%) motorcyclists who received hospital care had an ISS indicating mild or moderate injuries (ISS<16), but 725 experienced more serious injuries (ISS≥16).

- The odds of high ISS at any given age is 1.15 times greater than the odds of someone 10 years younger having high ISS.
- Among motorcyclists in a multiple-vehicle crash, unhelmeted riders had 1.06 times greater odds of high ISS than helmeted riders (helmets 6% effective).
- Among motorcyclists in a single-vehicle crash, unhelmeted riders had 1.77 times greater odds of high ISS than helmeted riders (helmets 43% effective).

Head Injury: There were 1,561 injured motorcycle riders who sustained a TBI, and 73.2% were not wearing a helmet at the time of the crash.

- Among riders in a single-vehicle crash, unhelmeted riders had 2.42 times greater odds of TBI than helmeted riders (helmets 59% effective).
- Among riders in a multiple-vehicle crash, unhelmeted riders had 1.51 times greater odds of TBI than helmeted riders (helmets 34% effective).
- Riders with known or suspected alcohol use at the time of the crash had 1.92 times greater odds of TBI than riders without known or suspected use.

Length of Stay: The average hospital LOS was 1.37 days among all motorcycle riders with non-fatal injuries and 3.25 days among those with non-fatal TBI injuries.

- Unhelmeted motorcyclists had 1.20 times greater odds of hospital LOS ≥ 2 days than helmeted motorcyclists.
- When a rider exceeded the speed limit or had a speed-related crash, the odds of hospital LOS ≥ 2 days was 1.52 times greater than those who were not speeding or did not have a speed-related crash.
- Multiple-vehicle crashes increased inpatient LOS by 16% when compared with a single-vehicle crash.
- When injury severity increased from mild/moderate (ISS<16) to high (ISS≥16), inpatient LOS increased by 92%.

Discharge disposition: Almost all (91.2%) of the injured motorcyclists who received hospital care were discharged home, but 1.7% were discharged to a rehabilitation facility.

- The odds of rehabilitation admission at any given age is 1.16 times greater than the odds of someone 10 years younger having rehabilitation admission.
- Motorcyclists who were involved in a multiple-vehicle collision had 1.60 times greater odds of discharge to a rehabilitation facility than those in single-vehicle collision.

Economic Impact: During 2005 through 2007, \$113,055,115 was spent on hospital care for motorcycle-related injuries in Ohio, which is an average of \$37,685,038 annually.

- Among riders 20 years of age, helmet use decreased hospital charges by 25% compared with no helmet use, whereas among riders 35 years of age, helmet use decreased hospital charges 18%. Hence, as the age of the rider increased, the reduction of hospital charges due to helmet use became less.
- When riders exceeded the speed limit or had a speed-related crash as reported by the police officer, hospital charges increased by 24% compared with riders who were not speeding or did not have a speed-related crash.
- When the severity of a motorcyclist injury increased from mild/moderate ($ISS < 16$) to high ($ISS \geq 16$), hospital charges increased by a factor of 7.05, indicating a 605% increase.



CONCLUSIONS

The findings of this study demonstrate motorcycle crash-related injury and death is a serious and frequent public health problem in Ohio. Prevention efforts should focus on reduction of motorcycle rider alcohol consumption, excessive speed, and increase helmet use. Although motorcycle helmets cannot reduce all forms of rider injury, our study demonstrates their effectiveness in reducing high injury severity, traumatic brain injury, hospital charges, and a hospital stay of 2 days or more. We recommend increases in educational efforts to reduce alcohol consumption and speed among motorcyclists, as well as to convey the importance of helmet use by all riders.

We support the Ohio Motorcycle Safety Strategic Plan.²² Data from this study specifically demonstrate the need for Section 1—Impaired Riding: Reduce crashes in which motorcyclists are impaired by alcohol or other drugs, and Section

2—Personal Protective Equipment: Increase the number of motorcyclists who choose to wear helmets and other personal protective equipment. Additionally, we support legislative action to institute a law requiring use of a helmet by all riders at all times while operating or riding a motorcycle in Ohio.

ACKNOWLEDGEMENTS

The Center for Injury Research and Policy of The Research Institute at Nationwide Children's Hospital would like to thank the Ohio Department of Public Safety and the Ohio Hospital Association for providing the data for analysis. This study was supported by a grant from the Division of Emergency Medical Services, Ohio Department of Public Safety. The analyses and conclusions in this article are those of the authors and do not necessarily reflect the opinions or policies of the funding agency or data providers.



REFERENCES

1. Web-based Injury Statistics Query and Reporting System (WISQARS), National Center for Injury Prevention and Control, Centers for Disease Control and Prevention. *10 leading causes of unintentional injury deaths, Ohio, 2007, all races, both sexes*. Retrieved July 16, 2010, from <http://webappa.cdc.gov/sasweb/ncipc/leadcaus10.html>
2. Web-based Injury Statistics Query and Reporting System (WISQARS), National Center for Injury Prevention and Control, Centers for Disease Control and Prevention. *10 leading causes of unintentional injury deaths, United States, 2007, all races, both sexes*. Retrieved July 16, 2010, from <http://webappa.cdc.gov/sasweb/ncipc/leadcaus10.html>
3. National Center for Statistics and Analysis, National Highway Traffic Safety Administration. *Traffic safety facts, 2008 data, Motorcycles*. DOT HS 811 159. Washington, DC: National Highway Traffic Safety Administration. Retrieved July 21, 2010, from <http://www-nrd.nhtsa.dot.gov/pubs/811159.pdf>
4. Federal Highway Administration. (January 30, 2007). *Motorcycle travel data*. [Memorandum]. Retrieved July 21, 2010, from <http://www.fhwa.dot.gov/motorcycles/20070130.cfm>
5. National Center for Statistics and Analysis, National Highway Traffic Safety Administration. (March, 2008). *Traffic safety facts, 2006 data, Motorcycles*. DOT HS 810 806. Washington, DC: National Highway Traffic Safety Administration. Retrieved July 21, 2010, from <http://www-nrd.nhtsa.dot.gov/pubs/810806.pdf>
6. National Center for Statistics and Analysis, National Highway Traffic Safety Administration. *Traffic safety facts, 2007 data, Motorcycles*. DOT HS 810 990. Washington, DC: National Highway Traffic Safety Administration. Retrieved July 21, 2010, from <http://www-nrd.nhtsa.dot.gov/pubs/810990.pdf>
7. National Highway Traffic Safety Administration. (January, 2008). *Traffic safety facts, Laws, Motorcycle helmet use laws*. DOT HS 810 877W. Washington, DC: National Highway Traffic Safety Administration. Retrieved September 20, 2010, from <http://www.nhtsa.gov/DOT/NHTSA/Communication%20&%20Consumer%20Information/Articles/Associated%20Files/810887.pdf>
8. National Highway Traffic Safety Administration. (October, 2009). *Motorcycle helmet use and head and facial injuries, Crash outcomes in CODES-linked data*. DOT HS 811 208. Washington, DC: National Highway Traffic Safety Administration. Retrieved September 21, 2010, from <http://www-nrd.nhtsa.dot.gov/pubs/811208.pdf>
9. National Center for Statistics and Analysis, National Highway Traffic Safety Administration. (December, 2009). *Traffic safety facts, Research note, Motorcycle helmet use in 2009—Overall results*. DOT HS 811 254. Washington, DC: National Highway Traffic Safety Administration. Retrieved July 21, 2010, from <http://www-nrd.nhtsa.dot.gov/pubs/811254.pdf>
10. CODES2000 software, Version 7.0. Morrisonville, NY: Strategic Matching, Inc.
11. Fellegi, I. P., & Sunter, A. B. (1969). A theory for record linkage. *J Am Stat Assoc*, 64, 1184-1210.
12. Jaro, M. A. (1995). Probabilistic linkage of large public health data files. *Stat Med*, 14, 491-498.
13. McGlinchey, M. H. (2004). A Bayesian record linkage methodology for multiple imputation of

missing links. ASA Proceedings of the Joint Statistical Meetings, 4001-4008. Alexandria, VA: American Statistical Association.

14. Barell, V., Aharonson-Daniel, L., Fingerhut, L. A., Mackenzine, E. J., Ziv, A., Boyko, V., et al. (2002). An introduction to the Barell body region by nature of injury diagnosis matrix. *Injury Prevention*, 8, 91-96.
15. Faul, M., Xu, L., Wald, M. M., Coronado, V. G. (2010). Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations and Deaths 2002-2006. Atlanta, GA: Centers of Disease Control and Prevention, National Center for Injury Prevention and Control.
16. ICDMAP-90 software. Baltimore, MD: Johns Hopkins University & Tri-Analytics, Inc.
17. Bureau of Labor Statistics, United States Department of Labor. CPI detailed report data for April 2009. Retrieved April 16, 2010, from <http://www.bls.gov/cpi/cpid0904.pdf>
18. Butler, M., & Beale, C. (1994). *Rural-urban continuum codes for metro and nonmetro counties, 1993*. Washington, DC: Department of Agriculture, Economic Research Service.
19. Federal Highway Administration. *Highway Statistics 2005, State Motor-Vehicle Registrations - 2005*. Retrieved November 10, 2010, from <http://www.fhwa.dot.gov/policy/ohim/hs05/pdf/mv1.pdf>
20. Federal Highway Administration. *Highway Statistics 2006, State Motor-Vehicle Registrations - 2006*. Retrieved November 10, 2010, from <http://www.fhwa.dot.gov/policy/ohim/hs06/pdf/mv1.pdf>
21. Federal Highway Administration. *Highway Statistics 2007, State Motor-Vehicle Registrations - 2007*. Retrieved November 10, 2010, from <http://www.fhwa.dot.gov/policyinformation/statistics/2007/pdf/mv1.pdf>
22. Governor's Highway Safety Office, Ohio Department of Public Safety. *Ohio Motorcycle Safety Strategic Plan*. (May, 2006). Retrieved December 12, 2010, from http://www.publicsafety.ohio.gov/links/mo_safety_plan.pdf.

OHIO CODES PROGRAM AT THE CENTER FOR INJURY RESEARCH AND POLICY

This report was prepared by the Ohio Crash Outcome Data Evaluation System (CODES) Program located within the Center for Injury Research and Policy (CIRP) of The Research Institute at Nationwide Children's Hospital.

CIRP works globally to reduce injury-related pediatric death and disabilities. With innovative research as its core, CIRP works to continually improve the scientific understanding of the epidemiology, biomechanics, prevention, acute treatment and rehabilitation of injuries. CIRP serves as a pioneer by translating cutting edge injury research into education, policy, and advances in clinical care. Learn more about CIRP at <http://www.injurycenter.org>.

The Ohio CODES Program at CIRP was established in 2004 with assistance from the national CODES Program of the National Highway Traffic Safety Administration. CODES represents a process of combining statewide databases in order to link crash report data with medical and financial outcome data. The goal of the Ohio CODES Program is to evaluate the impact of different risk and protective factors on injuries, their severity, and associated costs. The Ohio CODES Program has several partnerships within the state. These include the Governor's Highway Safety Office and the Division of Emergency Medical Services within the Ohio Department of Public Safety, the Ohio Hospital Association, and the Ohio Department of Health. Learn more about the Ohio CODES Program at <http://injuryresearch.net/codes.aspx>.



CENTER *for* INJURY RESEARCH & POLICY

*The Research Institute
at Nationwide Children's Hospital*

For more information on the Center for Injury
Research and Policy or this report, please visit
www.injurycenter.org.