

Factors contributing to Traumatic Brain and Spinal Cord Injury in Massachusetts Motorcycle Crashes

Massachusetts Crash-Related Injury Surveillance System, 2012 - 2015



Injury Surveillance Program, Massachusetts Department of Public Health

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The Massachusetts Crash-Related Injury Surveillance System (MA CRISS) includes data for persons treated in MA acute care hospitals for motor vehicle crash injuries whose hospital record linked with a MA police crash report. These data do not include all crashes involving injuries in MA, as they do not include cases in which crash victims were transported to out-of-state hospitals, police were not involved, crash reports were not submitted to the Registry of Motor Vehicles, or missing or incorrect data prevented data linkage. Data may contain some duplicate records and/or linkages of some hospital records with the wrong crash records.

MA Hospital Discharge data are compiled by the Center for Health Information and Analysis. Crash data are compiled by the MA Registry of Motor Vehicles.

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This report explores the circumstances surrounding motorcycle crashes that result in traumatic brain or spinal cord injuries. Understanding those circumstances can inform prevention programs and policies so fewer people suffer these serious injuries and potential long-term disability.¹

Head injury is the most prevalent injury sustained by motorcyclists killed in a crash.² In 2015, half (52%) of the 60 motorcycle (MC) operator fatalities in Massachusetts (MA) involved a traumatic brain injury (TBI).^{3,a}

In fiscal year (FY) 2015, there were 484 hospitalizations of MC operators in MA for nonfatal injuries. Of these hospitalized MC operators, 30% sustained a TBI and 2% sustained a spinal cord injury (SCI) in the crash.⁴ Studies in other states have found that 19% - 27% of hospitalized motorcyclists sustained a TBI or head injury in the crash.^{5,6}

Based on FY 2015 data, compared to hospitalized MC operators who did not sustain a TBI or SCI (TBI/SCI), MC operators who sustained a TBI/SCI had significantly higher mean hospital charges (\$112,000 vs. \$65,000, $p < 0.001$), and were nearly twice as likely to be discharged to a rehabilitation or other healthcare facility (40% vs. 22%, $p < 0.001$).⁴

In 2015, half of motorcycle operators killed and 30% of those hospitalized in Massachusetts sustained a traumatic brain injury in the crash.

We found few prior studies of risk factors for TBI and SCI in motorcyclist crashes. High speeds and collision with a fixed object are risk factors for both TBI and SCI.^{6,7,8} Additional risk factors for TBI include not wearing a helmet, drinking, and engine size of 1000 cc or greater.^{6,7} Additional risk factors for sustaining a SCI in a crash include rear-end impact, and single vehicle crash, but not helmet use or engine size.^{8,9}

The current study used linked 2012 - 2015 [MA Crash-Related Injury Surveillance System \(MA CRISS\)](#) data to identify MC operator and crash-related factors associated with sustaining a TBI/SCI in a crash. Note that MA CRISS data differ from the hospitalization data presented above in that MA CRISS data include only hospital injury cases that link to a police crash report. See box on left for further details.

This study focused on MC operators only. MC passengers were excluded. A [separate report](#) examines factors associated with car/truck drivers sustaining a TBI/SCI in a crash. We combined TBI and SCI because they are both neurological injuries associated with significant long-term disability.

^a Spinal cord injury diagnoses are under-reported in death data, so were not included here.

Characteristics of Hospitalized MC Operators and related Crashes in MA CRISS Data

Of the 1,053 hospitalized MC operators in 2012-2015 MA CRISS data (Jan. 1, 2012 - Sep. 30, 2015), nearly one in three (31%) sustained a TBI or SCI in the crash (TBI - 29% and SCI - 2%).^b These percentages are similar to those described in FY 2015 hospitalization data on page one.

TBI/SCI and demographic data were obtained from hospital discharge data.^c Helmet use, speeding, lane departure^d, and point-of-impact were obtained from crash data. Data on alcohol/drug intoxication were obtained from both data sources.^e Table 1 describes these characteristics in hospitalized MC operators who sustained a TBI/SCI in the crash and those who did not sustain a TBI/SCI in the crash.

Factors significantly associated with MC operators sustaining a TBI/SCI in a crash were intoxication, helmet use, and lane departure. Specifically, of hospitalized MC operators who sustained a TBI/SCI in the crash:

- 28% were identified as intoxicated on alcohol or drugs compared with 13% of MC operators who did not sustain TBI/SCI ($p < 0.001$).
- 16% were identified as not wearing a helmet compared with 11% of MC operators who did not sustain a TBI/SCI ($p = 0.04$).
- 40% were involved in a lane departure crash compared with 31% of MC operators who did not sustain a TBI/SCI ($p = 0.005$).

Speeding was identified more frequently in MC operators who sustained a TBI/SCI in the crash, but this association was not statistically significant ($p = 0.06$). Speeding may have been underestimated due to incomplete violation codes in crash data.

Consistent with fatal motorcycle crashes in MA,¹⁰ most MC operators in this study were male (96%). The small number of female MC operators prevent reliable statistical comparisons by sex. Counts and percentages of TBI/SCI by sex were not included in Table 1 due to confidentiality guidelines.

^b Not mutually exclusive. Six people sustained both a TBI and SCI.

^c ICD-9-CM codes in any field were used to identify TBI (800-801, 803-804, 850-854.19, 950(.1-.3) or 959.01) and SCI (806 or 952).

^d Lane departures by motorcyclist, including failure to keep in proper lane, wrong way riding, or crashed on shoulder or outside roadway.

^e See [Alcohol and Drug Involvement in Massachusetts Motor Vehicle Crashes](#) for indicators used to identify intoxication.

^f Denominator changes based on missing data.

^g Age was divided into two groups at the median age of 47.

^h Excludes 37 cases where race/ethnicity was missing. Small counts prevented us from analyzing the data by separate race/ethnicities.

ⁱ Excludes 110 cases where helmet use was missing.



Table 1. MC Operator and Crash-related Factors in Hospitalized MC Operators Who Sustained and did not Sustain a TBI/SCI in the Crash, 2012-2015 MA CRISS data (N = 1,053)

Factor	Sustained a TBI/SCI n (%) ^f	Did not sustain a TBI/SCI n (%) ^f
Total	324 (100%)	729 (100%)
Age (years) ^g		
Ages 46 and under	190 (59%)	415 (57%)
Ages 47 and older	134 (41%)	314 (43%)
Race/ethnicity ^h		
White, non-Hispanic	265 (85%)	583 (83%)
People of color	48 (15%)	120 (17%)
Alcohol/drug intoxication*		
Yes	90 (28%)	97 (13%)
Not documented	234 (72%)	632 (87%)
Helmet use ^{*i}		
Helmet worn	246 (84%)	577 (89%)
Helmet not worn	47 (16%)	73 (11%)
Speeding		
Yes	60 (19%)	102 (14%)
Not documented	264 (81%)	627 (86%)
Lane departure*		
Yes	129 (40%)	225 (31%)
Not documented	195 (60%)	504 (69%)
Point-of-impact ^j		
Lateral impact	122 (38%)	272 (38%)
Front/rear impact	195 (62%)	438 (62%)

* Significantly associated at $p < 0.05$ based on Chi-Square test.

MC Operator and Crash-related Factors Associated with Sustaining a TBI/SCI in a Crash

We calculated unadjusted odds ratios (ORs)^k to further understand factors that were significantly associated with sustaining a TBI/SCI in a crash. Figure 1 shows only the factors with ORs that were significantly associated with sustaining a TBI/SCI in a crash ($p < 0.05$). In this sample of hospitalized MC operators:

- MC operators identified as intoxicated on alcohol or drugs had 150% higher odds (OR = 2.51) of sustaining a TBI/SCI in the crash than MC operators who were not identified as intoxicated.
- MC operators identified as not wearing a helmet had 51% higher odds (OR = 1.51) of sustaining a TBI/SCI in the crash than those identified as wearing a helmet.
- Involvement in a lane departure crash increased the odds of sustaining a TBI/SCI in the crash by 48% (OR = 1.48), compared to MC operators not involved in a lane departure crash.

These findings are consistent with prior research that found that MC operators who had been drinking were at higher risk of sustaining a TBI in a crash.⁷ Alcohol intoxication in MC operators has also been associated higher in-hospital mortality compared to MC operators who were not intoxicated.¹¹ While most MC operators in the current study were not identified as intoxicated, it is concerning that nearly one in five (18%) were identified as intoxicated on alcohol/drugs at the time of the crash, given the strong association between intoxication and TBI/SCI.

Other studies have found that motorcyclists who were not wearing a helmet had twice the risk of sustaining a TBI compared to MC operators wearing a helmet.^{5,7,9} The risk of TBI/SCI associated with not wearing a helmet may be somewhat lower in this study due in part to the large number of cases missing helmet use data.

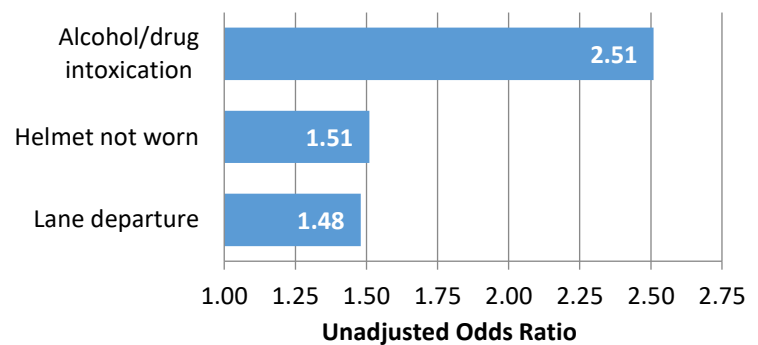
Our finding that lane departures increase the risk of TBI/SCI is consistent with prior studies that found collisions with fixed objects increased the risk of TBI and SCI in MC crashes,^{6,8} as fixed objects are usually outside of travel lanes.

Limitations: TBI cases may be underestimated, as milder TBI cases may not get diagnosed until after patients are discharged from the hospital. Intoxication rates may also be underestimated, as healthcare providers and police may not always test drivers for alcohol/drugs, or test results may not be documented in the hospital or crash record. Incomplete violation codes and missing data also limited our ability to identify intoxication, speeding, and helmet use. The low number of hospitalized MC operators who were female limited our ability to assess whether sex was associated with sustaining a TBI/SCI.

^k Unadjusted odds ratios do not take other potential contributing factors into account.



Figure 1. Odds Ratios for Factors Significantly Associated with Sustaining a TBI/SCI in a Crash, Hospitalized MC Operators, 2012-2015 MA CRISS data (N = 1,053)



Key Data Points

- In FY 2015, there were nearly 500 hospitalizations of MC operators in MA for crash-related injuries.
- In FY 2015, 30% of MC operators hospitalized in MA after a crash sustained a TBI/SCI in the crash.
- MC operators identified as intoxicated had 150% higher odds of sustaining a TBI/SCI in a crash than MC operators not identified as intoxicated.
- Not wearing a helmet and being in a lane departure crash each increased the odds of MC operators sustaining a TBI/SCI in a crash by about 50%.

Strategies to Prevent Traumatic Brain and Spinal Cord Injuries in Motorcycle Crashes

- Develop and implement motorcycle safety media campaigns targeting high-risk populations that will educate motorcyclists about the importance of rider safety, proper and consistent helmet use, and the dangers of speeding and alcohol- and substance-impaired riding.¹⁰
- Promote and raise awareness of the [Massachusetts Rider Education Program](#) (MREP), a program aimed to reduce the number of related fatalities and injuries in the Commonwealth through increasing the number of approved rider training courses for motorcyclists and increasing awareness and education of the risks of lack of helmet use, alcohol and drug intoxication, and speeding for both riders and other drivers.¹²
- Fund the MREP and its enhancements for the delivery of motorcycle training in urban and rural areas, and increase the number of certified motorcycle training instructors. In addition, support the expansion of other motorcycle rider education programs, including basic and advanced rider trainings, Deaf Riders Course, Rider Coach Training, and various refresher courses.¹²
- Conduct public information and education campaigns by attending motorcycle events, utilizing the motorcycle simulator, and using electronic message boards, public service announcements (PSAs), and other available resources to educate motorcyclists and other road users.¹²
- Partner with motorcycle education programs to implement Riders Helping Riders (RHR), an instructional program designed to encourage motorcyclists to intervene with their motorcyclist peers to prevent them from drinking and riding.¹³

Data Sources and References

Data Sources in the MA Crash-Related Injury Surveillance System used in these analyses:

- Inpatient Hospital Discharge data (Jan. 2012 – Sep. 2015), Center for Health Information and Analysis
- Crash Data System (Jan. 2012 – Sep. 2015), MA Registry of Motor Vehicles

¹ Chia-Ying Kuo, et al. Functioning and Disability Analysis of Patients with Traumatic Brain Injury and Spinal Cord Injury by Using the World Health Organization Disability Assessment Schedule 2.0. *Int J Environ Res Public Health*. 2015 Apr 14;12(4):4116-27.

² Kraus JF, et al. The effect of the 1992 California motorcycle helmet use law on motorcycle crash fatalities and injuries. *JAMA*. 1994; 272: 1506-1511.

³ MA Department of Public Health. *Registry of Vital Records and Statistics*.

⁴ Center for Health Information and Analysis. MA Inpatient Hospital Discharge data. Fiscal year Oct. 1, 2014 – Sep. 31, 2015.

⁵ Iowa Codes Fact Sheet: Traumatic brain injuries caused by motor vehicle crashes 2001-2003. 2007.

⁶ Dischinger PC, et al. Injury patterns and severity among hospitalized motorcyclists: A comparison of younger and older riders. *Annu Proc Assoc Adv Automot Med*. 2006;50:237-249.

⁷ Peek-Asa C, et al. Estimates of injury impairment after acute traumatic injury in motorcycle crashes before and after passage of a mandatory helmet use law. *Ann Emerg Med*. 1997;29:630-636.

⁸ Zulkipli ZH, et al. Motorcycle-related spinal injury: crash characteristics, *Accid Anal Prev*. 2012;49:237-44.

⁹ Khor D, et al. The impact of helmet use on outcomes after a motorcycle crash, *Injury*. 2017;48:1093-7.

¹⁰ Federal Fiscal Year 2021 MA Highway Safety Plan: <https://www.mass.gov/doc/ffy-2021-massachusetts-highway-safety-plan/download>

¹¹ Ahmed N, et al. Elevated blood alcohol impacts hospital mortality following motorcycle injury: A National Trauma Data Bank analyses. *Injury*. 2020;51(1):91-96.

¹² 2018 MA Strategic Highway Safety Plan: <https://www.mass.gov/doc/massachusetts-shsp-2018/download>

¹³ National Highway Transportation Safety Administration. [Volume I: Riders Helping Riders Evaluation](#) (DOT HS 811 023), 2018.

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