U.S. Department of Transportation
National Highway Traffic Safety Administration

TRAFFIC SAFETY FACTS
Research Note

NHTSA
www.nhtsa.gov

DOT HS 811 509

August 2011

Youth Motorcycle-Related Traumatic Brain Injury and State Helmet Laws, 2005–2007

Harold Weiss, PhD, MPH, MS,[a] Yll Agimi, MPH,[b] Claudia Steiner, MD, MPH,[c] Maria Vegega, PhD[d]

Introduction

Motorcyclists are 25 times more likely than passenger car occupants to die in motor vehicle traffic crashes and five times more likely to be injured per vehicle mile traveled (VMT) (National Highway Traffic Safety Administration, 2011). They are 58 times more likely to be killed than passenger vehicle occupants on a per trip basis (Beck, Dellinger, & O'Neil, 2007).

Motorcycle (MC) deaths and injuries rose between 1997 and 2008, before declining in 2009. Factors associated with the growth in fatalities and injuries include increased use of motorcycles for recreation, more powerful motorcycles, older riders, and the desire for fuel-efficient travel. An additional factor is the repeals of universal (all-age) helmet laws (Coben, Steiner, & Miller, 2007).

A similar trend is observed among young riders ages 12 to 20. Their death rate was 0.52 per 100,000 population in 1999 and increased to 0.99 per 100,000 population in 2007, the last year of available data, representing an 90% increase (Centers for Disease Control and Prevention—WISQARS (Web-based Injury Statistics Query and Reporting System)). The nonfatal (emergency department visits) motorcycle traffic-related injury rate (per 100,000 people) for youth 12 to 20 also increased from 63.9 in 2001 to 78.1 in 2007, a 22% increase (Centers for Disease Control and Prevention—WISQARS). In a recent review of trends in hospitalized traumatic brain injury (TBI), a significant increase in teenage male TBI hospitalization rates from 1998 to 2005 was reported for motorcycle crashes, one of but a few TBI causes showing increases (Bowman, Bird, Aitken, & Tilford, 2008). Youth are especially at risk for motorcycle injury due to increased risk-taking behavior and a lack of experience as new riders (Mullin, Jackson, Langley, & Norton, 2000; Zambon & Hasselberg, 2006).

Fundamental to reducing motorcycle head injury among MC riders is the use of proper safety helmets. In a recent Cochrane meta-analysis of 61 different observational studies, Liu et al. concluded that motorcycle helmets reduce head injury death by 42% and head injury by 69% (Liu et al., 2008). Despite demonstrated efficacy, 30 States abandoned universal helmet laws following withdrawal of Federal sanctions. In 1975, following eight years of sanctions, all but three States had universal helmet laws (Insurance Institute for Highway Safety, 2008). However in 1976, congressional action eliminated the withholding of highway-safety appropriations from States that did not require helmets among motorcyclists 18 and older. Federal helmet laws incentives were reintroduced in the early 1990s only to be reversed again by Congress in 1995. As of 2007, 20 States and the District of Columbia (51% of the U.S. population) had universal helmet laws (Insurance Institute for Highway Safety, 2008). Three States (6% of the population) had no helmet laws[1]. Twenty-seven of the remaining States (43% of the population) retained age-specific laws (Table 1).

[a] Center for Injury Research and Control and Graduate School of Public Health, University of Pittsburgh, Pittsburg, Pennsylvania

[b] Association of Schools of Public Health, Washington, DC

[c] Center for Delivery, Organization and Markets, Agency for Healthcare Research and Quality, Rockville, Maryland

[d] Office of Behavioral Safety Research, National Highway Traffic Safety Administration, Washington, DC

[1] Colorado introduced a helmet law in 2007, to cover riders under the age of 18, leaving only 3 States with no helmet laws of any kind.

Table 1
Helmet-Law Types and Percentage of Population in the AHRQ HCUP SIDs: United States, 2007

Helmet Law Type In 2007*	# of States (& DC) 2007	% of 2007 U.S. Population	% of 2007 Youth Population (Age 12-20)	HCUP SID 2005 # States	HCUP SID 2006 # States**	HCUP SID 2007 # States
I. Universal law (all age) (CA, DC, GA, LA, MD, MA, MI, MS, MO, NE, NV, NJ, NY, NC, OR, TN, VT, VA, WA, WV)	21	51.2 %	50.5 %	16	17.	15
II. <21 law (AR, FL, PA, RI, SC, TX, KY)	7	22.3 %	21.6 %	5	6	4
III. <19 law (DE)	1	0.3 %	0.3 %	0	0	0
IV. <18 law (CO, CT, HI, ID, IN, KS, MN, MT, NM, ND, OH, OK, SD, UT, WI, WY, AK, AZ)	18	20.1 %	20.1 %	11	11	12
V. <15 law (ME)	1	0.4 %	0.4 %	0	1	1
VI. No law (CO, IA, IL, NH)	3	5.7 %	7.1 %	4	4	3
TOTAL	**51**	**100.0%**		**36**	**39**	**35**

Source: Helmet law source: Insurance Institute for Highway Safety, at www.iihs.org/laws/HelmetUseCurrent.aspx
HCUP: Healthcare Cost and Utilization Project
SID: State Inpatient Database

* In 2007 Colorado changed from a no-helmet-law State to a <18 State. It was the only State whose helmet law status changed during the study period. Maine changed to a <18 law from a <15 law in mid-2009. The Missouri Governor vetoed a bill In July 2009 that would have changed it to a <21 State.

** States included in the SID are Arizona, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Vermont, Washington, West Virginia, Wisconsin, and Wyoming.

There is increasing evidence that partial age-specific youth helmet laws do not work well. In North Dakota (1977-1980), a "substantial decline" in helmet use by those 17 and younger was noted after passage of a partial age law (Heilman, Weisbuch, Blair, & Graf, 1982). In Texas (1991), only 29% of injured riders under age 18 were found to be helmeted under its partial age helmet law (U.S. General Accounting Office, 1991). In Florida (2000) downgrading to an age-specific law was associated with a 26% decline in helmet usage among young riders killed and a two-fold increase in young rider fatalities (Ulmer & Shabanova-Northrup, 2005).

In a 2006 study, the Insurance Institute for Highway Safety reported that in States with weak helmet laws helmets were worn by less than 40% of fatally injured minors (Insurance Institute for Highway Safety, 2008). In a national study from 1975 to 2004, Houston reported that universal helmet laws were correlated with a substantial reduction in motorcyclist fatalities and that partial coverage laws did not show a reduction in fatality rates compared to universal law States (Houston, 2007). Another multistate study addressing this issue was conducted by Coben et al. using AHRQ's 2001 Healthcare Cost and Utilization Project (HCUP) hospital discharge data from 33 States (Coben et al., 2007). It was the first study covering hospital discharges from multiple States to report that "partial requirement laws may not be protective of young riders." However, this study had the broader aim to address all age morbidity impacts of helmet requirements and did not focus on youth.

The goals of our study were to fill these gaps using additional States covering a larger population, and more recent (2005-7) AHRQ HCUP data. We examined the null hypothesis that if age-specific helmet laws are as effective as universal laws, there should be no difference in the proportion of motorcycle-related TBI versus other motorcycle injury in States with age-specific laws versus States with universal helmet laws. A shorter version of this study has been published in the December 2010 issue of the journal *Pediatrics* volume 126(6) pages 1149-55.

Methods

Retrospective data were obtained from the 2005-2007 State Inpatient Database (SID)(Agency for Healthcare Research and Quality, 2008) developed as part of HCUP. There were 36, 39 and 35 States contributing to the SID

in 2005-2007, respectively, which include almost 90% of all U.S. community hospital discharges.[2] The SID contains both patient demographics and clinical data and hospital level data. Details on how the SID data are collected can be found on the AHRQ Website (Agency for Healthcare Research and Quality, 2008). The University of Pittsburgh Institutional Review Board categorized this as an exempt study. Analyses were performed using the software Stata 10.0 (from StataCorp LP, College Station, TX) and SAS 9.1 (from SAS Institute Inc., Cary, North Carolina).

Cases were selected from 99.3 million discharges across the three years; first for youth ages 12 to 20 (n=4,526,446, 4.6%), and then to those with an injury (excluding medical misadventures) defined by acute injury E-codes in any of the E-code fields (n=328,196, 7.3%). In contrast to studies examining youth in customary 5-year age groups, we used this 9-year range because many State motorcycle helmet laws require youth age ≤20 to wear helmets even when people ≥21 are exempt. The lower age bound was chosen because of the sharp drop in incidence among cases <12. Ages were grouped using three equal age groups (12 to 14, 15 to 17, and 18 to 20). Motorcycle injuries were selected on the basis of International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) E-code matrix groupings (E810-E819, traffic) with a fourth digit of .2 (motorcyclist) or .3 (passenger) in any of the four E-code array fields. Analyses were conducted on the combined group of riders and passengers (passengers made up approximately 7%).

Although predominantly made up of street-registered motorcycles, selected E-codes may include motorized bicycles (mopeds), scooters, and mini-bikes. "Traffic" crashes are those that occurred on public highways. Non-traffic cases, which make up about one-third of the motorcycle injury hospital discharges, were excluded since helmet laws often differ according to whether vehicles are used on or off-road (American Motorcyclist Association). Thirteen cases with ambiguous traffic status were set to missing traffic status.

Traumatic brain injury (TBI) was defined on the basis of a TBI-related diagnoses in any of the first 10 diagnosis fields in accordance with ICD codes specified by the CDC TBI surveillance case definition (Butler & A., 2001). This definition includes ICD-9-CM diagnosis codes 800.0-801.9, 803.0-804.9, and 850.0-854.1. The code 959.01 (head injury unspecified) was also included. TBI codes that included late effects and complications (905.0 and 907.0) were excluded. TBI cases meeting the CDC case definition were grouped into three different types according to the Barell body-region by nature-of-injury diagnosis matrix and injury severity (National Center for Health Statistics). Intracranial injury was defined using AHRQ's Clinical Classification Software. In order to avoid duplicate counts because of hospital transfers, 265 patients who were discharged to another short-term care facility were excluded, consistent with the approach of other population-based hospitalization studies (Bowman et al., 2008).

Estimates for TBI-related long-term disability were computed from regression coefficients provided by Selassie et al (Selassie et al., 2008). Their model defined disability as "having one or more of: (a) functional limitation in at least 1 of the ADLs (activities of daily living); (b) significant post-injury symptoms that limited activities (c) significant cognitive complaints; or (d) significant problems in mental health" (Selassie et al., 2008). Injury severity was calculated utilizing the algorithms of the Injury Categorization (ICDPIC) Program which translates ICD diagnosis codes into Abbreviated Injury Scores (AIS) and Injury Severity Scores (ISS) (Clark, Hahn, & Osler, 2008).

Under the assumption that the proportion of motorcycle related head injuries is inversely related to helmet use by motorcyclists, we compared the proportion of young motorcyclists with head injuries in States with different helmet laws. This assumption is reasonable since helmet use has been shown to reduce head injuries (Liu et al., 2008).

Non-head injury serves as a proxy measure of exposure to head injury risk. When focused on severe injury (which require hospitalization), this proxy has been shown to be a reasonable alternative measure of exposure; other exposure indices, such as hours of riding or miles traveled, were not available (Scuffham, Alsop, Cryer, & Langley, 2000). This approach has been previously used in evaluating the effectiveness of bicycle and motorcycle helmet laws (Hagel, Macpherson, Rivara, & Pless, 2006; Macpherson et al., 2002; Mertz & Weiss, 2008; Robinson, 2006; Scuffham et al., 2000).

Most comparisons were limited to the three major helmet law types: (a) universal (all age), (b) under 21, and

[2] This percentage dropped in 2007 as data from Connecticut, Texas, Massachusetts, and New Hampshire were not available at the time of the study.

(c) under 18. Only one small State used the <15 partial helmet law, making it unsuitable for separate analysis, therefore it was excluded from analyses. Another State with <19 partial helmet law was not part of the HCUP dataset. Relative risks and 95% confidence intervals for proportional differences were calculated.

Results

There were 9,287 motorcycle traffic-related hospital discharges among 12- to 20-year-olds (representing 2.8% of all injuries in this age group) over the 3-year period. The age distribution was: 12-14 y/o = 1,134 (12%), 15-17 y/o = 2,400 (26%) and 18-20 y/o = 5,753 (62%). The number of discharges observed within each of the law types was: Universal = 4,602 (50%); <21 years = 1,916 (21%); <18 years = 2,313 (25%). Analyses excluded cases from <15 helmet law States, N = 32 (0.3%) and no helmet law States, N = 424 (4.6%). Mean ages and percentage male were similar across all three major law types (Table 2). Mean length of stay was greater for discharges in the <21 group but no different in the <18 group, when compared to the universal law States.

Significant increases in the proportion of discharges transferred to another facility and in-hospital deaths for all youth 12 to 20 were found between each of the two major partial law States compared to universal law States (Table 2). The proportion of cases with the first listed diagnosis (principal diagnosis) of intracranial injury also varied significantly by partial law type. In States with universal helmet laws, 16.2% of discharges had a principal diagnosis of intracranial injury compared to 18.0% and 20.0% for <21 partial law States and <18 partial law States, respectively (chi-square, p <.05 for both categories, compared to universal-law states).

Table 3 shows the relative risk of TBI severity as determined by the Barell matrix, comparing partial helmet laws States to universal helmet law States. Significant increased risks are demonstrated for serious/severe TBI in both partial law helmet States compared to universal helmet law States. The relative risk was smaller and of borderline statistical significance for <18 law when restricted to ages 12-17 (P=.072). The probability of long-term disability among cases with a TBI was 25% [95% CI = 23%-26%] in universal law States, 30% [95% CI = 27%-33%] in under 21 law States and 27% [95% CI = 25%-30%] in under 18 law States (not shown). There were no significant differences observed for cervical or thoracic spinal cord injury between the two major partial law types and universal law States.

Table 2
Characteristics of Youth Hospital Discharges Resulting From Motorcycle Injury According to State Law Type: USAHRQ, HCUP, SIDs, 2005–2007

	Universal Helmet Law States (n=16) (age 12-20)	Under 18 Helmet Law States (n=16) (age 12-20)	Under 21 Helmet Law States (n=4) (age 12-20)
Number of cases in group	**4,602**	**2,313**	**1,916**
TBI (%)	30.9	37.8	32.1
Principal diagnosis of intracranial injury (%)**	16.2	20.2	18.0
Age (mean)	17.6	17.6	17.7
Age (%)			
12	2.3	3.0	3.1
13	4.2	4.5	3.6
14	5.3	5.7	6.0
15	7.5	7.3	6.4
16	9.0	8.4	7.6
17	11.6	9.3	8.6
18	15.0	17.6	15.9
19	20.4	21.7	23.0
20	24.7	22.7	25.9
Males (%)**	89.5	87.3	88.2
Length of stay (days)			
Mean	5.1	5.1	6.3
Median	3.0	3.0	3.0
Disposition (%)*			
Routine	83.9	82.4	80.1
Transfer to other facility	6.4	**8.2	8.6
Home health care	7.3	6.5	8.2
Left against advice	0.7	0.3	0.8
Died	1.6	2.6	2.4
Payer (%)*			
Medicaid	20.4	16.5	16.7
Private	61.2	63.0	55.8
Self-pay	11.6	12.9	17.2
No charge	0.3	0.5	4.0
Other	6.5	7.0	6.2

* X^2,p<.0001
** X^2,p<.05

The age group specific pattern for three measures of TBI is compared for States with universal helmet laws to all States with partial helmet laws in Figures 1 through 3. Although each of the partial law States demonstrates higher risks of TBI across the combined age groups (Table 3), when the age groups are analyzed separately significant differences are observed in the (larger) 18-to-20 year age group alone. In Figure 1, a significantly higher percentage of TBIs occur in partial law States as compared to universal law States in the 18-to-20 year age group. This is not observed in the 12-to-17 year age

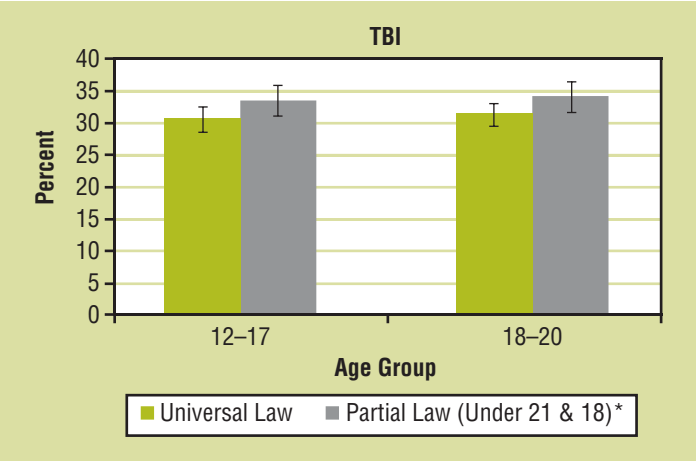
Table 3
RRs of Youth TBI Injury, Using Barell Matrix, Comparing Partial-Law and Universal-Law States: USAHRQ, HCUP, SIDs, 2005–2007

Law Type	Type 1 (Serious/Severe)	Types 2 and 3 (Moderate/Mild)
Universal law (referent), n (%)	476 (10.3)	326 (7.1)
All partial law for ages 12-20, n (%)	600 (14.2)	281 (6.6)
RR (95% CI)	1.37 (1.23-1.54)[a]	0.94 (0.80-1.10)
<18 law for ages 12-20, n (%)	382 (13.7)	176 (6.3)
RR (95% CI)	1.32 (1.16-1.50)[a]	1.08 (0.91-1.30)
<21 law for ages 12-20, n (%)	273 (14.3)	103 (5.4)
RR (95% CI)	1.38 (1.20-1.58)[a]	0.76 (0.61-0.94)
<18 law for only ages 12-17, n (%)	109 (12.4)	73 (8.3)
RR (95% CI)	1.20 (0.98-1.45)[b]	1.17 (0.92-1.49)

[a] p<.001
[b] p=.072

group. Similarly, in Figure 2, mean AIS scores for the head region are significantly higher in the States with partial helmet laws in the 18-to-20 year age group.

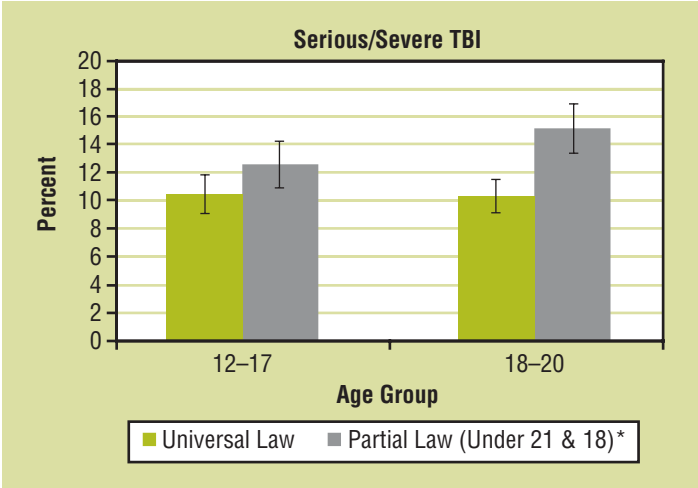
Figure 1
Percent TBI by Age Group & Helmet Law Type for Motorcycle-Related Hospitalizations



*excludes age 18-to-20 observations from <18 helmet law States

Finally, the percentage of severe/serious TBIs are significantly higher in the partial helmet law States compared to universal law States in the 18-to-20 age group. There is less difference between the discharges in States with universal helmet laws compared to States with partial helmet laws in the <18 population.

Figure 2
Percent Serious/Severe TBI by Age and Helmet Law Type for Motorcycle-Related Hospital Discharges; HCUP SID, 2005-2007



*excludes age 18-to-20 observations from <18 helmet law States

Discussion

This study showed a 37% increased risk of hospitalized serious/severe TBI for youth motorcycle riders in States with limited age helmet laws compared to youth in States with universal helmet laws. The largest impacts are observed for the most severe type of head injury in the largest group of injured young motorcycle riders, ages 18-20. There was also a significantly increased probability of long-term TBI-related disability and in-hospital death following a motorcycle crash for youth in States with limited age helmet laws. Helmet usage rates for youth drop substantially when universal helmet laws are repealed, even in States where youth riders are theoretically covered by partial age-specific laws (Coben et al., 2007; Houston, 2007; Kyrychenko & McCartt, 2006). This has been shown to affect youth motorcycle fatality rates and overall morbidity. This study extends established findings to hospitalized patients with traumatic brain injury.

The lower helmet use in States with limited age laws is likely related to the difficulty law enforcement officers' experience in gauging a rider's age during a potential traffic stop and enforcing a helmet law on a relatively small segment of the motorcycle riding population. Less rigorous enforcement may also result from perceived lack of priority once older age groups have been exempted from helmet-use compliance. From a behavioral perspective, these findings are consistent with "deterrent" theory which assumes that in States with the narrowest coverage of motorcycle helmet law,

enforcement is the weakest. Youth are less likely to use a helmet if they perceive a low likelihood of enforcement in a State with limited age laws than in States where enforcement is high and punishment is likely (Ross, 1982).

This was an ecologic study. No data on patient helmet use were available from hospital discharge data nor was age-specific observational data available. Exposure-based risk comparisons (e.g., ownership levels, registration rates, licensing, number of trips, or miles traveled) were not considered. This study was also limited because it did not include children who died before their hospitalization or were not admitted to the hospitals and thus may have underestimated the impact of helmet use if out-of-hospital deaths were higher in non-helmet States.

As in all observational studies, there is a risk for confounding that could influence the frequency of observed TBI beyond the helmet law differences (Hingson, Howland, Koepsell, & Cummings, 2001). Confounding is minimized though, in several ways. First, by studying a population-based intervention (helmet laws) and by selecting many large groups (States) for analysis and using all the States available for study, confounding is reduced.

Second, since the selection of cases is a census from States that includes most of the population (90%) of the United States, the results are nationally representative.

Third, the nature of the diagnosis and treatment of severe head injury means that almost all cases will be hospitalized in the States under study and thus captured with little State bias. While different States may have different out-of-hospital survival rates of TBI because of variation in EMS and trauma system development and thus bias introduced as to who survives to be admitted and captured by the database, fatal cases are a small part of our analyses and such variation should have little to do with the status of the State law and thus fairly randomly distributed across the States and groups under study.

Fourth, we avoid differences in confounding over time by using the same time period of analysis for all groups.

Fifth, all States but one had instituted their helmet law type under study several years before data was collected assuring proper classification of both the social and legal climate.

Sixth, different age-related demographic characteristics are minimized by selecting a narrow age range for study.

Finally, while demographic variables such as income, gender, and ethnicity and environmental variables such as speed, weather, and daylight hours may be factors in riding frequency and crash risk, they are not known to impact the distribution of serious injury types after a crash. In other words, the biomechanical forces that influence the likelihood of a TBI, relative to other injuries, are not likely to be affected by such differences among serious (hospitalized) injuries. Nevertheless, the proportional morbidity approach underlying this study, while appropriate for looking at State level policy interventions, has its limitations. A regression model with a variety of State-specific panel data taking into account individual State differences (i.e., motorcycle registration and crash rates, drinking age, speed limits, climate variables, alcohol consumption, quality of medical care, income, and population density, among others) would compliment this study.

Conclusions and Recommendations

This study quantifies for serious/severe TBI that which the National Transportation Safety Board has declared from fatality data, namely that "the most vulnerable and least risk-averse segments of the motorcyclist population are more likely to be unprotected in the absence of universal laws" (National Transportation Safety Board, 2007). In States with a <21 law, serious TBI among youth was 38% higher than in universal law States. Motorcycle riders ages 12 to 17 in <18 helmet law States had a higher proportion of serious/severe TBI and higher average AIS scores for head region injuries than same-age riders from universal helmet law States.

Effective prevention efforts to reduce the risk of both crashes and injury among youth, as in adult riders, are needed. Traumatic brain injuries are of particular concern because of their long-term impacts and high mortality risk. Although the youth helmet mandates were purportedly passed to maintain head protection for young riders, age-specific helmet laws increase the risk of death and serious head injury compared to universal laws. The only method shown to keep MC helmet use high among youth is to adopt or maintain universal laws.

Acknowledgements

This work was performed under NHTSA cooperative agreement with the National Highway Traffic Safety Administration (DTNH22-04-H-05087). We acknowledge assistance from Dr Eduard Zaloshnja (Pacific Institute for Research and Evaluation) and Dr. Anbesaw Selassie (Medical University of South Carolina) for calculating long-term TBI disability. We also thank Dr. David Clark for developing and sharing the ICD Programs for Injury Categorization software used for assigning injury severity. We also thank Dr. Coben and his colleagues for demonstrating in their earlier work the usefulness of the approach of using the SID to compare TBI and non-TBI diagnoses according to the type and coverage of motorcycle-helmet legislation. We also acknowledge the key role of the State data organizations, the HCUP participation of which made this study possible. These State data organizations are listed in a separate NHTSA Research Note.

References

Agency for Healthcare Research and Quality. (2008). Overview of the State Inpatient Databases (SID). 2009, from http://www.hcup-us.ahrq.gov/sidoverview.jsp

American Motorcyclist Association. State motorcycle laws. 2009, from http://www.amadirectlink.com/legisltn/laws.asp

Beck, L. F., Dellinger, A. M., & O'Neil, M. E. (2007). Motor vehicle crash injury rates by mode of travel, United States: using exposure-based methods to quantify differences. *Am J Epidemiol, 166*(2), 212-218.

Bowman, S. M., Bird, T. M., Aitken, M. E., & Tilford, J. M. (2008). Trends in hospitalizations associated with pediatric traumatic brain injuries. *Pediatrics, 122*(5), 988-993.

Butler, J. A., & A., L. J. (2001). *Central Nervous System Injury Surveillance: Annual Data Submission Standards—2000*. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control.

Centers for Disease Control and Prevention—WISQARS (Web-based Injury Statistics Query and Reporting System). 2009, from http://webappa.cdc.gov/sasweb/ncipc/mortrate10_sy.html

Clark, D. E., Hahn, D. R., & Osler, T. M. (2008). *Programs for injury categorization and scoring based on International Classification of Diseases (ICD) diagnosis codes*. Paper presented at the 8th World Conference on Injury Prevention and Safety Promotion.

Coben, J. H., Steiner, C. A., & Miller, T. R. (2007). Characteristics of motorcycle-related hospitalizations: comparing states with different helmet laws. *Accid Anal Prev, 39*(1), 190-196.

Hagel, B., Macpherson, A., Rivara, F. P., & Pless, B. (2006). Arguments against helmet legislation are flawed. *BMJ, 332*(7543), 725-726.

Heilman, D. R., Weisbuch, J. B., Blair, R. W., & Graf, L. L. (1982). Motorcycle-related trauma and helmet usage in North Dakota. *Ann Emerg Med, 11*(12), 659-664.

Hingson, R., Howland, J., Koepsell, T., & Cummings, P. (2001). *Ecologic Studies*. Paper presented at the Injury control; A guide to research and program evaluation.

Houston, D. J. (2007). Are helmet laws protecting young motorcyclists? *Journal of Safety Research, 38*(3), 329-336.

Insurance Institute for Highway Safety. (2008). Current U.S. motorcycle and bicycle helmet laws. Retrieved August 21, 2008, from http://www.iihs.org/research/qanda/helmet_use.html#cite27

Kyrychenko, S. Y., & McCartt, A. T. (2006). Florida's weakened motorcycle helmet law: effects on death rates in motorcycle crashes. *Traffic Inj Prev, 7*(1), 55-60.

Liu, B. C., Ivers, R., Norton, R., Boufous, S., Blows, S., & Lo, S. K. (2008). Helmets for preventing injury in motorcycle riders. *Cochrane Database Syst Rev*(1), CD004333.

Macpherson, A. K., To, T. M., Macarthur, C., Chipman, M. L., Wright, J. G., & Parkin, P. C. (2002). Impact of mandatory helmet legislation on bicycle-related head injuries in children: a population-based study. *Pediatrics, 110*(5), e60.

Mertz, K. J., & Weiss, H. B. (2008). Changes in motorcycle-related head injury deaths, hospitalizations, and hospital charges following repeal of Pennsylvania's mandatory motorcycle helmet law. *Am J Public Health*.

Mullin, B., Jackson, R., Langley, J., & Norton, R. (2000). Increasing age and experience: are both protective against motorcycle injury? A case-control study. *Inj Prev, 6*(1), 32-35.

National Center for Health Statistics. (November 20, 2008). The Barell Injury Diagnosis Matrix: A Framework for classifying injuries by body region and nature of the injury. Retrieved November

24, 2008, from http://www.cdc.gov/nchs/about/otheract/Ice/barellmatrix.htm

National Highway Traffic Safety Administration. (2011). Fatality Analysis Reporting System (FARS).

National Transportation Safety Board. (2007). *Safety Recommendation*. Retrieved. from http://www.ntsb.gov/recs/letters/2007/h07_38.pdf.

Robinson, D. L. (2006). No clear evidence from countries that have enforced the wearing of helmets. *BMJ, 332*(7543), 722-725.

Ross, H. L. (1982). *Deterring the drinking driver: Legal policy and social control*. Lexington, MA: Lexington Books.

Scuffham, P., Alsop, J., Cryer, C., & Langley, J. D. (2000). Head injuries to bicyclists and the New Zealand bicycle helmet law. *Accid Anal Prev, 32*(4), 565-573.

Selassie, A. W., Zaloshnja, E., Langlois, J. A., Miller, T., Jones, P., & Steiner, C. (2008). Incidence of long-term disability following traumatic brain injury hospitalization, United States, 2003. *Journal of Head Trauma Rehabilitation, 23*(2), 123-131.

U.S. General Accounting Office. (1991). *Highway Safety: Motorcycle Helmet Laws Save Lives and Reduce Costs to Society*. Washington, DC: U.S. General Accounting Office.

Ulmer, R. G., & Shabanova-Northrup, V. S. (2005). *Evaluation of the repeal of the all-rider motorcycle helmet law in Florida*. Washington, DC: National Highway Traffic Safety Administration; Report No. DOT HS 809 849.

Zambon, F., & Hasselberg, M. (2006). Socioeconomic differences and motorcycle injuries: age at risk and injury severity among young drivers. A Swedish nationwide cohort study. *Accid Anal Prev, 38*(6), 1183-1189.

U.S. Department of Transportation

National Highway Traffic Safety Administration

This research note and other general information on highway traffic safety may be accessed by Internet users at: www-nrd.nhtsa.dot.gov/CATS/index.aspx