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Characteristics of motorcycle-related hospitalizations: Comparing states with different helmet laws

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Abstract

This study compares U.S. motorcycle-related hospitalizations across states with differing helmet laws. Cross-sectional analyses of hospital discharge data from 33 states participating in the Healthcare Cost and Utilization Project in 2001 were conducted. Results revealed that motorcyclists hospitalized from states without universal helmet laws are more likely to die during the hospitalization, sustain severe traumatic brain injury, be discharged to long-term care facilities, and lack private health insurance. This study further illustrates and substantiates the increased burden of hospitalization and long-term care seen in states that lack universal motorcycle helmet use laws.

Keywords: Motorcycles; Injuries; Hospitalizations; Helmets

1. Introduction

Motorcycle-related trauma is an increasing public health problem in the United States. According to the National Center for Statistics and Analysis (NCSA) of the National Highway Traffic Safety Administration (NHTSA), motorcycle-related fatalities have increased each year from 1997 to 2004, with a total increase of 89% over this time frame (NHTSA, 2004a). In 2004, the most recent year with complete data, there was a total of 4008 motorcyclist fatalities (NHTSA, 2004b). While motorcycles account for about 2% of all registered vehicles and 0.3% of all vehicle miles traveled, nearly 9% of total U.S. traffic fatalities are attributed to motorcycle riding (NHTSA, 2003). Since 1997, the number of motorcycle registrations has also been increasing. However, the increasing rate of fatalities has exceeded the increasing rate of registrations. In 2002, the fatality rate per 100,000 registered motorcycles was 65.35, an 18% increase from the 55.30 rate reported in 1997. Similarly, the 2002 fatality rate per 100 million vehicle miles traveled was 34.23, a 63% increase from the 20.99 rate reported in 1997 (NHTSA, 2004a).

Several factors are associated with the recent increase in motorcyclist fatalities. The mean age of motorcyclists killed has increased consistently since 1994 and there has been a greater than 200% increase in the number of rider deaths among those over age 40 years. Over the last 10 years, larger motorcycles are figuring more prominently in fatal crashes, with the mean engine size increasing from 820 cm^3 in 1993 to 999 cm^3 in 2002 (NHTSA, 2003). More fatalities now occur on rural than urban roads, reversing a trend that existed from 1990 through 1997 (NHTSA, 2004c). Although the percentage of motorcycle operator alcohol involvement in fatal crashes continues to be higher than any other type of motor vehicle driver, the overall proportion of alcohol involvement in fatal motorcycle crashes declined from 1983 to 2003 (Paulozzi and Patel, 2004).

Over the last 10 years there have also been important changes in laws governing the use of motorcycle helmets and in the observed use of motorcycle helmets. In the fall of 1995, Congressional action changed a provision of the Intermodal Surface Transportation Efficiency Act (ISTEA) that dealt with motorcycle helmet use. Following this action, several states modified or repealed their *universal helmet laws*, which had required helmet usage for all riders. In 1997, helmet laws in Texas and Arkansas were changed from universal coverage to *partial use laws*, which

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only apply to a portion of the population, usually riders under a certain age. Similar changes were implemented in Kentucky in 1998, Louisiana in 1999, Florida in 2000, and Pennsylvania in 2003 (Insurance Institute for Highway Safety, 2006a). During this time, observational surveys demonstrated a significant decline in helmet use among motorcycle riders with national helmet use rates falling from 71% in 2000 to 58% in 2002 (NHTSA, 2003). Changes in helmet laws are likely a significant factor contributing to the nationwide increase in death rates, as helmets are estimated to be 37% effective in preventing fatal injuries and helmet usage declines significantly when states move from universal laws to partial use laws (NHTSA, 2003; Insurance Institute for Highway Safety, 2006a). In Florida, repeal of the universal helmet law was associated with an 81% increase in motorcyclist fatalities and an 82% increase in hospital admissions for head injuries (Ulmer and Northrup, 2005).

Prior research has demonstrated that, after controlling for environmental factors, universal helmet laws are associated with lower motorcyclist fatality rates (Morris, 2006). Much less information is available on nonfatal motorcycle-related injuries and the potential influence of state helmet laws. The NHTSA estimated a total of 76,000 nonfatal motorcycle-related injuries in 2004, based upon Police Accident Reports (NHTSA, 2004b). An estimated 30,505 hospital admissions were related to motorcycle injuries in 2001 and the total estimated hospital charges associated with these hospitalizations were more than US$ 841 million (Coben et al., 2004). Among these hospitalizations, the most common principal diagnoses were fractures of the lower limb (29.4%), fractures of the upper limb (13.1%), and intracranial injuries (12.3%) (Coben et al., 2004). Based upon differences in observed helmet use, the characteristics of motorcycle-related hospitalizations are likely to differ according to the type of helmet legislation in place. The primary objective of this study was to compare motorcycle-related hospitalizations across states with differing helmet laws. Specifically, we sought to determine and compare the injury patterns, hospitalization costs, and outcomes associated with these cases.

2. Methods

Data were obtained from the Healthcare Cost and Utilization Project (HCUP), maintained by the Agency for Healthcare Research and Quality (AHRQ). The data in HCUP are derived from hospital discharge summaries and abstracts, created by hospitals primarily for billing and payment purposes. The hospital discharge summary contains demographic information, the patient's conditions, the procedures the patient received, and other features about the hospital stay. Hospitals in many states provide all discharge summaries from all community hospitals to a state-funded data organization, a hospital association, or other private data organization either voluntarily or under mandate.

HCUP is built through a partnership between the state data organizations and AHRQ. Since 1988 the number of states contributing to HCUP has grown (AHRQ, 2004). The state data organizations provide their unique statewide database to HCUP. The data are then subjected to internal consistency and edit checks. Data elements that are similar across the states are recoded into a uniform coding scheme and data elements unique to individual states are retained if they are useful for research purposes. These uniformly formatted datasets are the core of the HCUP databases (Steiner et al., 2002). HCUP data have been used extensively for health services research and have been demonstrated to provide valid estimates of injury-related hospitalizations (AHRQ, 2006a; Coben and Steiner, 2003; Shulman et al., 2003).

In 2001, 33 states provided data to HCUP. The HCUP State Inpatient Database (SID) contains the universe of each participating states' community hospital inpatient discharge records. The 33 states contributing data to the SID captured approximately 80% of all hospital discharges in the United States. We chose 2001 because it was the most recent year with complete data at the time of the study.

Hospitalizations associated with motorcycle-related injuries were identified by searching all secondary diagnosis fields for cases that contained external cause of injury codes E810 through E825. To avoid duplicate counting of possible inter-facility transfers, cases with the source of admission identified as "another hospital" or "other health facility" were excluded from the analysis. For each identified case, the following additional variables were extracted: age, sex, principal diagnosis, secondary diagnoses, principal procedures, number of procedures, length of stay (LOS), in-hospital death, disposition of patient, expected primary payer, hospital charges, hospital region, and location/teaching status of hospital.

Injuries were classified using standard ICD-9-CM codes. Clinical diagnoses and procedures were grouped using Clinical

Table 1
Hospitalized motorcycle injury cases according to state helmet legislation

Helmet legislation	Total cases	Percent of in-hospital deaths	Percent disposition to short-term facilities	Percent disposition to long-term facilities	Percent with principal diagnosis of intracranial injury	Percent of admissions < age 21 years
Universal law ($n = 17$)	16105	1.80	4.01	8.82	11.52	16.75
No law or partial law ($n = 16$)	9689	2.52[a]	2.43[a]	10.92[a]	16.17[a]	15.45
No law ($n = 3$)	1765	2.61	3.12	11.78	18.41	14.73
Partial law ($n = 13$)	7924	2.50	2.27	10.73	15.67	15.61

Cases drawn from the State Inpatient Databases (SID) of the Healthcare Cost and Utilization Project (HCUP) 2001. Cases identified by searching all secondary diagnosis fields for cases that contained codes E810 through E825. To avoid duplicate counting of possible inter-facility transfers, cases with the source of admission identified as "another hospital" or "other health facility" were excluded from the analysis.

[a] Chi-square < 0.0001.

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Classifications Software (CCS), which aggregates individual ICD-9-CM codes into broad, mutually exclusive diagnosis and procedure groups (AHRQ, 2006b). The Barell Injury Matrix was used to display injuries according to diagnosis and body part involved (Barell et al., 2002).

At the time of this study 20 states had universal motorcycle helmet use laws, 27 states had partial use laws, and 3 states had no helmet use laws (Insurance Institute for Highway Safety, 2006b). Among the 33 states participating in HCUP at the time of the study, 17 had universal helmet laws, 13 had partial use laws, and 3 had no helmet law. States were grouped according to type of helmet legislation and analyses were conducted using the aggregate data for all cases identified within the different state groupings. Chi-square tests for categorical and unpaired *t*-tests for continuous variables were used to analyze for differences. To determine the risk of sustaining different injury types, relative risk calculations and 95% confidence intervals for Barell injury matrix groupings were derived. These calculations were conducted at the diagnosis level, including the principal diagnosis and all secondary diagnoses for each case identified, and the sum of all injury diagnoses as the denominator (Agresti, 1990; Fleiss, 1981).

3. Results

Across the 33 participating states, a total of 25,794 cases were identified as motorcycle-related hospitalizations. Of these, 16,105 cases occurred in states with universal laws, 7924 cases occurred in states with partial use laws, and 1765 cases occurred in states with no helmet law (Table 1). Comparing states with partial use laws to states with no laws, we found no significant differences in the proportion of cases with intracranial injury as the principal diagnosis, the proportion of cases dying during the hospital stay, and the disposition of cases to long-term or short-term health facilities. However, comparing states with universal laws to states with either no laws or partial laws, we found statistically significant differences in all of these outcomes. Across the state groupings there were no significant differences in the proportion of cases less than age 21 years.

These findings, plus the results from observational studies demonstrating similar helmet use rates in states with no laws and states with partial laws (NHTSA, 2004d), prompted our combining the cases across the 16 states with either no laws or partial laws into a single group for all subsequent analyses.

Table 2 displays the distribution of cases by state and compares other characteristics between states with universal laws and states with either partial or no helmet law in place. Several states contributed disproportionately to the overall number of cases within each group, with California and New York providing 41% of all cases in the universal law group and Florida and Texas providing 39% of all cases in the partial or no law group. Sixteen percent of all cases in states with partial or no helmet law reported intracranial injury as the principal diagnosis, compared with 11.5% of cases from states with universal helmet laws ($p < 0.0001$). Cases from states with partial or no helmet law were also more likely to die in the hospital, be discharged to a long-term care facility, and be self-pay ($p < 0.0001$). There

Table 2
Characteristics of admissions resulting from motorcycle injury

	Universal helmet laws ($n = 16105$ cases)	Partial or no helmet law ($n = 9689$ cases)
Percentage of cases by state		
Arizona		9.4
California	31.2	
Colorado		9.2
Connecticut		4.3
Florida		21.8
Georgia	4.7	
Hawaii		1.5
Illinois		5.9
Iowa		3.1
Kansas		1.9
Kentucky		4.1
Massachusetts	3.9	
Maryland	3.7	
Maine		1.2
Michigan	5.6	
Minnesota		3.8
Missouri	4.5	
North Carolina	5.3	
Nebraska	0.6	
New Jersey	4.4	
New York	10.2	
Oregon	3.1	
Pennsylvania	9.5	
Rhode Island		1.3
South Carolina		5.7
Tennessee	4.9	
Texas		16.9
Utah		3.0
Virginia	2.8	
Vermont	0.3	
Washington	4.6	
West Virginia	0.8	
Wisconsin		6.9
Percentage with principal diagnosis of intracranial injury	11.5	16.2[a]
Age (mean)	34.4	35.4[b]
Males (%)	90.4	87.4[a]
Length of stay (days)		
Median	3.0	3.0
Mean	5.4	5.8
Disposition (%)		
Routine	78.0	76.9
Short-term care	4.0	2.4[a]
Long-term care	8.8	10.9[a]
Home health care	6.3	6.5
Left against advice	1.0	0.7
Died	1.8	2.5[a]
Unknown	0.1	0.0
Payer (%)		
Medicare	2.9	2.9
Medicaid	8.8	6.4[a]
Private	68.5	66.3[a]
Self-pay	13.8	16.0[a]
No charge	0.3	2.4[a]
Other	5.8	5.9

Cases drawn from the State Inpatient Databases (SID) of the Healthcare Cost and Utilization Project (HCUP) 2001. Cases identified by searching all secondary diagnosis fields for cases that contained codes E810 through E825. To avoid duplicate counting of possible inter-facility transfers, cases with the source of admission identified as "another hospital" or "other health facility" were excluded from the analysis.

[a] Chi-square < 0.0001.

[b] *t*-Test < 0.0001.

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Table 3
Characteristics, charges, and disposition by leading principal diagnosis for motorcycle-related hospitalizations

Principal diagnosis	Died in hospital (%)		Percentage with intracranial injury as secondary diagnosis[a]		Percentage transferred to long-term care[a]		Mean length of stay[a] (days)		Mean total charges[a] (dollars)	
	Universal law	Partial or no law	Universal law	Partial or no law	Universal law	Partial or no law	Universal law	Partial or no law	Universal law	Partial or no law
Fracture lower extremity	0.29	0.11	5.03	5.47	8.10	10.37[b]	4.96	5.60[c]	30189	30049
Fracture upper extremity	0.05	0.26	7.61	8.71	4.72	5.00	3.19	3.57	21786	19735
Intracranial injury	8.80	11.30	8.69	10.43	20.06	24.53[b]	8.00	8.93	49983	44190
Other fractures	0.98	0.87	9.73	9.20	11.76	12.05	6.11	5.51	34934	25059[c]
Crush/internal injury	3.82	3.50	13.02	11.73	5.87	6.51	7.01	6.83	39728	32425
All others	0.65	0.83	7.98	7.64	7.65	8.66	4.94	5.09	27179	22919

Cases drawn from the State Inpatient Databases (SID) of the Healthcare Cost and Utilization Project (HCUP) 2001. Cases identified by searching all secondary diagnosis fields for cases that contained codes E810 through E825. To avoid duplicate counting of possible inter-facility transfers, cases with the source of admission identified as "another hospital" or "other health facility" were excluded from the analysis.

[a] Excludes in-hospital deaths.

[b] Chi-square < 0.005.

[c] *t*-Tests < 0.0001.

were no significant differences found in hospitalization length of stay.

Table 3 examines outcome differences between the state groupings according to principal diagnosis categories. Among all cases, those with intracranial injury demonstrated the highest in-hospital mortality, longest lengths of stay, and highest hospital charges. Cases with intracranial injury were also most likely to require transfer to a long-term care facility following the initial hospitalization and those from states without universal laws were significantly more likely to require long-term care than those from states with universal laws ($p < 0.005$). We also found that cases with a principal diagnosis of lower extremity fracture hospitalized in states without universal laws had longer lengths of stays ($p < 0.0001$) and were more likely to be transferred to long-term care facilities ($p < 0.005$) than cases of lower extremity fracture from states with universal laws.

Table 4 illustrates differing injury patterns according to the type of state helmet law. These data include all injury diagnoses (principal and secondary) for each case in the dataset. Cases from states without universal helmet laws were 41% more likely to sustain the most severe forms of traumatic brain injury (Type 1 TBI RR = 1.41; 95% CI: 1.32–1.50). Cases from states without universal helmet laws were also more likely to sustain other head and facial injuries and less likely to sustain torso and extremity injuries. There were no significant differences seen in the proportion of cases sustaining spinal cord injury according to type of helmet legislation.

4. Discussion

The increasing trend in motorcycle rider fatalities has been well documented. The literature on non-fatal injuries is less substantive, with the majority of prior studies limited to single hospital case series or single state evaluations following the repeal of motorcycle helmet laws. This study examined differing injury patterns and other characteristics of hospitalized motorcycle-related injuries among riders from 33 states with different helmet laws. Our findings support prior work in this area and provide greater detail on the characteristics of these cases. Hospitalized cases from states without universal helmet laws were more likely to have intracranial injury and more likely to sustain severe intracranial injury. These cases incur higher treatment costs, were more likely to die while in the hospital, and were more likely to be transferred to long-term care facilities following their acute hospital stay. Cases from states without universal helmet laws were also more likely to lack private medical insurance.

Our cross-sectional analysis demonstrates that, among hospitalized cases, those located in states without universal helmet laws are at increased risk to have intracranial injury as the principal diagnosis. Similar findings were demonstrated in a recent in-depth evaluation of motorcyclist injuries in Florida, where head/brain/skull injuries represented 16.9% of the principal diagnoses when Florida had a universal helmet law and 22.0% of the principal diagnoses following change of the law to a partial helmet use requirement (Ulmer and Northrup, 2005). Overall, a 40% increase in hospital admissions and an 82.2% increase in head related injury admission was seen during the post-law change period in Florida. In Taiwan, where motorcycles are the most common means of transportation, the number of hospitalized motorcycle-related head injuries decreased by 33% following implementation of a universal helmet law (Chiu et al., 2000).

An analysis of motorcycle-related admissions to U.S. trauma centers also found similar results. That study examined hospitalizations from 130 hospitals within 25 states over an 8-year period and included information on actual helmet use of the injured patients. Based upon a total of 9769 patients, the authors found non-helmeted motorcyclists at increased risk for mortality, head injury, and subsequent discharge to a rehabilitation facility (Hundley et al., 2004). We report similar findings, based upon a 33 state sample that captures approximately 80% of all hospital discharges in the United States and includes all community hospitals in each state. Additionally, our state-level analysis found that patients from states lacking universal helmet laws had a 41% increased risk of Type 1 TBI diagnoses. Diagnoses in this category include head injuries likely to result in permanent disability including, for

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Table 4
Injury matrix for motorcycle-related hospitalized cases

Injury location/type	Universal law (% of total diagnoses)	Partial/no law (% of total diagnoses)	Relative risk (95% confidence intervals)
TBI			
Type 1	1931 (3.93)	1743 (5.52)	1.41 (1.32–1.50)
Type 2	1465 (2.98)	853 (2.70)	0.91 (0.83–0.99)
Type 3	74 (0.15)	72 (0.23)	1.52 (1.10–2.09)
Other head, face, neck			
Other head	875 (1.78)	1032 (3.27)	1.84 (1.68–2.01)
Face	3269 (6.65)	2770 (8.78)	1.32 (1.26–1.39)
Eye	333 (0.68)	285 (0.90)	1.33 (1.14–1.56)
Neck	77 (0.16)	34 (0.11)	0.69 (0.46–1.03)
Unspecified	836 (1.70)	798 (2.53)	1.49 (1.35–1.64)
Spinal cord injury			
Cervical	115 (0.23)	90 (0.29)	1.22 (0.93–1.60)
Thoracic	133 (0.27)	62 (0.20)	0.73 (0.54–0.98)
Lumbar	52 (0.11)	18 (0.06)	0.54 (0.32–0.92)
Sacrum–coccyx	4 (0.01)	3 (0.01)	1.17 (0.29–4.72)
Spine-back Unsp.	11 (0.02)	4 (0.01)	0.57 (0.19–1.68)
Vertebral column injury			
Cervical	653 (1.33)	551 (1.75)	1.31 (1.17–1.47)
Thoracic	590 (1.20)	337 (1.07)	0.89 (0.78–1.02)
Lumbar	646 (1.31)	337 (1.07)	0.81 (0.71–0.93)
Sacrum–coccyx	286 (0.58)	159 (0.50)	0.87 (0.71–1.05)
Spine-back Unsp.	4 (0.01)	1 (0.00)	0.39 (0.06–2.47)
Torso			
Chest	6026 (12.26)	3568 (11.31)	0.92 (0.89–0.96)
Abdomen	2691 (5.48)	1370 (4.34)	0.79 (0.74–0.84)
Pelvis-urogenital	1835 (3.73)	990 (3.14)	0.84 (0.78–0.91)
Trunk	794 (1.62)	468 (1.48)	0.92 (0.82–1.03)
Back-buttock	193 (0.39)	122 (0.39)	0.98 (0.79–1.23)
Upper extremity			
Shoulder-upper arm	4172 (8.49)	2517 (7.98)	0.94 (0.90–0.99)
Forearm-elbow	2826 (5.75)	1685 (5.34)	0.93 (0.88–0.98)
Hand-wrist-fingers	2488 (5.06)	1481 (4.69)	0.93 (0.87–0.99)
Other and Unsp. UE	1049 (2.13)	701 (2.22)	1.04 (0.95–1.14)
Lower extremity			
Hip	719 (1.46)	348 (1.10)	0.75 (0.66–0.86)
Upper leg-thigh	1595 (3.25)	862 (2.73)	0.84 (0.78–0.91)
Knee	1141 (2.32)	650 (2.06)	0.89 (0.81–0.98)
Lower leg-ankle	5158 (10.50)	3113 (9.87)	0.94 (0.90–0.98)
Foot-toes	1883 (3.83)	1185 (3.76)	0.98 (0.91–1.05)
Other and Unsp. LE	2786 (5.67)	1712 (5.43)	0.96 (0.90–1.01)
Other and unspecified			
Other, Multiple	106 (0.22)	52 (0.16)	0.76 (0.55–1.06)
Unspecified	1521 (3.10)	1141 (3.62)	1.17 (1.08–1.26)
System Wide & Late Effects	798 (1.62)	435 (1.38)	0.85 (0.76–0.95)
Total	49135 (100)	31549 (100)	

example, cerebral contusions, cerebral lacerations, and epidural hematomas.

Prior research has examined how the acute medical costs of a head injury compare with the costs of other motorcycle-related injuries, consistently finding that head injured patients incur greater hospital charges, with differences ranging from 79% to 178% higher (Lawrence et al., 2002; Orsay et al., 1995; Bried et al., 1987; Max et al., 1998; NHTSA, 1996). Similarly, the highest mean hospital charges in our sample were seen among cases with a principal diagnosis of intracranial injury. There was, however, little variation in acute medical costs between states with differing helmet laws. The similar short-term medical costs between helmeted and non-helmeted motorcycle crash victims have been previously reported (Lawrence et al., 2002). However, these previous studies may have underestimated the potential cost savings associated with helmet use because all patients included in these analyses met the threshold of having sustained injuries serious enough to warrant hospitalization. A more recent cost analysis that included data on motorcycle crash patients who did not require hospitalization concluded

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that helmet non-use results in an excess cost of US$ 3618 for every motorcycle crash, or a total of over US$ 250 million in excess costs annually (Eastridge et al., 2006).

Apart from acute medical costs, relatively little attention has been devoted to the potential long-term disability and associated total societal costs of these injuries. Hotz and colleagues reported follow-up outcomes with motorcyclists injured following the repeal of Florida's universal helmet law. They successfully contacted 48% of the injured motorcyclist at 1-year following injury and found that 51% reported continuing physical deficits (Hotz et al., 2004). We report significant differences in the disposition of hospitalized cases according to type of helmet law. States without universal helmet laws are more likely to have patients transferred to long-term care facilities following their initial hospitalization. Nearly 25% of cases from such states with a principal diagnosis of intracranial injury required disposition to a long-term care facility. Indeed, for nearly all of the most common principal diagnoses, cases from states without universal helmet laws were more likely to require disposition to a long-term care facility, reaching statistical significance for those with intracranial injury and those with lower extremity fractures (Table 3). While the incidence of secondary intracranial injuries for those with a principal diagnosis of lower extremity fracture did not differ significantly between the state groupings, the increased severity of secondary TBI injury among those from states without universal laws may have contributed to this finding.

We also found differences in the insurance status among hospitalized cases according to type of state helmet law, with those from states without universal laws more likely to be classified as "self pay." Prior research has also reported that non-helmeted motorcyclists are more likely to have either no health insurance or government-funded insurance (Hundley et al., 2004; Lawrence et al., 2002). These findings have significant implications, given the increased proportion of cases discharged to long-term care facilities in these same states.

Several additional findings from the current study are noteworthy. There were an overall higher number of hospitalizations occurring in states with universal helmet laws in place. While our objective was to focus on the characteristics of hospitalized cases, not the prevalence or rate of hospitalization, this seemingly paradoxical finding warrants some commentary. Similar findings, based upon cross-sectional state comparisons using unadjusted fatality rates, have been previously reported. However, once adjusted for exposure variables such as temperature and population density, states with full helmet laws actually have lower motorcyclist death rates than states without such laws (Branas and Knudson, 2001) (Morris, 2006). We found a similar pattern of higher unadjusted hospitalization rates in states with universal helmet laws. While we did not perform a multivariate analysis attempting to explain this higher hospitalization rate, we believe this is also related to exposure variables as our unadjusted hospitalization rates were found to correlate significantly with unadjusted fatality rates ($r = 0.864$) in the 33 HCUP states.

Certain states, most notably California, Texas, Florida, and New York, contributed large numbers of cases to the dataset. This is reflective of population density, the number of registered motorcycles, and motorcycling activity. In 2001, California had 488,000 registered motorcycles, 50% more than the state with the second highest number of registrations (US DOT, 2002). While it is possible that other state-related characteristics, beyond type of helmet legislation, may be contributing to the differences we report, examination of these factors was beyond the scope of this study and may be a topic for future research.

We attempted to compare states with universal laws to states with partial laws and states with no helmet laws, but the small number of states with no laws ($n = 3$) limited these analyses. While not attaining statistical significance, we found an overall increasing trend in the in-hospital mortality, the proportion of cases with a principal diagnosis of intracranial injury, and the proportion of cases discharged to long-term care facilities in relationship to the lack of helmet regulations. Several states that have repealed universal helmet laws have continued requiring young riders (less than age 21 or less than age 18) to wear helmets. We found little difference in the proportion of hospitalized cases among those less than 21 years of age across states with differing helmet laws, suggesting that these "partial requirement" laws may not be protective of young riders. Similarly, observational surveys have found little difference in helmet use rates among states with no law in place and states with partial requirements, possibly related to the difficulty in attempting to enforce partial requirement laws (NHTSA, 2004d).

Limitations to this study include the lack of specific helmet use information on individual cases, as this information is not included in hospital discharge data and therefore not included in HCUP. The financial data within HCUP are based on hospital charges, not actual costs. Hospital charges are generally more than actual costs. However, it should also be noted that the hospital charge data do not include a number of important cost items including physician professional fees, emergency transportation costs, and subsequent rehabilitation costs. Given our findings related to the disposition of cases to long-term care facilities, further in-depth study of the associated rehabilitative, disability, and lost productivity costs is warranted.

Policy makers contemplating the removal of universal motorcycle helmet laws should take these results, and those from other published studies, under consideration. Research indicates that removal of such laws will result in a sharp reduction in helmet usage (Insurance Institute for Highway Safety, 2006a). Fatalities and motorcycle-related hospitalizations, especially those sustaining TBI, will increase. Patients from states lacking universal helmet laws are 41% more likely to sustain the most severe forms of TBI. These hospitalized cases with brain injuries incur the highest mean hospital charges and a large proportion will require long-term care in rehabilitation facilities and/or nursing homes. Hospitalized patients in states without universal helmet laws are more likely to lack private health care insurance. Ultimately the public will bear much of the resulting substantial financial burden associated with these cases.

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The following 33 states provided inpatient data for 2001: Arizona, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Illinois, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, and Wisconsin. We thank Pam Owens and Mike Furbee for assistance with statistical analysis. This work was funded by the Agency for Healthcare Research and Quality.

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