SAM HASSENBUSCH YOUNG NEUROSURGEON AWARD

Helmeted vs Nonhelmeted: A Retrospective Review of Outcomes From 2-Wheeled Vehicle Accidents at a Level 1 Trauma Center

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Unintentional injury remains the leading cause of death and disability for people 1 to 44 years of age in the United States.[1,2] The majority of injuries are from motor vehicle accidents, including automobiles, trucks, motorcycles, and bicycles, as well as pedestrians hit by vehicles. Injuries resulting in traumatic brain injury result in >30% of the deaths and contribute to significant morbidity for survivors. Traumatic brain injury is estimated to affect 1.5 million Americans yearly and results in 52 000 deaths and $60 billion in medical costs and lost wages.[3-5] Injury prevention devices include safety belts for automobiles and helmets for 2-wheeled vehicles. Many steps in legislation have been taken to enforce seatbelt use for injury prevention, and now 49 of 50 states have mandatory seatbelt laws enforced by fines for adults. Helmet requirements lack such legislation, and currently only 20 states have universal helmet laws.

In regard to helmet use, numerous observational studies demonstrate that motorcycle helmets reduce the risk of death and head injury up to 42% and 69%, respectively.[6,7] Despite these data, Florida does not currently have a mandatory helmet law; the Florida legislature repealed its helmet law in 2000. In the 10 years since this change, helmet use has dropped dramatically, and motorcycle fatalities have increased rapidly. The current law states that helmets are not required for riders of motorized 2-wheeled vehicles who are >21 years of age with at least $10 000 of health insurance coverage.

Current research has demonstrated an increased risk of neurological injury and death associated with no helmet use in motorcycles; however, few studies have evaluated discharge outcomes and hospital and societal costs.[8-12] In addition, controversy still exists regarding the actual healthcare impact of Florida's helmet law repeal.[13,14] In this study, we analyzed all 2-wheeled vehicle accidents evaluated at a level 1 trauma center over a 5-year period, comparing all outcomes, costs, and insurance status for helmeted and nonhelmeted riders.

PATIENTS AND METHODS

We reviewed the University of Florida Trauma Registry from January 2005 to June 2010. The University of Florida Trauma Center services 12 northern Florida counties with a total population estimated at 1 million people. Records were searched to identify patients from 2-wheeled vehicle accidents who met the following criteria: paramedic trauma alerts triage criteria or any patient with an *International Classification of Disease*, 9th revision, code of 800 to 904 who was admitted for 24 hours or died in the emergency department. Patients were stratified according to the use of a helmet at the time of the accident. Outcomes were compared for baseline population statistics, Glasgow Outcome Scale score, cost of hospitalization, discharge outcome, and health insurance status. Statistical methods include χ^2 tests, *t* tests, and analysis of variance as appropriate to compare data groups. Patient outcomes were compared by use of a logistic regression analysis. *P* values were adjusted by the Bonferroni method, and values of $P < .05$ were considered significant.

RESULTS

Patient Demographics

From January 2005 to June 2010, a total of 1439 patients were involved in a 2-wheeled vehicle accident who arrived as a trauma alert or had a traumatic injury requiring at least a 24-hour hospitalization. One hundred eight patients were excluded for unknown helmet status. Of the 1331 remaining patients, 995 (74.8%) were involved in motorcycle accidents, 249 (18.7%) were involved in bicycle accidents, and 87 (6.5%) were involved in scooter/moped accidents. The majority of riders were male (1134 of 1331). Of these, 749 riders were nonhelmeted and 582 were helmeted. In the motorcycle group, there were 995 patients, 522 helmeted and 473 nonhelmeted. In the motorcycle subgroup, women were less likely to be wearing a helmet (women, 57 of 127 [45%] vs men, 465 of 868 [54%]; $P < .01$). The average age of helmeted riders was significantly lower (35.2 vs 40.8 years; $P < .001$). In the low-power cycle group, there were 87 total patients. Most riders tended to be nonhelmeted (52 of 62 men [84%] and 10 of 13 women [88%]). The average age of the helmeted rider tended to be higher (43.5 vs 38.2 years, helmeted vs nonhelmeted, respectively), but no statistical significance was found. For the population of bicycle riders, there were 249 total patients, 204 male and 45 female. The average

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age of helmeted riders tended to be higher (39.1 vs 33.9 years, helmeted vs nonhelmeted), but no statistical significance was seen. These data are summarized in Table 1.

Initial Glasgow Coma Scale Score and Outcomes

Initial Glasgow Coma Scale (GCS) score was recorded for 1330 patients. The average initial GCS score was lower in all subgroups for the nonhelmeted population; however, this was statically significant only for motorcycle riders. A total of 201 patients had a GCS score <8. For each subgroup, there was a greater proportion of nonhelmeted riders with a GCS score <8: for motorcycles, 10.2% vs 21.8%; for low-power scooters, 0% vs 13.9%; and for bicycles, 8.5% vs 15.3%. Average GCS scores are given in Table 2 for all groups.

For hospital outcomes, overall survival was evaluated. In addition, outcomes were divided as good (ie, home or rehabilitation) vs poor (skilled nursing facility or death). For motorcycles, a significant association existed between helmet use and survival. Riders without helmets were significantly more likely to die than riders with helmets (estimated odds ratio, 2.080; 95% CI, 1.239-3.490; $P = .006$). Additionally, nonhelmeted riders were significantly more likely to experience poor outcomes (discharge to skilled nursing facility or death), with an estimated odds ratio of 1.708 (95% confidence interval, 1.266-2.304; $P = .005$). Among motorcycle riders, men were slightly more likely to die in accidents than women, and older riders were slightly more likely to die than younger riders, although this did not reach statistical significance. For low-power scooters, no significant associations existed between age, sex, or helmet use. For bicycle riders, the only significant predictor of outcome was age (estimated odds ratio, 1.05 for each additional year of age; 95% confidence interval, 1.012-1.089; $P = .002$). Individual discharge status frequencies are given in Table 2.

Costs and Insurance Status

For all vehicle types, hospital charges were skewed to the right, with a few expensive stays raising the overall average. Because of this, we report both the mean values and the median charges, along with the minimum, maximum, and 25th, 75th, and 90th percentiles. For motorcycle riders, the average and median charges were significantly higher in nonhelmeted patients. For bicycle and scooter patients, no statistical significance was found; however, overall maximum charges were greatest in the nonhelmeted patients. In regard to insurance status, overall, riders wearing helmets were significantly more likely to have insurance than nonhelmeted riders ($P < .001$). Positive insurance status was statistically significantly higher in both the helmeted motorcycle and bicycle subgroups but was not significant in the helmeted scooters subgroup. The total hospital charge breakdown can be seen in Table 3 and the Figure.

DISCUSSION

Motorcycle helmet laws have varied greatly across the individual states over the past 50 years. By 1975, all but 3 states had mandatory helmet laws, but beginning in the late 1970s, many states began repealing these laws.[15-20] Despite a remarkable amount of early observational and experimental data supporting the use of helmets in injury prevention for 2-wheeled vehicles, the Florida legislature repealed its universal helmet law in 2000. Since that time, there has been a 2-fold increase in motorcycle fatalities and a 30% to 50% reduction in motorcycle helmet use; however, it remains controversial whether the mortality cause is secondary to the helmet law repeal or simply an increase in motorcycle registration.[12-14,21,22] Regardless, in many other states without a universal helmet law, death rates from head injuries among motorcyclists are reported to be twice as high as in states with universal laws.[23] In Arkansas, after a similar helmet law repeal in 1997, there was a noted increase in nonhelmeted crash

TABLE 1. Patient Demographics

All Patients		Helmet	Nonhelmeted	
Total, n	1331	582	749	
Male	1134	512 (45.2)	622 (54.9)	Women less likely to wear helmet, $P = .01$[a]
Female	197	60 (35.53)	127 (64.74)	
Age, y		35.72 ± 17.58	38.71 ± 16.93	Average age of helmeted riders lower, $P = .002$[a]
Motorcycle, n	995	522	473	
Male	868	465 (53.5tpgoto "7)	403 (46.43)	Women less likely to wear helmet, $P < .05$[a]
Female	127	57 (44.88)	70 (55.12)	
Age, y		13.57 ± 0.17	12.26 ± 0.25	Average age of helmeted riders lower, $P < .001$[a]
Scooter/moped, n	87	13	74	
Male	62	10 (16.13)	52 (83.87)	Proportion men vs women helmeted, $P > .05$
Female	45	3 (12.0)	10 (88.0)	
Age, y		43.46 ± 19.58	38.22 ± 21.01	Age difference in helmeted riders, $P = 1.0$
Bicycle, n	249	47	202	
Male	204	37 (18.14)	167 (81.86)	Proportion men vs women helmeted, $P > .05$
Female	45	10 (22.22)	35 (77.88)	
Age, y		39.11 ± 19.73	33.91 ± 19.70	Age of helmeted tended to be older, $P = .31$

[a]Significant.

TABLE 2. Initial Glasgow Coma Scale Score and Outcomes[a]

All Patients	Helmeted	Nonhelmeted	
All patients			
GCS score	13.68 ± 0.73	12.46 ± 0.62	Average GCS score for helmeted riders higher, $P = .001$[b]
Home, n (%)	479 (82.3)	563 (75.17)	Odds ratio for poorer outcomes (home/rehabilitation vs SNF/death), 1.680; 95% CI, 1.268-2.225; $P = .001$[b]
Rehabilitation, n (%)	53 (9.11)	78 (10.31)	
SNF, n (%)	23 (3.95)	43 (5.74)	
Death, n (%)	27 (4.64)	65 (8.69)	
Motorcycle			
GCS score	13.57 ± 0.17	12.26 ± 0.25	Average GCS score of helmeted riders higher, $P < .001$[b]
Home, n (%)	427 (81.80)	335 (70.82)	Odds ratio for poorer outcomes (home/rehabilitation vs SNF/death), 1.708; 95% CI, 1.266-2.304; $P = .001$[b]
Rehabilitation, n (%)	49 (9.39)	61 (12.9)	
SNF, n (%)	22 (4.21)	32 (6.77)	
Death, n (%)	24 (4.60)	45 (9.51)	Odds of death, 2.304; $P < .05$[b]
Scooter/moped			
GCS score	14.77 ± 0.17	13.05 ± 0.46	Average GCS score difference, $P > .05$
Home, n (%)	11 (84.65)	64 (86.49)	Odds ratio for poorer outcomes (home/rehabilitation vs SNF/death), 0.928; 95% CI, 0.179-4.825; $P = .93$
Rehabilitation, n (%)	1 (7.69)	4 (5.41)	
SNF, n (%)	0 (0.00)	3 (4.05)	
Death	1 (7.69)	3 (4.05)	
Bicycle			
GCS score	13.57 ± 0.57	12.82 ± 0.30	Average GCS score difference, $P > .05$
Home, n (%)	41 (87.23)	154 (81.19)	Odds ratio for poorer outcomes (home/rehabilitation vs SNF/death), 1.850; 95% CI, 0.714-4.795; $P = .21$
Rehabilitation, n (%)	3 (6.38)	13 (6.44)	
SNF, n (%)	1 (2.13)	8 (3.69)	
Death, n (%)	2 (4.26)	17 (8.42)	

[a]CI, confidence interval; GCS, Glasgow Coma Scale; SNF, skilled nursing facility. For odds of poor outcome, SNF and death are given, as well as overall mortality odds.
[b]Significant.

scene fatalities, higher admission rates for nonhelmeted survivors, and a negative economic impact on the healthcare system.[24-26] Similar results have been seen in other states with similar legislation changes, including Louisiana, California, and Texas.[27-29] A review of the National Trauma Data Bank demonstrated results similar to our study, with nonhelmeted motorcyclists having worse outcomes, requiring more hospital resources, and having increased hospital charges, as well as being insured less frequently and having poor reimbursement.[30,31]

As noted previously, the efficacy of motorcycle helmet use in reducing traumatic brain injury and death has been clearly established. A meta-analysis by Liu et al[7] of 61 observation studies demonstrated a risk reduction of death and head injury by 42% and 69%, respectively. Despite adequate literature support, opposition to helmet use in motorcycles still exists for multiple reasons. Reasons include but are not limited to individual freedom,[32] theorized increased crash incidence from decreased peripheral vision, and a theorized increased cervical spine injury risk. Recent studies, however, demonstrate a lower cervical spine injury risk with helmet use.[33]

The literature for bicycles and low-power scooters is lacking, although most studies suggest improved safety with helmet use.[34-40] A Cochrane Review of retrospective studies by Macpherson and Spinks[36] demonstrated an increase in helmet use and a decrease in head injury rates after legislation for mandatory youth bicycle helmet laws. Our population of

TABLE 3. Insurance Status[a]

	Helmeted With Insurance, n (%)	Nonhelmeted With Insurance, n (%)	*P*
Motorcycle (3 patients without insurance information)	424 (81.5)	341 (72.3)	.001[b]
Scooter/moped	10 (76.9)	54 (73.0)	> .05
Bicycle	44 (93.6)	147 (72.8)	.002[b]

[a]Interestingly, despite the given Florida law, nonhelmeted patients were significantly less likely to have insurance.
[b]Significant.

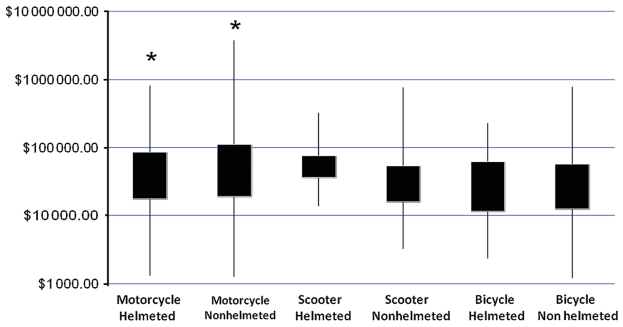

FIGURE. Total hospital charges. Hospital charges for each subgroup are shown. For motorcycle riders, helmeted riders have significantly lower hospital charges, and the nonhelmeted subgroups received the maximum hospital charges.

helmeted moped/scooter and bicycle riders is too small to find statistical significance, but trends exist that favor helmet use. Interestingly, partial helmet laws with age-based restrictions have been shown to provide little, if any, protection to youth riders because it is difficult to enforce age-based restrictions.[41-44]

The first aim of our study was to evaluate the efficacy of helmets in reducing fatalities and improving functional outcome. For our largest population, motorcycle riders, our results clearly demonstrate that helmets are effective in decreasing mortalities and improving outcomes at discharge. Helmets act as a preventer of primary injury, and as a result, we see a higher GCS score at the time of admission. For low-power cycles and bicycles, the helmeted population was too small to draw any statistically significant conclusions; however, trends in GCS score, morality, and discharge outcomes exist favoring their use.

The second aim of our study was to evaluate the economic impact of helmet use. We initially evaluated total hospital charges. As expected from our mortality and outcomes data, helmets significantly reduce the hospital charges for motorcycle riders involved in accidents. Again, from our smaller population of helmeted riders on scooters and bicycles, no significant effect could be found. Not surprisingly, however, maximum hospital charges were incurred by patients who were not wearing a helmet for all subgroups. The current law in Florida regarding optional helmet use is for those riders who have $10 000 in health insurance to cover the costs associated with an accident. Knowing this law, one would have expected the nonhelmeted riders to have insurance; however in all groups, a larger percentage of nonhelmeted patients did not have insurance. This was statistically significant in both the motorcycle and bicycle groups. These data are likely an underestimate of insurance status because patients with severe traumatic brain injury or spinal cord injury qualify for Medicare after 30 days of hospitalization, thus adding positive insurance status to those most severely injured who also had the highest inpatient charges.

If one were to estimate the cost savings for motorcycle helmet use, the average hospital charges for a nonhelmeted motorcycle patient would be $95 376.80 and the for helmeted motorcycle patient would be $71 774.04. This demonstrates an average cost savings per helmeted patient of $23 602.76. Similar savings with helmet use have been seen in other studies.[45,46] For our population of 473 nonhelmeted riders over a 5-year period, this resulted in a staggering total increase in charges of $11 164 106 for a single level 1 trauma center with a catchment region of 12 counties and approximately 1 million people.

CONCLUSION

Our findings suggest that the age and insurance exemption of the law should be revoked and a universal helmet law be reinstated in the state of Florida. Motorcycle helmets significantly reduce overall morbidity and mortality, improve discharge outcome, and are cost-effective in healthcare savings. For low-power scooters and bicycles, trends exist that also support helmet use.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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