Title
Helmet use and bicycle-related trauma injury outcomes

Journal
Brain Injury, 33(13-14)

ISSN
0269-9052

Authors
Scott, Lagina R
Bazargan-Hejazi, Shahrzad
Shirazi, Anaheed
et al.

Publication Date
2019-12-06

DOI
10.1080/02699052.2019.1650201

Peer reviewed

HHS Public Access

Author manuscript

Brain Inj. Author manuscript; available in PMC 2023 January 20.

Published in final edited form as:

Brain Inj. 2019 ; 33(13-14): 1597–1601. doi:10.1080/02699052.2019.1650201.

Helmet use and bicycle-related trauma injury outcomes

Lagina R. Scott[a], **Shahrzad Bazargan-Hejazi**[a], **Anaheed Shirazi**[b], **Deyu Pan**[c], **Steven Lee**[d], **Stacey A. Teruya**[a], **Magda Shaheen**[a]

[a]David Geffen School of Medicine, Charles R. Drew University of Medicine and Science, Los Angeles, USA

[b]Psychiatry, Charles Drew University of Medicine and Science, Los Angeles, CA, USA

[c]Preventive and Social Medicine, Charles Drew University of Medicine and Science, Los Angeles, CA, USA

[d]General Surgery Residency at Harbor-UCLA Division of Pediatric Surgery, UCLA and Harbor-UCLA Harbor-UCLA Academic Office, Los Angeles, CA, USA

Abstract

Background: It is essential to identify factors that predict helmet use, so as to mitigate the injury and mortality from bicycle accidents.

Objective: To examine the relationship between helmet use and the bicycle-related trauma injury outcomes among bicyclists with head/neck injury in the US.

Methods: Data from the 2002–2012 National Trauma Data Bank were used, including all trauma bicycle riders involved in bicycle-related accidents whose primary reason for the hospital or Intensive Care Unit stay was head or neck injury. Using multiple logistic regression, the association between helmet use, Injury severity score (ISS), length of stay in hospital (HLOS) and Intensive Care Unit (ICULOS), and mortality was examined.

Results: Of the 76,032 bicyclists with head/neck injury, 22% worn helmets. The lowest was among Blacks, Hispanics, and <17 years old. Wearing a helmet significantly reduces injury severity, HLOS, ICULOS, and mortality (i.e total and in-hospital). Males had a severe injury, longer HLOS, ICULOS, and higher mortality than female. Blacks and Hispanics had longer HLOS and ICULOS and higher total mortality than Whites, but had a similar chance for in-hospital mortality.

Conclusions: More effort is needed to enhance helmet use among at-risk bicycle riders, which may reduce injury severity, HLOS, ICULOS, and mortality.

Keywords

Helmet use; traumatic brain injury; cycling

CONTACT Shahrzad Bazargan-Hejazi, shahrzadbazargan@cdrewu.edu; shahrzadb@ucla.edu, College of Medicine, Charles R. Drew University of Medicine and Science (CDU) & David Geffen School of Medicine at the University of California at Los Angeles (UCLA).

Conflict of Interest

The authors report no conflicts of interest in this work.

Introduction

Approximately 67 million people ride bicycles in the United States, yielding about 15 billion hours of cycling per year (1). One of the important and highly preventable causes of traumatic brain injury is bicycle and sports-related injuries (2). Patients can be presented with maxillofacial trauma, dental injuries (3), and intracranial head injury. The latter is the most common, and accounts for about 21% of all bicycle-related injuries that result in inpatient hospital stays (4), Skull and face fractures, in comparison, are relatively rare, and account for only 6% of all such hospitalizations (4).

Bicycle helmets have been shown to protect against severe brain injuries and death (5–7). Using detailed finite element simulations, one study has even illustrated the real-time protective effect of a helmet in a bicycle accident (8). Despite such research, less than half of children and adults in the United States report wearing a helmet while riding (9). The promotion of an all-ages bicycle helmet law is a fundamental preventative strategy for reducing major bicycle-related head trauma (10). Past studies in the United States, in fact, also suggest that implementing an all-ages bicycle helmet law would result in decreasing the severity of head injuries and bicycle-related fatalities (9,11,12). However, the effect of mandatory helmet use does not appear equal and even across all racial and ethnic groups. In one study, for example, the increase in usage was greater among White students. This effect results in an even greater disparity in injury and death rates when compared to racial and ethnic minorities (13). Another study showed that 6 years after helmet legislation in Toronto children riding in high-income areas were significantly more likely to wear a helmet while riding bicycles than children in low-income areas across all years. (13)

A survey of the literature reveals a scarcity of research on the social determinants of helmet use, and their effect on bicycle-related injury outcomes. The aims of this study are 1) to report racial/ethnic differences in helmet use among bicyclists with head/neck trauma injury in the United States, and 2) to identify relationships between age, gender, race/ethnicity, and bicycle-related trauma injury outcomes. This research is expected to lay the foundation for future investigation into why helmet usage is uneven across racial, ethnic, and socioeconomic groups, and potentially for other voluntary health behaviors. The objective of the study was to examine the relationship between helmet use and the bicycle-related trauma injury outcomes measured through injury severity score (ISS), hospital (HLOS), and ICU length of stay (ICU LOS), and mortality among bicyclists with head/neck injury in the United States.

Methodology

Study design

We analyzed data from the National Trauma Data Bank (NTDB) from 2002 to 2012. Maintained by the American College of Surgeons, the NTDB contains more than 2.7 million patient records, contributed by over 900 trauma centers and emergency rooms across the United States, and is updated annually. Our study population includes 76,032 trauma-admitted patients involved in a bicycle-related accident (variable provided by the

NTDB), whose primary reason for the hospital or ICU stay was head or neck injury. Patients who died at the scene, or in route to the emergency room or trauma center, were included in the analysis.

Variables and measurements

The main predictor variable was helmet use (patients were identified as those who were using a helmet during the time of the accident, and those who did not). Other predictor variables were age, gender, and race/ethnicity. Age was categorized as three age groups: <18 years old, 18–40 years old, and 40 years and older. Gender was reported as male and female. Race/ethnicity was reported as White, Black, Hispanic, Asian/Pacific Islander (API) and others. NTSB provided all variables.

The outcome measures included: (1) *Injury severity score (ISS)*, an anatomical scoring system that provides an overall score for patients with multiple injuries. The subscores of the three most severely injured body regions are squared. These are added together to produce the ISS score (14) which was categorized into 5 groups: minor injury (1–3), moderate injury (4–8), serious injury (9–15), severe injury (16–24), and critical injury (25–75). It has further been categorized into two groups: (1) hospitalized, but not in the intensive care unit (ICU). (2) *ICU length of stay*, defined as the number of consecutive days during which the patient was hospitalized in the intensive care unit (ICU). (3) *Mortality*, defined as the patient died from injuries sustained in the bicycle accident both during their stay in the trauma center and in the emergency department or outside trauma center or emergency department. It was categorized as yes/no.

Statistical analysis

Descriptive statistics was used to depict the population characteristics and examine the distribution of the variables. Continuous variables were reported as mean, standard deviation, median and interquartile range (IQR). The level of missing data was 9.7% (N= 7375) and we used listwise deletion of the missing data. Categorical variables were reported as number and percent. We tested the difference in the ISS, HLOS, and ICULOS by helmet use and demographics using non-parametric Mann Whitney U test for gender and Kruskal–Wallis test for age groups and race/ethnicity. We tested the difference in the total mortality and in-trauma center mortality by helmet use and age, gender, race/ethnicity using chi-square test.

To test the independent relation between helmet use and the HLOS, ICULOS, and ISS, we used the Zero-inflated Negative Binomial Regression Model adjusting for the demographic variables. Data were presented as adjusted Beta coefficient and standard error.

To test the independent relation between helmet use and the total mortality and the in-trauma center mortality, we used multiple logistic regression adjusting for the demographic variables. Data were presented as adjusted odds ratio (AOR) and 95% confidence intervals (CI). Data were analyzed using SAS version 9.4 and p-value <0.05 was considered statistically significant.

Results

We considered 76,032 trauma-admitted patients involved in a bicycle-related accident diagnosed with head or neck injury (Table 1). Of these, 33.7% were <17 years old, 27.0% were 18–39 years old, and 39.3% were 40 years and older. Males constituted 81.1% of the study population, and females 18.9%. Sixty-one percent (61.3%) of the population was White, 12.4% Hispanic, 10.1% Black, 3.9% Other, and 2.7% Asian/Pacific Islander (API). For the injury severity, 15% had a minor injury and 53.8% had serious/critical injuries.

Only 22% (N = 16,789) of the overall study population reported wearing helmets when involved in their bicycling accident. The highest percent of helmet use was among adults ≤40 years old (31.8%) and the lowest was among and children <17 years (12.1%) ($p < .05$). Female had a higher percent of helmet use (28.3%) compared to male (20.6%) ($p < .05$). Helmet use for Whites and Asian/Pacific Islanders (APIs) was higher (27.3% and 26.6%, respectively) than that for Hispanics and Blacks (7.6% and 6%, respectively) ($p < .05$) (Table 1).

Injury-related outcomes HLOS and both total mortality and in-hospital mortality varied significantly by helmet use ($p < .05$). ISS and ICULOS were not statistically different by helmet use ($p > .05$). Patients wearing helmets had lower HLOS, total mortality and in-hospital mortality compared to those who did not wear helmets when involved in their bicycling accident ($p < .05$) (Table 1).

Overall, males with head/neck injuries had higher HLOS, ICULOS, and ISS than females with head/neck injuries (Adjusted β = 0.195; 0.177; and 0.595, respectively), $p < .001$). Blacks, Hispanics and Asian with head/neck injuries had higher HLOS and ICULOS than Whites with head/neck injuries (Adjusted β = 0.201; 0.243, respectively, for Blacks; 0.144, 0.140, respectively, for Hispanic; and 0.111, 0.119, respectively, for API, $p < .001$) respectively) (Table 2).

Helmet use, age, gender, and race/ethnicity (Blacks and Hispanics) were significant predictors of ISS ($p < .05$). Helmet users, patients <40 years of age, and Hispanics and Blacks had lower ISS relative to comparison groups (reference groups: helmet non-users, patients ≥40 years old, Whites, respectively) (Adjusted β = −0.67 for Helmet users, −3.13 for age 0–17 years, −2.56 for age 18–39 years, −0.717 for Blacks, and −0.869 for Hispanics, respectively, $p < .001$). Males had higher ISS compared to females (Adjusted β = 0.595, $p < .001$) (Table 2).

For total mortality, males with head/neck injuries were 36% more likely to die from injuries sustained in bicycle accidents than females with head/neck injuries (AOR = 1.36, $p < .05$), as were Blacks and Hispanics with head/neck injuries were 19% and 17%, respectively, more likely to die from injuries sustained in bicycle accidents compared to Whites with head/neck injuries (AOR = 1.19 and 1.17, respectively, $p < .001$) (Table 3). For in-hospital mortality, males with head/neck injuries were 31% more likely to die from injuries sustained in bicycle accidents than females with head/neck injuries (AOR = 1.31, $p < .05$) (Table 3). For both total mortality and in-hospital mortality, patients younger than 40 years of age with

head/neck injuries had a lower chance of mortality relative to those ≤40 years old ($p < .05$) (Table 3).

Discussion

Only more than one fifth (22%) of the adult population and 12% of the younger riders in our study used helmets while riding a bicycle. This is roughly consistent with other research which reported less than 50% utilization rates in both adult and younger population (9,15–17). Several barriers to helmet use have been identified such as being “uncomfortable,” “annoying,” and lack of access to helmet and lack of knowledge regarding helmet use (18–20).

Significant differences in helmet usage among different races/ethnicity have also been identified in prior research. For example, usage attributed to new mandatory helmet laws in different cities found the largest increase among White students (13). In another study, an analysis of National Trauma Data Bank (NTDB) data from 2007, 2010, and 2011 also indicates that White children younger than 16 years of age were more likely to wear helmets when involved in a bicycle accident, compared to Black peers (21). In a retrospective observational study of children aged<18, Black and Hispanic children were less likely to wear helmets (22). We found similar racial and ethnic differences in helmet usage: Blacks were the least likely to use helmets, followed by Hispanics. Conversely, Whites and Asian Pacific Islanders were most likely to use helmets.

Many studies have reported the clear protective benefit of helmets. Meehan, et al. associated lower fatality rates in child cyclists involved in bicycle-motor vehicle Bicycle with helmet safety laws. (23). Likewise, in a recent study in Illinois, helmet use was reported to be protective against traumatic brain injury in the pediatric population (22). In an adult study population, although motorcycle helmets use was associated with a decrease in fatality rates, no significant difference of mortality, ICU admission rates, and HLOS was observed between bicyclists with and without helmets (24). Our analysis supports the protective effect of helmet use and highlights the need to educate different populations on the significant protection afforded by helmets. Considering all race/ethnicity as a whole, bicyclists who wore them and suffered head/neck injury were less likely to have lower HLOS, lower ICULOS, and die than those who did not. In our analysis, males had a higher chance to have serious/severe/critical injury, were more likely to have longer days of hospital or ICU stays and were more likely to die from their injuries. Analysis of ISS indicates that ISS is lower when using a helmet relative to not using a helmet. Previous studies have found that if a collision occurs, the odds of a fatal outcome are less if the motorcycle operator was a woman which can be explained by the effect of gender on engaging in risky behaviors.

Wearing a helmet was also associated with lower hospital or ICU days of stay, and these patients were less likely to die, compared to non-helmet users. This decrease in mortality and lower hospital and ICU stay are consistent with changes seen following the enactment of a mandatory helmet law, and safety information campaigns in Washington State in 1990 (25).

It is perhaps not surprising that females were more likely to have worn a helmet than males when involved in an accident. It is not entirely clear, however, why males in general had higher hospital and ICU stay days, and in mortality. Compared to Whites, there was a significantly higher hospital and ICU length of stay, and higher mortality for Blacks and Hispanics. Patients who are hospitalized or in ICU for that length of time are seriously or critically injured. They may have been involved in crashes so severe that wearing a helmet had little effect on outcomes or suffered serious injury other than to the neck or head. In our analysis, females and males benefitted almost equally by wearing a helmet. The same may be said about mortality; it is possible that patients who succumbed within a relatively short time to their injuries may have been involved in such serious accidents that the use of a helmet could not change the final outcome, for both genders.

Our findings and other research suggest that mandatory helmet laws can improve injury and mortality outcomes of bicycling accidents. However, it remains unclear why compliance seems uneven across different races/ethnicities when helmet use is mandated by law.

Limitations

The National Trauma Data Bank NTDB is known to suffer from significant underreporting. Moreover, data on the type or design of helmet worn by participants were not available. We also did not attempt to differentiate between the mechanics of injury, such as that caused by falling against the curb, or that which resulted from a collision with a motor vehicle. The division of age into two or three categorical variables (for example, age, ISS) with a rigid cut off value may lead to bias to interpret the data.

Conclusions

Our findings reveal a general underutilization of bicycle helmets; only 21% of males, 28% of females, and 12% of children <17 years old who suffered head/neck injury reported using them. The race/ethnicity with the smallest proportion of helmet use were Blacks (6%) and Hispanics (7.6%). These groups suffered from longer hospital and ICU stays, and only Hispanics suffered from higher mortality rates. Overall, our findings suggest wearing a helmet is likely to reduce injury severity, HLOS, ICULOS, and mortality. Further research is necessary into why helmet use practice is low and uneven across racial/ethnic groups. In addition, our results imply that these at-risk groups may benefit from injury prevention and outreach programs that aim to increase helmet use and reduce the risk of head injury and hospitalization.

These patients may have been critically or mortally injured or also suffered a serious injury to other parts of the body, such that a helmet could offer protection against extended stays or even death. This warrants further study to differentiate injury mechanism of injury.

Acknowledgments

Research for this article was supported in part by NIH Accelerated Excellence in Translational Sciences (AXIS) grant number 2U54MD007598-07; and the University of California at Los Angeles (UCLA) Clinical and Translational Science Institute (CTSI), grant number UL1TR001881

Funding

This work was supported by the University of California at Los Angeles (UCLA) Clinical and Translational Science Institute (CTSI) [UL1TR001881]; NIH Accelerated Excellence in Translational Sciences (AXIS) [U54MD007598 (formerly U54RR026138)].

References

1. Joseph B, Azim A, Haider AA, Kulvatunyou N, O'Keeffe T, Hassan A, Gries L, Tran E, Latifi R, Rhee P. Bicycle helmets work when it matters the most. Am J Surg. 2017;213(2):413–17. doi:10.1016/j.amjsurg.2016.05.021. [PubMed: 27596799]
2. Dagher JH, Costa C, Lamoureux J, de Guise E, Feyz M. Comparative outcomes of traumatic brain injury from biking accidents with or without helmet use. Can J Neurol Sci. 2016;43(1):56–64. doi:10.1017/cjn.2015.281. [PubMed: 26786638]
3. Stranges E (Thomson Reuters), Uscher-Pines L. (RAND), Stocks C. (Agency for Healthcare Research and Quality). Emergency department visits and hospital inpatient stays for bicycle-related injuries, 2009. Rockville, MD: Agency for Healthcare Research and Quality; June 2012. HCUP Statistical Brief #135. Available from http://www.hcup-us.ahrq.gov/reports/statbriefs/sb136.pdf
4. Bicyclists and other cyclists: 2013 data. (Traffic Safety Facts. Report No. DOT HS 812151), N.C.f.S.a. Analysis, Editor. 2015, May National Highway Traffic Safety Administration: Washington, DC.
5. Olivier J, Radun I. Bicycle helmet effectiveness is not overstated. Traffic Inj Prev. 2017;18(7):755–760. [PubMed: 28436737]
6. Sethi M, Heidenberg J, Wall SP, Ayoung-Chee P, Slaughter D, Levine DA, Jacko S, Wilson C, Marshall G, Pachter HL, et al. Bicycle helmets are highly protective against traumatic brain injury within a dense urban setting. Injury. 2015;46(12):2483–90. doi:10.1016/j.injury.2015.07.030. [PubMed: 26254573]
7. Thompson DC, Rivara FP, Thompson R. Helmets for preventing head and facial injuries in bicyclists. Cochrane Database Syst Rev. 1999;(4):Cd001855. doi:10.1002/14651858.CD001855.
8. Fahlstedt M, Halldin P, Kleiven S. The protective effect of a helmet in three bicycle accidents – A finite element study. Accid Anal Prev. 2016;91:135–43. doi:10.1016/j.aap.2016.02.025. [PubMed: 26974030]
9. Jewett A, Beck LF, Taylor C, Baldwin G. Bicycle helmet use among persons 5 years and older in the United States, 2012. J Safety Res. 2016;59:1–7. doi:10.1016/j.jsr.2016.09.001. [PubMed: 27846992]
10. Kraemer JD. Helmet laws, helmet use, and bicycle ridership. J Adolesc Health. 2016;59(3):338–44. doi:10.1016/j.jadohealth.2016.03.009. [PubMed: 27160663]
11. Olivier J, Creighton P. Bicycle injuries and helmet use: a systematic review and meta-analysis. Int J Epidemiol. 2017;46(1):278–92. doi:10.1093/ije/dyw153. [PubMed: 27450862]
12. Hofmann LJ, Babbitt-Jonas R, Khoury L, Perez JM, Cohn SM. Fact and fiction regarding motorcycle helmet use, associated injuries, and related costs in the United States. Cureus. 2018;10(11):e3610. doi:10.7759/cureus.3610. [PubMed: 30693163]
13. Kraemer JD. Bicycle helmet laws and persistent racial and ethnic helmet use disparities among urban high school students: a repeated cross-sectional analysis. Inj Epidemiol. 2016;3(1):21. doi:10.1186/s40621-016-0086-3. [PubMed: 27747557]
14. Linn S The injury severity score–importance and uses. Ann Epidemiol. 1995;5(6):440–46. [PubMed: 8680606]
15. Ebell MH, Desai K. Impact of age, location, and bicycle style on helmet usage by adults. Traffic Inj Prev. 2012;13(2):150–54. doi:10.1080/15389588.2011.644255. [PubMed: 22458793]
16. Rezendes JL. Bicycle helmets: overcoming barriers to use and increasing effectiveness. J Pediatr Nurs. 2006;21(1):35–44. doi:10.1016/j.pedn.2005.06.005. [PubMed: 16428012]
17. Dellinger AM, Kresnow MJ. Bicycle helmet use among children in the United States: the effects of legislation, personal and household factors. J Safety Res. 2010;41(4):375–80. doi:10.1016/j.jsr.2010.05.003. [PubMed: 20846554]

18. Pierce SR, Palombaro KM, Black JD. Barriers to bicycle helmet use in young children in an urban elementary school. Health Promot Pract. 2014;15(3):406–12. doi:10.1177/1524839913512329. [PubMed: 24334544]

19. Forjuoh SN, Schuchmann JA, Fiesinger T, Mason S. Parent-child concordance on reported barriers to helmet use by children. Med Sci Monit. 2003;9(10):Cr436–41. [PubMed: 14523333]

20. Baeseman ZJ, Corden TE. A social-ecologic framework for improving bicycle helmet use by children. Wmj. 2014;113(2):49–51. [PubMed: 24908898]

21. Gulack BC, Englum BR, Rialon KL, Talbot LJ, Keenan JE, Rice HE, Scarborough JE, Adibe OO. Inequalities in the use of helmets by race and payer status among pediatric cyclists. Surgery. 2015;158(2):556–61. doi:10.1016/j.surg.2015.02.025. [PubMed: 26044110]

22. Williams C, Weston R, Feinglass J, Crandall M. Pediatric bicycle helmet legislation and crash-related traumatic brain injury in Illinois, 1999–2009. J Surg Res. 2018;222:231–37. doi:10.1016/j.jss.2017.11.006. [PubMed: 29229283]

23. Meehan WP 3rd, Lee LK, Fischer CM, Mannix RC. Bicycle helmet laws are associated with a lower fatality rate from bicycle-motor vehicle collisions. J Pediatr. 2013;163(3):726–29. doi:10.1016/j.jpeds.2013.03.073. [PubMed: 23706604]

24. Kuo SCH, Kuo P-J, Rau C-S, Chen Y-C, Hsieh H-Y, Hsieh C-H. The protective effect of helmet use in motorcycle and bicycle accidents: a propensity score-matched study based on a trauma registry system. BMC Public Health. 2017;17(1):639. doi:10.1186/s12889-017-4649-1. [PubMed: 28784110]

25. Mock CN, Maier RV, Boyle E, Pilcher S, Rivara FP. Injury prevention strategies to promote helmet use decrease severe head injuries at a level I trauma center. J Trauma. 1995;39(1):29–33. discussion 34–5. doi:10.1097/00005373-199507000-00004. [PubMed: 7636907]

Table 1.

Bivariate analysis of demographics and injury outcomes by helmet use among bicyclists with head/neck trauma injury in the NTDB 2002–2012.

Variables	Bicyclists with head/neck injury (n = 76032)			
	Total (n = 76032)	Helmet Use (n = 16789)	No Helmet (n = 59243)	*p*-value
Age				
0–17	25603 (33.7%)	3107 (12.1%)	22496 (87.9%)	<0.0001
18–39	20549 (27.0%)	4192 (20.4%)	16357 (79.6%)	
≥40	29880 (39.3%)	9490 (31.8%)	20390 (68.2%)	
Gender				
Male	61645 (81.1%)	12723 (20.6%)	48922 (79.4%)	<0.0001
Female	14387 (18.9%)	4066 (28.3%)	10321 (71.7%)	
Race/Ethnicity *				
White	46590 (61.3%)	12710 (27.3%)	33880 (72.7%)	<0.0001
Black	7650 (10.1%)	462 (6.0%)	7188 (94.0%)	
Hispanic	9474 (12.4%)	722 (7.6%)	8752 (92.4%)	
API **	2078 (2.7%)	553 (26.6%)	1525 (73.4%)	
Other	2977 (3.9%)	538 (18.1%)	2439 (81.9%)	
Injury Outcomes				
Injury severity score (ISS)				
mean ± SD	11.06 ± 9.33	11.15 ± 9.22	11.03 ± 9.36	0.0638
Median (IQR)	9.00 (12.00)	9.00 (12.00)	9.00 (12.00)	
Injury severity score (ISS) groups				
Minor (1–3)	10616 (15.4%)	2045 (19.3%)	8571 (80.7%)	<0.0001
Moderate (4–8)	21359 (30.9%)	4749 (22.2%)	16610 (77.8%)	
Serious (9–15)	16344 (23.6%)	4174 (25.5%)	12170 (74.5%)	
Severe (16–24)	15380 (22.2%)	3144 (20.4%)	12236 (79.6%)	
Critical (25–75)	5480 (7.9%)	1091 (19.9%)	4389 (80.1%)	
HLOS (day)				
mean ± SD	3.50 ± 7.87	3.08 ± 5.36	3.62 ± 8.47	–
Median (IQR)	1.00 (3.00)	1.00 (3.00)	1.00 (3.00)	0.0060
ICULOS (day)				
mean ± SD	3.81 ± 6.91	3.59 ± 6.36	3.87 ± 7.03	–
Median (IQR)	2.00 (3.00)	2.00 (2.00)	2.00 (3.00)	0.3168
Total mortality (N=)	2295 (3.0%)	357 (2.1%)	1938 (3.3%)	<0.0001
In hospital (N = 1188)	1738 (2.3%)	264 (1.6%)	1474 (2.5%)	<0.0001
ED/Before arrival to ED	557 (0.7%)	93 (0.6%)	464 (0.8%)	<0.0021

* Race/Ethnicity total missing 7263 (9.6%)

** Asian/Pacific Islander

Wilcoxon test was used to test median differences in ISS, HLOS, ICULOS.

Table 2.

Adjusted beta coefficient and standard error [$] of the hospital (HLOS) and ICU length of stay (ICULOS), and injury severity score (ISS) mortality in relation to helmet use among cyclist with head/neck injury, NTDB 2002–2012.

	Injury outcomes		
	HLOS	ICULOS	*ISS*
Predictors	**Adjusted β (SE)**	**Adjusted β (SE)**	**Adjusted β (SE)**
Helmet use			
Yes	−0.272 (0.017) **	−0.142 (0.019) **	−0.6709 (0.1012) *
No	Ref	Ref	Ref
Race/ethnicity			
White	Ref	Ref	Ref
Black	0.201 (0.024) **	0.243 (0.024) **	−0.7176 (0.1209) *
Hispanic	0.144 (0.021) **	0.140 (0.023) **	−0.8691 (0.2163) *
Asian/PI	0.111 (0.040) *	0.119 (0.046) *	−0.1186 (0.2165)
Other	0.240 (0.036) **	0.129 (0.039) *	−0.1173 (0.1813)
Age			
0–17	−0.933 (0.018) **	−0.656 (0.017) **	−3.1333 (0.0842) *
18–39	−0.497 (0.017) **	−0.282 (0.018) **	−2.5572 (0.0886) *
≥40	Ref	Ref	Ref
Gender			
Male	0.195 (0.018) **	0.177 (0.019) **	0.5948 (0.0902) *
Female	Ref	Ref	Ref

* Statistically significant at $p < 0.001$

** Statistically significant at $p < 0.0001$

$ Using Zero-inflated Negative Binomial Regression Model

Table 3.

Adjusted odds ratio (AOR) [$] and 95% confidence interval (CI) [$] of the mortality in relation to helmet use among cyclist with head/neck injury, NTDB 2002–2012.

	Total mortality (in-hospital plus ED)	***In hospital Mortality***
Predictors	**AOR (95% CI)**	**AOR (95% CI)**
Helmet use		
Yes	0.56 (0.50–0.63) [**]	0.52 (0.45–0.59) [**]
No	Ref	Ref
Race/ethnicity		
White	Ref	Ref
Black	1.19 (1.04–1.37) [*]	1.09 (0.93–1.28)
Hispanic	1.17 (1.03–1.34) [*]	1.14 (0.98–1.32)
Asian/PI	1.28 (1.00–1.63)	1.17 (0.88–1.56)
Other	1.18 (0.95–1.46)	1.09 (0.85–1.41)
Age		
0–17	0.27 (0.24–0.31) [**]	0.22 (0.19–0.25) [**]
18–39	0.47 (0.42–0.52) [**]	0.45 (0.40–0.51) [**]
≥40	Ref	Ref
Gender		
Male	1.36 (1.21–1.54) [**]	1.31 (1.14–1.51) [**]
Female	Ref	Ref

[*] Statistically significant at $p < 0.001$

[**] statistically significant at $p < 0.0001$

[$] Multiple logistic regression