

Motorcycle Helmet Use and Legislation: A Systematic Review of the Literature
By Matthew Byrnes, M.D., and Susan Gerberich, Ph.D.

Minnesota Medicine, Clinical and Health Affairs, January 2012

<http://www.minnesotamedicine.com/Past-Issues/Past-Issues-2012/January-2012/Motorcycle-Helmet-Use-and-Legislation>

■ Although there has been a marked improvement in the safety profiles of cars and in car crash outcomes, there has been a marked worsening in outcomes of motorcycle collisions. Motorcycles account for only 2% of vehicle registrations in the United States, but motorcycle collisions account for 10% of traffic deaths. Further, motorcycle riders are 34 times more likely to die in a traffic collision than automobile drivers. Motorcycle helmet use has been suggested to be an effective way to reduce death and disability after traffic collisions, and enactment of universal helmet laws has been suggested as a means to enforce helmet use. This article presents findings from an analysis of National Highway Traffic Safety Administration data and studies in the medical literature on the impact of motorcycle helmet use and helmet legislation on the risk of death or injury in motorcycle accidents. The authors found voluminous support for motorcycle helmet use as a way to prevent severe traumatic brain injury and traffic fatalities.

Trauma is the most common cause of mortality among children and young adults. Many trauma-related deaths are the result of traffic collisions. According to the National Safety Council, approximately 40,000 traffic fatalities occur each year in the United States. Although there has been a marked improvement in the safety profiles of cars and in automobile-related crash outcomes, there has been a marked worsening in outcomes of collisions involving motorcycles. Motorcycle fatalities increased by 89% from 1997 to 2004.¹ Although motorcycles account for only 2% of vehicles registered in the United States, collisions involving motorcycles account for 10% of traffic deaths.^{1,2} Further, motorcycle riders are 34 times more likely than automobile drivers to die in a traffic collision.³ Motorcycle-related fatalities have been steadily increasing over the past 15 years. This roughly corresponds to a time period during which helmet use has decreased by 20%.² As such, motorcycle injuries represent a significant public health issue.

Use of helmets has been suggested as an effective way to reduce death and disability caused by collisions involving motorcycles. Laws requiring the use of helmets were on the books in nearly every state in the 1970s (see “Helmet Laws in the United States,” p. 62).^{2,4,5} Those laws have been steadily repealed in many states over the past three decades. In 1968, Minnesota enacted a universal helmet law. It was revised in 1977, requiring helmet use only among those 17 years of age and younger.

In this article, we review the literature on motorcycle helmet use and helmet laws as they pertain to injury prevention.

Methods

This review is based on a search of articles listed in PubMed during the past 25 years, using the search terms “motorcycle helmet and injury” (363 references); “motorcycle helmet laws” (110 references); and “motorcycle helmet legislation” (165 references). We excluded case reports and articles that were not published in English. We evaluated abstracts and obtained full copies of those studies that appeared to be original research or meta-analyses. Studies that focused on

countries other than the United States were excluded, as each country has unique legislative and traffic considerations, making international comparisons difficult. The bibliography sections of the selected articles were reviewed to identify additional references.

Effect of Helmet Use on Morbidity and Mortality

A number of studies have looked at the effect of motorcycle helmet use on outcomes of motorcycle crashes.^{3,6} (For a full list of the studies examined click [here](#).) Although their methodologies vary, these studies almost uniformly demonstrate the benefits of helmet use in reducing mortality. A total of 29 studies were found that evaluated the effect of motorcycle helmet use on traffic injuries and fatalities in the United States; each one noted a benefit to helmet use.

Studies done by the National Highway Traffic Safety Administration (NHTSA) concluded that for every 100 motorcycle fatalities, 37 lives could be saved through helmet use.² Two meta-analyses have been conducted on helmet use and injury.^{6,7} They included 61 and 53 primary studies, respectively (although there is significant overlap of primary studies included in them). The meta-analyses found that the highest-quality studies reported that the incidence of brain injury could be reduced by 72% and the risk of death could be reduced by 42% with helmet use.

Anti-helmet lobbyists have argued that helmets may reduce the risk of head injury but that they increase the risk of spine fractures. Several studies evaluated this theory, and none have found any difference in the incidence of cervical spine fractures among helmeted riders.⁸⁻¹¹ As such, the bulk of the literature does not support the argument that helmet use results in greater cervical spine injury rates.

Effect of Helmet Laws on Traffic Fatalities and Injuries

■ National Studies

We found 13 studies that evaluated the effect of helmet legislation on the outcome of traffic collisions involving motorcycles in the United States.^{2,4,12-21} A summary of these studies is listed in the table on this page. Among them, 12 showed a benefit of universal motorcycle helmet legislation, and one showed no difference with legislation. The advantage of national studies is that they are able to evaluate trends in all states and can compare outcomes in states with universal helmet laws with those of states without universal helmet laws. The disadvantage is that nearly all of these studies draw from the same database, the Fatality Analysis Reporting System (FARS) database, which tracks motorcycle deaths in every state and is administered by the NHTSA.¹⁸ This database only includes fatalities, which prohibits us from making inferences with respect to nonfatal injuries. Additionally, studies that evaluate the same database utilize the same cohort of subjects, so repeated studies do not represent unique study samples. The NHTSA data show two major upward trends in motorcycle fatality rates since 1975. The first began in 1976 and the second began in 1995. Both years correspond to the repeal of federal legislation that provided states with incentives to enact helmet laws. Although this observation does not take into account other factors that affect traffic fatalities, it provides a framework for discussion.

Houston et al. conducted multiple analyses of FARS data from 1975 to 2004.^{4,15,22,23} During this time period, multiple legislative changes took place, including the repeal of helmet laws in some states. They noted a 12% to 23% increase in fatalities in the states that most recently

repealed their laws compared with states that still have universal helmet laws. They also noted a 28% reduction in fatality rates in the calendar years in which states had universal helmet laws compared with the years after they repealed their helmet laws.

French et al. compiled an extensive, multi-agency database that may not be subject to the selection biases suggested in the FARS database and allows for a much more in-depth evaluation of traffic fatalities.¹⁴ They used it to evaluate motorcycle crashes from 1990 to 2005 and found that universal helmet laws reduced nonfatal injuries by 20%. They also found a 24% reduction in fatalities in states with universal laws compared with states that had partial laws or no laws. They concluded that of the various public policy options, universal helmet laws have the greatest potential to reduce motorcycle fatalities.

In 2001, Coben et al. used the Healthcare Cost and Utilization Project database, which includes data from 33 states, to evaluate nonfatal injuries.¹³ Using a cross-sectional design, they identified a difference in intracranial injuries between states with and without universal helmet laws (16% vs. 11%, respectively) and noted that riders in states with universal helmet laws were 41% less likely to have severe brain injuries than riders in states without such laws. In states with universal helmet laws, the need for long-term care following motorcycle crashes also was reduced.

The number of lives that would be saved by universal helmet laws was calculated by Dee et al.² They noted that between 2,000 and 2,500 motorcycle fatalities occur each year among unhelmeted riders and estimated that 650 lives would be saved every year if all states had universal helmet laws, assuming that every rider wears a helmet and that helmets are 25% to 35% effective in preventing fatalities.

Not all studies demonstrated a positive effect of helmet legislation, however. Branas et al. evaluated the FARS database from 1994 to 1996.¹² After controlling for multiple variables, they found no changes in the fatality rate per motorcycle registrations. This study has been criticized because of the very narrow time period examined, the lack of inclusion of the repeal time period, and its statistical model.¹⁵ Additionally, a power analysis was not conducted.

■ State-Based Studies

Our literature review included 16 state-based studies. Of those, 14 showed a benefit to universal helmet laws, and two showed no changes with universal helmet laws (Figure). Six states repealed helmet legislation in the years that followed the Congressional action of 1995; two additional states have reinstated helmet laws in recent years. We examined the effect of law changes in Florida, Pennsylvania, Louisiana, Arkansas, California, and Maryland, as these are the states in which studies on this topic have been published.

Florida • Florida repealed its universal helmet law in 2000. Okeefe et al. evaluated motorcycle riders who presented to a single hospital in Miami following a crash.²⁴ They noted that fatalities increased between 1997 (n=22) and 2003 (n=43); however, the number of fatalities standardized for motorcycle registrations did not change. This study has been criticized for its limited geographic range and its dependence on hospital records rather than population-based databases. Another study found that brain injuries increased after the state's universal helmet law was

repealed.²⁵ Yet another that utilized a statewide database concluded that repeal of the law resulted in a 25% increase in crash fatalities;²⁶ 117 additional deaths were attributed to the law's repeal during the years 2001-2002.

California • California enacted helmet legislation for the first time in 1992. Kraus et al. evaluated medical records from 18 California hospitals in 10 counties between 1991 and 1993, and reported a reduction in skull fractures and traumatic brain injuries among motorcycle riders from 38% to 25% following the legislation.²⁷ This study has been criticized for using hospital records rather than population-based databases, its narrow time period, and the lack of control for other factors. The authors also evaluated police reports and death certificates in 11 California counties and found that fatality rates per motorcycle registration were reduced by 26.5%.²⁸

Pennsylvania • Pennsylvania's universal helmet law was repealed in 2003. Mertz et al. evaluated the Pennsylvania Department of Transportation's database and noted that fatalities caused by head injury increased by 66% after repeal of the legislation.²⁹ This is likely the most complete state-based study, as it relies on a population-based database rather than individual hospital records.

Arkansas • Arkansas repealed its universal helmet law in 1997. Although total motorcycle fatalities did not increase, there was a significant increase in fatalities among unhelmeted riders.^{30,31}

Maryland • Maryland enacted a universal helmet law in 1992. Auman et al. reviewed fatalities in the state during a three-year period before and after the helmet law was enacted.³² They found the number of motorcycle-related fatalities dropped by 55% despite the number of motorcycle registrations remaining the same during that time period.

Louisiana • Louisiana repealed its universal helmet law in 1999 and then re-enacted it in 2004. During the repeal period, statewide motorcycle-related fatalities increased by 3% to 4%.³³ There have not been any studies published to date that have evaluated the reinstatement of the universal helmet law.

Other states • Mock et al. evaluated motorcycle trauma at a single trauma center in the state of Washington and noted a reduced incidence of traumatic brain injury after the state instituted its universal helmet law.³⁴ A similar trend was noted in Nebraska.³⁵ Proscia et al. compared outcomes in New York, which has a universal helmet law, with those in Connecticut, which has a partial law, and reported that riders wore helmets more often in New York and that the number of fatalities was higher in Connecticut.³⁶

States with partial laws • Twenty-seven states including Minnesota have partial laws regarding helmet use. These laws typically require riders under the age of 18 or 21 to wear a helmet. Houston et al. noted that fatalities among riders ages 15 to 20 years of age were 31% lower in states with universal helmet laws than in states with partial laws.²² Further, states with partial helmet laws had fatality rates similar to states with no helmet laws. Several other studies reached the same conclusion.^{37,38} It has been suggested that partial helmet laws are difficult to enforce,

as police have to make a rapid determination of a rider's age, which likely leads to under-enforcement.

The effect of partial laws on nonfatal injuries has been studied less extensively. Coben et al. noted that a variety of nonfatal injuries were seen less often in states with universal helmet laws than in those with no or partial laws.¹ Weiss et al. noted that the incidence of traumatic brain injury was 38% higher among youths in states with partial helmet laws than those in states with universal helmet laws.³⁷

Discussion

The actual effect of helmet legislation could deviate from the expected effects for a number of reasons.² The Peltzman hypothesis has suggested that the protective effects of universal helmet legislation may be mitigated by increased risk-taking among riders.² Additionally, universal helmet laws could give a false sense of security, thereby increasing the number of motorcycle riders, which could result in more fatalities. Alternatively, helmet laws could be more efficacious than predicted. Universal helmet laws could result in greater police scrutiny of motorcycle riders, which could result in fewer crashes. Additionally, some people may stop riding motorcycles if they are required to wear a helmet. Dee et al. evaluated these possibilities with a retrospective review of the FARS database.² This review was significant in that it focused on the years 1988 to 2005, which corresponded with changes in urban traffic, the size of motorcycle engines, and legislation. The expected reduction in traffic fatalities was estimated by assuming an opportunity to influence 50% of motorcycle riders with legislation as well as a 34% efficacy rate of helmets in reducing fatalities. This led to an expected 20% reduction in fatalities. Several national studies have reported actual reductions much higher than 20%, which suggests that the Peltzman hypothesis is incorrect and that helmet laws may have benefits that extend past simple helmet usage.

Weather differences among states can be a confounding factor in evaluating motorcycle fatalities. However, Morris, et al. found that there was a reduction in mortality associated with helmet laws despite controlling for weather differences.¹⁸ Similarly, in controlling for various states' licensing and training requirements, McGwin et al. noted that the relative risk of death was 0.77 among states with universal helmet laws.¹⁷

A concern with the interpretation of these studies is that there are a variety of ways to calculate mortality from traffic crashes.³⁹ As such, the metric used to calculate mortality rates varied across studies. The three most commonly used metrics in the national database studies were fatalities per motorcycle registration, fatalities per population, and fatalities per mile driven. These metrics have been used to standardize mortality rates. State-level studies typically report either unadjusted rates or fatalities per motorcycle registration. Although this has been a criticism lodged against motorcycle helmet studies, the conclusions that are drawn from them are consistent between methodologies. Regardless of the metric used, the majority of studies indicate that motorcycle helmets and helmet use legislation are effective in reducing motorcycle collision fatalities.^{2,14}

Other criticisms of helmet studies include the fact that it is difficult to evaluate driving habits across states. For instance, it is possible that risk-taking behavior is higher in certain states and

that these behaviors are the driving force behind increased fatalities. Additionally, helmet studies focus on various time periods, which make comparison between studies difficult. There also has been a trend toward motorcycles with larger engines that could result in increased fatalities, independent of helmet use.¹⁵ National studies have attempted to control for these variables by using time series analyses. The final criticism is that no studies are able to accurately evaluate fatality rates as a function of miles driven.

None of these criticisms significantly alter the conclusion of the vast majority of studies that motorcycle helmet use and universal helmet laws are associated with a reduction in traffic fatalities.

Conclusion

The evidence for the protective effects of motorcycle helmets is very strong. There is convincing evidence that motorcycle helmet use reduces both traumatic brain injuries and death after collisions. A preponderance of evidence also suggests that universal helmet laws are very effective in reducing fatalities and injuries associated with motorcycle collisions, although a couple of studies dispute the effect of helmet legislation. It is likely that 500 to 1,000 lives could be saved each year by national adoption of universal helmet laws. MM
Matthew Byrnes is with the University of Minnesota's Division of Acute Care Surgery and North Memorial Medical Center's Division of Trauma. Susan Gerberich is with the University of Minnesota's School of Public Health.

References

1. Coben J, Steiner C, Miller T. Characteristics of motorcycle-related hospitalizations: Comparing states with different helmet laws. *Accid Anal Prev.* 2007;39(1):190-6.
2. Dee TS. Motorcycle helmets and traffic safety. *J Health Econ.* 2009 Mar;28(2):398-412.
3. Savolainen P, Mannering F. Probabilistic models of motorcyclists' injury severities in single- and multi-vehicle crashes. *Accid Anal Prev.* 2007 Sep;39(5):955-63.
4. Houston DJ, Richardson LE, Jr. Motorcycle safety and the repeal of universal helmet laws. *Am J Public Health.* 2007 Nov;97(11):2063-9.
5. Derrick AJ, Faucher LD. Motorcycle helmets and rider safety: a legislative crisis. *J Public Health Policy.* 2009 Jul;30(2):226-42.
6. Liu BC, Ivers R, Norton R, Boufous S, Blows S, Lo SK. Helmets for preventing injury in motorcycle riders. *Cochrane Database Syst Rev.* 2008;23(1):CD004333.
7. Liu B, Ivers R, Norton R, Blows S, Lo SK. Helmets for preventing injury in motorcycle riders. *Cochrane Database Syst Rev.* 2004;(2):CD004333.
8. Peek-Asa C, McArthur DL, Kraus JF. The prevalence of non-standard helmet use and head injuries among motorcycle riders. *Accid Anal Prev.* 1999;31(3):229-33.
9. Johnson RM, McCarthy MC, Miller SF, Peoples JB. Craniofacial trauma in injured motorcyclists: the impact of helmet usage. *J Trauma.* 1995;38(6):876-8.
10. Goslar PW, Crawford NR, Petersen SR, Wilson JR, Harrington T. Helmet use and associated spinal fractures in motorcycle crash victims. *J Trauma.* 2008;64(1):190-6; discussion 196.
11. Wagle VG, Perkins C, Vallera A. Is helmet use beneficial to motorcyclists? *J Trauma.* 1993;34(1):120-2.
12. Branas CC, Knudson MM. Helmet laws and motorcycle rider death rates. *Accid Anal Prev.* 2001;33(5):641-8.

13. Coben JH, Steiner CA, Miller TR. Characteristics of motorcycle-related hospitalizations: comparing states with different helmet laws. *Accid Anal Prev.* 2007;39(1):190-6.
14. French MT, Gumus G, Homer JF. Public policies and motorcycle safety. *J Health Econ.* 2009;28(4):831-8.
15. Houston DJ, Richardson LE. Motorcyclist fatality rates and mandatory helmet-use laws. *Accid Anal Prev.* 2008;40(1):200-8.
16. Mayrose J. The effects of a mandatory motorcycle helmet law on helmet use and injury patterns among motorcyclist fatalities. *J Safety Res.* 2008;39(4):429-32.
17. McGwin G Jr, Whatley J, Metzger J, Valent F, Barbone F, Rue LW 3rd. The effect of state motorcycle licensing laws on motorcycle driver mortality rates. *J Trauma.* 2004;56(2):415-9.
18. Morris CC. Generalized linear regression analysis of association of universal helmet laws with motorcyclist fatality rates. *Accid Anal Prev.* 2006;38(1):142-7.
19. Sosin DM, Sacks JJ, Holmgren P. Head injury—associated deaths from motorcycle crashes. Relationship to helmet-use laws. *JAMA.* 1990;264(18):2395-9.
20. Sosin DM, Sacks JJ. Motorcycle helmet-use laws and head injury prevention. *JAMA.* 1992;267(12):1649-51.
21. Sass TR, Zimmerman PR. Motorcycle helmet laws and motorcyclist fatalities. *J Regulatory Economics.* 2000;18(3):195-215.
22. Houston DJ. Are helmet laws protecting young motorcyclists? *J Safety Res.* 2007;38(3):329-36.
23. Houston DJ. The case for universal motorcycle helmet laws. *South Med J.* 2010;103(1):1-2.
24. O’Keeffe T, Dearwater SR, Gentilello LM, Cohen TM, Wilkinson JD, McKenney MM. Increased fatalities after motorcycle helmet law repeal: is it all because of lack of helmets? *J Trauma.* 2007;63(5):1006-9.
25. Hotz GA, Cohn SM, Popkin C, et al. The impact of a repealed motorcycle helmet law in Miami-Dade County. *J Trauma.* 2002;52(3):469-74.
26. Kyrychenko SY, McCartt AT. Florida’s weakened motorcycle helmet law: effects on death rates in motorcycle crashes. *Traffic Inj Prev.* 2006;7(1):55-60.
27. Kraus JF, Peek C. The impact of two related prevention strategies on head injury reduction among nonfatally injured motorcycle riders, California, 1991-1993. *J Neurotrauma.* 1995;12(5):873-81.
28. Kraus JF, Peek C, McArthur DL, Williams A. The effect of the 1992 California motorcycle helmet use law on motorcycle crash fatalities and injuries. *JAMA.* 1994;272(19):1506-11.
29. Mertz KJ, Weiss HB. Changes in motorcycle-related head injury deaths, hospitalizations, and hospital charges following repeal of Pennsylvania’s mandatory motorcycle helmet law. *Am J Public Health.* 2008;98(8):1464-7.
30. Bledsoe GH, Schexnayder SM, Carey MJ, et al. The negative impact of the repeal of the Arkansas motorcycle helmet law. *J Trauma.* 2002;53(6):1078-86; discussion 1086-7.
31. Bledsoe GH. Arkansas and the motorcycle helmet law. *J Ark Med Soc.* 2004;100(12):430-3.
32. Auman KM, Kufera JA, Ballesteros MF, Smialek JE, Dischinger PC. Autopsy study of motorcyclist fatalities: the effect of the 1992 Maryland motorcycle helmet use law. *Am J Public Health.* 2002;92(8):1352-5.
33. Ho EL, Haydel MJ. Louisiana motorcycle fatalities linked to statewide helmet law repeal. *J La State Med Soc.* 2004;156(3):151-2,4-5,7.

34. 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.
35. Muelleman RL, Mlinek EJ, Collicott PE. Motorcycle crash injuries and costs: effect of a reenacted comprehensive helmet use law. *Ann Emerg Med*. 1992 Mar;21(3):266-72.
36. Proscia N, Sullivan T, Cuff S, et al. The effects of motorcycle helmet use between hospitals in states with and without a mandatory helmet law. *Conn Med*. 2002 Apr;66(4):195-8.
37. Weiss H, Agimi Y, Steiner C. Youth motorcycle-related brain injury by state helmet law type: United States, 2005-2007. *Pediatrics*. 2010;126(6):1149-55.
38. Brooks E, Naud S, Shapiro S. Are youth-only motorcycle helmet laws better than none at all? *Am J Forensic Med Pathol*. 2010;31(2):125-9.
39. Lin MR, Kraus JF. Methodological issues in motorcycle injury epidemiology. *Accid Anal Prev*. 2008;40(5):1653-60.