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Bicycle Helmet Laws are Associated with a Lower Fatality Rate from Bicycle-Motor Vehicle Collisions

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Abstract

Objective—To assess the association between bicycle helmet legislation and bicycle-related deaths sustained by children involved in bicycle-motor vehicle collisions.

Study design—We conducted a cross sectional study of all bicyclists aged 0-16 years included in the Fatality Analysis Reporting System (FARS) who died between January 1999 and December 2010. We compared fatality rates per age-specific state populations between states with helmet laws and those without helmet laws. We used a clustered Poisson multivariate regression model to adjust for factors previously associated with rates of motor vehicle fatalities: elderly driver licensure laws, legal blood alcohol limit (< 0.08% vs. 0.08%), and household income.

Results—A total of 1,612 bicycle-related fatalities were sustained by children <16 years old. There were no statistical differences in median household income, the proportion of states with elderly licensure laws, or the proportion of states with a blood alcohol limit of > 0.08 between states with helmet laws and those without helmet laws. The mean unadjusted rates of fatalities were lower in states with helmet laws (2.0/1,000,000 vs. 2.5/1,000,000; $p=0.03$). After adjusting for potential confounding factors, states with mandatory helmet laws continued to be associated with a lower rate of fatalities (adjusted Incidence Rate Ratio 0.84; 95% CI 0.70, 0.98).

Conclusions—Bicycle helmet safety laws are associated with a lower incidence of fatalities among child bicyclists involved in motor vehicle collisions.

Keywords

cyclists; traumatic brain injury; death; legislation

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In the United States, approximately 900 people annually die in bicycle crashes, three quarters of them from head injuries.¹ Bicycle helmets were introduced more than 30 years ago in an attempt to decrease these.² Over the last twenty years, several case-controlled and epidemiological studies have demonstrated the efficacy of bicycle helmets, showing a lower risk of injury and death for bicyclists wearing helmets compared with unhelmeted cyclists.³⁻¹⁰ Thompson et al found that riders wearing bicycle helmets had an 88% reduction in their risk of brain injury, when compared with riders without helmets.⁹ Furthermore, a meta-analysis of case-controlled studies examining the efficacy of bicycle helmets in cyclists involved in a crash or fall, which included over 11,000 subjects, helmets were shown to provide a 63%-88% reduction in the risk of head, brain, and severe brain injury for bicyclists of all ages.¹ The American Academy of Pediatrics recommends that all bicyclists wear a properly fitted bicycle helmet every time they ride, and they encourage legislation requiring helmet use by all bicyclists.¹¹

Initially, educational and promotional campaigns were developed to increase bicycle helmet use among riders.¹² Such campaigns were expensive and demonstrated only limited success.¹² Given the documented benefits of helmets, mandatory helmet laws were introduced as an easy-to-implement means of increasing helmet usage.¹² Legislators across the United States enacted laws mandating the use of bicycle helmets, but often limited the requirement to children less than 16 years old. Several investigators have studied the effect of bicycle helmet laws on helmet usage^{4, 13, 14} and on the rates of bicycle-related head injuries and death on a local level,^{4, 15, 16} but the effect of such legislation on the national rates of injury is unknown.

We sought to assess the effect of bicycle helmet legislation nationally, by examining the association between bicycle helmet legislation and bicycle-related deaths due to motor vehicle crashes sustained by children less than 16 years old using a large national database.

METHODS

We conducted a cross sectional study using data obtained from the Fatality Analysis Reporting System (FARS). The FARS is a census compiled by the National Highway Traffic Safety Administration (NHTSA) that includes data from all motor vehicle crashes that occur on a traffic way customarily open to the public and result in the death of a motorist or non-motorist within 30 days of the crash. The FARS contains detailed information on the vehicles, cyclists, drivers, occupants, and non-occupants involved in the crash as well as details regarding helmet use of adults and children. The FARS data are derived from a census of fatal traffic crashes within the 50 states, the District of Columbia, and Puerto Rico. The NHTSA has a cooperative agreement with an agency in each state government to provide specific information in a standard format on crashes that result in a fatality from each state. All FARS data on fatal motor vehicle traffic crashes is gathered from the state's own source documents, coded on standard FARS forms, and checked for consistency by NHTSA. A detailed coding manual is produced annually and is augmented by FARS classes and an annual system-wide FARS meeting designed to reinforce uniform coding practices.

Most state laws regarding the use of bicycle helmets apply only to children, usually under the age of 16 years. Therefore, we identified all bicyclists aged 0-16 years included in the FARS database that died between January 1999 and December 2010.

All U.S. states and the District of Columbia were included in the analysis. We adjusted for the following factors that have been previously associated with motor vehicle fatalities and could potentially affect bicycle injuries: age-based elderly licensure laws, legal blood

alcohol limit (< 0.08% vs. 0.08%), and median state household income.¹⁸⁻²⁴ Because pediatric bicyclist-motor vehicle collisions are uncommon on highways, we did not adjust for legislation regarding speed limits. We calculated the number of state-years that helmet use laws were in effect by multiplying the number of states with the helmet law by the number of years that the law was in effect during the study period. Date of helmet law passage and enactment were obtained from several sources including the Insurance Institute for Highway Safety and the Governor's Highway Safety Administration.

Our primary outcome measure was death.

Data Analyses

We compared fatality rates in states with helmet laws to those without helmet laws. All states that passed helmet laws during the study period did so within a short time interval, at the start of our study period. Therefore, in order to be conservative in our estimates, they were analyzed as having a law. To determine fatality rates, we used the total number of deaths divided by age-specific state populations obtained from the United States Census Bureau.²⁵ Next, we created a multivariate model to account for other legislative and economic factors previously shown to be associated with motor vehicle fatalities. We used a clustered Poisson multivariate regression model adjusted for maximum legal blood alcohol limit, median household income and age-based elderly licensure laws. We defined age-based elderly licensure laws as those laws that had specific age-based renewal procedures; that is, at a given age, the State may reduce the time interval between license renewal, restrict the ability to obtain license renewal by mail, require on-road testing, require a physician's report, and/or require specific vision, traffic law, and sign knowledge. To account for state-level effects not included in our model, we utilized state level clustering in the multivariate model. All of the data analyses were performed using STATA SE, version 11 (StataCorp, College Station, TX).

RESULTS

There were more than 200 state-years of mandatory helmet legislation during the study period (Table I), with 16 states having already enacted laws regarding helmet use at the start of the study period. The overall rate of bicycle-related fatalities in the United States in 1999 was 4.0/1,000,000 children. Although there were no statistical differences in median household income, the proportion of states with age-based licensure laws, or the proportion of states with a legal blood alcohol limit of > 0.08 between those states with helmet laws and those without helmet laws, the rates of bicycle-related fatalities were significantly lower in states with mandatory helmet legislation (Table II).

During the 12 year study period, a total of 1,612 bicycle-motor vehicle related fatalities were sustained by children <16 years old. The mean unadjusted rates of fatalities sustained by children <16 years old was significantly lower in states with helmet laws than states without helmet laws (2.0/1,000,000 children vs. 2.5/1,000,000 children; $p=0.03$) yielding an Incidence Rate Ratio (IRR) of 0.83 (95% CI 0.69, 0.99). When we adjusted for other motor vehicle legislation and economic factors in the multivariate analysis, helmet laws continued to be associated with a lower risk of fatalities (adjusted IRR 0.84; 95% CI 0.70, 0.98).

DISCUSSION

Our study shows that bicycle helmet safety laws in the United States are associated with a lower national incidence of fatalities among bicyclists less than 16 years old who suffer collisions involving a motor vehicle. In 1999, only 16 states had bicycle helmet laws; those states had a lower rate of fatalities than the 35 states without helmet laws. After adjusting for

other motor vehicle legislation and state specific economic factors, states with helmet laws demonstrated a 20% decrease in the rate of bicycle-motor vehicle related deaths and injuries compared with states without helmet laws.

Our findings are in contrast with a recent review of pediatric trauma patients in Los Angeles County that reported that the statewide helmet law had no significant effect on helmet use or on the proportion of pediatric head injury patients who were helmeted.²⁶ Other previous studies, however, have reached conclusions similar to ours. Using a trauma registry in San Diego County, California, Ji et al showed that helmet use increased after the introduction of legislation, and that helmet use by bicycle-related trauma patients was associated with a decreased odds of suffering a serious head injury.⁴ Similarly, a study using the discharge records of all California public hospitals found the proportion of traumatic brain injuries sustained by youth bicyclists decreased by 18% after bicycle safety helmet legislation.¹⁵ In addition, an examination of bicycle related mortality rates in Ontario, Canada, by Wesson et al showed that the rate of bicycle related mortality decreased significantly after the introduction of a law requiring pediatric bicyclists (<18 years old) to wear a helmet when riding on a public way.¹⁶

As with many of the above studies, which illustrate a decrease in the risk of serious head injury after the introduction of mandatory bicycle helmet laws, our study shows that on a national level, states with mandatory pediatric bicycle helmet laws have a lower incidence of fatalities after collisions involving cyclists and motor vehicles. Our findings support the legislation of mandatory bicycle helmet use by children.

In this information age, when parents can be inundated with injury prevention information concerning their children, legislation can be an important factor in helping parents adhere to best practice guidelines. This phenomenon has been seen in other mandatory safety laws, such as the use of booster seats by children. In one study about booster seat use, many parents commented that they looked to the law to guide them about appropriate car seat use for their children.²⁷ Similarly, a state-wide survey of parents found that 70% of part-time booster seat users said they used them because they believed it was the law, and over 90% of part-time and non-booster seat users reported it would be easier for them to use a booster seat if there were a law.²⁸ For children ages 4-7 years old, booster seat laws lead to an increase in booster use, and decrease the risk suffering a fatality during a motor vehicle collision.²⁹

Our results must be interpreted in light of several limitations. The FARS database is limited to injuries sustained during a motor vehicle collision that resulted in the death of at least one person within 30 days of the collision. As a result, our findings likely underestimate the effects of the mandatory helmet laws, as we did not capture all pediatric bicycle-related injuries. Indeed, previous authors have shown the benefit of bicycle helmet usage and mandatory helmet legislation in reducing head injuries and death.^{1,3,4,6,15,16} Second, little is known about the degree of helmet law enforcement by states, the independent effect of which can be hard to assess, although previous studies suggest that mandatory helmet laws are enforced in certain circumstances and communities,^{32,33} and have shown an increase in helmet use after the introduction of legislation.^{4,12-14} Finally, some authors argue that mandatory helmet laws decrease bicycle ridership, and therefore, the benefits of helmets preventing head injuries may be offset by the medical problems that arise from a decreased number of cyclists.^{30, 31} Our study does not address the effect of helmet laws on ridership.

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Abbreviations

FARS	Fatality Analysis Reporting System
NHTSA	National Highway Traffic Safety Administration
US	United States

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Table 1

Number of State-Years that Policy in Effect

Law	No. State-Years (n=561)
Helmet laws	219
Maximum highway speed limit, mph 65	209
Age-based licensure law	341
Blood alcohol level of 0.08	437

Table 2

State-Level Statistics in 1999 (50 States and the District of Columbia, n=51)

	States with Helmet Laws (n=16)	States without Helmet Laws (n=35)
Bicycle Fatalities sustained by children <16 years per 1,000,000 children, mean (SD)*	2.7 (2.3)	4.5 (4.6)
Median household income median (interquartile range)	52,739 (48,599, 59,298)	50,543 (42,767, 59,757)
Other State Laws, No. (%) of states		
Age-based licensure laws	8 (50%)	23 (66%)
Blood alcohol level of 0.08	6 (38%)	15 (43%)

*
p<0.05