

Bicycle Helmet Laws Are Associated with a Lower Fatality Rate from Bicycle–Motor Vehicle Collisions

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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 who died between January 1999 and December 2010. We compared fatality rates in 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 1612 bicycle-related fatalities sustained by children aged <16 years were evaluated. There were no statistically significant 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 fatality rate was lower in states with helmet laws (2.0/1 000 000 vs 2.5/1 000 000; $P = .03$). After adjusting for potential confounding factors, lower fatality rates persisted in states with mandatory helmet laws (adjusted incidence rate ratio, 0.84; 95% CI, 0.70–0.98).

Conclusion Bicycle helmet safety laws are associated with a lower incidence of fatalities in child cyclists involved in bicycle–motor vehicle collisions. (*J Pediatr* 2013;163:726–9).

In the US, 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 this fatality rate.² Over the last 20 years, several case-controlled and epidemiologic studies have demonstrated the efficacy of bicycle helmets, reporting a lower risk of injury and death for cyclists wearing helmets compared with unhelmeted cyclists.^{3–10} Thompson et al⁹ found that riders wearing bicycle helmets had an 88% lower risk of brain injury compared with riders without helmets. In a meta-analysis of case-control studies examining the efficacy of bicycle helmets in cyclists involved in crashes or falls, which included more than 11 000 subjects, helmets were shown to provide a 63%–88% reduction in the risk of head, brain, and severe brain injury in cyclists of all ages.¹ The American Academy of Pediatrics recommends that all cyclists wear a properly fitted bicycle helmet for every ride, and encourages legislation requiring helmet use by all cyclists.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 US enacted laws mandating the use of bicycle helmets, but often limited the requirement to children under 16 years old. Several investigators have studied the effect of bicycle helmet laws on helmet use^{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 remained unexamined.

We sought to assess the effect of bicycle helmet legislation nationally, by examining the association between helmet laws and deaths due to bicycle–motor vehicle crashes sustained by children aged <16 years 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 occurring on a traffic way customarily open to the public and result in the death of a motorist or nonmotorist within 30 days of the crash. The FARS contains detailed information on the vehicles, cyclists, drivers, occupants, and nonoccupants involved in each 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.

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FARS Fatality Analysis Reporting System
NHTSA National Highway Traffic Safety Administration

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The NHTSA has a cooperative agreement with an agency within each state government to provide specific information in a standard format on crashes that result in a fatality in that state. All FARS data on fatal motor vehicle traffic crashes are gathered from the states' 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.¹⁷

Most state laws regarding the use of bicycle helmets apply only to children, usually under age 16 years. Thus, we identified all bicycle-motor vehicle related fatalities sustained by children aged <16 years between January 1999 and December 2010 and included in the FARS database. All US 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 $\geq 0.08\%$), 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.

We compared fatality rates in states with helmet laws and states 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. Thus, to keep our estimates conservative, we considered these states to have a law. To determine fatality rates, we used the total number of deaths divided by age-specific state populations obtained from the US Census Bureau.²⁵ We created a multivariate model to account for other legislative and economic factors previously 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 used state-level clustering in the multivariate model. All of the data analyses were performed using Stata SE, version 11 (Stata-Corp, College Station, Texas). As all FARS data is de-identified and publicly available, the study was considered exempt from review by the institutional review board of Boston Children's Hospital.

Table I. Number of state-years that laws were in effect

Law	No. of state-years (n = 561)
Helmet laws	219
Maximum highway speed limit ≤ 65 mph	209
Age-based licensure law	341
Blood alcohol level $\geq 0.08\%$	437

Results

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

During the 12-year study period, a total of 1612 bicycle-motor vehicle related fatalities were sustained by children aged <16 years. The mean unadjusted fatality rate in children aged <16 years was significantly lower in states with helmet laws compared with states without helmet laws (2.0/1 000 000 children vs 2.5/1 000 000 children; $P = .03$), yielding an incidence rate ratio 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 incidence rate ratio, 0.84; 95% CI, 0.70-0.98).

Discussion

Our findings show that US bicycle helmet safety laws are associated with a lower national incidence of fatalities among bicyclists aged <16 years who suffer collisions involving a motor vehicle. In 1999, only 16 states had bicycle helmet laws, and the fatality rates were lower in those states than in 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 concluded 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 have reached conclusions similar to ours, however. In an analysis of 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 patients with bicycle-related trauma was associated with a decreased

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