Booster Seat Laws and Fatalities in Children 4 to 7 Years of Age

WHAT'S KNOWN ON THIS SUBJECT: Previous studies have demonstrated that booster seat legislation decreased fatalities in children. However, these studies have not accounted for confounding factors such as other legislation and temporal trends in safety.

WHAT THIS STUDY ADDS: This study demonstrates that state booster seat laws are associated with decreased rates of fatalities and injuries in children 4 to 7 years of age in the United States, with the strongest effects in the older children.

abstract

FREE

OBJECTIVE: To determine whether state booster seat laws were associated with decreased fatality rates in children 4 to 7 years of age in the United States.

METHODS: Retrospective, longitudinal analysis of all motor vehicle occupant crashes involving children 4 to 7 years of age identified in the Fatality Analysis Reporting System from January 1999 through December 2009. The main outcome measure was fatality rates of motor vehicle occupants aged 4 to 7 years. Because most booster laws exclude children 6 to 7 years of age, we performed separate analyses for children 4 to 5, 6, and 7 years of age.

RESULTS: When controlling for other motor vehicle legislation, temporal and economic factors, states with booster seat laws had a lower risk of fatalities in 4- to 5-year-olds than states without booster seat laws (adjusted incidence rate ratio 0.89; 95% confidence interval [CI] 0.81–0.99). States with booster seat laws that included 6-year-olds had an adjusted incidence rate ratio of 0.77 (95% CI 0.65–0.91) for motor vehicle collision fatalities of 6-year-olds and those that included 7-year-olds had an adjusted incidence rate ratio of 0.75 (95% CI, 0.62–0.91) for motor vehicle collision fatalities of 7-year-olds.

CONCLUSIONS: Booster seat laws are associated with decreased fatalities in children 4 to 7 years of age, with the strongest association seen in children 6 to 7 years of age. Future legislative efforts should extend current laws to children aged 6 to 7 years. *Pediatrics* 2012;130:996–1002

AUTHORS: Rebekah Mannix, MD, MPH,[a] Eric Fleegler, MD, MPH,[a] William P. Meehan III, MD,[a,b,c] Sara A. Schutzman, MD,[a] Kara Hennelly, MD,[a] Lise Nigrovic, MD, MPH,[a] and Lois K. Lee, MD, MPH[a]

Divisions of [a]Emergency Medicine, and [c]Sports Medicine, Children's Hospital Boston, Boston, Massachusetts; and [b]The Micheli Center for Sports Injury Prevention, Boston Massachusetts

KEY WORDS
trauma, legislation, motor vehicle collisions

ABBREVIATIONS
CI—confidence interval
FARS—Fatality Analysis Reporting System
MVC—motor vehicle collision
NHTSA—National Highway Transportation and Safety Administration

All authors contributed to the conception, study design, data analysis, and manuscript preparation of this study.

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Address correspondence to Rebekah Mannix, MD, MPH, 300 Longwood Ave, Boston, MA 02115. E-mail: rebekah.mannix@childrens.harvard.edu

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Motor vehicle collisions (MVCs) are the third leading cause of death and the fifth leading cause of injury to children 1 to 18 years old in the United States.[1] Because of their short stature, children <4 years old are optimally restrained by an appropriate car seat when traveling in a motor vehicle. The appropriate use of car seats for this age group has resulted in a decreased risk of death or injury.[2–5] Since 1985, all 50 states and the District of Columbia have passed legislation requiring car seats for children <4 years old.[5]

For children >4 years and up to 8 years old or a height of 4 feet 9 inches, booster seats are highly effective in preventing injuries and death during MVCs.[6,7] Despite the effectiveness of booster seats, a survey conducted in 2008 by the National Highway Traffic Safety Administration (NHTSA) revealed that only 48% of 4- and 5-year-olds and 35% of 6- and 7-year-olds were restrained in booster seats. Between 2001 and 2009, legislation requiring the use of booster seats for children 4 years of age and older passed in 47 states and the District of Columbia; however, the age requirements vary state to state.[8]

These booster seat laws have been previously shown to increase booster seat use as well as decrease MVC-related hospitalizations, injury rates, and fatalities.[9–11] However, the national effect of booster seat legislation while controlling for additional factors known to influence motor vehicle fatality rates has not been described. Moreover, no study to date has evaluated the effect of legislation on older children with the use of data on the national level. We sought to evaluate the effectiveness of booster seat laws and proper booster seat restraint on MVC-related fatalities sustained by children aged 4 to 7 years after accounting for other factors that are known to influence motor vehicle fatality rates.

METHODS

Database

This study uses data from the Fatality Analysis Reporting System (FARS). The FARS is a census compiled by the NHTSA and includes data from all motor vehicle crashes that occur on a traffic way customarily open to the public and that result in the death of a vehicular occupant within 30 days of the crash.[12] The FARS is compiled primarily from the police accident report and contains detailed information on the vehicles, drivers, occupants, and nonoccupants involved in the crash as well as details regarding safety system and restraint use by 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 fatal crashes occurring in the 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.

Study Population

We identified all motor vehicle occupants aged 4 to 7 years who died in MVCs occurring between January 1999 and December 2009. Because the majority of states during the study period did not enact booster seat legislation that included 7-year-olds, we performed separate analyses for the 4- to 5-year-olds, 6-year-olds, and 7-year-olds.

Statewide Factors

All US states and the District of Columbia were included in the analysis. We collected the following factors that have been previously associated with motor vehicle fatalities: primary enforcement of mandatory seatbelt laws, highway speed limits (≤65 mph vs >65 mph), legal blood alcohol limit (<0.08% vs ≥0.08%), rates of adult (aged 25–54 years) fatalities, median state household income, as well as year to adjust for temporal trends.[13] For each year of the study, we evaluated whether each state had implemented the legislation listed above. We then calculated the number of state-years that booster seat laws were in effect by multiplying the number of states with a booster seat law by the number of years that the law was in effect during the study period.

To determine the impact of the booster seat legislation on the rate of fatalities, we defined the "before" period as the years before the calendar year in which the law was implemented and the "after" period as the years after the calendar year in which the law was implemented. The year of booster seat law implementation was excluded. Date of booster seat law passage and enactment were obtained from several sources including the NHTSA, the Insurance Institute for Highway Safety,[14] and Advocates for Highway and Auto Safety[15] (Fig 1) and confirmed by Internet searches of dates of implementation of legislative acts.

Crash Factors

The FARS database has detailed information regarding the type of restraint system used at the time of the crash and whether it was used properly. Children are classified as being properly restrained in a booster or child safety seat, restrained in a lap and/or shoulder belt only, restrained improperly in a child safety seat or booster seat, restrained improperly in a safety belt only, unknown restraint, or no restraint.

Outcome Measure

Our primary outcome measure was death within 30 days after a MVC.

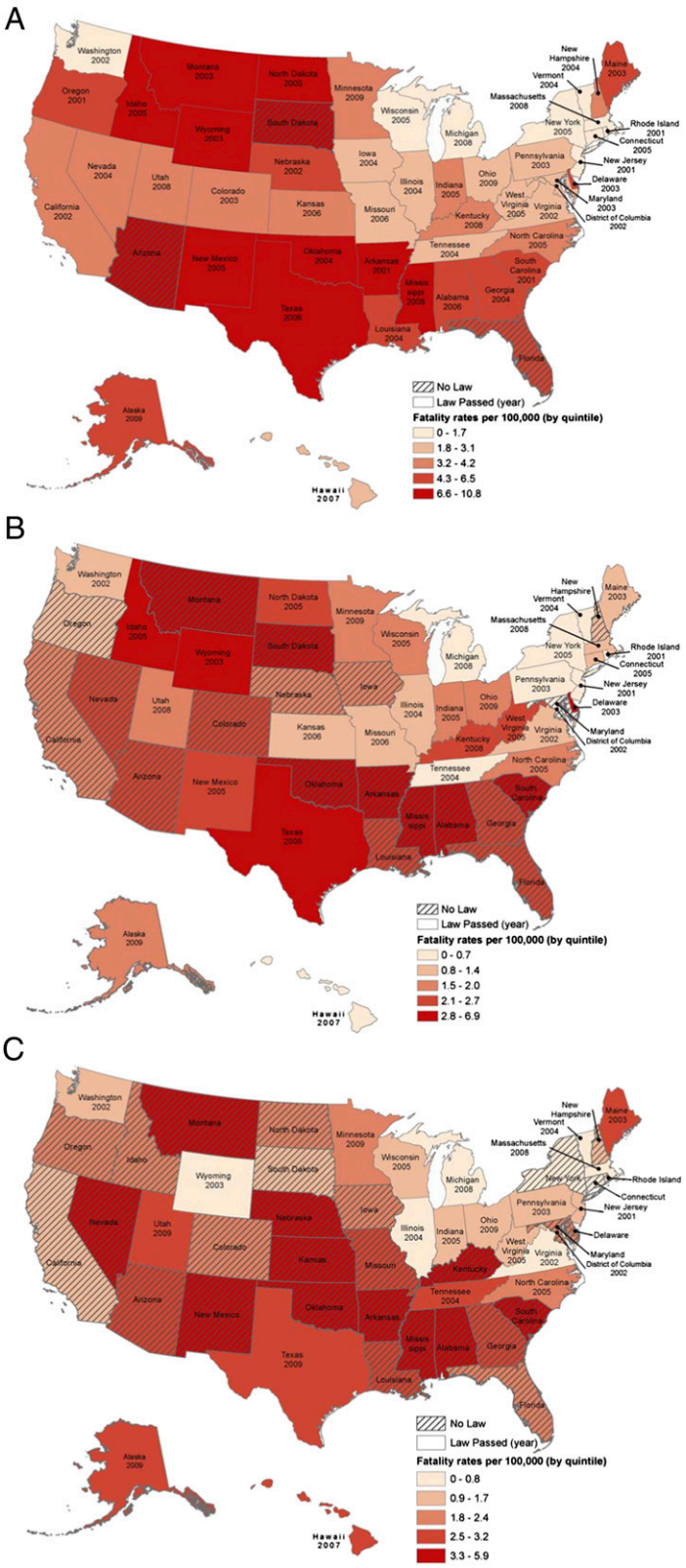

FIGURE 1
State-level statistics on fatality rates per 100 000 children since the passage of booster seat legislation. A, 4 to 5 years old. B, 6 years old. C, 7 years old. Rates in states without booster seat laws calculated for study period.

Data Analysis

First, we evaluated the number of children involved in a MVC with a fatality who were properly restrained in a booster seat by using a χ^2 test to evaluate the association of booster seat usage with fatality. We performed separate analyses for children 4 to 5 years of age and 6 and 7 years of age.

To evaluate the relationship between booster seat laws and fatal injuries sustained by children aged 4 to 7 years, we used states that enacted legislation during the study period to compare rates of fatalities before and after the legislation was implemented. To determine rates of death, we used the total number of deaths divided by age-specific state populations obtained from the US Census Bureau.[16] In addition, because rates of death possibly decreased owing to temporal trends alone, we created a linear regression with death rate as the outcome and an interaction term for year and booster seat legislation to assess whether changes in death rates were different before and after legislation (ie, the slope of the decrease was steeper after legislation than before legislation). For states that did not enact booster seat legislation, we performed a test of linear trend to evaluate whether fatality rates changed during the study period and also compared rates in the first half of the study period (1999–2003) with rates in the second half of the study period (2004–2009).

Finally, we created a multivariate model to account for other legislative and economic factors associated with motor vehicle fatalities. We used a multivariate Poisson regression model adjusted for state highway speed limit, maximum legal blood alcohol limit, adult fatality rates, and median household income as well as year to adjust for temporal trends. Because the majority of booster seat laws do not apply to 6- to 7-year-olds, we analyzed 4- to

5-year-olds and 6- and 7-year-olds separately. All the data analyses were performed by using Stata SE, version 11 (StataCorp, College Station, TX).

RESULTS

A total of 3639 MVC-related fatalities were sustained by children aged 4 to 7 years from 1999 to 2009. At the start of the study period, no states had enacted laws regarding booster seat use and the rate of motor vehicle fatalities in children aged 4 to 7 years in the United States was 2.8/100 000 (Table 1). During the 11-year study period, 47 states and the District of Columbia passed booster seat legislation, representing 219 state-years of booster seat legislation for children 4 to 5 years of age and 126 and 77 state-years for children 6 and 7 years of age, respectively, during the study period (Table 2).

Booster Seat Use

In 1999, at the start of the study period, 9% of 4- to 5-year-old children involved in a MVC with a fatality were properly restrained in a booster seat; by 2009, the rate of proper booster seat restraint increased to 41% in this age group. In 1999, <0.9% of 6-year-olds and 0.1% of 7-year-olds involved in a MVC with a fatality were restrained in a booster seat. By 2009, 23% of 6-year-olds and 12% of 7-year-olds were properly restrained in a booster seat. On χ^2 analysis, decreased fatality rates were associated with proper booster seat use in children 4 to 5 years of age ($P < .001$), children 6 years of age ($P = .009$), and children 7 years of age ($P = .004$).

State Fatality Rates

In states that enacted a booster seat law during the study period, the mean unadjusted rates of fatal injuries sustained by children aged 4 to 5 years before legislation was 5.7 children/100 000, with state-specific rates ranging from 0.4 children/100 000 to 18.0 children/100 000. After enacting legislation, the mean fatality rate of 4- to 5-year-olds decreased to 4.2 children/100 000 ($P = .02$), with state-specific rates ranging from 0 children/100 000 to 10.8 children/100 000 (Fig 1A). For states that enacted legislation, the decline in death rates was greater after legislation than before ($P < .001$ for interaction term). In states that did not enact booster seat legislation for 4- to 5-year-olds, fatality rates did not decrease from the first half of the study period to the second half ($P = .1$) nor was there a linear trend over the study period ($P = .3$).

In states that enacted booster seat legislation that included 6-year-olds, the mean unadjusted fatality rate in 6-year-old children was 2.3 children/100 000 before legislation, it decreased to 1.5 children/100 000 after legislation ($P = .04$) (Fig 1B), and the decline in death rates was greater after legislation than before ($P < .001$ for interaction term). There was no change in the fatality rates for 6-year-olds from the first half to the second half of the study period in states that did not enact booster seat laws for this age group ($P = .8$) nor was there a linear trend over the entire study period ($P = .8$).

There were no changes in the before and after unadjusted mean fatality rates in 7-year-olds in states that enacted booster seat legislation for this age group ($P = .2$) (Fig 1C). However, for states that enacted legislation, the decline in death rates was greater after legislation than before ($P < .001$ for interaction term). For states that did not enact 7-year-old–specific legislation, rates in the first half of the study period did not differ from those in the second half ($P = .2$) nor was there a linear trend over the entire study period ($P = .2$).

When other motor vehicle legislation, temporal, and economic factors were controlled for in the multivariate analysis, states with booster seat laws had a lower risk of fatalities in 4- to 5-year-olds than states without booster seat laws (adjusted incidence rate ratio 0.89; 95% confidence interval [CI] 0.81–0.99). The association with legislation was even stronger in older children such that states with booster seat laws that included 6-year-olds had an adjusted incidence rate ratio of 0.77 (95% CI 0.65–0.91) and those that included 7-year-olds had an adjusted incidence rate ratio of 0.75 (95% CI 0.62–0.91).

TABLE 1 Baseline State-Level Statistics for 1999 (50 States and the District of Columbia, $n = 51$)

Statistic	1999
Motor vehicle fatalities in children 4- to 7-y-old per 100 000 children, mean (SD)	2.8 (1.9)
Booster seat law 4- to 5-y-olds	0 (0)
Booster seat law 6-y-olds	0 (0)
Booster seat law 7-y-olds	0 (0)
Other state laws, n (%) of states	
Speed limit, mph	16 (31)
≤65	35 (69)
>65	
Seatbelt	
Primary enforcement	26 (51)
Blood alcohol level of 0.08	21 (41)
Other, median (interquartile range)	50 853 (46 882–59 757)
Median household income	

DISCUSSION

This study demonstrates on a national level that state legislation mandating booster seat use for children aged 4 to 7 years is associated with decreased rates of MVC fatalities, even after

TABLE 2 Number of State-Years That Policy in Effect

Law	No. State-Years (n = 561)
Booster seat law 4- to 5-y-olds	219
Booster seat law 6-y-olds	126
Booster seat law 7-y-olds	77
Maximum highway speed limit, mph	
≤65	209
Seatbelt laws	
Primary enforcement	286
Blood alcohol level of 0.08	437

controlling for temporal and other legislative factors. In the unadjusted comparison of MVC fatality rates over time in states that enacted booster seat legislation during the study period, decreased rates were noted for children in the 4- to 5-year-old and 6-year-old age groups, but not in the 7-year-old age group. In contrast, in states with no booster seat legislation, there were no statistically significant changes in fatality rates for any age group. After controlling for other motor vehicle legislation as well as temporal and economic factors, states with booster seat laws had decreased MVC fatality rates in all age groups compared with states with no laws, with the greatest change in the 7-year-old age group, which highlights the importance of booster seat legislation, in particular, for this age group. Demonstrating decreased fatality rates in the older children (ie, 6- to 7-year-olds) covered by booster seat legislation could have a significant impact on future legislation designed to extend the coverage of current legislation to children >5 years of age.

Although the use of booster seats has increased since 2000, when rates of booster seat use were <10%,[17] there remains room for improvement. In this study we found that the majority of children aged 4 to 7 years involved in MVCs with fatalities are not restrained properly in a booster seat. Our findings are similar to those of the 2010 Insurance Institute for Highway Safety report that demonstrated that 34% of children aged 4 to 7 years use seat belts only, without a booster seat, whereas another 11% are completely unrestrained.[18] The American Academy of Pediatrics (AAP) best-practice recommendation for children whose weight or height is above the limit for forward-facing child car seats is to use a belt-positioning booster seat until the lap/shoulder belt fits properly.[19] Typically a booster seat should be used from the age of 4 years until the child is between the ages of 8 and 12 years and is 4 feet 9 inches in height.[3]

Legislation is an effective way of changing outcomes due to MVCs. Legislation regarding minimum alcohol-drinking age,[20,21] elderly licensure,[13] seat belt use,[22,23] the use of child safety seats for children from birth through 5 years,[24,25] and graduated driver licensing for teenagers[26–28] have decreased motor vehicle–related deaths and injuries in the United States. Similarly, our data show that, even after controlling for other motor vehicle legislation, as well as controlling for temporal and economic factors that could influence MVC fatalities in children, the enactment of booster seat laws further reduces childhood fatalities. This protective effect is greatest in the children aged 6 and 7, although only 16 states had booster seat laws that included 7-year-olds as of 2009.

Booster seat laws increase booster seat use. One study comparing 16 states and the District of Columbia with and without booster seat laws reported age-appropriate restraint use for children aged 4 to 7 years, including forward-facing car seats as well as booster seats, was 39% more likely in states with laws.[29] A survey of parents of 4- to 8-year-old children about carpooling and booster seats found that parental report of child safety seat use while carpooling was associated with the presence of state booster seat laws. These authors suggested that social norms related to booster seat use are shaped by state laws.[30] A parental focus group also cited legislation as 1 strategy to increase booster seat use.[31] However, the vast majority of states do not have booster seat legislation that includes children 6 to 7 years of age. Given the effectiveness of booster seat legislation in increasing their use and, more importantly, in reducing the number of fatalities associated with MVCs, legislators should consider extending all state laws to include all children over the age of 5 years who have not reached the best-practice height recommendation of 4 feet 9 inches. Legislation that reflects the best-practice recommendations can help guide parents in the most effective ways to protect their children while riding in a motor vehicle, although differences in state laws regarding age requirements may cause confusion and decreased compliance.

Legislation alone will not suffice. Barriers to booster seat use include parental lack of knowledge about booster seat recommendations, difficulty using booster seats, children refusing to use booster seats, cost of the seats, and lack of knowledge regarding booster seat effectiveness in reducing death and injury rates.[28,29,31] Therefore, a multifaceted approach including education, public awareness campaigns, incentives for including built-in booster seats in motor vehicles, and financial assistance could improve outcomes more than legislation alone.

Our findings must be considered in the light of several limitations. By using the FARS database, we are limited to analyzing MVCs that resulted in the death of at least 1 person within 30 days of the collision. As a result, our findings likely underestimate the effects of the

booster seat laws, because we did not capture nonfatal pediatric MVC-related injuries. Furthermore, little is known about the degree of enforcement of booster seat laws across states and over time; however, primary enforcement booster seat laws are cited by law enforcement as an important component to effective enforcement of the law compared with secondary laws.[32] Although we attempted to adjust for other types of motor vehicle safety legislation, we had no means of ascertaining overall state-level compliance with the booster seat law, and there may be additional factors that were not considered in our model. However, we included adult rates of fatalities to control for some of these effects. In addition, we did not account for height and/or weight requirements, which may extend the effect of legislation past the specified age groups. Finally, we were not able to control for individual MVC level effects, and it is possible, although unlikely, that unrestrained or improperly restrained children were in higher force crashes, accounting for the higher incidence of fatalities.

CONCLUSIONS

This study demonstrates on a national level the effectiveness of booster seat legislation on decreasing fatalities in children from 4 through 7 years of age. This protective effect appears to be even more important for children aged 6 to 7 years, who are not routinely covered under state laws. Legislation mandating the use of booster seats should include children at least until the age of 7 and preferably until they reach the recommended height of 4 feet 9 inches for safe seat belt use without a booster seat.

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OBESITY AND THE MIND: *While it is known that obesity is associated with several abnormal metabolic conditions such as hypertension and diabetes, the relationship between obesity and cognition is not well understood. New data from French researchers published in* Neurology *(August 21, 2012; "Obesity phenotypes in midlife and cognition in early old age") confirms findings reported in children (*Pediatrics*: October 2012; "Obesity and Metabolic Syndrome and Functional and Structural Brain Impairments in Adolescence") and suggests that a direct negative relationship in adults exists. In the 1990s, the researchers surveyed 6,401 adults ranging in age from 39-63 years old. Participants had metabolic parameters such as triglyceride levels as well as their body mass index (BMI) measured. Over the next 10-15 years, the study participants completed three sets of cognitive tests measuring memory, reasoning, and semantic and phonemic fluency. At entry, participants were defined as normal weight (BMI 18.5-24.99 kg/m^2), overweight (BMI 25-29.99 kg/m^2) or obese (BMI >30 kg/m^2). Among study participants, 31% had abnormal metabolic profiles (defined as having two of the following: elevated glucose levels, high LDL cholesterol, low HDL cholesterol, or elevated blood pressure) while 52.7% were normal weight, 38.2% overweight, and 9.1% obese. An abnormal metabolic profile coupled with obesity was associated with a faster cognitive decline. Among the obese, the decline in global cognitive functioning was similar in the metabolically normal and abnormal groups. However, in the metabolically abnormal group, the decline on the global score was faster among obese than normal weight individuals. In the metabolically normal group, the decline in the global cognitive score was similar across the three weight groups. Researchers propose that vascular pathology or hormone regulation linked to increased fat stores might be responsible for the connection to cognition. Regardless of the reasons for these correlations, this study highlights the importance of maintaining a healthy lifestyle through adequate nutrition and exercise, no matter what the scale says.*

Noted by Leah H. Carr, BS, MS-III

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