Effect of Booster Seat Laws on Appropriate Restraint Use by Children 4 to 7 Years Old Involved in Crashes

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Objective: To quantify the independent contribution of recently enacted booster seat laws on appropriate restraint use by child passengers in motor vehicles.

Design: Longitudinal study of children involved in crashes with data collected via insurance claims records and a validated telephone survey.


Participants: Probability sample of 5198 vehicles in crashes involving 6102 children aged 4 to 7 years, representing 78,159 vehicles and 91,752 children.

Main Exposures: Booster seat law provisions, child age, state, and secular trends.

Main Outcome Measure: Reported appropriate restraint use for this age group, including forward-facing child safety seats, belt-positioning booster seats, and combination seats.

Results: Children aged 4 to 7 years in states with booster seat laws were 39% more likely to be reported as appropriately restrained than were children in other states (prevalence ratio [PR], 1.39; 95% confidence interval [CI], 1.14-1.70). Children aged 4 to 5 years were 23% more likely (PR, 1.23; 95% CI, 0.80-1.42) and children 6 to 7 years twice as likely (PR, 2.09; 95% CI, 1.46-2.99) to be reported as appropriately restrained. For children aged 6 to 7 years, when compared with no law, laws through age 7 years were most effective (PR, 3.71; 95% CI, 2.49-5.42), followed by laws through age 4 or 5 years (PR, 1.43; 95% CI, 0.89-2.24).

Conclusion: Given the higher current use of age-appropriate restraints among children 4 to 5 years compared with older children, future upgrades to child restraint laws should include children through at least age 7 years to maximize the number of children properly restrained for their age.

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than 4 years. Although the increases in age-appropriate restraint occurred in conjunction with and after enactment of booster seat laws, the causal effect of the laws on child restraint use has not been clearly established. State characteristics and other promotional efforts that result in increasing child restraint use over time may confound the effect of a law. The Partners for Child Passenger Safety study has tracked child safety seat and booster seat use in 16 states since December 1998, predating all booster seat use laws. Thus, this study provides a unique opportunity to examine the effect of safety laws on safety device use because baseline rates were low across states before law enactment, not all states have enacted laws (as of July 1, 2006, 38 states and the District of Columbia have some form of booster seat law), and enactment of the existing laws has spanned several years. This enables us to reduce confounding due to differences in prelaw booster use prevalence across states and to account for underlying national trends with time in booster seat use that would occur even without booster seat laws.

### METHODS

#### STUDY POPULATION AND DATA COLLECTION

Data were collected from December 1, 1998, through December 31, 2004. A description of the study methods has been published previously. The project consists of a large-scale, child-specific, crash surveillance system; insurance claims from State Farm Mutual Automobile Insurance Co (Bloomington, Ill; hereafter referred to as State Farm), function as the source of subjects, with telephone survey and on-site crash investigations serving as the primary sources of data.

Vehicles qualifying for inclusion were insured by State Farm, model year 1990 or newer, and involved in a crash with at least 1 child occupant younger than 16 years. Qualifying crashes were limited to those that occurred in 16 states and the District of Columbia, representing 4 regions of the United States (East: New York, New Jersey [before November 2001], Pennsylvania, Delaware, Maryland, Virginia, West Virginia, North Carolina, and the District of Columbia; Midwest: Ohio, Michigan, Indiana, and Illinois; South: Texas [after June 2003]; and West: California, Nevada, and Arizona).

After policyholders consented to participate in the study, limited data were transferred electronically to researchers at The Children's Hospital of Philadelphia and the University of Pennsylvania. Data in this initial transfer included a coded variable describing the level of medical treatment received by all child occupants as reported by the policyholder (no treatment, physician office or emergency department only, admitted to the hospital, or death). A stratified cluster sample was used to select vehicles (the unit of sampling) for the conduct of a telephone survey with the driver. Vehicles with children who received medical treatment after the crash were oversampled so that most of the injured children would be selected while ensuring that the overall population was representative. If a vehicle was sampled, all child occupants in that vehicle were included in the survey. Drivers of sampled vehicles were contacted by telephone and, if medical treatment had been received by a passenger, screened via an abbreviated survey to verify the presence of at least 1 child occupant with an injury. All vehicles with at least 1 child who screened positive for injury and a 10% random sample of vehicles in which all child occupants who were reported to receive medical treatment but screened negative for injury were selected for a full interview; a 2.5% sample of crashes in which no medical treatment was provided was also selected.

Based on an analysis of data for the period of this study (Figure 1), claim representatives correctly identified 96% (441,804/458,817) of eligible vehicles, and 69% (236,351/341,206) of policyholders who were eligible for sampling consented to participation in this study. Of those who consented, 18% were sampled for an interview, 78% (33,967/43,294) of whom were successfully contacted and screened for the full survey. A total of 16,433 subjects completed full surveys, representing an overall inclusion rate of 32% of eligible subjects. Comparison of the included sample with known population values from State Farm claims revealed little difference: in both the sample and the population; 40%, 36%, and 24% of the vehicles were located in the East, Midwest, and West, respectively, and 58% of the sampled vehicles were model 1996 or newer. In the sample, 53% were passenger cars, 20% were minivans, 18% were sport-utility vehicles, 6% were pickup trucks, and 2% were large passenger vans, compared with 55%, 18%, 18%, 7%, and 2% in the population, and 32% were non-

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**Figure 1.** Derivation of the study sample from initially eligible population, December 1, 1998, through December 31, 2004. "At the onset of the project, consent was obtained from all eligible subjects before sampling. Beginning in June 2003, sampling of eligible subjects was performed, thus restricting consent to those who would go on to the screening interview. †Includes refusals, failure to contact the subject, and incomplete data collection.

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drivable, compared with 30% of the population. The mean age of the child occupants in the sample was 6.9 years, compared with 7.3 years in the population.

For the current analysis, the study sample consisted of vehicles with child occupants aged 4 through 7 years in a valid seating position with a driver at least 16 years of age. This accounted for 6102 children in 5198 vehicles, representing 91 752 children in 78 159 vehicles.

**VARIABLE DEFINITIONS**

Two categorical variables describing booster seat law status were created. The first differentiated whether there was any booster seat law in place in the state at the time of the crash, regardless of the enforceable age. The second was a 3-level variable: booster law for children aged 4 to 7 years, booster law for children aged 4 to 3 years old only, and no booster seat law. Delaware was included with the 4 to 5-year-old law group even though their law (effective January 1, 2003) included 6-year-olds as well. This resulted in the reclassification of only 3 children. In addition, a 2-level categorical variable for age of the child (4-5 years vs 6-7 years) was used for the analyses.

The outcome of interest was age-appropriate restraint use. Retrained status of children was determined from the telephone survey and was classified as either appropriately restrained for child occupant age vs all other (inappropriately restrained for their age group with those who were unrestrained). Appropriate restraint for this age group includes all forward-facing child safety seats (including forward-facing convertible seats with harness), boosters (including high-back and backless booster seats), and those combination seats designed as forward-facing child safety seats with the harness and a booster without the harness. Inappropriate restraint for this age group includes shield boosters (seats that are installed in the vehicle with the lap portion of the adult seat belt and have a padded shield, as opposed to a harness, to keep the child in place) and all seat belt use (whether lap only, lap-shoulder, or shoulder only). Among the 169 children aged 4 to 7 years for whom paired information about restraint type was available from both the telephone survey and crash investigations, agreement (child restraint vs no child restraint [belt or unrestrained]) was 96% (k value for agreement beyond chance, 0.86; 95% confidence interval [CI], 0.77-0.97) between the driver report and the crash investigator. The sensitivity of the telephone survey (using the crash investigations as the standard) was 92% (95% CI, 73%-99%) and varied little by whether states had booster seat laws (100%; 95% CI, 99%-100%) or no booster seat laws (89%; 95% CI, 69%-98%). The specificity was 97% (95% CI, 93%-99%) and also varied little in states with (98%; 95% CI, 96%-100%) and without (97%; 95% CI, 91%-99%) booster seat laws. Crash investigations were generally performed for crashes resulting in injury to child occupants, which has been demonstrated to result in greater accuracy of reported restraint use.13

Separate verbal consent was obtained from eligible participants for the transfer of claim information from State Farm, for the conduct of the telephone survey, and for the conduct of the crash investigation. The study protocol was reviewed and approved by the institutional review boards of both The Children’s Hospital of Philadelphia and the University of Pennsylvania School of Medicine.

**DATA ANALYSIS**

The primary purpose of these analyses was to compare age-appropriate restraint use for children aged 4 through 7 years in states with booster seat laws vs states without such laws. Poisson regression modeling was used to compute the relative prevalence, or prevalence ratio (PR), of appropriate restraint of 4- to 7-year-old children in those states with booster seat laws compared with those in states without booster seat laws. Considering that states adopted different provisions as part of their laws, we considered 2 different models to investigate the effects of booster seat laws: 2-level (any law vs no law) and 3-level (law applied to 4- to 7-year-old children, law applied to 4- to 5-year-olds only, or no law). To account for the possibility that states that passed booster seat laws may already have higher rates of booster seat use than states that did not pass such laws, our regression models included main effects for each state in the study. Similarly, to account for the increasing use of booster seats later in the study even in states without booster seat laws, main effects for each 6 months of the study were also included in the model. Finally, our models adjusted for age of the child (4-5 years vs 6-7 years). We also considered interactions between the effect of the law and the age of the child (4-5 years vs 6-7 years). To graphically display how prevalence trends varied with time for the average child in our data, according to child age and the age range included in each law, we entered into the model a term for the percentage of the data that came from each state in lieu of the state’s dummy variable. Predicted probabilities of appropriate restraint at 6-month intervals by age and law status were obtained from the regression models by replacing the dummy variable for a given state by the percentage of the study population in the state, effectively averaging across the study population.

Because sampling was based on the likelihood of an injury, subjects least likely to be injured were underrepresented in the study sample in a manner potentially associated with the predictors of interest.14 To account for this potential bias, sampling weights equal to the inverse of the probability of selection were used in computation of the Poisson regression model parameters. Inasmuch as the regression residuals do not have a Poisson distribution because the outcome is dichotomous, a bootstrap procedure was used with 5000 resamplings to compute 95% CIs for the Poisson regression parameters of interest via the percentile method15 (ie, the 125th and 4875th largest parameter estimates from the 5000 resamplings constituted the 95% CI). Poisson, rather than logistic, regression was used because the outcome of interest (age-appropriate restraint use) is relatively common, preventing the interpretation of odds ratios as PRs.16,13 Clustering, nested by crash within state, was accounted for by resampling not individual subjects but entire state clusters as part of the bootstrap procedure.

**RESULTS**

Table 1 gives the status of the booster seat laws in the states under study and provides the unweighted sample size of children from each state and the prevalence of age-appropriate restraint use for children in the first vs last year of the study. As noted, 7 states and the District of Columbia have laws that went into effect during the study. As noted, 7 states and the District of Columbia have laws that went into effect during the study and 9 states did not have a booster seat law during the study. Children aged 4 to 5 years constituted 53% of the sample, and children 6 to 7 years constituted 47%.

Table 2 gives the unadjusted percentages of 4- to 5-year-old and 6- to 7-year-old child occupants reported as appropriately restrained, by 6-month intervals. The table gives percentages for all states combined and separately by whether a booster seat law was in effect at the time. Between the first 6 months of 1999 and the last 6 months of 2004, appropriate restraint use increased from 21.9% to 74.8% for children aged 4 to 5 years and from 3.0% to 22.9% for children aged 6 to 7 years.
The results of the Poisson regression model that adjusted for age, state, and date of crash indicated that children aged 4 to 7 years in states with booster seat laws were, overall, 39% more likely to be reported as appropriately restrained in crashes than were children in other states (PR, 1.39; 95% CI, 1.14-1.70). The effect of the law varied depending on the age of the child: children aged 4 to 5 years were 23% more likely to be reported as appropriately restrained (PR, 1.23; 95% CI, 0.80-1.42), whereas those aged 6 to 7 years were twice as likely to be reported as appropriately restrained (PR, 2.09; 95% CI, 1.44-3.01; P = .001 for test of interaction between age of child and presence of law).

Figure 2 shows how the predicted probability of appropriate restraint varied by age (+5 years vs 6-7 years) and by the type of law at the time (law for 4- to 5-year-olds only, law for 4- to 7-year-olds, or no law), by 6-month intervals, and averaged across states. Considering differences by type of law, we found that reported appropriate restraint use was 28% higher in states with a law for 4- to 5-year-olds only (PR, 1.28; 95% CI, 1.00-1.66) and 53% higher in states with a law for 4- to 7-year-olds (PR, 1.55; 95% CI, 1.19-2.05) than in states with no law. Considering interaction between type of law and age of the child, we found that, for 4- to 5-year-olds, the increase was greater when the law applied only to this age group (PR, 1.26; 95% CI, 1.00-1.60) than when it applied to those through age 7 years (PR, 1.08; 95% CI, 0.80-1.42), although this difference between the 2 law groups was not statistically significant (P = .33). For 6- to 7-year-old children, the effect was stronger when the law included those aged 4 through 7 years (PR, 3.71; 95% CI, 2.49-5.42) than when it included only those aged 4 to 5 years (PR, 1.43; 95% CI, 0.89-2.24; P < .001 for test of difference between the law groups among 6- to 7-year-olds).

Our analyses quantified the independent contribution of booster seat laws on increases in appropriate restraint use, taking into account specific law provisions, child age, state, and time period.
and secular trends. We found that amending child restraint laws to include booster seat provisions had an independent effect on increasing appropriate restraint use by children aged 4 through 7 years.

Between 1999 and 2004, large increases were reported in appropriate restraint use (including child safety seats, booster seats, and combination seats) for children aged 4 through 7 years involved in crashes. Appropriate restraint use in 4- to 5-year-olds increased from 21.5% to 74.8%, and for 6- to 7-year-olds increased from 3.0% to 22.9%. In states with booster seat laws, children aged 4 to 5 years were not significantly more likely to be reported as appropriately restrained than in states without such laws (PR, 1.23; 95% CI, 0.80-1.42), whereas children aged 6 to 7 years were more than twice as likely to be reported as appropriately restrained than in states without such laws (PR, 2.09; 95% CI, 1.46-2.99). The effect of the law was related to the exact provisions of the law for 6- to 7-year-olds: the effect was stronger when the law included children aged 4 through 7 years (PR, 3.71; 95% CI, 2.49-5.42) than when it included only those aged 4 to 5 years (PR, 1.43; 95% CI, 0.89-2.24).

The results of this study must be interpreted in light of several potential limitations. First, because of the voluntary nature of the study, just more than half of the eligible subjects for the study participated, leading to the possibility of selection bias. However, ongoing comparisons between the included sample and the eligible population demonstrate little difference in several key characteristics of relevance to the study, suggesting that the effect of potential selection bias on our results is likely limited. Second, the study relies on driver report for information on restraint use and may be subject to misclassification. Our survey data demonstrate a good level of agreement with information obtained by on-site crash investigations, particularly for age-appropriate restraint use. Overall, the probability was high that a child between 4 and 7 years of age was correctly classified as either restrained in a child restraint or not in the survey if identified as such according to evidence from on-site crash investigations (sensitivity, 92%; specificity, 97%). This did not vary by whether states had booster laws. Therefore, although use of self-reported restraint remains a limitation of the study, we believe it has a limited effect on the observed results. Third, this study included children involved in crashes of insured vehicles of model year 1990 or newer. Results may not be generalizable to children riding in older or uninsured vehicles.

Scientists, safety advocates, and others have promoted upgrading child restraint laws so that they are in

Figure 2. Predicted prevalence of appropriate restraint, based on Poisson regression model that included main effects for states (averaged across each state’s percentage in the sample), 6-month intervals, booster seat laws (age 4-7 years vs age 4-5 years vs no law), age (4-5 years and 6-7 years), and interactions between age and booster seat laws. Predicted prevalence for booster seat laws started when the first law went into effect.

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Scientists, safety advocates, and others have promoted upgrading child restraint laws so that they are in
alignment with best practice recommendations.18 Previous research demonstrates that parents cite their state law as a source of information when making child restraint decisions.10 Findings of our study strengthen the arguments in favor of booster seat provisions as part of child restraint laws and also inform the debate about the exact nature of the provisions. Our data suggest that booster seat provisions for children aged 4 through 7 years will have some effect on all children in this age range. Given the current greater use of appropriate restraints for 4- to 5-year-olds compared with older children, future upgrades to child restraint laws should target all children through at least age 7 years to achieve the greatest effect on overall child restraint use. States with booster seat laws that currently apply to children through age 5 years could expect further increases in appropriate restraint use among 6- and 7-year-olds by amending their laws to include these older children. Pediatricians should recognize the value of laws to families in informing them of their safety practices. They should familiarize themselves with the elements of the child restraint and other traffic laws in their state and stress the information as part of anticipatory guidance.

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