Recent Trends in Child Restraint Practices in the United States

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ABSTRACT. *Objective.* **To assess the success of recent outreach activities to promote appropriate child restraint in motor vehicles by examining trends in restraint types used by children under age 9 in 3 large regions of the United States.**

Methods. **Cross-sectional study was conducted of children who were under age 9 and in crashes of insured vehicles in 15 states, with data collected via insurance claims records and a telephone survey. A probability sample of 8730 crashes involving 10 195 children, representing 128 291 crashes involving 149 820 children, was collected between December 1, 1998, and November 30, 2002. Parent report was used to determine restraint type used in the crash. Logistic regression models were used to analyze the secular trend of restraint type use.**

Results. **Overall, for children under age 9, seat belt use decreased significantly from 49% to 36% between 1998 and 2002; for 7- and 8-year-olds, from 97% to 92%; and for 3- to 6-year-olds, from 63% to 34%. Concurrently, gains were achieved in overall child restraint use from 49% to 63%, for 7- and 8-year-olds, from 2% to 5%; and for 3- to 6-year-olds, from 35% to 65%. Child restraint use remains stable for children from birth to 2 years of age (from 97% in 1998 to 98% in 2002). Both the use of child safety seat and belt positioning booster seat increased significantly, whereas shield booster seat use decreased significantly.**

Conclusion. **Although considerable achievements have been realized over a short period of time, substantial inappropriate restraint still remains: 62% of children aged 4 to 8 remain inappropriately restrained in adult seat belts. Parents hear safety messages when they are relevant to their children. As a result, sustained efforts about appropriate restraint must continue to maintain and improve the gains achieved in appropriate child restraint use. The additional benefits realized by recent changes in child restraint laws remain to be evaluated.** *Pediatrics* **2004;113:e458–e464. URL: http://www.pediatrics.org/cgi/content/full/113/5/e458;** ***motor vehicle safety, child safety seats, seat belts, belt positioning booster seats.***

ABBREVIATIONS. AAP, American Academy of Pediatrics; NHTSA, National Highway Traffic Safety Administration; CSS, child safety seat; BPB, belt-positioning booster seat; ShB, shield booster seat.

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Motor vehicle crashes remain the leading cause of death and acquired disability in children.[1] The American Academy of Pediatrics (AAP)[2] and the National Highway Traffic Safety Administration (NHTSA)[3] recommend appropriate restraint of children in motor vehicles on the basis of child age and size to reduce injury risk. Children younger than 1 year or weighing <20 lb should ride rear-facing in child safety seats (CSSs). If a CSS accommodates a child rear-facing to higher weights, then for optimal protection, the child should remain rear-facing to the maximum weight of the car safety seat as long as the top of the head is below the seat back. Once children have outgrown their rear-facing CSS, they should be restrained in a forward-facing CSS until the upper weight limit (typically 4 years of age and 40 lb) for the child restraint. Children who have outgrown their CSS should be restrained in a belt-positioning booster seat (BPB) with 3-point seat belt until the seat belt fits properly (~80 lb and 57 inches in height, typically at least 8 years of age).

Although seat belts are better than no restraint at all, appropriate child restraint has demonstrated effectiveness in reducing injury risk when compared with restraint by seat belts alone. Recent evidence demonstrates that CSSs reduce the risk of severe, life-threatening injury by 71% when compared with seat belt restraint alone for children between the ages of 12 and 47 months.[4] BPBs reduce the risk of head and brain injuries, all internal organ injuries, spinal cord injuries, and extremity fractures by 59% when compared with seat belt restraint in 4- to 7-year-old children.[5] In particular, BPBs virtually eliminated seat belt syndrome in these children; that is, injuries to the abdominal organs and lumbar spine and spinal cord.

Multiple federal, nonprofit, and corporate organizations; health and medical providers (especially in pediatric practices working in concert with the AAP); industry and child passenger safety specialists; and advocates came together in the 1990s in the United States to promote appropriate restraint of children in motor vehicles. The first emphasis was on CSS use by the youngest children, those under age 4. In 1999, we reported that child restraint use by children under age 3 exceeded 90% but that at age 3, half of children were not restrained in CSSs.[6] By age 4, the most prevalent form of restraint was seat belt, and, at that time, few children over age 5 were using booster seats. Strong laws have been associated with increased seat belt usage[7]; however, state laws for child restraint use varied widely and did not conform to current best practice guidelines.[7–9]

In 2000, the NHTSA launched a new wave of outreach efforts by multiple groups focused on appropriate restraint for children over age 4.[10] The primary foci of these efforts were improved access to BPBs, educational and media campaigns, and upgraded laws. At the time of this article's writing, 22 states (Arkansas, California, Colorado, Delaware, Illinois, Louisiana, Maine, Maryland, Montana, Nebraska, Nevada, New Hampshire, New Jersey, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, Virginia, Washington, and Wyoming) and the District of Columbia had passed upgraded child restraint laws that require the use of booster seats for children over age 4.[11] Many other states are actively considering similar upgrades to their child restraint laws so that they are in line with best practice recommendations. In light of this recent outreach activity, the objective of this study was to examine trends in restraint type used among children under age 9 to evaluate the success of these efforts in improving appropriate child restraint usage in older children while maintaining realized benefits in appropriate restraint of the youngest children in 3 large regions of the United States.

METHODS

Study Population and Data Collection

Data were collected from December 1, 1998, to November 30, 2002. A description of the study methods has been published previously.[12] The project consists of a large-scale, child-specific crash surveillance system: insurance claims from State Farm Insurance Corporation (Bloomington, IL) function as the source of subjects, with telephone survey and on-site crash investigations serving as the primary sources of data. 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.

Vehicles that qualified for inclusion were State Farm insured and involved in a crash with at least 1 child occupant under age 16. Only vehicles from model year 1990 and later were studied to focus on current vehicle safety-design features. Qualifying crashes were limited to those that occurred in 15 states and the District of Columbia, representing 3 large regions of the United States (East: New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, North Carolina, District of Columbia; Midwest: Ohio, Michigan, Indiana, Illinois; West: California, Nevada, 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 contact information for the insured, the ages and genders of all child occupants, and a coded variable describing the level of medical treatment received by all child occupants as reported by the policyholder.

A stratified cluster sample was designed to select vehicles (the unit of sampling) for the conduct of a telephone interview with the driver. Vehicles that contained children who received medical treatment after the crash were oversampled so that the majority of injured children would be selected while maintaining the representativeness of the overall population. When 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 a passenger had received medical treatment, 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 for which no medical treatment was received were also selected. Claim representatives correctly identified 95% of eligible vehicles, and 74% of policyholders consented for participation in this study. Of these, 19% were sampled for interview and an estimated 81% of these were interviewed successfully. The full interview involved a 30-minute telephone survey with the driver of the vehicle and parent(s) of the involved children. Only adult drivers and parents were interviewed. The median length of time between the date of the crash and the completion of the interview was 6 days, with 95% of interviews completed within 47 days of the crash.

The eligible study population consisted of all 10 195 children who were younger than 9 years and riding in 8730 State Farm–insured vehicles that were 1990 or newer and whose driver reported a crash claim between December 1, 1998, and November 30, 2002. Complete data on crash date and child's age were acquired for the study sample. The percentage of missing data on restraint type was no more than 1%.

Variable Definitions

Restraint status of children was determined from a series of questions in the telephone survey that probed descriptions of the restraint type and how it was used. Children were classified as unrestrained or restrained, with the restraint type further classified as CSS (either forward- or rear-facing), BPB, shield booster seat (ShB), and seat belt. Rear-facing CSS included infant seats designed for rear facing only (many of these seats have a handle to carry the seat) and rear-facing convertible seats (these seats are designed to be used either in a rear- or forward-facing orientation). Forward-facing CSSs included forward-facing convertible seats and forward-facing combination seats used with the internal harness (these seats are used with an internal harness until the child reaches the manufacturer's maximum weight limit and then are converted to a BPB by removing the internal harness). BPBs included high-back and backless booster seats and those combination seats used without the internal harness. ShBs are 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. The definition of seat belt included lap only, lap/shoulder, and shoulder only.

Among the 161 children for whom paired information on restraint use was available from both the telephone survey and crash investigations, agreement was 88% between the driver report and the crash investigator ($\kappa = .74$, $P < .0001$).

Data Analysis

The primary purpose of these analyses was to examine trends in restraint use by the total group and 6 age groups (0-2, 3, 4, 5, 6, and 7-8) from December 1, 1998, to November 30, 2002. The beginning of the study period is defined as its first 6 months (December 1, 1998, to May 31, 1999), and the end of the study period is defined as its last 6 months (June 1, 2002, to November 30, 2002). Because sampling was based on the likelihood of an injury, subjects who were least likely to be injured were underrepresented in the study sample in a manner potentially associated with the predictors of interest.[13] To account for this potential bias and to adjust for the clustering of subjects by vehicle, we used analytical methods to account for sampling weights, sampling strata, and sampling units. The sample weights, defined as the inverse of the inclusion probability of the child in the sample, account for the differential sampling rates. Weighted data then reflect estimates for the entire population in an approximately unbiased manner. Because of the complex sample design, we used SAS-callable SUDAAN: Software for the Statistical Analysis of Correlated Data, Version 8.0 (Research Triangle Institute, Research Triangle Park, NC) for all data analyses. Descriptive statistics, consisting of frequencies for categorical variables, were determined. To describe the relationship of restraint use and time in a functional form, we modeled the log-odds of a given restraint type used (vs other) as a linear function of time via logistic regression, both using the total sample and restricted to each of the 6 age groups. The secular trends in restraint type use are then reported and plotted as the predicted probabilities resulting from this logistic regression, overall and for each age group. The dependent variables examined were CSS use, ShB use, BPB use, and seat belt use. Eight 6-month periods (from December 1, 1998, to November 30, 2002) were used as the independent variable to assess the time

effect. Wald χ^2 statistical test was performed for the significance of the time effect.

RESULTS

Table 1 displays the distribution of restraint type by total and age group and 2 time periods (the first 6 months and the last 6 months of the study period). The distribution of restraint type varies by age group and time period, and very few young children were unrestrained.

Total Group Under Age 9 (Unweighted n = 10 195)

Overall, at the end of the study period, 63% of children in this age group were restrained in a child restraint (CSS, ShB, or BPB); however, 62% of children aged 4 to 8 remain inappropriately restrained in adult seat belts. The probability of CSS use in the entire population increased significantly from 0.40 to 0.52, and the probability of BPB use also increased significantly from 0.03 to 0.11 (both $P \leq .001$). The probability of ShB use decreased significantly from 0.06 to 0.02, and the probability of seat belt use decreased significantly from 0.51 to 0.34 (both $P \leq .001$).

0- to 2-Year-Olds (Unweighted n = 3134)

At the end of the study period, 98% of children in this age group were restrained in a child restraint. The probability of CSS use, ShB use, and seat belt use remained stable for this age group. The probability of BPB use showed a small but statistically significant increase ($P = .028$). BPB use increased significantly from 0.004 to 0.02 over the time period of study.

3-Year-Olds (Unweighted n = 1122)

Figure 1 shows the trends in restraint type used by 3-year-olds. At the end of the study period, 95% of children in this age group were restrained in a child restraint. There was no significant trend in the probability of BPB use. CSS use increased significantly from 0.41 to 0.85 ($P \leq .001$). In contrast, the probability of ShB use decreased from 0.30 to 0.03 ($P \leq .001$). Concurrently, the probability of seat belt use decreased from 0.20 to 0.06 ($P = .003$).

4-Year-Olds (Unweighted n = 1181)

Figure 2 shows the trends in restraint type used in this age group. At the end of the study period, 74% of children aged 4 were restrained in a child restraint. The probability of ShB use showed no significant trend, whereas the probability of CSS use showed a highly statistically significant increase from 0.19 to 0.48 ($P \leq .001$). The probability of BPB use also increased from 0.10 to 0.22 ($P = .03$). Conversely, the probability of seat belt use showed a highly statistically significant decreasing trend from 0.60 to 0.23 ($P \leq .001$).

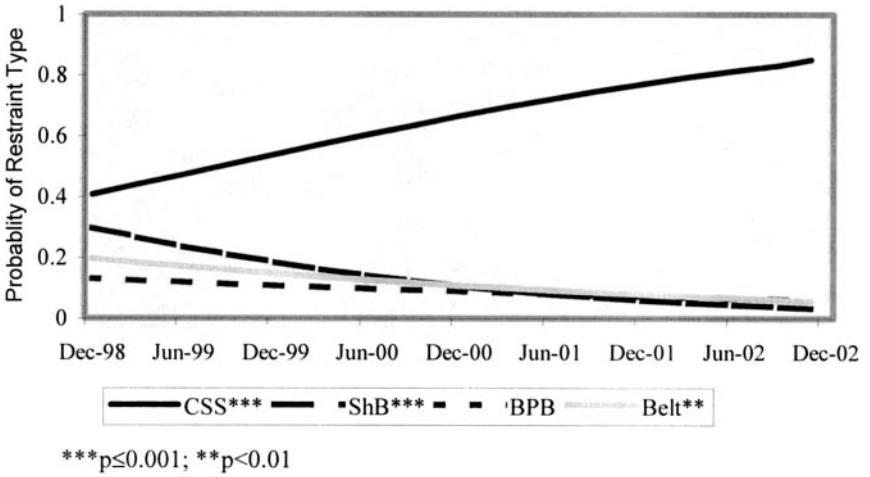
5-Year-Olds (Unweighted n = 1164)

Figure 3 (the CSS trend and BPB trend lines are virtually identical; for separating these 2 lines, 0.5% was added to the intercept for calculating the probability of BPB use) shows the trends in restraint type used by 5-year-olds. At the end of the study period, 48% of children in this age group were restrained in a child restraint. The probability of ShB use showed

TABLE 1. Distribution of Restraint Type Usage by Child's Age Group and Time Period in Motor Vehicle Crashes (Unweighted N = 10195) in Three Large US Regions*

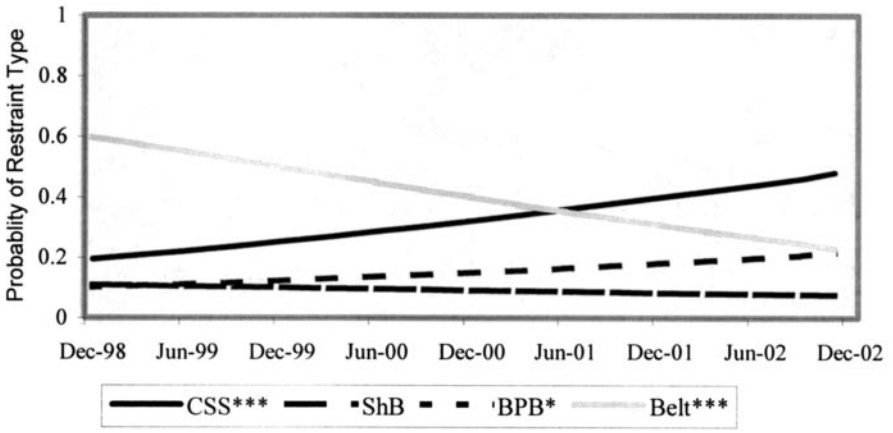
Age/Time Period	Restraint Type				
	CSS (Weighted %; Unweighted N)	ShB (Weighted %; Unweighted N)	BPB (Weighted %; Unweighted N)	Seat Belt (Weighted %; Unweighted N)	No Restraint (Weighted %; Unweighted N)
0–2					
1998†	93.4 (411)	2.5 (14)	0.6 (3)	2.9 (15)	0.6 (3)
2002‡	95.2 (287)	1.4 (3)	1.1 (5)	2.3 (8)	0.02 (1)
3					
1998	47.0 (83)	19.8 (24)	15.6 (15)	16.1 (31)	1.5 (6)
2002	87.1 (86)	1.6 (7)	6.2 (8)	3.7 (15)	1.5 (2)
4					
1998	22.6 (41)	5.5 (13)	9.1 (15)	62.1 (122)	0.7 (2)
2002	51.6 (48)	5.4 (6)	16.9 (15)	25.6 (43)	0.5 (3)
5					
1998	6.6 (7)	3.8 (8)	1.8 (4)	86.3 (160)	1.5 (5)
2002	20.7 (15)	4.2 (6)	23.2 (21)	49.9 (63)	2.0 (3)
6					
1998	2.1 (4)	1.4 (3)	0.8 (3)	91.6 (159)	4.1 (13)
2002	8.8 (9)	0.04 (1)	20.3 (15)	70.7 (80)	0.1 (3)
7–8					
1998	0 (0)	0 (0)	1.8 (2)	96.6 (347)	1.6 (17)
2002	2.3 (3)	0 (0)	2.9 (7)	92.3 (205)	2.5 (12)
Total					
1998	40.9 (546)	4.5 (62)	3.8 (42)	49.4 (834)	1.4 (46)
2002	51.8 (448)	1.8 (23)	8.9 (71)	36.5 (414)	1.0 (24)

* Because of rounding of the decimal and the response of unknown, the presented percentage (number) by age group may not equal 100% (total number).
† The first 6 months of the study period: from December 1, 1998, to May 31, 1999.
‡ The last 6 months of the study period: from June 1, 2002, to November 30, 2002.



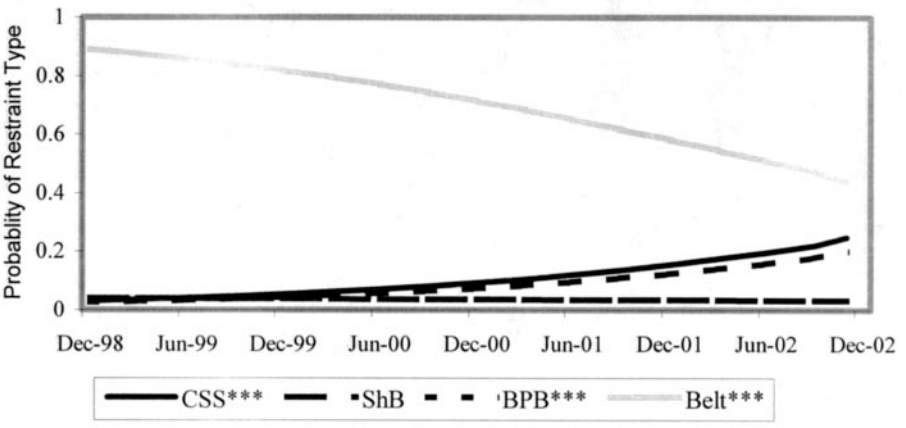
***p≤0.001; **p<0.01

Fig. 1. Trends in restraint type used by children age 3 between 1998 and 2002.



***p≤0.001; *p<0.05

Fig. 2. Trends in restraint type used by children age 4 between 1998 and 2002.



***p≤0.001

Fig. 3. Trends in restraint type used by children age 5 between 1998 and 2002. The CSS trend and BPB trend lines are virtually identical. For separating these 2 lines, 0.5 was added to the intercept for calculating the probability of BPB use.

no significant trend, whereas the probability of CSS use increased from 0.03 to 0.25 ($P = .002$). The probability of BPB use also showed a highly statistically significant increase from 0.03 to 0.25 ($P \leq .001$). Conversely, the probability of seat belt use showed a highly statistically significant decrease from 0.89 to 0.44 ($P \leq .001$).

6-Year-Olds (Unweighted $n = 1134$)

At the end of the study period, 29% of children in this age group were restrained in a child restraint. The probability of CSS use increased from 0.01 to 0.09 ($P = .012$). The probability of BPB use also showed a highly statistically significant increase from 0.01 to 0.25 ($P \leq .001$). In contrast, the proba-

bility of ShB use showed a decreasing trend from 0.02 to 0.002 ($P = .07$). Concurrently, the probability of seat belt use decreased from 0.94 to 0.68 ($P \leq .001$).

7- and 8-Year-Olds (Unweighted $n = 2460$)

At the end of the study period, 5% of children in this age group were restrained in a child restraint. Trends in ShB use could not be analyzed because of the small number ($n = 3$) over the study period. The probability of CSS and BPB uses both showed a small increases in use from <0.01 to 0.03 and <0.01 to 0.05, respectively ($P = .03$ for CSS; $P = .043$ for BPB). In contrast, the probability of seat belt use showed a small but statistically significant decrease from 0.97 to 0.90 ($P = .016$).

DISCUSSION

Our research findings demonstrate dramatic shifts in the distribution of restraint types used by US children under age 9 over a short period of time between 1998 and 2002. Overall, there was a 29% increase (from 49% to 63%) in child restraint system use for children under age 9 with a concomitant 27% decrease in seat belt use. At the beginning of the study, approximately half (49%) of children in the study population were inappropriately restrained by seat belts, and approximately half of them (49%) were in child restraints. By the end of the study, the majority of children in the study population (63%) were in child restraints, and 36% of them used seat belts. Among children aged 4 to 8, however, more than half (62%) remained inappropriately restrained in seat belts.

In our crash-based study, for children under age 9, the prevalence of serious injury remained stable over the period of the study ($P = .13$): from a low of 1.3% (unweighted $n = 132$) for the first half year to 1.4% (unweighted $n = 131$) for the last half year. Despite the increased use of child restraint for these young children, the prevalence of serious injury remained essentially unchanged within this short period of time. Because the cause of injury for children in crashes is multifactorial,[14] this stability might be the result of the change of other factors or the high seat belt usage for children aged 4 to 8 over the study period. This might further indicate the need for continued efforts and promotions for booster seat use for children in this age group.

The NHTSA began a standardized child passenger safety training and certification program in March 1998. Since then, >27 000 individuals have been certified as child passenger safety technicians.[15] These individuals have participated in thousands of community-based child safety seat clinics and have been a source of information on appropriate restraint guidelines, including the use of booster seats. In addition, several government- and industry-sponsored initiatives have drawn significant media attention to the importance of booster seats. The NHTSA made booster seats the focus of its Child Passenger Safety Week educational campaign in February 2000. Although not an exhaustive list of the many outreach initiatives to promote appropriate child restraint, the following demonstrate major corporate investments. State Farm Insurance Corporation has conducted a nationwide education campaign of its 35 million policyholders via a mass mailing of information on booster seats and conducts an annual child safety day in May. Safe Kids, through General Motors sponsorship, conducts child safety seat checks, and Daimler-Chrysler sponsors a web site to find a child passenger safety technician and conducts child safety seat checks at their dealerships. Ford Motor Corporation, through its BoostAmerica campaign, increased the public's awareness of the need for booster seats and distributed 1 million booster seats across the country. Furthermore, over the 4 years of data collection, materials by the AAP, such as "Car Safety Seats: a Guide for Families" and "Selecting and Using the Most Appropriate Car Safety Seats for Growing Children: Guidelines for Counseling Parents," also played a major role in informing pediatricians, other health care providers, and parents about age-appropriate restraint usage for children under 9.[2,16]

Other studies have demonstrated increased use of child restraints by US children. In 2001, National Safe Kids[17] reported that, among children aged 4 to 8 observed in their convenience sample, 37% were estimated to use a booster seat. Compared with 27% of booster seat use among children aged 4 to 8 observed in a convenience sample in 1999, this increase is substantial.[18] According to an observational study conducted by the NHTSA[18] on the use of child restraints in 2002, for children aged 1 to 3, the use of forward-facing child safety seats increased to 62% in 2002 from 39% in 2000. Our study supports and extends these results by describing trends in specific restraint types used for each age of child. Our methods highlighted that the greatest gains were demonstrated for children aged 3 and that although there was an increase noted overall in booster seat use, use of specific types of boosters varied. Despite gains in appropriate restraint, a great proportion of older children, especially the 7- and 8-year-olds, were still inappropriately using the vehicle seat belt as their restraint. This points to the need for continued and improved intervention efforts that promote appropriate restraint for children aged 4 to 8.

Qualitative studies[19,20] identified lack of knowledge about the importance of appropriate restraint and the risks associated with premature use of seat belts as major barriers for parents to restrain their 4- to 8-year-old children appropriately. The most important barrier identified was the lack of concordance between state laws and best practice recommendations. In addition, as emphasized in their planning for a national strategy to increase booster seat use for children aged 4 to 8, the NHTSA[10] proposed addressing challenges such as "the lack of information among parents or caregivers," "young child's desire to act grown up and not to have to sit in any type of child restraint," and "inconsistency of state laws pertaining to protecting older children and booster seat use." Sustained outreach efforts and upgrades to state child restraint laws are important in addressing these barriers or challenges.

Fewer children were restrained in ShBs recently than in previous years. The reduction in ShB usage reflects both a marked reduction in marketing and

sale of ShB concomitant with the time of the study and parents' following the safety message of the AAP. It is important to highlight that, according to current recommendations for appropriate restraint of children, many children who use ShBs were not following best practice. On the basis of current Federal Motor Vehicle Safety Standards established by the NHTSA,[21] ShB have not been certified by their manufacturers for use by children who weigh >40 lb. Even in the weight group of 30 to 40 lb, the AAP recommends the use of a full harness child restraint as best practice because of limited upper body protection in ShB and a risk of ejection from the ShB in a rollover crash.[22]

The increasing trend in CSS use among children over age 4 deserves attention. Before 2000, few CSSs were rated by manufacturers to hold children who weigh >40 lb.[23] The promotion of appropriate restraint for children under 9 had an impact on the design of the new CSSs. Several of the new CSS makes can hold children up to 50 lb,[16,24] yet few of these seats are likely in our study. Our data showed a dramatic increase in the CSS use by 4- to 5-year-old children. The emphasis on appropriate child restraint use for older children had a significant impact on child passenger protection in the United States. Many parents delayed graduation of children to seat belts until older ages. As an added benefit, many more children stayed in CSSs through age 4, with a substantial minority continuing through age 5. Educational efforts aimed at promoting booster seat use by children over age 4 seemed to "raise the bar" for all children, reducing premature graduation out of CSSs and into seat belts. The risks and benefits of harness restraint by children who weigh >40 lb should be evaluated.

At the current time, federal legislation is pending to encourage states to upgrade their child restraint laws to mandate the use of booster seats for children over age 3 (Cathy Chase, Advocates for Highway and Auto Safety, personal communication; www.saferoads.org; 2003). Our results may assist state and federal policymakers by demonstrating the current level of interest on the part of parents to restrain their older children appropriately.

It is important to note that this research was conducted on crashes involving State Farm Insurance Co policyholders only. State Farm is the largest insurer of automobiles in the United States; therefore, its policyholders are likely representative of the insured public in the United States. The surveillance system is limited to children who occupy insured vehicles that are model year 1990 and newer. Thus, the results may not be generalizable to the restraint use of child passengers in vehicles that are older than 1990 or uninsured vehicles. Also, the extent of underreporting or overreporting of restraint type use cannot be determined, although the findings are consistent with other research.[17,18]

Implications

These results reflect very current trends in child restraint usage. Although considerable achievements have been realized over a short period of time, substantial inappropriate restraint still remains: 62% of children aged 4 to 8 remain inappropriately restrained in adult seat belts. Parents hear safety messages when they are relevant to their children. As a result, sustained efforts about appropriate restraint must continue to maintain and improve the gains achieved in appropriate child restraint use. The additional benefits realized by recent changes in child restraint laws remain to be evaluated.

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