A long description about this cover

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REPORT TO CONGRESS

National Highway Traffic Safety Administration
U.S. Department of Transportation
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Improving The Safety of Child Restraints
BOOSTER SEAT STUDY

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Executive Summary

Enacted on November 1, 2000, the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act contains provisions on improving the performance of child restraints. In Section 14(h), "Improving the Safety of Child Restraints - Booster Seat Study," the TREAD Act mandates that the Secretary of Transportation initiate and complete a study, ***taking into account the views of the public, on the use and effectiveness of automobile booster seats for children; compiling information on the advantages and disadvantages of using booster seats; and determining the benefits, if any, to children from use of boosters with lap/shoulder belts compared to children using lap/shoulder belts alone***.

The report provides background information regarding the review and progress of child safety in automobile crashes in the United States, a summary of the National Highway Traffic Safety Administration's (NHTSA) activities in promoting child safety, a summary of the Agency's regulatory actions, and a review of public perception on the use and effectiveness of booster seats based on various surveys. Additionally, a summary of survey results in which parents, caregivers, and/or children were participants and other applicable findings are also presented.

Effectiveness of Booster Seats

Since 1975, child restraint systems have saved more than 4,000 children from fatal injuries. During that time, the ***total number*** of child occupant deaths has not dropped significantly. However, the ***fatality rate*** for children under ten years of age significantly dropped, due to concurrent increases in the U.S. child population and a near doubling of the number of miles Americans travel on our Nation's highways since 1975. On average, about 1,000 children under 10 years of age are killed per year in motor vehicle crashes in the United States.

It is estimated that approximately 47 percent of the fatally injured children in the 0 through 9[1] years old age group are generally unrestrained. For children under the age of 15 years, approximately 60 percent are unrestrained among those who are fatally injured.

Research on the effectiveness of child safety seats has found them to reduce fatal injury by 71 percent for infants (less than 1 year old) and by 54 percent for toddlers (1 - 4 years old) in passenger cars. For infants and toddlers in light trucks, the corresponding reductions are 58 percent and 59 percent, respectively[2].

Using 1988 through 1997 data from the Fatality Analysis Reporting System (FARS), NHTSA estimated the effectiveness of rear seat lap/shoulder belts at 54 percent for 9 - 14 year olds and 48 percent for 5 - 8 year olds in passenger cars[3]. Proper belt fit is believed to occur for children approximately 9 years of age or older. Placing a 4 - 8 year old in a belt positioning booster (BPB) seat secured by a lap/shoulder belt will have the same effectiveness in the rear seat as lap/shoulder belts for the 9 - 14 years old children, i.e., 54 percent. Thus, a six- percent increase in the effectiveness for the 4 - 8 year old children in booster seats is realized. If children who are not using child safety restraints are restrained with lap/shoulder belts, approximately 150 lives could be saved annually. If booster seats are assumed to have an additional effectiveness of 6 percent, 19 more lives could be saved, provided all eligible children used booster seats. Assuming the level of booster seat use increased to about 75 percent, the additional benefits may only reach approximately 14 lives saved.

However, the effectiveness of booster seats is not currently evaluated on the basis of mitigation of injuries as well. It is noted that the data currently available in estimating the effectiveness of booster seats are limited. The data lack details necessary to assist the Agency in identifying the types, makes, and models of child restraints involved in crashes,

proper restraint use and subsequent performance. This deficiency hinders the Agency's efforts in making precise estimates on effectiveness of booster seats. The estimates provided in this report are based on the best information currently available from the Agency's own data and other sources. To determine booster seat effectiveness, modification to the current electronic data collection system (EDCS) is in place as of January 2002. The modified data collection system will include updated child restraint variables and attributes as well as new methodologies for field data collection.

Use of Booster Seats

When a child can no longer fit into a convertible or other forward-facing child restraint, the recommended next step is a belt positioning booster seat. The greatest gain in occupant protection for this age group is obtained by getting unrestrained child passengers in any form of occupant restraint. Unfortunately, children are being moved into adult safety belts too soon instead of restraints appropriate for their age and size. Belt-positioning booster (BPB) seats are designed for use with lap/shoulder belts. They should not be used with lap-belts only, because the lack of upper body restraint, coupled with the fact that the child is raised higher on the vehicle seat, could place the child at greater risk of head injury when restrained by lap-belt only.

In 1998, NHTSA gathered information on booster seats by including booster seats in the expanded Motor Vehicle Occupant Safety Survey (MVOSS). The 1998 nationally representative telephone survey included questions about booster seat use. While 76 percent of these participants said they were aware of booster seats, 21 percent said they had not heard of them, and 3 percent were unsure. Of those who were aware of booster seats, 53 percent said they had used them for their children at some time.

Advantages and Disadvantages of Booster Seats

It is well known that, by properly restraining children, serious and fatal injuries can be prevented in motor vehicle crashes. The motivation behind the development of booster seats is to improve lap/shoulder belt fit for child occupants. Properly designed booster seats that improve the belt fit and comfort could encourage their use and thus increase safety.

Beyond the safety advantages of using booster seats, early exposure of children to the safety risks of not using proper restraints is likely to carry through to their adult life. This should improve their safety habits such as using safety belts and paying closer attention to safety risks. Other advantages of booster seats include potential reduction of the risk of injuries to children due to nonuse or improper use of child restraints.

Currently, the Agency is not aware of any known disadvantages of booster seats.

Conclusions

Fatalities and injuries to children under 10 years of age remain high and these casualties occur because nearly half of the children in this age group generally travel in automobiles unrestrained. Although current data are limited, it is estimated that approximately 150 lives could be saved, annually, if those children who are not using child restraints are restrained with lap/shoulder belts. Further, if all those children who are ready for booster seats used them and lap/shoulder belts, an additional 19 lives could be saved every year.

FOOTNOTES

1. For the purpose of this report, when citing age ranges, the word "through" and the dash symbol "-" mean the latter value is inclusive. For example, "0 through 9" and "0-9" years old mean that children 9 years old and under are included in the range. Zero "to" 9 years old means children up to but not including children that are 9 year olds.

2. National Center for Statistics and Analysis - 1999 Traffic Safety Fact Sheet: Children
3. These values were obtained as result of further analysis of data presented in the report, “Effectiveness of Lap/Shoulder Belts in the Back Outboard Seating Positions," Evaluation Division, Plans and Policy. NHTSA, Washington, DC, June 1999. DOT HS 808 945.

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Improving The Safety of Child Restraints
BOOSTER SEAT STUDY

Chapter 1
Background

This chapter presents the purpose of this report, an overview regarding the progress of child safety in the United States, a summary of NHTSA's activities in promoting child safety, a summary of the Agency's regulatory actions, and discussion of issues regarding obstacles in the wide spread use of booster seats.

Enacted on November 1, 2000, the Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act, Public Law 106-414 (114 Stat. 1800), contains provisions on improving the performance of child restraints. In Section 14(h), "Improving the Safety of Child Restraints - Booster Seat Study," the TREAD Act mandates that the Secretary of Transportation initiate and complete a study on booster seats. This study should take into account the views of the public on use and effectiveness of automobile booster seats for children; compiling information on the advantages and disadvantages of using booster seats; and determining the benefits, if any, to children from use of boosters with lap/shoulder belts compared to children using lap/shoulder belts alone. This report is written to satisfy that Congressional requirement. For the purpose of this report, booster seats are defined as devices which function as a bridge in the transition of the child from toddler or convertible child restraints to the vehicle adult belt systems. (A convertible restraint is especially adjustable so that it can be used rear-facing by an infant or a very young child, and forward-facing by a toddler. A forward-facing only or belt-positioning booster child restraint positions a child forward-facing only and is not capable of being adjusted to face an infant rearward.)

The Safety Problem

Since 1975, traffic crashes have been the leading cause of death for children. Based on 1997 mortality data from the National Center for Health Statistics, they were the leading cause of death for children of every age from 6 through 14 years old. While the total number of child occupant deaths has not changed significantly from year to year, the fatality rate has decreased steadily due to concurrent increases in the U.S. child population and a near doubling of the number of miles Americans travel on our Nation's highways[4]. The pattern of injuries as opposed to fatalities in young children is far more difficult to obtain because of the paucity of data. With the addition of new variables and attributes related to child safety restraints, effective January 2002, NHTSA's National Automotive Sampling System (NASS) Crashworthiness Data System (CDS) data will have the potential for providing such information.

Approximately 47 percent of passenger vehicle occupants fatally injured under 10 years of age were unrestrained.

In 1999, there were a total of 41,717 traffic fatalities in the United States. Of these fatalities, the 0 through 9 years old age group accounted for 1,043 or 3 percent of all passenger vehicle occupant fatalities. In 1999, there were a total of 3,236,000 people injured from motor vehicle crashes in the United States. Out of these the 0 - 9 years old age group accounted for 163,000 or 5 percent of all passenger vehicle occupants injured. This represents approximately 3 fatalities and 447 injuries to children under 10 years of age among passenger vehicle occupants every day in the United States in motor vehicle crashes. Of those passenger vehicle occupants fatally injured under 10 years of age, 495 or 47 percent were unrestrained. These various statistics indicate that fatal and serious injuries in motor vehicle crashes to child occupants continue to be a serious problem.

Table 1: Percent of Unrestrained Passenger Vehicle Occupants Involved in Fatal Crashes By Age Group , 1999[5]

0-4 Years	5-9 Years	10-14 Years	15-20 Years	All Other	Total
28%	40%	49%	54%	43%	45%

Table 1 shows, by age group, the percentage of passenger vehicle occupants who were involved in fatal crashes that were unrestrained. Forty percent of those children ages 5 - 9 years old, those that should be restrained in booster seats, were riding unrestrained in vehicles that became involved in fatal crashes. This indicates that a significant portion of children in this age group are riding unrestrained at any time.

A detailed examination of the FARS data for 1991 through 1999 show that, on average, there are approximately 476 fatalities occurring per year in the age group 4 through 8 years old in vehicle crashes. In a number of these cases (average 62 per year) it is not known whether any type of restraints were in use at the time of the crash.

Table 2: Passenger Vehicle Occupants, Ages 4 - 8 Years Old, Killed, By Year and Restraint Use: FARS 1991-1999

Year	Child Safety Seat	Lap and/or Shoulder Belt	None Used	Other/ Unknown	Total
1991	4	84	283	69	440
1992	10	99	281	53	443
1993	3	110	265	57	435
1994	9	131	273	74	487
1995	14	129	274	66	483
1996	15	152	264	54	485
1997	14	166	265	60	505
1998	8	176	268	60	512
1999	15	154	268	62	499
Average	**10**	**133**	**271**	**62**	**476**

On average, no restraints were used by approximately 271 (57 percent) of these occupants, and 133 children (28 percent) on average used lap and/or shoulder belts. This leaves only about 10 fatalities (2 percent) per year that occur while using some type of child safety seat. The distribution of the fatalities in this age group for the period 1991 through 1999 is given in Table 2.

In addition, children are being moved into adult safety belts too soon. A NHTSA observational study showed that of the children who had outgrown their child safety seat, at about age 4 and a weight of 40 pounds, only 6 percent were in booster seats[6]. Children can move to an adult safety belt when they can firmly place their back against the vehicle seat back cushion with their knees naturally bent over the vehicle seat cushion. This typically occurs when a child is about 4 feet 9 inches tall. For children from 4 to 8 years old, properly used booster seats can help prevent injury by making adult-sized safety belts fit correctly[7]. Unfortunately, few children who could benefit from booster seats use them. Most studies confirm booster seat use rates mentioned above as being below 10 percent. Survey data show that these children often use safety belts instead or are totally unrestrained.

Table 3: Recommended Child Restraint Use
Proper Child Safety Seat Use Chart Buckle Everyone.

Children Age 12 and Under in Back!

	INFANTS	TODDLER	YOUNG CHILDREN
WEIGHT	Birth to 1 year up to 20-22 lbs.	Over 1 year and Over 20 lbs.-40 lbs.	Over 40 lbs. up to 80 lbs.[8]
TYPE of SEAT	Infant only or rear-facing convertible	Convertible/Forward-facing	Belt positioning booster seat
SEAT POSITION	Rear-facing only	Forward-facing	Forward-facing

Table 3 shows the various types of child safety restraints, along with the current recommendations for transitioning to the next type of restraint system. See Appendix 1. Also, see policy change indicated in Footnote 8.

Children's Hospital of Philadelphia (CHOP), under a collaboration between CHOP, the University of Pennsylvania and State Farm Insurance Companies, known as Partners for Child Passenger Safety (PCPS), is collecting data on children 15 years old and younger who are involved in motor vehicle crashes. The goal of PCPS is to gain a better understanding of the characteristics of vehicles, restraint use, and crash dynamics, as well as the impact of these elements on child injuries. In an ongoing study, CHOP[9] found that 83 percent of 125,000 children (3 through 8 years old) involved in crashes were not appropriately restrained. They were either out of their child safety seats too soon, or they were not in booster seats. Most of these children were in adult safety belts. There was a three-fold increased risk of significant injury to children who were in adult safety belts when compared to children in booster seats. Most of these injuries were to the head and brain, with injury to the brain being the least likely from which to recover. There were also abdominal and spinal cord injuries. Nearly all of the children who sustained abdominal and spinal cord injuries were in adult safety belts. In general, children in booster seats sustained no serious injuries.

Progress of Child Passenger Safety in the United States

Over the past 25 years, our Nation has achieved significant gains in child passenger safety. Since 1975, child restraint systems have saved more than 4,000 children from fatal injuries. During that time, the occupant fatality rate for children under age 10 dropped 22 percent and is now only one-quarter of the occupant fatality rate for all ages combined.

Figure 1: Occupant Fatality Rates by Age

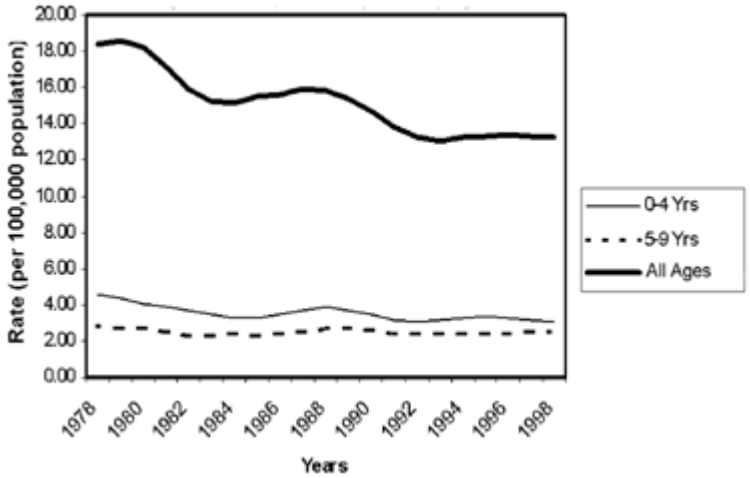
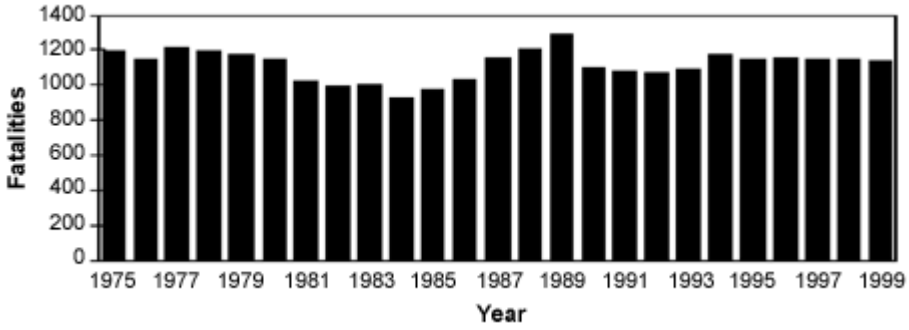


Figure 1 shows occupant fatality rates in motor vehicle crashes per 100,000 population for the U.S. from 1978 to 1998 and compares it to the fatality rate for children in two age groups, 0 - 4 years and 5 - 9 years of age. Figure 2 gives the

annual child occupant fatalities for the years 1975 to 1999 for those under the age of 10 years. On average, about 1,000 passenger vehicle occupants under 10 years of age are killed per year in motor vehicle crashes in the United States[10].

Annually, approximately 1,000 passenger vehicle occupants under 10 years of age are killed per year in motor vehicle crashes.

Figure 2: Child Occupant Fatalities by Year



Public Awareness of Booster Seats

In a continued effort to gain some insight on the use of booster seats, NHTSA expanded the Motor Vehicle Occupant Safety Survey (MVOSS) to include booster seats. In 1998, NHTSA included questions about booster seat use in a telephone survey[11] of a randomly selected national sample of about 4,000 persons age 16 and older. A subgroup of 754 parents or caregivers of children under the age of 6 years old were asked if they were aware of booster seats. While 76 percent of these participants said they were aware of booster seats, 21 percent said they had not heard of them, and 3 percent were unsure. Of those who were aware of booster seats, 53 percent said they had used them at some time for their children.

Survey results indicate that children who should be in booster seats often use safety belts.

The survey indicates that children who should be in booster seats often use safety belts instead. While most participants thought children in rear-facing seats were expected to move on to other safety seats, 14 percent expected their older children to use safety belts. Slightly more than half (55 percent) of the parents whose children used child safety seats said that when their children outgrew a child seat, they would use a different seat or booster seat. Forty-three percent answered either that the children would graduate to safety belts or that they did not know what would happen.

In spite of the documented effectiveness of child safety seats[12], the fact remains that many families still do not use them. Although there are child safety seat laws in every State and the District of Columbia, most laws do not apply to older children or booster seat use. In the study performed for NHTSA by CHOP, it was found that gaps in State child passenger safety laws and seat belt use laws lead to low booster seat use rates and premature graduation of children from safety seats to adult safety belts. Though child restraint laws have helped to increase the use of child restraints for younger children, they often fail to conform to the current best practices[13].

NHTSA's Active Role in

Promoting Booster Seats

NHTSA has been a national leader in promoting child passenger safety. Working together with our private and public partners, we have seen increased usage of child safety seats in the last 10 years. During the past several years, NHTSA has pursued partnerships with other government organizations, industry, safety advocates, and others to best address the issue of proper restraint use for older children--including those that have outgrown the convertible/forward-facing child safety seat.

On November 19, 1998, the Secretary of Transportation and the NHTSA Administrator announced the formation of the Blue Ribbon Panel II: Protecting Our Older Child Passengers. This panel was formed to recommend ways to increase the use of age- and size-appropriate occupant restraints by children ages 4 through 15 whenever they are riding in a motor vehicle. Recommendations from this work were presented on March 15, 1999, to government, industry, and safety organizations. These recommendations addressed issues related to legislation and enforcement, marketing and public education, product design, research, and funding. A complete list of panel recommendations can be found at http://www.actsinc.org/whatsnew_6.html.

To address the issue of nonuse of booster seats, in 1999 NHTSA awarded over $900,000 to six States and communities for pilot and demonstration programs to increase booster seat use for children 4 to 8 years old, as well as to promote safety belt use among older children. Initiatives were developed that targeted parents, caregivers, physicians, and to children themselves.

In one grant program, daycare centers modified their transportation policies to include the use of booster seats when they travel with children ages 4 to 8. They also hosted seat belt checks in their parking lots, and provided education to parents (brochures) and children (coloring books) about the importance of using child safety seats, booster seats and seat belts. In another grant site, physician prescription pads were developed providing a "prescription for a booster seat". These were provided to the pediatricians in the grant community. Educational seminars on child restraint use were also given to the pediatricians. The prescriptions were linked to coupons at local stores for reduced price booster seats. Child safety seat clinics were highly publicized to parents and caregivers in the grant sites.

Additionally, in one Hispanic community a "booster seat fiesta" was conducted. This entailed a party atmosphere where children and adults learned about the importance of buckling up with local sports heroes. They also received free car and booster seats at a child seat clinic which was part of the fiesta. One grant site developed a puppet that was used to educate children in preschools through second grade about using a booster seat. Educational materials were also developed to be taken home to parents.

These are a few examples of initiatives that were implemented within grant communities to increase the use of booster seats use among 4 to 8 year olds. Final reports from these programs have been submitted and a guide is being developed to provide information that will enable and encourage communities to promote the use of booster seats.

In February 2000, based on the Blue Ribbon Panel II recommendations, NHTSA launched the Don't Skip a Step national booster seat campaign to educate parents about the risks of improperly positioned adult safety belts and the effectiveness of belt-positioning booster seats for children ages 4 to 8 years. The Agency later introduced a campaign (called 4 Steps for Kids) to promote the use of booster seats for children who have outgrown convertible/forward-facing child safety seats.

In April 2001, the Association for the Advancement of Automotive Medicine (AAAM) sponsored an international conference, Booster Seats for Children: Closing the Gap Between Science and Public Policy, consisting of leading child passenger safety experts in medicine, engineering, public policy, research, and enforcement. A major goal of that conference was to develop scientifically based recommendations that would guide future research and lead to public policies, including regulation and legislation, on booster seats and other restraint systems. The recommendations are available at the website address www.carcrash.org/recs.html. The basis for the recommendations is stated in Appendix 2.

NHTSA has been a close partner in the development and refinement of the “Boost America!” program sponsored by Ford Motor Company. Ford’s multi-million dollar program, launched on April 30, 2001, will give away hundreds of

thousands of booster seats. Ford has also awarded $1 million in grants to local organizations to support grassroots booster seat advocacy and distribution efforts. In addition, the program will distribute preschool and elementary school educational materials promoting booster seat use. The Agency plans to continue to work with retailers, child safety seat and vehicle manufacturers to raise consumer awareness of booster seats. In addition, the Agency sought public input to identify potentially effective interventions to increase booster seat use. As required by the TREAD Act, NHTSA has developed a 5-year strategic plan to increase booster seat use for 4 to 8 year old children.

History of NHTSA's Regulatory Activities on Booster Seats

In July 1991, noting that many new developments and changes had emerged in motor vehicles and child restraint systems since the issuance of the 1979 final rule for enhancing child safety, NHTSA issued a planning document that discussed research and possible upgrades to Federal Motor Vehicle Safety Standard (FMVSS) No. 213 (Docket 74-09; Notice 21: 56 FR 32544, July 17, 1991).

The 1991 planning document acknowledged that the ability to adequately test certain types of child restraint systems, most notably child booster seats and infant carriers, was limited by the range of dummies specified in FMVSS No. 213. Because there were only two dummies, questions arose regarding whether child restraint systems could be adequately tested to ensure desirable levels of protection to children having a wide range of weights and heights.

The planning document noted that the development of a full range of test dummy sizes was a critical step in ensuring that child restraint systems provide the safety envisioned in FMVSS No. 213 for all children. The document also noted that activities were already underway within the Agency to develop and adopt new test dummies into 49 CFR 572. NHTSA planned to incorporate the new dummies into FMVSS No. 213 for use in compliance testing following their incorporation into 49 CFR 572. The compliance test dummies included surrogates for a newborn, a 9-month-old, and a 6-year-old child. These dummies weighed 7.5 pounds, 20 pounds, and 48 pounds, respectively.

In the 1991 Agency Planning Document, it was also noted that the incorporation of the newborn, 9-month-old and 6-year-old test dummies into Part 572, and using them in addition to the pre-existing 3 year-old (33 pound) dummy in FMVSS No. 213, would significantly increase the Agency's ability to ensure high levels of safety to children in child restraint systems. Expanding the family of test dummies used to test and certify child restraint systems would allow for tests that were more representative of the real world and more meaningful in assessing the safety performance of child restraint systems. The 6 year-old dummy is currently used to test booster seats with the Type II (i.e., lap/shoulder) belt configuration.

In response to the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 (Pub. L. 102-240; December 18, 1991), NHTSA was directed to initiate a rulemaking on child booster seat safety and other issues. The ISTEA directive originated in S. 1012, a bill reported by the Senate Committee on Commerce, Science, and Transportation, and was added verbatim to the Senate's Surface Transportation bill (S. 1204). The Senate Commerce Committee report on S. 1012 expressed concerns about suggestions that booster seats, "depending on their design, can be easily misused or are otherwise harmful," and that some child seat [shield] boosters "may not restrain adequately a child in a crash."

The Committee's concerns about the possible inability of a booster seat to restrain some children adequately stemmed from a study performed by Calspan Corporation (now Veridian Corporation) titled "Evaluation of the Performance of Child Restraint Systems" (DOT HS 807 297, May 1988). Calspan found that when the then-manufactured (shield) booster seats were tested with test dummies representing the range of children for whom the seats were recommended, the booster seats did not appear to be able to adequately restrain those test dummies. When tested to the requirements of FMVSS No. 213, however, the booster seats passed the requirements because the standard specifies the use of only one dummy -- representing a 3-year-old, 33-pound child -- for the testing. The implication of these test results was that test dummies representative of a wide range of child sizes were needed in FMVSS No. 213 to more effectively test the performance of booster seats and other child restraint systems. What seemed especially needed was an array of dummies representing children at or near the extremes of the weight ranges identified by a manufacturer as being suitable for any type of child restraint.

NHTSA conducted additional research tests following the Calspan study to obtain more data about (shield) booster seat

performance with different dummies (“Evaluation of Booster Seat Suitability for Children of Different Ages and Comparison of Standard and Modified SA103C and SA106C Child Dummies; VRTC-89-0074, February 1990). Nine booster seats were tested with the three dummies used in the Calspan study -- the 9-month-, 3-year- and 6-year-old dummies. The seats performed well with the 3-year-old dummy, but were generally unsuitable for the 9-month-old and 6-year-old dummies.

Current Federal Motor Vehicle Safety Standard No. 213 Requirements

Current requirements in FMVSS No. 213 apply only to those child restraints for children weighing 50 pounds or less. The following discussion highlights current provisions in Standard No. 213 relating to the performance of ***all*** child restraint systems:

1. The performance of a child restraint system is evaluated in dynamic tests involving a 30 mph velocity change, which is representative of a severe crash. Each child restraint is tested while attached to a standardized seat assembly. Booster seats are tested while attached to the standard seat assembly by a lap/shoulder belt.
2. To protect the child, limitations are set on the amount of force that can be exerted on the head and chest of a child test dummy during the dynamic testing. (S5.1.2 of Standard No. 213). To reduce the possibility of injury that child occupants in child restraint systems may incur if they contact vehicle interior surfaces during a crash, limitations are also set on the amount of frontal head and knee excursions that can be experienced by the test dummy.
3. During dynamic testing, no load-bearing or other structural part of any child restraint system may separate so as to create jagged edges that could cut and injure a child.
4. To prevent injuries to children during crashes from contact with the surfaces of the child restraint itself, the standard specifies requirements for the size and shape of those surfaces.
5. Information necessary for the proper use of the child restraint system must be permanently labeled on the child restraint and presented in an information booklet that accompanies the child restraint system. The child restraint must also provide a special location or compartment on the child restraint system in which the information booklet may be permanently stored, so that the parent or other user of the child restraint can always have available the necessary safety information (S5.5 of Standard No. 213). Standard No. 213 also requires each child restraint system to be accompanied by a postage-paid registration form so that purchasers can register with the manufacturer and thereby be directly notified in the event of a safety recall. Manufacturers must retain the names and addresses of registrants for a period of six years. (S5.8 of Standard No. 213; 49 CFR Part 588).
6. Each material used in a child restraint system must meet the flammability requirements of S4 of FMVSS No. 302 (49 CFR §571.302) (S5.7 of Standard (No. 213).

An increasing number of child restraint manufacturers claim adequate performance of some of their child restraints at weights beyond what is tested under FMVSS No. 213. The Agency has been asked to consider using dummies weighing more than 50 pounds in testing these restraints for compliance with the standard. (The 6-year-old dummy, currently used for testing all restraints for children weighing more than 40 pounds, weighs 48 pounds.) Booster seats are recommended for use by children weighing from 40 to as much as 80 to 100 pounds. Again the current standard does not address these upper weight limits. Section 14(b)(6) of the TREAD Act, however, directs the Agency to consider whether to amend Federal Motor Vehicle Safety Standard No. 213 (49 CFR 571.213) to cover restraints for children weighing up to 80 pounds.

Comments and Recommendations Regarding Booster Seat Evaluation

In September 1996, the National Transportation Safety Board (NTSB) published a report that examined the performance and use of occupant protection systems for children -- child restraint systems, vehicle safety belts, and air bags (“The Performance and Use of Child Restraint Systems, Seatbelts, and Air Bags for Children in Passenger Vehicles,” PB96-917005, NTSB/SS-96/01, September 1996). The study also examined the adequacy of relevant

Federal Motor Vehicle Safety Standards, the comprehensiveness of State child restraint and safety belt use laws, and the adequacy of public information and education on child passenger protection. As part of this report, the Safety Board noted concerns that booster seats that restrain children who weigh more than 50 pounds are not subject to any performance standards; however, booster seats are necessary for some children above that weight. NTSB Safety Recommendation H-96-25 recommended that NHTSA "revise FMVSS 213, "Child Restraint Systems," to establish performance standards for booster seats that can restrain children up to 80 pounds."

In March 1998, the Agency sent a questionnaire to each of the child restraint manufacturers requesting information about their current and projected booster seat designs and related issues that may affect the advent of new booster seat designs. While only three of the fourteen manufacturers responded to the inquiry, each responder noted similar concerns regarding booster seats in general. The manufacturers noted that: (1) the lack of state regulations effectively limit the market demand for booster seats, and as a result, the public is not generally aware of the need to use booster seats; (2) dynamic testing of booster seats should not be required, since they believed that dynamic test is really nothing more than a revalidation of the vehicle's Type II belt system[14]; and (3) there is no test device between the existing 6-year-old and 5th percentile female dummies for use in certifying seats at higher weights. The questionnaire and subsequent responses have been placed in the Docket NHTSA-1999-5426.

On March 15, 1999, the Blue Ribbon Panel II presented recommendations to government, industry, and safety organizations that addressed issues related to legislation and enforcement, marketing and public education, product design, research, and funding. Concerning the TREAD provisions asking for a higher weight limit for FMVSS No. 213 and a corresponding dummy for use in testing restraints certified to these higher weights, the Blue Ribbon Panel II recommended that:

"Efforts should be accelerated to develop a universally acceptable test dummy of approximately 10-year-old size to fill the gap between the 6-year-old and 5th percentile female dummies. The new dummy could be used by both vehicle and child restraint system manufacturers to test and evaluate their restraint systems; and NHTSA should define and regulate belt positioning devices that change the geometry of the safety belt relative to target (the highest weight for which any particular device is designed) occupants weighing up to 100 pounds. The regulation should include booster seats and shoulder belt positioners, whether aftermarket or built-in, but exclude adjustable shoulder belt anchorages already subject to FMVSS 210, Seat Belt Assembly Anchorages."

Section 14(b)(2)(A) of the TREAD Act directs the Agency to consider whether to require the use of anthropomorphic test devices that represent a greater range of sizes of children including the need to require the use of an anthropomorphic test device that is representative of a 10-year-old child. The Agency is currently evaluating a prototype 10-year-old dummy for consideration for incorporation into FMVSS No. 213. The 10-year-old prototype weighs over 70 pounds. It can be potentially used as a fitting device for booster seats with the vehicle's lap/shoulder belt system or as a test device for booster seats in accordance with the recommendations for higher weight. The use of a test surrogate for the 10 year old will be determined after it undergoes a complete technical evaluation. As an interim measure, the Agency has developed and tested a weighted Hybrid III 6-year-old dummy. Metal weights were inserted to increase the dummy's weight from 48 pounds to approximately 63 pounds. The seated height of the dummy was increased by one inch. The weighted dummy can be used to test child restraint systems that recommend usage for children weighing up to 65 pounds. The prototype weighted 6 year old is currently being dynamically evaluated for repeatability and reproducibility.

A Notice of Proposed Rulemaking addressing the adoption of the weighted 6 year-old dummy into Part 572 was published in the Federal Register on May 1, 2002 (21806).

FOOTNOTES

4. Child Restraint System Safety Plan, Docket # NHTSA-2000-7938, Comment #1.
5. National Center for Statistics and Analysis - *1999 Traffic Safety Fact Sheet: Children.*
6. Decina and Knoebel, Patterns of Misuse of Child Safety Seats, NHTSA, Washington, DC, DOT HS 808 440, January 1996.
7. Weber, K., Crash Protection for Child Passengers: A Review of Best Practice, UMTRI Research Review, July - September 2000, Vol. 31, No. 3.

8. During the time period in which this report was compiled, the recommendation of NHTSA and other safety organizations on the use of booster seats specified that children who have outgrown their child seat, who weigh between 40 and 80 pounds, and who have not reached 4'9" in height, should use the seats. Additional data and information on the subject have been accumulated since the recommendation was originally made. In response, NHTSA has established the following guidelines: **All children who have outgrown child safety seats should be properly restrained in booster seats until they are at least 8 years old, unless they are 4'9" tall.**
9. Transcript of Booster Seat Education Public Meeting, Docket # NHTSA-2001-9785, Comment #19.
10. Fatality Analysis Reporting System, 1975 - 1999.
11. 1998 Motor Vehicle Occupant Safety Survey, Vol. 3, Child Safety Seat Report, July 2000.
12. Kahane, C.J., An Evaluation of the Effectiveness and Benefits of Safety Seats, NHTSA, DOT-HS-806- 889, 1986.
13. Winston, F.K., Moll, E.K., Durbin, D.R., & Kassam-Adams, N., The Premature Graduation of Children from Child Restraints to Vehicle Safety Belts. NHTSA, DOT-HS-809-256, June 2001.
14. In the NPRM that proposed to amend FMVSS No. 213 to facilitate the manufacture of belt-positioning booster seats, NHTSA stated that "Standard 213's existing dynamic test would better ensure that belt-positioning seats provide a sufficient level of safety than static tests because it simulates a frontal crash." The subsequent final rule amending FMVSS No. 213 noted that "Commenters overwhelmingly supported dynamically testing belt-positioning seats."

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Chapter 2
Public Perception - Use and Effectiveness

On August 16, 2001, a Federal Register Notice (Docket Number NHTSA-2001-10359) was published requesting comments to obtain the public's view on the use and effectiveness of belt positioning booster seats- compiling information on the advantages and disadvantages of using booster seats and determining the benefits, if any, to children from the use of booster seats with lap/shoulder belts compared to children using lap/shoulder belts alone. Comments were due September 17, 2001.

Use of Booster Seats

When a child can no longer fit into a convertible or other forward-facing child restraint, the recommended next step is a booster seat. Booster seats are not restraint systems by themselves since they work with the vehicle's belt system. They are considered positioning devices because they help establish proper belt fit for children. There are two types of booster seats: shield and belt-positioning boosters[15].

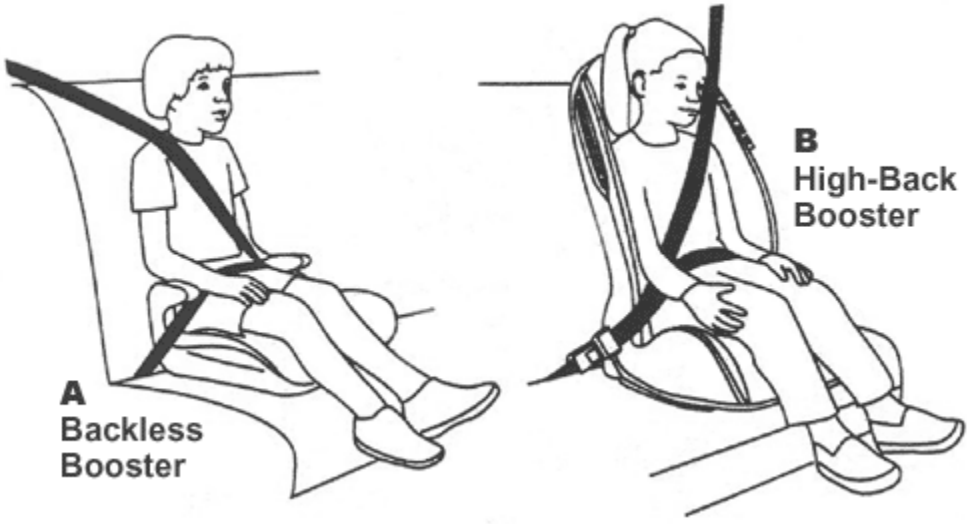
Shield boosters today are not recommended for use with the shield for children weighing over 40 pounds.

The shield booster is a booster seat with a shield that is secured in front of the child using the vehicle's lap-belt. Shield boosters (Figure 3) were originally designed for use in seating positions with only a vehicle lap-belt (and for children weighing up to 60 pounds); for example, typically rear seat environment in American cars until the last decade. Lap/shoulder belt configurations have only been required in rear outboard seating positions in vehicles since 1989. Typically, the lap-belt goes across the front of the shield, transferring the load from the belt to a wider, flexible shield surface protecting the child's torso and abdomen. There is currently only one model available in the market. Shield boosters today are not recommended for use with the shield for children weighing over 40 pounds. Therefore, they are not applicable to the target child population of this study.

Figure 3: Shield Booster Seat

Belt-positioning booster (BPB) seats are designed for use with lap/shoulder belts; they should not be used with a lap-belt only. The lack of upper body restraint with a lap-belt only, coupled with the fact that the child is raised higher on the vehicle seat, puts the child at greater risk of head injury. The BPB seat comes in two forms: backless (sometimes called “lowback”) and high-back. See Figure 4[16]. The belt-positioning booster seat is designed to raise the child up so that the occupant geometry is more like that of an adult in a vehicle seat. It helps to route the vehicle’s lap/shoulder belt to establish proper fit on the child. Some BPB seats provide small handles or guides under which the lap-belt and lower end of the shoulder belt are routed, but some just have a slot or depression for the belt path (Figure 4).

Figure 4: Belt Positioning Booster Seats



The lap-belt should fit low and over the child’s hips. The shoulder belt should cross the child’s shoulder and sternum; this helps distribute crash forces to the stronger bony structures. Many booster seats have high backs that not only offer the child rear head protection but also have upper belt guides to optimize the location of the vehicle’s shoulder belt[17].

Figure 5: Proper Lap/Shoulder Belt Fit

A child should continue to use a booster seat until the vehicle's adult belt system fits properly (Figure 5):

"Correct safety belt fit is not usually achieved until a child is 9 years old, the age at which the child's femur length is long enough for the child to sit against the back of the seat, the anterior superior iliac spines are sufficiently developed to anchor the belt, and the child's sitting height is sufficient for the shoulder belt to fit properly over the shoulder and sternum[18]."

NHTSA currently recommends all children who have outgrown child safety seats should be properly restrained in booster seats until they are at least 8 years old, unless they are up to 4 feet 9 inches tall. For best protection, it is also recommended that parents should avoid using shoulder-belt adjusters or other alternatives, such as placing the child on a pillow, cushion or book.

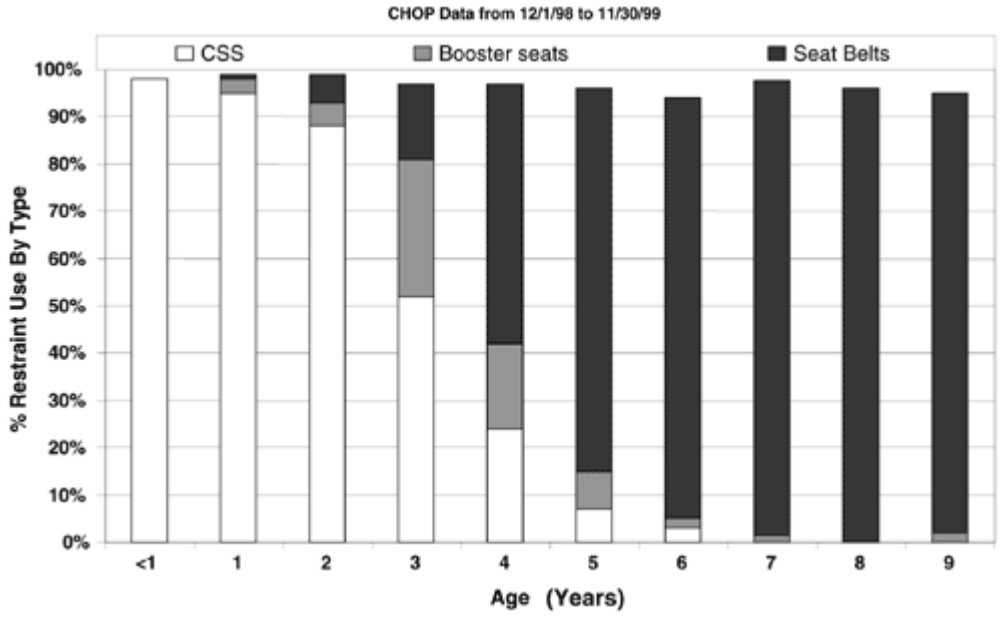
In response to the request for public comments, the American Automobile Association (AAA)[19] offered the following comments on the guidelines for booster seat use:

- Parental confusion is widespread because there are no federal performance standards for booster seats; appropriate parameters for target population usage are unclear;
- More research is needed in a timely manner since many states are enacting booster seat laws with varying age and weight requirements;
- Addressing/resolving the above issues must be a top priority; and
- It is critical to have federal performance standards for children weighing more than 50 pounds to ensure that booster seats are designed to provide maximum protection and minimum confusion for parents. Thus, having a standard that specifically covers children weighing more than 50 pounds is essential to improve restraint laws.

Table 4: Distribution of Percent of Restraint Type by Age - 1998-1999 CHOP

Restraint	< 1	1	2	3	4	5	6	7	8	9
Safety Belt	0%	1%	6%	16%	55%	81%	89%	96%	96%	93%
CSS*	98%	95%	88%	52%	24%	7%	3%	0%	0%	0%
Booster Seat	0%	3%	5%	29%	18%	8%	2%	1.5%	0%	2%
Unrestrained	2%	1%	1%	2.5%	2%	2.5%	5%	2.5%	4%	5%

*CSS = Child Safety Seats



A study using a sample of 5,312 children under age 10 found that restraint use was 97 percent. Table 4 presents detailed information about restraint use by age[20].

In the study by Children's Hospital of Philadelphia (CHOP), booster seat use peaks for children that are 3 years old. Twenty-nine percent of 3 year olds were restrained by booster seats, while another 16 percent were restrained in safety belts. Fifty-five percent of 4 year olds were restrained in adult safety belts. About one-fourth (24 percent) of 4 year olds were in child safety seats, while another 18 percent were in booster seats. In this study, about half of the children using booster seats were using shield boosters. Of the children ages 4 to 8 years old, for whom booster seats are the recommended form of restraint, 83 percent are instead restrained by adult safety belts.

In response to the request for public comments, AAA cited data obtained from a study of child restraint check up events in Florida. They found that 44 percent of 4 to 8 year olds use booster seats. Also, AAA cited data obtained from the Washington State club members. Of the AAA Washington club members, who transport children between the ages of 4 and 8 years old or weighing less than 80 pounds, 49 percent indicated they always use a booster seat. Eighteen percent indicated they never use a booster seat. Of those who rarely or never use a booster seat, 47 percent felt it is not necessary for additional safety protection. Twenty percent of participants cited that the lack of booster seat use was due to child resistance. Seven percent of participants cited cost as a factor[21]. The CHOP and AAA studies show that booster seat usage varies by state.

Barriers to Using Booster Seats

While some data for children show booster use greater than 10 percent, there are barriers that can potentially prevent booster seat usage. In response to the request for public comment, CHOP stated that premature graduation occurs for a variety of reasons. Parents identified potential barriers to optimize restraint use:

- a parent's perception of risk of their child being injured in crash situational circumstances (e.g. extra adult or children in vehicle)
- child behavior
- child discomfort
- the law
- availability of booster seat
- cost
- convenience/ease of use

These barriers prevented some parents in the study from using or regularly using proper restraints. Some suggestions offered by parents to overcome barriers to booster seat use:

- educate parents on successful parenting strategies for resistive children
- educate parents on benefits of booster seats over safety belt adjusters
- stress importance of proper safety belt fit and booster seat and safety belt functions
- strengthen laws to match best practice show stepwise progression (infant seat to child safety seat to booster seat to safety belt) on all child safety seat boxes and in-store displays

In December 2000, NHTSA and DaimlerChrysler Corporation jointly conducted a random national survey of adults and caregivers with children under 6 years old. The survey specifically addressed the lack of booster seat usage and misunderstandings[22]. Survey results showed:

- 96 percent do not know correct usage; the respondents thought it was safe to secure a child at about 5 years of age in safety belts.
- 95 percent believed state requirements adequately protected children.
- After cited applicable state laws, 88 percent of respondents still believed state requirements adequately protected children.
- 46 percent of respondents are unaware of recommendations by safety officials to have child seats inspected.

Misuse of Booster Seats

Like most other child safety restraints, booster seats are being also misused. Decina and Knoebel[23] conducted a study for NHTSA which involved observations of the restraint use of 5,865 children under 60 pounds in 4,019 vehicles in four states (Mississippi, Missouri, Pennsylvania and Washington). Overall restraint use for the target children was 87.2 percent. About one-third of the children observed (n=1,871) weighed 40 - 60 pounds. For the booster seat-weight children, 40 - 60 pounds, child safety seat use was only 6.1 percent, safety belt use was 75.3 percent, and 18.6 percent were unrestrained.

When child safety seats were used, misuse was similar in the infant and toddler age groups (79.4 percent and 81.1 percent, respectively). Child safety seat misuse was much lower for children 40 - 60 pounds (50.0%). Frequent types of misuses for booster seats are presented in Table 5. When considering specific elements, most safety belts (88.3 percent) were used correctly with booster seats. For the children who were secured in safety belts (36.6 percent) rather than car seats or booster seats, the misuse rate for safety belts was 67.6 percent. The most common types of safety belt misuse were the lap-belt being positioned to ride too high (up on the abdomen instead of over the hips) and the belts not being secured tight enough.

Table 5: Booster Seats by Safety Belt Use Status - 1995

Safety Belt Use	Number	Percent
Correct	535	88.3
Unbuckled/Disconnected	12	2.0
Misrouted	6	1.0
Improper Use/Fit	53	8.7
Total	606	100

Child restraint use was linked to driver restraint use. When the drivers were using their safety belts, only 5.4 percent of the children were not restrained in some way. Also, the child safety seat misuse rate was lower for drivers who used their safety belts (78.7 percent) compared to drivers who did not use their safety belts (88.0 percent).

Another study, Taft et al.[24], gathered information on the restraints of more than 17,500 children who were brought to car seat check-up events. They found that, overall, 85 percent of the car seats observed were misused, with an average of two errors per seat.

This study showed that only 5 percent of booster seat-aged children actually ride in booster seats. Data were collected on 1,284 belt-positioning booster seats and 783 shield booster seats. Frequent types of misuse for both types of booster seats are presented in Table 6.

Table 6: Types of Misuse for Belt-Positioning and Shield Booster Seats At Check-Up Events, 1997 -1998

Booster Seat Type	Type of Misuse	Misuse Rate (%)
Belt-positioning booster (n=1,284)	Child not in recommended weight/height range for seat	15
Belt-positioning booster (n=1,284)	Safety belt not fitting over shoulder and upper thighs	14
Belt-positioning booster (n=1,284)	Safety belt not routed correctly	12
Belt-positioning booster (n=1,284)	Safety belt not fitting snugly	6
Shield Booster (n=783)	Safety belt not holding seat tightly	32
Shield Booster (n=783)	Child not in recommended weight/height range for a seat	24
Shield Booster (n=783)	Locking clip not used according to directions	14

A third study was conducted based on an assessment of 227 booster seats observed at safety seat clinics. It focused specifically on patterns of misuse for booster seats[25]. Guidelines, in general, urge the use of child safety seats for children under 40 pounds and then booster seats for children 40 to 80 pounds. This study, however, found that a majority of the children in shield booster seats (68 percent) and belt-positioning booster seats (63 percent) weighed less than 40 pounds. Overall, 56 percent of booster seats were misused in at least one way, though misuse varied significantly by type of booster seats. Sixty-eight percent of shield booster seats were misused compared with 20 percent of belt-positioning booster seats. Morris et al., attribute this to the ways in which the different booster seats are installed and used. A belt-positioning booster seat just rests on the vehicle seat and the lap/shoulder belt is fastened around the child. On the other hand, shield booster seats are designed for use in seating positions with only a vehicle lap-belt. Thus, they suffer compatibility issues between the vehicles and the shield boosters. Analysis found that shield boosters were 8.7 times more likely to be misused than belt-positioning booster seats, and that children who weighed under 40 pounds were 2.1 times more likely to be riding in a misused seat than children who weighed 40 pounds or more. There was no significant difference in misuse found when comparing two age groups (children under 4 years old vs. children 4 years or older). Table 7 presents modes of misuse as evaluated by trained child passenger safety technicians.

Table 7: Misuse Modes for Belt-Positioning and Shield Booster Seats Assessed At Safety Seat Clinics- Pennsylvania and New Jersey, 1997 -1998

Booster Seat Type	Misuse Mode	Misuse Rate(%)
Belt-positioning booster (n=164)	Shoulder belt incorrectly positioned	14
Belt-positioning booster (n=164)	Child inappropriate height/weight for booster seat	6
Belt-positioning booster (n=164)	Inappropriate vehicle seat belt system for	6

	booster seat	
Belt-positioning booster (n=164)	Vehicle seat belt routed incorrectly	4
Shield Booster (n=59)	Locking clip used incorrectly or not used at all, when needed	78
Shield Booster (n=59)	Booster seat not secured tightly with seat belt	73
Shield Booster (n=59)	Shield not close to child's body	21
Shield Booster (n=59)	Inappropriate seat belt system for booster seat*	9
Shield Booster (n=59)	Vehicle seat belt routed incorrectly	8
Shield Booster (n=59)	Child inappropriate height/weight for booster seat	7
Shield Booster (n=59)	Booster seat in a crash	2

*NOTE: The researcher denotes the vehicle lap/shoulder belt systems as being inappropriate for use with shield boosters. Vehicle lap/shoulder belt systems can be used with shield boosters per the manufacturers' instructions.

The most common types of misuse for belt-positioning booster seats were: shoulder belt incorrectly positioned (14 percent); child of inappropriate height/weight for booster seat (6 percent); and vehicle seat belt routed incorrectly (4 percent).

The most common types of misuse for the shield booster seats were: locking clip used incorrectly or not used when needed (78 percent); booster seat not secured tightly with vehicle seat belt (73 percent); and shield not close to child's body (21 percent).

Booster Seats and Lap/Shoulder Belt Fit in Young Children

In an effort to identify and assess general parameters (e.g., height, age, and weight) for the booster seat population, the Agency conducted a survey in 1994 of 155 child volunteers, ages 7 to 12 years. The objective was to assess their fit in vehicles and booster seat restraints[26]. The data from this small nonrepresentative sample of the national population were compared to an extensive anthropometry study of children conducted in 1975 by the University of Michigan. Average height and sitting height data matched well, while children in a 1994 study appeared to be heavier than those in the 1975 study.

In the restraint fit survey, each child sat in the rear seat with the lap/shoulder belt alone and in three different belt-positioning booster seats (Volvo, Kangaroo and Century CR-3) in three vehicles (Ford Taurus, Pontiac Sunbird and Dodge Caravan). The major findings from this study were:

- Sitting up straight improved both lap/shoulder belt fit.
- The "slouch factor," where children scoot forward to allow comfortable leg positions rather than sit up straight and put pressure on their legs (i.e., calves), appears to frequently cause poor belt fit.
- Booster seats greatly improve belt fit over the rear seat alone (two-thirds poor fit occurring when lap/shoulder belts are used alone while only one-fifth of the booster seats resulted in poor fit).
- The minimum size for using lap/shoulder belts alone was found to be a sitting height of 30 inches, a standing height of 59 inches, and a weight of 81 pounds. A child with the height requirements but a smaller weight would also probably have an acceptable belt fit, while a child with the weight requirement but not the height requirements (i.e., shorter) may not have an acceptable belt fit with the belt alone.

- Children who could fit well in boosters and had good/fair fits were generally 79 pounds or less. Weight seems the most important factor, since their sitting heights varied from 23 to 30 inches, and their standing heights ranged from 47 to 61 inches.
- The majority of children in this study had better belt fit with the booster than with the rear seat belt alone, regardless of size.

Recommendations from the 1994 fit study were as follows:

- A more extensive anthropometry study of older children should be conducted to update the study performed by the University of Michigan Transportation Research Institute in 1975.
- Booster and vehicle seat designs that force children to sit up straight, by allowing the knees to normally bend with the lower legs supported, would improve belt fit.
- Although boosters improved belt fit, the 20% of children who still had poor belt fit with boosters indicate that more improvements in fit can be made[27].

Although a child's weight seems to be the most important factor in determining good fit, weight alone should not be the only determining factor -- sitting height seems to be an important secondary factor for good fit when using a booster seat.

Other Belt Positioning Devices

Belt-positioning after-market devices are being sought by consumers in an effort to accomplish proper belt fit for children. Safety advocates questioned the safety of these devices that tended to change the safety belt geometry. Belt positioning devices tended to redirect the lap belt portion of the restraint over the child's abdomen. The devices would also inadvertently position the shoulder belt portion of the belt system across the child's neck. In 1993, NHTSA conducted a series of 35 dynamic sled tests using FMVSS No. 213 procedures and compliance criteria to evaluate after-market devices ("seat belt positioners") that are designed to reposition the shoulder belt to provide for improved fit and/or comfort. Three devices - Child-Safer^{TM}, SafeFit^{TM} and Seatbelt Adjuster^{TM} - were tested using the 3- and 6-year-old and the 5th percentile female dummies. Tests were also conducted without the belt positioning devices. Based upon the research and test results, the following conclusions were made:

1. Use of the Child-Safer^{TM} device resulted in a general increase in dynamic responses (i.e., increased displacement of the head, knee, upper body, etc.), regardless of occupant size.
2. Increase in dynamic responses was observed in approximately half of the tests conducted with the SafeFit^{TM} device.
3. Minimal increase in dynamic responses for the three sizes of dummies were observed when tested with the Seatbelt Adjuster^{TM}.

The apparent leading motivation behind the development of these types of devices is to improve lap/shoulder belt fit on the occupant. All of the devices evaluated in this study produced some degradation in the performance of the lap/shoulder belt system as compared to baseline (lap/shoulder belt only) conditions, depending upon the size of the occupant and the impact orientation.

With the promulgation of the final rule for FMVSS 208 (59 FR 39472, August 3, 1994) requiring that Type II safety belts be either (1) integrated with adjustable vehicle seats, or (2) equipped with a means of providing adjustment capability to improve belt fit and comfort, it was anticipated that increased belt usage would occur due to improved comfort with OEM equipment, and that the need for after-market seat belt positioners would decrease, or they will be eliminated.

A notice of proposed rulemaking (NPRM) was published in the Federal Register August 13, 1999 (64 FR 44164), which proposed to adopt a consumer information regulation for these types of devices. In the NPRM, the Agency proposed to define "seat belt positioners" as "a device, other than a belt-positioning seat, that is manufactured to alter the positioning of Type I and/or Type II belt systems in motor vehicles." Among other things, the NPRM proposed to require the devices to be labeled as not suitable for children of a certain age, e.g., under 6 years old, or a certain height.

These recommendations were made based on the availability of belt positioning booster seats, which provide the benefits of proper belt fit for children.

Premature Graduation from Child Restraints to Safety Belts

The Children's Hospital of Philadelphia (CHOP) completed a study for NHTSA to determine reasons for the premature graduation of children from child safety seats to vehicle safety belts and suggest strategies for increasing booster seat use. The project utilized multiple methods, including literature review, discussions with experts, facilitated brainstorming sessions, focus groups with both parents and children, and one-on-one in-depth discussions with parents. This section summarizes parents' perspectives of booster seats as related in seven adult focus groups and 3 dozen one-on-one discussions.

The CHOP study identified a number of factors contributing to use and non-use of booster seats. While deficits in knowledge concerning child passenger safety and the benefits of booster seats were significant factors in premature graduation of children to safety belts, the study determined that education alone would not solve the problem because of other obstacles to booster seat use.

Perceptions of risk and knowledge of best practices for child restraint played major roles in premature graduation. The parents of young children using safety belts generally believed that they were taking the necessary steps to protect their children. This compared to a greater level of anxiety expressed by parents of children using booster seats that their children were at-risk of injury. This latter group of parents appeared less confident in their ability to protect their children, even when restraints were being used. The booster seat parents also were more proactive in seeking information concerning child passenger safety, and displayed greater awareness of issues regarding that topic. These parents tended to be better informed as to design and installation of booster seats, child passenger safety laws, guidelines for child restraint use, and the risks of prematurely moving children to adult safety belts.

Most parents participating in this research knew that children who outgrow their safety seat should move to a booster seat. They tended to be surprised, however, when they learned at what point current guidelines say the child is ready to graduate from a booster seat to safety belts, expecting the transition to occur sooner. Thus inducing all parents to switch to booster seats once their children have outgrown child safety seats would still be insufficient to achieve the usage called for by current best practices. The CHOP study concluded that strategies are also needed to keep the children in booster seats until the appropriate transition point is reached.

The study found some confusion among parents concerning the purpose of booster seats. For example, one participant stated "To be honest, I never really got it. It just boosts them up - it's not as good as a car seat." As indicated by this comment, some parents not only failed to understand the role of booster seats, but also did not fully appreciate how safety belts work.

Explaining the risks posed to children by premature use of safety belts and the recommended best practices for child restraint use seemed to have a powerful impact in improving the use of booster seats. After project team members presented this information, a number of study participants asserted their intent to either change their current practices or re-evaluate their choice of child restraints.

Beyond the issue of lack of awareness, there were a number of other barriers to booster seat use raised by the parents. The child's resistance to child restraints played a major role in the decision by some parents to transition their child to safety belts. While all parent groups in the study experienced child resistance, the parents of children using adult safety belts conceded "giving in" to the protestations rather than continue insisting on booster seat use. This contrasted with the parents of children using booster seats, who drew a sharp distinction between negotiating with their children over safety and non-safety issues. While a non-safety item such as bath time was open for negotiation, issues related to safety were non-negotiable. If the child resisted using booster seats, these parents were not going to allow their children to win the battle. As indicated from parent comments, accomplishing this entailed the exercise of good parenting skills, including:

- Being Consistent: Always requiring that the child use a booster seat, with no exception;
- Starting Early: Establishing the non-negotiable policy right from the start;
- Being The Parent: “Taking a stand” as to the right thing to do, and never giving in;
- Communicating Safety: Explaining the importance of using booster seats to the child; and
- Emphasizing Individuality: Taking the proper steps to protect your child regardless of what other parents are doing.

The parents indicated that various situational factors could influence the type of restraint used. If there were multiple children in the vehicle, a child’s booster seat may be given up to another child, or parents may allow all the children to use safety belts so that they feel “equal.” There were times when parents had no choice but to have the child use a safety belt, because the booster seat was unavailable or the booster seat was incompatible with the vehicle being driven. Some parents said the length of the trip, the weather, or their mood affected their choice of child restraint.

Several other aspects of booster seats also had a bearing on their use. Many parents reported difficulty installing their booster seats. Some complained about confusing instructions, with no means to confirm correct installation, or incompatibility with the design features of their vehicles. Other complaints revolved around inconvenience as booster seats were described as big and bulky and awkward to transport. There were also issues concerning the perceived safety of the seats. Parents were uncomfortable with a seat that was not anchored to the vehicle and holding their child in the secure manner to which they had been accustomed with child safety seats. Some parents related incidents where the child unfastened the latches or the latches broke, or cases where a booster seat shifted or slid out from under a child. Perceived comfort of the child was an added factor in decisions concerning the choice of restraint. Some parents graduated a child to safety belts because the child looked uncomfortable in the child restraint, even though the child may not have been expressing any discomfort. In general, movement of children to safety belts was often attributed to the child having become too big or having outgrown the child restraint.

Parents were inclined to protect their children according to their understanding of what were the best ways of keeping their children safe. They would do what they thought was best, regardless of what the law said. However, some parents relied on the law as a guide to the safest form of restraint. There were instances in the study where parents justified restraining their children with safety belts based on the law. Yet the laws in both States where the information gathering occurred fell short of current safety guidelines by permitting safety belt use before the recommended age. A point raised by some parents in the study was that children were better able to accept that they had to use a child restraint if they were told it was the law.

The parents suggested a number of strategies for addressing the problem of premature graduation to safety belts. Many of these related to “getting the message out” as they perceived a need for the public to be better informed. They identified places, professions, spokespersons, media, programs, and types of information that could be useful in this endeavor. As indicated earlier, parents of booster seat users stressed parenting skills as an important way to increase booster seat use. Some parents thought that upgrading laws, and enforcing them, could help. Other suggestions involved having a system where the child progresses from a safety seat, to a high back booster, and to a low back booster. The low back booster might seem less a “baby seat” to the older child and could be better accepted. There also were suggestions for a “four-in-one” safety seat that would extend from infancy through booster seat age, as well as booster seats built into vehicles.

The parents pointed to various weaknesses in the guidelines, and some suggested a less standardized criterion for determining the optimal form of restraint for any given child. According to the parents, adding a guideline communicating how a safety belt should fit the child would be applicable to all children regardless of their frame, and perhaps make the importance of proper safety belt fit more understandable to parents than age or weight requirements.

Summary of 2000 Motor Vehicle Occupant Safety Survey (MVOSS) on Booster Seat Use

NHTSA conducts a national telephone survey of the general public ages 16 and older on a biennial basis to assess attitudes, knowledge, and (self-reported) behavior regarding occupant protection. A subset of the sample, termed

parents/caregivers, receives a detailed set of questions on child restraint use. For the year 2000 survey, the parent/caregiver subset was composed of drivers who lived with one or more children age 8 or younger (often parents, but could be other relatives or non-relatives) as well as a small number of parents who had a child in that age range who did not live with them but whom the parents at least on occasion drove. The interviewers selected a specific child as the referent for the child restraint questions. If there were multiple eligible children in the household, the interviewers randomly chose one child as the referent. The survey opened in the field on November 8, 2000, and closed on January 21, 2001, at which time there were nearly 1,500 completed cases in the parent/caregiver subset.

The initial questions explored the type of restraint used by children, if any. If the parent/caregiver reported that the child used a child restraint, then the survey asked about strap location in order to distinguish whether the child used an infant seat, forward facing child seat, or booster seat. This was designed to avoid confusion over seat terminology by the public ("booster seat" was not a commonly known term when MVOSS was initiated in 1994). Both infant seats and front facing child safety seats must have straps crossing both of the child's shoulders. A strap over one shoulder is characteristic of a belt positioning booster (BPB). If neither shoulder has a strap across it, then this would be considered a shield booster. Thus if the parent/caregiver said that there was a strap over only one shoulder, or over neither shoulder, then the survey considered that a booster seat. Follow-up probes were added to the 2000 survey in an attempt to corroborate the "booster seat" determinations based on strap location. While in many cases they did so, there were sufficient discrepancies to underscore the difficult nature of determining the type of child seat over the phone. Thus readers are cautioned that there is a degree of error within the survey estimates concerning the type of seat being used attributable to terminology issues and inconsistencies in responses.

Using the strap definition for booster seats, MVOSS determined that: a) some children are using booster seats well before the recommended ages of 4 through 8, and b) relatively few children use booster seats within the recommended age range. Table 8 shows the weighted percentage of children using child restraints by child's age. The number of actual cases per individual age range from 117 to 199, with 6 out of the 9 age groups having more than 160 cases each.

Some misreporting by respondents is evident in Table 8, such as a 6-year-old using an infant seat and several infants using booster seats. However, there were several cases involving 1-year-olds where the respondent reported strap location consistent with booster seats, affirmed that strap location on the first follow-up probe, and then said "yes" when asked if it was a booster seat on the second probe. This was not true for the infant booster seat users (all affirmed the strap location but most said it was not a booster seat when directly asked, although a couple were unsure). Thus answers to a combination of questions suggested that some children at least as young as age 1 were using booster seats.

Table 8: Information From Parents/Caregivers:
Weighted Percentage Of Children Who At Least
On Occasion Use A Child Restraint By Age

Ages	< 1	1	2	3	4	5	6	7	8	4-8
Never Uses Child Seat or Booster	4%	7%	5%	7%	22%	58%	80%	89%	93%	70%
Booster Seat	7%	5%	5%	17%	28%	24%	12%	6%	4%	14%
Front Facing Child Seat	21%	74%	86%	73%	46%	15%	7%	3%	2%	14%
Infant Seat	56%	11%	3%	1%	-	-	1%	-	-	**
Never Drive Child	2%	2%	**	-	**	1%	**	1%	1%	1%
***Don't Know or Refused**	10%	1%	1%	2%	3%	1%	-	**	1%	1%

*These primarily are cases where parent/caregivers either said they did not know, or refused to respond, when administered the introductory question asking how often the child rides in a child restraint when they drive (most were refusals).

**Less than 0.5%-Zero cases

Booster seat use began increasing noticeably at age 3 (17%) and peaked at age 4 (28%). By age 5 most children were no longer using child restraints, usually because they had been graduated to adult safety belts. The child restraint section of MVOSS concluded with a series of questions in which interviewers explicitly asked parents/caregivers if they had ever seen or heard of booster seats before that day, if they had ever used booster seats, and whether they had concerns about their safety. About one-in-six parents/caregivers either had never seen or heard of booster seats (15%) or else did not know if they had (1%). Among the majority (84%) who were aware of booster seats, more than half (58%) had at some time used a booster seat when driving with their child or children. Most began using the booster seat when the child was age 3 (36%) or age 4 (31%), although some claimed to have started using it when the child was age 2 (15%), age 1 (2%), or even an infant (1%). The remainder either gave an older age for onset (12%) or else refused to respond (5%). [Note that numbers do not add to 100% due to rounding.]

Information on child's weight again showed that use of booster seats sometimes occurs prematurely. Whereas safety professionals recommend that children weighing 40 to 80 pounds use booster seats, one-half (50%) of the parents/caregivers who said they had used boosters reported that usage began at lower weights. Most often onset was for children weighing 30 to 39 pounds (38%), but it also was sometimes 20 to 29 pounds (12%) or even below 20 pounds (0.5%). Only 28% reportedly began using boosters when the child weighed 40 to 49 pounds. The remainder either did not know (15%), refused to respond (1%), or gave a weight above 49 pounds (6%).

Among those parents/caregivers who had seen or heard of booster seats, almost one-quarter (23%) acknowledged concerns about their safety while another 6% were unsure if they had safety concerns. The remaining 71% had no safety concerns. When all parents/caregivers are considered, only 60% were both aware of booster seats and also had no concerns about their safety (71% of the 84%). Complaints about booster seats volunteered by parents/caregivers often revolved around the lack of a secure attachment to the vehicle, and the perception that the booster seat would not adequately restrain and protect the child in the event of a crash.

Consumer Complaints Relating to Belt Positioning Booster Seats

In an effort to assess documented consumer complaints on belt positioning booster seats, queries were made by NHTSA's Office of Defects Investigation (ODI). A review of the ODI's database resulted in 32 complaints related to belt positioning booster seats. Of the 32 complaints, 25 were related to specific components of the booster seat and the remaining 7 were related to fit of the booster. The shoulder belt guide was the component most complained about, and in nearly all the cases the shoulder belt guide (also referred to as comfort clip and shoulder belt positioner) had become ineffective due to tearing off or breaking apart. The majority of complaints related to fit consisted of improper position of the shoulder belt attributed to ineffective shoulder belt guides.

Summary of Public Comments on Booster Seats

In response to the request for public comments, DaimlerChrysler Corporation (DCC) and Mercedes-Benz USA (MBUSA) state that they have been encouraging the safe transportation of children through various campaigns which have been very effective in educating parents and caregivers.

Chrysler, Jeep and Dodge dealers offer a child seat inspection service under the "Fit for a Kid." Campaign. When originally piloted in September 1999, 20 percent of parents were properly installing child safety seats (CSS). Recent data show that more than 50 percent are installing their CSS properly.

Of 30,000 child seat inspections conducted through "Fit for a Kid," only 7 percent were conducted on booster seats. Parents with multiple children are typically making appointments for infants or younger toddlers. The older child is typically already graduated to an adult safety belt or is totally unrestrained. This emphasizes that parents are unaware of the need for transporting children in booster seats. It appears that parents/caregivers are not confused about which type

of seat to use but are unaware of NHTSA guidelines for booster seats.

Public Perception on the Effectiveness of Booster Seats

Limited information is available regarding the public's perception on the effectiveness of booster seat. However, some comments are available from focus group meetings from the Premature Graduation study[28]. Parents were uncomfortable with a seat that was not anchored to the vehicle and holding their child in the secure manner to which they had been accustomed with child safety seats. Therefore, they believed that the booster seat was not as safe as the forward-facing toddler child safety seat. Some parents related incidents where a booster seat shifted or slid out from under a child.

In response to a request for comments, AAA states that, regarding ease of use, comfort, and convenience, Florida State AAA members prefer booster seats over convertible seats. AAA noted that parents have raised concerns about using booster seats for children over 50 pounds[29].

DCC states that it is generally recognized that the geometry of a safety belt is designed to secure adult passengers and may not fit well for children. Having the child correctly placed in the booster seat will significantly improve the belt geometry and will result in higher restraint effectiveness. DCC states that, "While booster seats reduce the possibility of 'submarining,' the addition of adjustable belt guides…can reduce the possibility even further, which has been verified through our testing." DCC urges NHTSA to carefully evaluate and consider the comments from the medical community, and experts from the Partners for Child Passenger Safety (PCPS)[30].

CHOP/PCPS stated that principal benefits of belt positioning booster seats will be most realized in protecting against injuries > 2 on the Abbreviated Injury Scale (AIS), notably concussions, intra-abdominal and spinal injures. They stated that the vast majority of safety belt related injuries to young children are in fact non-fatal. Therefore, an evaluation of effectiveness using death as an outcome of interest might not be an appropriate approach to take[31].

FOOTNOTES

15. Weber, K., Crash Protection for Child Passengers: A Review of Best Practice, UMTRI Research Review, July - September 2000, Vol. 31, No. 3.
16. Weber, K., Crash Protection for Child Passengers: A Review of Best Practice, UMTRI Research Review, July - September 2000, Vol. 31, No. 3.
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18. Morris, S.D., Arbogast, K.B., Durbin, D.R., & Winston, F.K., Misuse of Booster Seats. *Injury Prevention*, 2000 (6), pp. 281 - 284.
19. American Automobile Association's response to Request for Public Comments, Docket # NHTSA-2001-10359.
20. Winston, F.K., Moll, E.K., Durbin, D.R., & Kassam-Adams, N., The Premature Graduation of Children from Child Restraints to Vehicle Safety Belts. NHTSA, DOT-HS-809-256, June 2001.
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26. Klinich, K.D., Pritz, H.B., Beebe, M.S., Welty, K. & Burton, R.W., Study of Older Child Restraint/Booster Seat Fit and NASS Injury Analysis, DOT-HS-808-248, November 1994.
27. Note: The details in this study regarding "poor" fit with the booster seat are not clear. It is not clear whether these children were ready for a booster seat.
28. Winston, F.K., Moll, E.K., Durbin, D.R., & Kassam-Adams, N., The Premature Graduation of Children from Child Restraints to Vehicle Safety Belts. NHTSA, DOT-HS-809-256, June 2001.
29. American Automobile Association's response to Request for Public Comments, Docket # NHTSA-2001-10359.
30. DaimlerChrysler Corporation's response to Request for Public Comments, Docket # NHTSA-2001-10359.

31. CHOP's response to Request for Public Comments, Docket # NHTSA-2001-10359.

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Chapter 3
Benefits to Children from Usage

Real World Experience in the United States

Increased use of child restraints is important because they are highly effective when used properly. Child restraints function by absorbing and safely distributing the crash forces over the child's body, while holding the child in place and reducing the risks of contact with vehicle interior components or preventing ejection from the vehicle.

CHOP indicates that children who are belted in only a lap-belt may be at risk of abdominal injuries in a crash, if the belts are used incorrectly or they move up the pelvis during a crash. CHOP further states that it is evident in the National Automotive Sampling System (NASS) data, lap-belt restrained children had a four-fold increase in the incidence of injuries to the abdomen and pelvis[32].

Using a booster seat improves the proper fit of the vehicle's shoulder belt by raising the child up high in the vehicle seat and thereby improving the belt fit on the child. The safe use of the vehicle's shoulder belt portion of a three-point restraint system is determined by the geometry of the vehicle's belt system as it interacts with the anatomy of the child. Since the vehicle belt geometry varies from car to car, a safety belt system may fit a child properly in one vehicle, but when the same child is placed in a different vehicle, the shoulder and/or lap-belt may not fit properly.

If the shoulder belt lies across the face, or in front of the neck, some children may place the belt behind him or her, reducing the belt's effectiveness. Belt positioning booster seats enable the child to place the shoulder belt properly.

Since there are no effectiveness figures for booster seats, NHTSA uses the effectiveness of lap/shoulder belts as a proxy for booster seats. It is assumed that because the booster seat lifts the children up and makes the belts fit better, it is feasible to use the effectiveness of lap/shoulder belts, for the 9 - 14 year old, as a surrogate for the effectiveness of booster seats for 4 - 8 year old children. (See Table 9.)

Table 9: Estimated Percent Effectiveness of Belt Positioning Booster Seats in Passenger Vehicles

Passenger Cars	Front Seat	Rear Seat
AIS 1	10	5.5
AIS 2-5	60	59
Fatal	55	54
Light Trucks	**Front Seat**	**Rear Seat**
AIS 1	10	5.5
AIS 2-5	72	83

Fatal	67	78

Using 1988 through 1997 data from the Fatality Analysis Reporting System (FARS), NHTSA estimated the effectiveness of rear seat lap/shoulder belts at 54 percent for 9 - 14 year olds and 48 percent for 5 - 8 year olds in passenger cars[33]. Proper belt fit is believed to occur for children approximately 9 years of age or older. Placing a 4 - 8 year old in a belt positioning booster (BPB) seat secured by a lap/shoulder belt will have the same effectiveness in the rear seat as lap/shoulder belts for the 9 - 14 years old children, i.e., 54 percent.

Based on available FARS statistics for the period 1991-1999 the number of children in the age group 4 to 8 years of age who are killed in crashes, on average, is 476 per year. Out of these, the status of restraint use is unknown for approximately 13 percent. If these unknown fatalities are distributed among those in child safety seats, those using lap belts or lap/shoulder belts, and those who are unrestrained, the distribution is approximately 12 fatalities in child safety seats, 152 in lap and lap/shoulder belts, and 312 using no restraints. The effectiveness of rear seat lap/shoulder belts when used by children in this age group is approximately 48 percent in passenger cars. If those children who are not using child safety restraints are restrained with lap and shoulder belts, approximately 150 lives could be saved, annually. If booster seats are assumed to have an additional effectiveness of 6 percent, 19 more lives could be saved, provided all eligible children used booster seats. Assuming the level of booster seat use increased to only about 75 percent, the additional benefits could only reach approximately 14 lives saved.

If all unrestrained children used lap and shoulder belts or booster seats with lap and shoulder belts, 150-169 lives could be saved, annually.

During a 2-year time period, December 1998 - October 2000, of the CHOP study (under the auspice of the PCPS), the weighted data sample consisted of 113,387 children, 33.6 percent of whom were between 4 and 8 years of age[34]. While restraint use overall was very high (95 percent), the majority of children between 4 and 8 years of age were not using appropriate restraints for their age. The 1998 - 2000 CHOP data showed that booster seat use peaked at age 3 and dropped dramatically after age 4. Over the time period of the study, overall booster seat use among 4 to 6 year olds increased from <5 percent to 18 percent. Among 4 year olds specifically, booster use increased from 9 percent to 32 percent. Among children using booster seats, approximately one half used shield boosters. In the last 6 months of the study period, a trend was noted in increased belt-positioning booster use. There was significant geographic variation in booster seat use among various states covered in the study states, with a two-fold variation in use between the states which had the highest use (Maryland) and the state with the lowest (Indiana).

The analysis of the data showed, compared to unrestrained children, 2 to 5-year old children using any type of safety belts were 53 percent less likely to suffer significant injuries. An additional 60 percent incremental reduction in risk of injury was noted among children using child restraints (both child safety seats and booster seats) when compared to those in the safety belts. When analyses were restricted to 4 to 5-year old children in either the safety belts or booster seats, children in the safety belts were noted to be over three times as likely to suffer significant injuries than children in booster seats. Children in the safety belts were at particular risk of significant head injuries when compared to children in booster seats.

In order to account for differences in the age and seating position of children in safety belts verses booster seats, multivariate logistic regression analyses were conducted to determine the independent effect of the restraint type on a child's risk of injury. Separate models were constructed for frontal impact and side impact. Results of the multivariate analyses indicated that, even after adjusting for age, seating position, and vehicle damage, children restrained by safety belts were more than three times as likely to be injured than children restrained in booster seats in frontal crashes. There was a similar trend noted for side impact crashes, though due to the limited sample size, the results were not statistically significant. Of note, however, was the significant increase in the risk of head injury for children in safety belts in side impact crashes when compared to children in booster seats. Abdominal and spinal injuries were found to be extremely rare among children in booster seats.

Data from the Partners for Child Passenger Safety Study indicate that, while overall booster seat use among 4 through 8 year old children remains low, significant increases have been noted over the past 2 years. This suggests that recent attention paid to increase the public's awareness of the role of booster seats has begun to show an effect. In addition, the data clearly demonstrate that booster seats provide an important incremental benefit in safety to children over safety belts alone. Not only do they reduce the overall risk of injury to children, they appear to specifically reduce head, abdominal and spinal injuries. This is likely due to the improved trunk support and reduced head excursion that one would expect with the improved fit of the safety belt when used with a belt-positioning booster seat.

Real World Experience in Sweden

While booster seat usage is low in the U.S. and most of NHTSA's current data collection systems do not collect detailed real-world crash information on these seats, European countries have utilized booster seats for decades. Booster seat cushions were developed in Sweden and Australia in the mid-1970s to allow children to take advantage of the vehicle's built-in upper and lower torso restraint, and they have been used there and elsewhere successfully ever since[35]. In Sweden, the use of booster seats has been widespread for a number of years.

At the Booster Seat Conference sponsored by the Association for the Advancement of Automotive Medicine, Dr. Murray MacKay presented summaries of a number of studies published on booster seat effectiveness in Sweden[36]. MacKay reported on a study performed by Langweider and Hummel in 1989, in which questionnaire data were analyzed. As part of this study, a newspaper campaign was run on child safety in which parents who had been in crashes with children in their vehicles were invited to respond to a questionnaire giving details of their collisions - 3,300 were written to and 1,000 responded. Of those, 870 responses involving 1,153 children had enough detail for evaluation. This yielded a sample of 288 children who were restrained, including 51 in booster seats, and 865 who were unrestrained. The main thrust of the study related to the patterns of injury and their severity to children of all age groups. No specific comparative analysis of booster seats was done. The study illustrates the difficulties in obtaining detailed information on this issue.

MacKay also reported on a 1999 Langwieder et.al. in-depth study of 593 restrained children (0 - 12 years) involved in crashes. The survey data showed that, following the passage of a child restraint law in Germany in 1993, 93 percent of children from 0 to 12 years of age were restrained by 1998. Of these, only 54 percent in the age range 6 to 12 were restrained. The in-depth analysis of the data showed that 27 children were in booster seats with lap/shoulder belts, and 119 were in lap/shoulder belts only. Of those two groups, the incidence of a AIS 2 and greater injuries was 11 percent for booster seat cases compared to 27 percent for the lap/shoulder belt alone. With such small numbers, the authors were only able to report a trend with regard to booster seat use and the incidence of injuries.

MacKay reported on a 1993 study by Rattenbury and Gloyns in the U.K. of restrained child occupants who were killed in car crashes. The data came from police accident reports. The fatal accident reports contained a substantial amount of detail along with photographs, coupled with post-mortem reports which are conducted on most road deaths in Britain. Of 144 cases (of children less than 14 years of age), 6 were using booster seats with adult belts. No specific comparisons were made of the cases with and without booster seats, but the authors emphasized the great importance of intrusion, especially in side impacts, and the high incidence of head injury, rather than any injuries arising from the restraints themselves.

MacKay summarized a 1994 Henderson report on an in-depth study of 247 children involved in crashes. The sample was skewed towards the serious injury producing crashes. Of all restrained children, 88 percent received injuries of Maximum AIS (MAIS) 2 or less. The overall conclusion from the study was that all restraint types are effective in reducing injuries. The data, relating to the older children wearing various types of restraints, are extracted from the study and are shown in Table 10.

Table 10: Maximum AIS by Restraint Use

	Injury Levels							
Restraint Type	**0**	**1**	**2**	**3**	**4**	**Fatal**	**All**	**%**

Lap/shoulder Belt	11	83	13	7	1	6	121	67.2
Lap-belt only	5	21	3	2	1	3	35	19.5
Booster Seat	8	12	3	0	0	1	24	13.3
Total	24	116	19	9	2	10	180	100.0

Based on small numbers, the data suggest that booster seat users had a lower incidence of AIS 2 and greater injuries than those in adult lap/shoulder belts alone. The same data were presented in 1996 giving more detail on some of the specific cases. The importance of limiting intrusion and preventing forward contacts was emphasized as being the main limiting conditions on good restraint performance, rather than injury from the restraint system itself. Like prior work, the booster seat data indicated some enhanced performance in booster seats over adult belts alone.

Finally, MacKay summarized a 1987 Carlsson et.al. report on the experience in the Volvo accident data file from 1976 to 1986. They examined injury rates for children in the 3 to 10 year age group. These are shown in Table 11.

Table 11: AIS Injury Levels by Restraint Use

Restraint Type	AIS 1	AIS 2-3	AIS 4-6	Number
Safety Belts	31.3	3.5	0.9	115
Booster Seats	31.1	3.9	-	103
Unrestrained	30.0	8.6	1.9	536

From this short review, it is clear that the availability of a large set of data and analytical difficulties in drawing solid conclusions about the relative merits of booster seats over lap/shoulder belts alone for children in the age range between 4 and 10 years are substantial. While adult belts may provide good protection, booster seats probably provide appreciable benefits in preventing injuries and reducing their severity. That advantage may be not only in terms of enhanced crash performance but also in terms of greater acceptability and hence, use by children in the awkward age group of users between child seats and adult belts.

Real World Experience in Canada

In Canada there are three primary classifications of children's restraint systems regulated under the Canadian motor vehicle safety regulations: rearward facing infant restraints; child restraints; and booster cushions[37]. Booster cushions are for children who have outgrown their child restraint system and are for children who are at least 40 lbs. The three types of booster cushions sold in Canada are: simple booster cushions (platform with arms), boosters with abdominal shields, and high back booster cushions. Four Transport Canada accident databases were reviewed concerning the performance of booster cushions in motor vehicle collisions: Passenger Car Study, Special Directed Studies, Hospital Study, and a Special Defect Investigations Study. The first three studies of 44 collisions indicate that all booster cushions provided a high level of occupant protection in the event of a motor vehicle collision, with the exception of extremely severe collisions and ones with intrusion into the occupant compartment. The fourth study of 10 staged vehicle rollover tests investigated field complaints that abdominal shield booster cushions allowed ejection of a child weighing less than 40 lbs. during a rollover incident. When booster cushions are used properly by children who weigh at least 40 lbs., they all provide a high level of occupant protection for children who have outgrown their child restraint system.

Limitations of Available Data in Determining Effectiveness

The National Automotive Sampling System (NASS) Electronic Data Collection System (EDCS) currently lacks the detail/specificity necessary to assist the Agency in identifying the types, makes and models of child restraints involved in crashes, restraint use/installation and subsequent performance. This lack of critical child restraint related data hinders the Agency and others in their efforts to properly analyze child-involved crash outcomes, particularly child-related injuries and child restraint performance in real-world crashes. With the addition of new variables and attributes related to child safety restraints, effective January 2002, NHTSA's National Automotive Sampling System (NASS) Crashworthiness Data System (CDS) data will have the potential for providing such information.

Typically, the EDCS Child Seat/Restraint variables are coded by field researchers as "Unknown" or "Other." Unknown variables are especially common when there is a lack of information in the field, e.g., child restraint removed from the crash vehicle, child restraint destroyed, parent/caregiver unfamiliar with child restraint, etc. Many of the current child restraint variables are outdated and are no longer representative of current child restraint types and designs.

The Crash Outcome Data Evaluation System (CODES), General Estimates System (GES), Fatality Analysis Reporting System (FARS), and State data systems focus on retrospective population-based data computerized at the State level and include crash data reported by police, EMS transport data, and emergency department and hospital discharge data. NHTSA has funded 25 States to develop CODES that involve the linkage of person-specific crash data to injury data to generate outcome information for crash victims transported by EMS, treated in the emergency department and discharged or admitted to the hospital. CODES states have expanded their linked data to also include information from death certificates, medical registries such as for trauma or head and spinal cord injuries, licensing and registration processes for drivers and vehicles, and inventory data such as for roadways. Characteristics of the person, vehicle, event and roadway can be linked to their specific medical and financial outcomes using CODES crash data. CODES does not develop data systems but increases the value of existing data systems through linkage technologies. The CODES project within a State has no control over the actual data collected, but as a result of the linkage process has been able to encourage improvement in the quality of State data.

All CODES states document safety equipment use for all drivers and for all persons injured in the crash. Some CODES states also document safety equipment use for the uninjured passengers. Unfortunately, the States do not define safety equipment use uniformly. Some define it generally as "restraints used or not used." Others define the type of restraint, such as shoulder belt only, lap-belt only, shoulder and lap-belt or child restraint/safety seat. Ninety-two percent (23/25) of the CODES states document the use of child restraints, but no CODES state documents booster seat use. The CODES data provide medical outcome for all children that linked to a medical record (EMS, emergency department, hospital, medical registry such as for trauma, death certificate, etc.). However, not all of the children documented as "injured" link to a medical record because of missing data or lack of sufficient identifiers (date of birth/age, sex, time, location, event date, etc.). Some children documented as "not injured" by the police do link to a medical record and are found to have serious injuries.

When and if "booster seat use" is added to the State crash reports, the CODES data can be used for booster effectiveness studies similar to those already submitted to Congress on the benefits of safety belts and motorcycle helmets. In the meantime, the use of child safety restraints/seats by age as currently documented in State crash data files can be used to provide context for the sampled and detailed booster seat data collected by NHTSA prospectively at the time of the crash.

The National Occupant Protection Use Survey (NOPUS) is a nationally observational survey composed of two studies: the Moving Traffic Study and the Controlled Intersection Study. The Controlled Intersection Study component of the NOPUS collects data on child safety seats and shoulder belt usage. The observation protocol for determining restraint use of children does not allow for direct interface with the child or the parent/caregiver in the vehicle. Booster seat (more likely the high back type) information may be collected but included by error as a forward-facing child restraint. Obtaining specific data for booster seat age children would require some modification to the NOPUS protocol.

The PCPS collaboration is a one-of-a-kind research program exclusively focused on child passenger motor vehicle crashes. The data are useful in identifying how kids are being transported and injured in motor vehicles. However, the data are not nationally representative. The data are based solely on insured motor vehicle population, thus a sample obtained only from State Farm Insurance claims.

The Swedish studies are very useful in providing some insight regarding restraint use, patterns of injury, their severity,

and the effect of compartmental intrusion in crashes. However, the crash environment in Sweden does not resemble that in the United States. Additionally, child safety recommendations may vary from those followed in the United States. Also, although booster seats have been in use for decades, very little Swedish data are available. The age ranges for children using booster seats are also not clearly defined.

Although the Canadian crash environment is somewhat similar to the U.S., the research is based on a small sample of crashes and laboratory tests. Also note that the age ranges in the real world Canadian data are unknown.

Scientific/Experimental Test Data

Crash tests and real-world data indicate different types of problems according to Adrian Lund of the Insurance Institute for Highway Safety. Crash test injury measures indicate that shoulder belts may cause neck injury. Real-world data show that lap-belts could cause abdominal injuries. The Hybrid III dummy has no measurement capability to assess the potential for abdominal injuries. Test dummy configurations are not representative of postures of children as they ride in vehicles. The following paragraphs summarize NHTSA's findings from compliance and research tests of booster seats. These results are found in Appendix 3.

Research tests were conducted as part of meeting the TREAD Act requirements related to child safety. Tests were conducted using Hybrid III dummies in lap/shoulder belts and belt positioning booster seats with lap/shoulder belt configurations. The kinematics generally improved with the BPB seat configuration when compared to lap/shoulder belt alone.

Compliance tests under FMVSS No. 213 are currently conducted with Hybrid II dummies, which do not have the capability to measure neck loads and bending moments. However, injury measures are based on chest acceleration (G's), the Head Injury Criteria (HIC), and knee and head excursions. Compliance results from Fiscal Year 1998 through 2000 show the following trends:

- HIC declined fairly significantly with a reduction in the percentage of standard injury assessment reference values (IARV) by 8 percent.
- Chest G's declined fairly significantly with a reduction in the percentage of IARV by 10 percent.
- Average head excursions declined slightly (3 percent).
- Average knee excursions rose slightly (2 percent).

FOOTNOTES

32. Winston, F.K., Moll, E.K., Durbin, D.R., & Kassam-Adams, N., The Premature Graduation of Children from Child Restraints to Vehicle Safety Belts. NHTSA, DOT-HS-809-256, June 2001.
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36. MacKay, M., Booster Seats for Children - Closing the Gap Between Science and Public Policy Conference, Association for the Advancement of Automotive Medicine, April 2001, Washington, D.C.
37. Dance, D.M., Booster Seats for Children - Closing the Gap Between Science and Public Policy Conference, Association for the Advancement of Automotive Medicine, April 2001, Washington, D.C.
38. Injury Measurements: HIC and chest G values and knee and head excursions are used to predict injury risk in frontal crashes. HIC is a measure of the risk of head injury and chest G is a measure of chest injury risk. The reference values for these measurements are the thresholds for compliance used to assess new motor vehicles with regard to frontal occupant protection during crash tests, FMVSS No. 208. For HIC, a score of 1000 is equivalent to a 30 percent risk of a serious head injury (skull fracture). In a similar fashion, chest G of 60 equates to a 20 percent risk of a serious chest injury. These values are the Injury Assessment Reference Values (IARV). For all these measurements, higher scores indicate a higher risk for the likelihood of injuries. The head excursion limits are 711mm (28") for tethered and 813mm (32") for non-tethered. The knee excursion limit is 914mm (36") for both tethered and non- tethered.

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Improving The Safety of Child Restraints
BOOSTER SEAT STUDY

Chapter 4
Summary and Conclusions

Public Perception

The 2000 Motor Vehicle Occupant Safety Survey revealed that about one-in-six parents/caregivers either had never seen or heard of booster seats (15 percent) or else did not know if they had them (1 percent). Among the majority (84 percent) who were aware of booster seats, more than half (58 percent) had at some time used a booster seat when driving with their child or children.

Information on the child's weight showed that use of booster seats sometimes occurs prematurely. While safety experts, at the time of the report, recommended that children weighing 40 to 80 pounds use booster seats, one-half (50 percent) of the parents/caregivers who said they used booster seats reported that usage began at lower weights.

Among those parents/caregivers who had seen or heard of booster seats, almost one-quarter (23 percent) acknowledged concerns about their safety while another 6 percent were unsure if they had safety concerns. Complaints about booster seats volunteered by parents/caregivers often revolved around the lack of a secure attachment to the vehicle, and the impression that the booster seat would not adequately restrain and protect the child in the event of a crash.

The Children's Hospital of Philadelphia (CHOP) premature graduation study identified a number of factors contributing to use and non-use of booster seats. While deficits in knowledge concerning child passenger safety and the benefits of booster seats were significant factors in premature graduation of children to safety belts, the study determined that education alone would not solve the problem because of other obstacles to booster seat use. Perceptions of risk and knowledge of best practices for child restraint played major roles in premature graduation. The study found some confusion among parents concerning the purpose of booster seats. For example, one participant stated "To be honest, I never really got it. It just boosts them up - it's not as good as a car seat." As indicated by this comment, some parents not only failed to understand the role of booster seats, but also did not fully appreciate how safety belts work.

The study also revealed that beyond the issue of lack of awareness, there were a number of other barriers to booster seat use raised by the parents. The child's resistance to child restraints played a major role in the decision by some parents to transition their child to safety belts. Many parents reported difficulty installing their booster seats. Some complained about confusing instructions, with no means to confirm correct installation, or incompatibility with the design features of their vehicles. Other complaints revolved around inconvenience as booster seats were described as big and bulky and awkward to transport.

Parents suggested a number of strategies for addressing the problem of premature graduation to safety belts. Many of these related to "getting the message out" as they perceived a need for the public to be better informed. They pointed to various weaknesses in the guidelines, and some suggested a less standardized criterion for determining the optimal form of restraint for any given child. According to the parents, adding a guideline communicating how a safety belt should fit the child would be applicable to all children regardless of their frame, and perhaps make the importance of proper safety belt fit more understandable to parents than age or weight requirements. Overcoming these barriers can facilitate the establishment of practical, uniform child safety laws.

Properly designed booster seats that improve

belt fit and comfort could encourage their use; thus, increase safety

Information regarding public perception of the advantages and disadvantages of booster seats is not readily available. It is well known that, in spite of the advantages of using child restraints, many parents do not use such restraints, especially booster seats. The apparent motivation behind the development of booster seats is to improve lap/shoulder belt fit for child occupants. In the absence of properly fitting lap/shoulder belt systems, children often avoid wearing them or wear them improperly. Therefore, properly designed booster seats that improve the belt fit and comfort could encourage their use and thus increase safety. Belt positioning aftermarket devices are constantly sought by parents to improve belt fit for children. This demand has brought to market several devices which are not of proper design. In such cases, they tend to change safety belt geometry and occasionally redirect the lap belt portion of the belt over a child's abdomen. Sometimes they also inadvertently position the shoulder belt across the child's neck.

Real World Experience

Many European countries have utilized booster seats for decades. Booster seat cushions were developed in Sweden and Australia in the mid-1970s to allow children to take advantage of the vehicle's built-in upper and lower torso restraint (i.e., lap/shoulder belt), and they have been used there and elsewhere successfully ever since. In Sweden, the use of booster seats has been widespread for a number of years. However, Swedish studies have shown the difficulties in obtaining adequate data in determining the relative merit of booster seats over the vehicle's lap/shoulder belt for children 4 to 10 years of age. The studies found that: (1) a large percentage of children are unrestrained; (2) although booster seats have been available for decades, it is difficult to obtain adequate data to draw solid conclusions about the relative merit of booster seats over lap/shoulder belts alone for children 4 to 10 years old; (3) for children that sustained serious-to-fatal injuries, intrusion was an important factor affecting the outcome; and (4) the authors emphasized the great importance of limiting intrusion (especially in side impacts) and preventing forward contacts (rather than injury from the restraint itself) to prevent/reduce high incidence of head injuries. The results from the Canadian studies reiterated the importance of limiting intrusion into the occupant compartment.

Studies performed by CHOP found that while restraint use was very high (95 percent), the majority of children in the age group 4 - 8 years of age were not appropriately restrained. Booster seat use peaked at age 3 years old and dramatically dropped after age 4 years old. There was a 60 percent reduction in risk of injury among children using child restraints (both child safety seats and boosters) when compared to those in any type of safety belts. When restricted to 4 to 5 year olds in either safety belts or booster seats, children in the safety belts were over three times as likely to suffer a significant injury than children in booster seats.

Laboratory Test Findings

Booster seats appear to be performing well in compliance and in research tests. However, safety advocates have expressed concerns regarding the accuracy of laboratory tests in assessing the performance of booster seats. Researchers indicate that crash tests and real world data indicate different problems. Crash tests injury values indicate that shoulder belts may cause neck injury in children. Real-world data show that lap-belts could cause abdominal injuries. The Hybrid III offers no measurement capabilities to assess potential abdominal injuries. Test dummy configurations are also not considered to be representative of postures children use while riding in automobiles.

Conclusions

On average, about 1,000 children under 10 years of age are killed per year in motor vehicle crashes in the United States. It is estimated that approximately 47 percent of the fatally injured children in the 0 through 9 years old age group are generally unrestrained. For children under the age of 15 years, approximately 60 percent are unrestrained among those who are fatally injured. Research on the effectiveness of child safety seats has found them to reduce fatal injury by 71 percent for infants (less than 1 year old) and by 54 percent for toddlers (1 - 4 years old) in passenger cars. For infants and toddlers in light trucks, the corresponding reductions are 58 percent and 59 percent, respectively.

However, the effectiveness of booster seats needs to be further evaluated on the basis of mitigation of injuries as well. It is noted that the data currently available in estimating the effectiveness of booster seats are limited. The data lack details necessary to assist the Agency in identifying the types, makes, and models of child restraints involved in crashes, proper restraint use and subsequent performance. This deficiency hinders the Agency's efforts in making precise estimates on effectiveness of booster seats.

When a child can no longer fit into a convertible or other forward-facing child restraint, the recommended next step is a belt positioning booster seat. The greatest gain in occupant protection for this age group is obtained by getting unrestrained child passengers in any form of occupant restraint. Unfortunately, children are being moved into adult safety belts too soon instead of restraints appropriate for their age and size.

Properly designed booster seats that improve the belt fit and comfort could encourage their use and thus increase safety. Beyond the safety advantages of using booster seats, early exposure of children to the safety risks of not using proper restraints is likely to carry through to their adult life. This should improve their safety habits such as using safety belts and paying closer attention to safety risks.

Although current data are limited, it is estimated that approximately 150 lives could be saved, annually, if those children who are not using child restraints are restrained with lap/shoulder belts. Further, if all those children who are ready for booster seats used them, an additional 19 lives could be saved every year.

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Appendix 1
Agency CRS Guidelines

Child Passenger Safety

NHTSA
People Saving People
www.nhtsa.dot.gov

Child Safety Seat Recalls Search | Fitting/Inspection Stations | Technician Contact Locator

- Child Passenger Safety Laws
- One Minute Safety Seat Checklist
- Types of Child Safety Seats
- Child Safety Seat Dictionary
- Child Safety Seat Registration Form
- Child Safety Seat Recalls
- A Parent's Guide To Booster Seats
- NHTSA Regional Offices
- Compliance Testing
- Child Passenger Safety Training Programs
- Air Bag On/Off Switch Installer Locator
- Reporting Problems with Car Child Safety Seat
- Guide to Community Preventive Services
- Sálvele la Vida a su Bebé (in spanish)

Select a Child Passenger topic for more information.

Site Search - select a CPS topic - GO

Proper Child Safety Seat Use Chart

Buckle Everyone. Children Age 12 and Under in Back!

	INFANTS	TODDLER	YOUNG CHILDREN
WEIGHT	Birth to 1 year at least 20-22 lbs.	Over 1 year and Over 20 lbs.-40 lbs.	Over 40 lbs. Ages 4-8, unless 4'9".
TYPE of SEAT	Infant only or rear-facing convertible	Convertible / Forward-facing	Belt positioning booster seat
SEAT POSITION	Rear-facing only	Forward-facing	Forward-facing
ALWAYS MAKE SURE:	Children to one year and at least 20 lbs. in rear-facing seats Harness straps at or below shoulder level	Harness straps should be at or above shoulders Most seats require top slot for forward-facing	Belt positioning booster seats must be used with both lap and shoulder belt. Make sure the lap belt fits low and tight across the lap/upper thigh area and the shoulder belt fits snug crossing the chest and shoulder to avoid abdominal injuries
WARNING	All children age 12 and under should ride in the back seat	All children age 12 and under should ride in the back seat	All children age 12 and under should ride in the back seat

Child Safety Seats

This site provides a list of new child restraints and features; new vehicles and Child Safety features; proper tips for installing and using child safety restraints.

Corazón de mi vida Kit

- 4 Steps for Kids
- How to solve problems you may have installing your child car seat

Child Seat Help
Fitting/Inspection Stations
Technician

Child Transportation Safety Tips

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Improving The Safety of Child Restraints
BOOSTER SEAT STUDY

Appendix 2
Facts Derived from the International Booster Seat Conference

Booster Seats for Children: Closing the Gap Between Science and Public Policy

The Association for the Advancement of Automotive Medicine (AAAM) is an international multidisciplinary organization dedicated entirely to motor vehicle crash injury prevention and control. The AAAM sponsored an international conference on April 23-24, 2001, in Washington, DC, of leading child passenger safety experts in medicine, engineering, research, enforcement and child safety to promote scientifically sound public policy on child booster seats in motor vehicles.

A major goal of the conference was to develop scientifically based recommendations that will lead to public policies, including regulation and legislation, on booster seats and that will guide future research in child occupant restraint systems. These recommendations were based on the following factual information derived from the conference. These facts are cited below. To review the complete the list of recommendations go to www.carcrash.org.

1. **FACT:** Studies show that between 40 and 50 percent of 4 to 8 year old children in fatal crashes are totally unrestrained. Studies also show that generally when parents and other adults are not restrained, young children also are unrestrained.
2. **FACT:** Recent data suggest that adult belts reduce injury risk by about 60 percent for 4 to 10 year olds compared to being unrestrained. Furthermore, preliminary data indicate that the use of size appropriate restraints, such as booster seats, for this age group may reduce the risk of injury by 70 to 80 percent compared to being unrestrained.
3. **FACT:** Differences in technical regulations relative to child restraint devices, including booster seats, from one country to another, are counterproductive. These differences inhibit the introduction of improvements in restraints, expend resources unnecessarily and limit the scientific exchange that can promote the more widespread adoption of science based policies reflecting new knowledge.
4. **FACT:** Acceptability of any restraint system is fundamental to its proper use. Particularly with children, the proper position of the shoulder portion of a three-point lap/shoulder belt will encourage correct use.
5. **FACT:** The usage rate for booster seats by children who have outgrown their convertible child restraints is very low. A recent NHTSA survey indicated that more than 20 percent of parents of young children have not even heard of booster seats. And where they are used, the level of misuse of child restraints, including booster seats, is still fairly high.
6. **FACT:** The rate at which various components of the human body develop varies significantly by age. Most of the research to date on development of human tolerance injury criteria has focused on adults through the use of human volunteers, cadavers and animal surrogates. Not all of these techniques are available for developing child injury criteria. While advances have been made in developing child injury criteria using scaling techniques, this work is only in an embryonic stage. However, the continued improvement of child restraint systems, including boosters, is directly related to a much better understanding of tolerance limits of this segment of the population.
7. **FACT:** A comprehensive federal standard for certifying booster seats for the range of children who could benefit from them does not currently exist in the United States. Fundamental to the adoption of a standard is the availability of appropriate anthropomorphic test devices (i.e., dummies). In the early 1990s, the NHTSA initiated

the Large Child Dummy Development program. Almost a decade later, NHTSA announced in the Child Restraint System Safety Plan, November 2000, that work on a 10 year old dummy has been ongoing with the Society of Automotive Engineers and final specifications were expected in December 2000. A prototype dummy is currently being evaluated.

8. **FACT:** The assessment of the performance of booster seats using current test procedures, dummies and injury criteria does not match the real world information on crash injuries.
9. **FACT:** Current restraint system design is based on the use of three-point lap/shoulder belts. Studies have shown, however, that two point lap belts as well as current three-point lap/shoulder belts pose unnecessary risk of spinal and abdominal injuries to children. For example, the shoulder portion of a three-point belt tends to pull the lap section up into the soft tissue area of young children whose anatomical structure is not developed adequately to fit a three-point belt system optimally. Also, three point belts, improperly used, such as placing the shoulder belt behind the child, fail to protect children adequately.
10. **FACT:** Approximately 30 percent of rear seat occupants are 10 years old or younger. Of these, half are less than 4 years of age and the other half are between 4 and 10 years old.
11. **FACT:** Police have an important role to play in promoting child passenger safety, not only in enforcing occupant restraint laws, but also in collecting information on the use of child restraints, including boosters, in real world crashes. Currently, no discrimination is made on police collision report forms between different types of child restraints.
12. **FACT:** Very little information is currently available about real world injury tolerance for the pediatric population due in part as a result of lack of documentation of injuries at all severity levels on fatally and non fatally injured child occupants in motor vehicle crashes. In addition, radiographic evidence is often absent. As a result, certain injuries are under detected and therefore underrepresented.

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BOOSTER SEAT STUDY

Appendix 3
Research and Compliance Laboratory Tests

Review of Data from Tests Performed by the Vehicle Research Center

As part of meeting the TREAD Act requirements related to child safety, the National Highway Traffic Safety Administration conducted research tests at the Vehicle Research and Test Center. Two series of tests were performed to compare: (1) the Hybrid II and Hybrid III 3- and 6-year-old dummies, and (2) the standard Hybrid III 6-year-old (HIII-6C) with a weighted Hybrid III 6-year-old (HIII-6CW). The following technical data are provided to show more detailed test results.

Dummy Equivalency Tests

Table A contains the summary of results from tests conducted with the HII-6C and HIII-6C dummies seated in the Cosco Grand Explorer and the Century Breverra Classic, both with lap/shoulder belts, and tested per FMVSS 213 parameters. The tabulation in this table are the head and knee excursion distances, the head injury criterion (HIC), and the resultant chest acceleration (chest G).

Table A: Sled Test Results for HII-6C and HIII-6C Comparison

Test No.	Dummy Type	Restraint Configuration	Head Excur. (Req. ≤ 32 in.)	% of Std. IARV	Knee Excur. (Req. ≤ 36 in.)	% of Std. IARV	HIC (Req. ≤ 1000)	% of Std. IARV	Chest G (Req. ≤ 60)	% of Std. IARV
TRC487	Hyb. II	Grand Explorer w/ l/s belt	18.1	57%	24.1	67%	454	45%	65.8	110%
TRC435	Hyb. III	Grand Explorer w/ l/s/ belt	19.9	62%	23.0	64%	1141	114%	54.0	90%
TRC486	Hyb. II	Breverra w/ l/s belt	18.9	59%	25.4	71%	530	53%	44.6	74%
TRC442	Hyb. III	Breverra w/ l/s belt	21.0	66%	24.4	68%	974	97%	54.3	91%
TRC443	Hyb. III	Breverra w/ l/s belt	21.5	67%	21.7	60%	825	83%	54.4	91%

The results presented in Table A show slightly greater head excursion values for the HIII-6C than the HII-6C, and similar knee excursion results for the two dummy designs. The excursion results are fairly repeatable, and none of the dummies tested in either child restraint system approach the head or knee excursion injury criteria value. Higher HIC

values were recorded for the HIII-6C in all cases, for both belt positioning booster seats tested. This is believed to be due primarily to the difference in neck designs between the Hybrid II and Hybrid III dummy. Overall, the HIII-6C exhibits a consistent chest acceleration value (54.0 - 54.4 G's), while the HII-6C chest acceleration values varies from 44.6 - 65.8 G's. Additionally, the chest acceleration value from the test with the HII-6C seated in the Cosco Grand Explorer exceeds the injury criteria.

Evaluation of Weighted HIII 6 -year-old Dummy

A series of 3 sled tests using the FMVSS 213 pulse (24 G, 30mph) was conducted to evaluate the performance of the HIII-6CW (weighted) and the HIII-6C (standard). Both dummies were seated in the Century Breverra Metro belt positioning booster seat, and were belted using the vehicle lap/shoulder belt system. No top tethers were used. The seating location on the sled buck test seat fixture, dummy seating height, and weighted components were examined and adjusted during this test series. Table B summarizes the test matrix for this series, and also shows the objective for running each test.

Table B: Test Matrix for Evaluating the HIII-6CW and HIII-6C with FMVSS 213 Pulse

Test Number	Left-Side Occupant	Right-Side Occupant	Objective
W6_05	HIII-6C	HIII-6CW	Determine if seating location (left/right side) affects response
W6_06	HIII-6C (+1" spacer)	HIII-6CW	Determine the effects of raising seating height without an increase in weight
W6_07	HIII-6CW (spine weights only)	HIII-6C (+1" spacer)	Determine the effects of increasing upper torso weight without an increase in seating height, and verify the results of test W6_05

Table C contains a summary of the test results for this series of tests. Based on these tests, it was determined that: seating location on the sled buck does not seem to have an effect on the dummy performance; variations in performance between the HIII-6C and the HIII-6CW appears to be due primarily to the one inch increase in seating height with the HIII-6CW disbursing weight throughout the dummy may be a more desirable alternative; and the increased seating height for the HIII-6CW is reasonable when adding 8.9 pounds to the overall dummy weight. A heavier dummy is logically expected to be taller. Also, increasing the dummy seating height by one inch does not have a significant effect on the percentile rank of the six-year-old child dummy.

Table C: Summary of Sled Test Results for Standard and Weighted HIII 6-year-old Dummies

Test No.	Dummy Location	Dummy Type	HIC (Req. ≤ 1000)	% of Std. IARV	Head Excur. (Req. ≤ 32 in.)	% of Std. IARV	Chest G (Req. ≤ 60)	% of Std. IARV	Nij (Req. ≤ 1.0) **	% of Std. IARV	Neck Z Force Tension (Req. ≤ 1490 N) **
05	Right	HIII-6CW	412	41%	20.9	65%	54.2	90%	1.076	108%	1484
05	Left	HIII-6C	670	67%	20.6	64%	52.4	87%	1.267	127%	1875
06	Right	HIII-6CW	416	42%	21.6	68%	55.9	93%	0.969	97%	1368
06	Left	HIII-6C	507	51%	22.5	70%	56.2	94%	1.091	109%	1656
07	Right	HIII-6C (+ 1" spacer)	502	50%	20.6	64%	50.5	84%	1.058	106%	1648

07	Left	HIII-6CW (spine wt. only)	732	73%	21.0	66%	60.8	101%	1.146	115%	2467	

Note: ** denotes IARV criterion that is applicable under FMVSS No. 208, but not currently under FMVSS No. 213

Table D: Sled Test Matrix for HIII-6CW Using FMVSS 213 Pulse

Test Number	Restraint Configuration
W6V2_01	Graco Cherished Cargo Booster Seat w/ lap/shoulder belt
W6V2_02	Century Breverra Metro Booster Seat w/ lap/shoulder belt
W6V2_03	No booster seat - lap/shoulder belt only
W6V2_04	Graco Cherished Cargo Booster Seat w/ lap/shoulder belt
W6V2_05	Century Breverra Metro Booster Seat w/ lap/shoulder belt
W6V2_06	No booster seat - lap/shoulder belt w/ shoulder belt routed under the arm

A second series of 6 sled tests using the FMVSS 213 pulse (24 G, 30 mph) and buck were conducted to evaluate the performance of the HIII-6CW (see test matrix in Table D). All tests were conducted using modified 1999 Grand Am lap/shoulder belts. The seat belt retractors were removed and replaced with a manually adjustable tensioner. The seat belts were pre-tensioned to 2 lbs prior to each test to prevent the dummy from “peeling out” of the shoulder belt as observed in prior sled testing.

Table E: Summary of Sled Test Results for Weighted HIII 6-Year-Old Dummy

Test No.	Restraint Configuration	HIC (Req. ≤ 1000)	% of Std. IARV	Head Excur. (Req. ≤ 32 in.)	% of Std. IARV	Chest G (Req. ≤ 60)	% of Std. IARV	Nij (Req. ≤ 1.0)**	% of Std. IARV	Neck Z Force Tension (Req. ≤ 1490 N) **	% of Std. IARV
V2-01	Graco Cherished Cargo w/ l/s belt	774	77%	21.0	66%	56.8	95%	1.189	119%	2811	187%
V2-02	Century Breverra Metro w/ l/s belt	649	65%	19.9	62%	54.0	90%	1.266	127%	2958	199%
V2-03	No BPB; l/s belt only	1210	121%	16.6	52%	44.7	75%	1.755	176%	4227	284%
V2-04	Graco Cherished Cargo w/ l/s/ belt	546	55%	20.6	64%	58.5	98%	1.146	115%	2532	170%
V2-05	Century Breverra Metro w/ l/s belt	431	43%	21.0	66%	58.3	97%	0.934	93%	1536	103%
V2-06	No BPB; l/s belt w/ shoulder belt under arm	612	61%	26.7	83%	38.4	64%	1.304	130%	2378	160%

Note: ** denotes IARV criterion that is applicable under FMVSS No. 208, but not currently under FMVSS No. 213

In general, the sled test results indicate repeatable performance of the HIII-6CW with the Tungsten alloy weights, particularly when the same booster seat is used. In most cases, similar curve patterns are illustrated for the repeated tests, although the peak magnitudes vary slightly between the tests. Table E summarizes the results from this test series (HIII-6CW).

Compliance Test Data Summary

A review of compliance test data for belt-positioning booster seats utilizing the 6-year old-dummy for the period of Fiscal Year 1998 (first year of compliance testing using the 6-year-dummy) through Fiscal Year 2000 (most recent test year completed) are found in Table F.

Table F: Compliance Test Data Summary

Fiscal Year Compliance Test/Number of Tests	Avg. HIC (Req: ≤ 1000)	% of Standard IARV	Avg. Chest g (Req: ≤ 60)	% of Standard IARV	Avg. Head Excursion (Req: ≤ 32 in.)	% of Standard IARV	Avg. Knee Excursion (Req: ≤ 36 in.)	% of Standard IARV
1998/13	441	44%	46	76%	20	62%	24	66%
1999/14	373	37%	42	70%	21	65%	25	70%
2000/22	358	36%	40	66%	19	59%	25	68%

The tests were conducted at Detroit Testing Laboratories and Veridian Engineering in FY 1998 and FY 1999, and at Patuxent River Naval Air Center and Veridian Engineering in FY 2000.

Some observations of this data are as follows:

HIC and chest g's declined fairly significantly between FY 1998 and FY 2000 with a reduction in the percentage of standard injury assessment reference values by 8 percent and 10 percent, respectively. Average head excursions declined slightly over the same time period (3 percent) and average knee excursions rose slightly (2 percent).

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Improving The Safety of Child Restraints
BOOSTER SEAT STUDY

Appendix 4
Glossary of Terms

NHTSA Dictionary of Child Safety Seat Terms

- **AIS:** The Abbreviated Injury Scale is universally accepted as the foundation of injury severity scaling systems. The AIS was developed to provide researchers with a simple numerical method for ranking and comparing injuries by severity, and to standardize the terminology used to describe injuries.
- **Belt Anchor Points:** Fixed locations where the safety belt's latch plate and buckle are anchored to the vehicle structure.
- **Belt Path/Route:** The manufacturer's required place where the safety belt passes around or through the child restraint.
- **Belt-Positioning Booster Seat (BPB):** A platform that raises the child (provides a taller sitting height) so adult lap and shoulder belts fit better; some have high backs as well. Never use with a lap belt only across the child.
- **Belt Webbing:** A term used to refer to the vehicle seat belt material.
- **Booster Seats:** Are intended to be used as a transition to lap/shoulder belts by older children who have outgrown convertible seats (over 40 pounds). They are available in high backs, for use in vehicles with low seat backs or no head restraints, and no-back; booster bases only.
- **Buckle:** The locking mechanism of the vehicle belt and child safety seat buckle/latch plate system. Buckles are typically mounted/attached to fabric webbing and/or by metal or plastic stalks.
- **Car Seat:** Common term for a specially designed device that secures a child in a motor vehicle, meets federal safety standards, and increases child safety in a crash.
- **CDS:** Crashworthiness Data System
- **Chest Acceleration and Chest Deflection:** Chest Acceleration (Chest G's) and Chest Deflection address the risk of chest injury.
- **Child Safety Seat/Child Restraint:** A crash tested device that is specially designed to provide infant/child crash protection. A general term for all sorts of devices including those that are vests or car beds rather than seats.
- **CODES:** The Crash Outcome Data Evaluation Systems data system focuses on retrospective population-based data computerized at the State level and include crash data reported by police, EMS transport data and emergency departments and hospital discharge data. CODES involve the linkage of person-specific crash data to injury data to generate outcome information for crash victims transported by EMS, treated in the emergency department and discharged or admitted to the hospital.
- **Combination Child Seat/BPB:** A type of forward facing child restraint that is used with an internal harness system to secure a child up to 40 pounds and then, with the removal of the internal harness, is used as a high back belt positioning booster (BPB) seat.
- **Compliance Tests:** Rigorous crash and static testing done to assure that manufacturers meet required federal standards (in this case, FMVSS 213). Performance requirements established by National Highway Traffic Safety Administration (NHTSA).
- **CPS:** Child Passenger Safety
- **Crash Pulses:** A crash pulse is the graph or picture of how quickly the vehicle occupant compartment is decelerating at different times during a crash.

- **FARS:** Fatal Analysis Reporting System. FARS is a census of roadway traffic crashes that result in property damage and loss of human life.
- **FMVSS 213:** Federal Motor Vehicle Safety Standard that pertains to all restraint systems intended for use as crash protection in vehicles for children up to 50 pounds.
- **Harness Strap:** This refers to the child seat straps used to secure the child into the safety seat.
- **Head Injury Criterion or HIC:** Head Injury Criterion or HIC addresses the risk of head injury.
- **IARV:** Injury Assessment Reference Values. See injury criteria.
- **Injury Criteria and Performance Limits:** In general In a crash test, sled test, or static out-of-position test, measurements are taken from the test dummy instruments that indicate the forces that a person would have experienced under the same conditions. FMVSS No. 208 specifies several injury criteria. For each criterion, the Standard also specifies a performance limit, based on the level of forces that create a significant risk of producing serious injury.
- **Injury Criteria:** Injury criteria are performance limits for various injury criteria to address the risk of several types of injuries. Among these injury criteria are:
- **Lap Belt:** A safety belt anchored at two points, for use across the occupant's thighs/hips.
- **Lap/Shoulder Belt:** A safety belt that is anchored at three points and restrains the occupant at the hips and across the shoulder; also called a “combination belt”.
- **Latch Plate:** The part of the buckle mechanism that slides into the buckle; usually the part that affects the length of the belt. Switchable latch plates have a lock button to allow the seatbelt to be locked around the child safety seat.
- **Locking Clip:** A flat H-shaped metal clip intended to fasten together belt webbing (lap and shoulder portion) at a sliding latch plate, to prevent the webbing from sliding through. Typically the clip which comes attached with most child safety seats. Should be fastened just above the latch plate. Cannot be used in place of a Heavy Duty Locking Clip.
- **Locking Latch Plate:** A latch plate that holds the lap belt snug after it has been adjusted. Type of latch plate that contains a metal bar on the underside of the hardware that “locks” the belt in position.
- **Manual Seat Belt:** A seat belt that must be fastened and adjusted by the occupant, often found in the rear center seating position.
- **National Highway Traffic Safety Administration (NHTSA):** The federal Agency that sets performance requirements for motor vehicles and items of motor vehicle equipment such as child restraints.
- **NASS:** The National Automotive Sampling System is the mechanism through which the NHTSA collects nationally representative data on motor vehicle traffic crashes to aid in the development, implementation, and evaluation of motor vehicle and highway safety countermeasures.
- **NASS CDS:** NASS Crashworthiness Data System has detailed data on a representative, random sample of thousands of minor, serious, and fatal crashes. There are 24 field research teams that study about 5,000 crashes a year involving passenger cars, light trucks, vans, and utility vehicles.
- **Nij:** Nij addresses the risk of neck injury.
- **OEM:** Original equipment manufacturer
- **Premature Graduation:** The early transition from child safety seats to vehicle belts.
- **Rear-Facing Infant Seat:** Type of child restraint system that is specifically meant for use by children from birth up to approximately 20 pounds used in the rear-facing mode only.
- **Retractor:** A mechanism that rolls up the unused webbing of the safety belt when it is not in use and takes up slack around the user.
- **Seat Belt:** The webbing, anchor and buckle system that restrains the occupant and/or child safety seat in the vehicle.
- **Seat Belt Positioning Devices:** These are products marketed and sold to adjust the vehicle seat belt to fit a child. There are no federal safety standards for these products. NHTSA recommends the use of child safety seats and booster seats instead of these products.
- **Seat Bight/Seat Crack:** The intersection between the bottom vehicle seat cushion and the back cushion.
- **Shield Booster Seat:** A platform that raises the child and positions a small convex shield across the lap and lower abdomen to restrain the child. A vehicle lap belt restrains the booster seat. Some models have removable shields and covert to a belt-position booster seat (BPB).
- **Shoulder Belt Positioners or Comfort Guides:** Devices (some built in and some add-ons) that can be used to reposition shoulder belts so they fit across the shoulder rather than across the neck. Aftermarket

belt positioners are not currently tested by NHTSA.

- **Sliding Latch Plate:** A latch plate that moves freely on a continuous loop of vehicle belt webbing.
- **Test Dummies:** In FMVSS No. 213 several test dummies are used to represent children of different sizes. These dummies are: 9-month old dummy, representing an infant; and Hybrid 3-year-old and 6-year-old child dummies, representing young children.
- **Type I Safety Belt:** A safety belt anchored at two points, for use across the occupant's thighs/hips. A lap belt.
- **Type II Safety Belt:** (a lap/shoulder belt) A safety belt that is anchored at three points and restrains the occupant at the hips and across the shoulder; also called a “combination belt”. A lap/shoulder belt.
- **Whiplash Injury:** An injury to the neck usually caused by sudden whipping of the head backward during a rear impact collision.

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