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Car Seat Safety – Why are Children Still at Risk of Injury and Death?

Literature Review

BY

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Degree to be awarded: M.P.H.

Executive MPH

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M.P.H., Emory University, 2015

B.A., Carleton University, 1997

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An abstract of
A Thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University
in partial fulfillment of the requirements of the degree of
Master of Public Health in the Executive MPH program
2015

## Abstract

CAR SEAT SAFETY – WHY ARE CHILDREN STILL AT RISK OF INJURY AND DEATH?
LITERATURE REVIEW

BY

Juliette Marie Merchant

The Centers for Disease Control and Prevention (CDC) lists motor vehicle crashes as the leading cause of death among children in the United States. Each year nearly 250,000 children in the United States are injured in motor vehicle crashes, and approximately 2000 die from their injuries (NHTSA 2013, Bae, Anderson et al. 2014). From 2000 to 2013 a staggering 32,044 children from birth to 15 years of age were killed in traffic fatalities (WISQARS 2015).

School aged children between the ages of 4 to 8 years old are particularly at risk for injury as passengers in motor vehicles because they are often too big for a car seat but too small for a seat belt. Seat belts don't fit children properly until they are at least 57" (4'9") tall and weigh between 80 and 100 pounds. Booster seats are designed to improve belt fit by altering the seated position of the child by changing the belt routing.

CDC recommends using age and size appropriate child restraints systems (CRS) in the back seat until they are large enough to safely fit into an adult seat belt properly. This means the lap belt lays across the upper thighs, not the abdomen, and the shoulder belt lays across the shoulder and chest, not the neck or face (Sauber-Schatz, West et al. 2014).

When installed and used properly, CRS can prevent injuries and save lives. Although laws and public awareness campaigns have increased the use of restraints, many children continue to be unrestrained or improperly restrained.

This systematic review of literature will investigate potential reasons children are still at risk for injury and death as occupants of motor vehicles. What is the most effective way to education parents of school age children about the critical importance of booster seats? The examination of the literature will focus on child passenger policy and legislation; booster seat interventions for school age children between 4 to 8 years old; education program strategies and technology implications affecting child restraint use.

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## ACKNOWLEDGEMENTS

I thank God for the peace of mind to finally realize everything happens in the time it's supposed to happen. I am incredibly grateful for the many people who were brought into my life to help accomplish the goal of competing this program. I am forever indebted to Kathy Miner for encouraging me from my initial inquiry call when an MPH seemed like a long shot. Thank you for your patience, guidance and challenging me to do better. Most importantly, thank you for believing in me. Special thanks to Dr. Terri McFadden for always being willing to help whenever I've asked – you are the quintessential kind soul.

I'm grateful for meeting Ana Everett, you opened my mind to a whole new world and set me on this course forever changing my thinking. Thank you for being my game changer.

Thanks to my children Jaylen, Shanna, Avery and Zoe you are my inspiration to want to do better. I am so proud to be your mother. Thank you for being my best safety ambassadors and loudest cheerleaders. This journey is proof that you can accomplish anything by just focusing of what's directly ahead. I can't wait to see you all shine.

I am incredibly thankful for the love and support of my parents. You've never stopped encouraging and reminding me of the importance of education. Mommy thank you for your incredible and invaluable gift of time again and again – there are no words to truly express my gratitude for all you've done to help me finish this degree.

Thanks to my friend Dianne Alexis, you are a great role model and my living example of the poem "Footprints" always unselfishly there to lend a hand. From helping me make sense of prevention effectiveness to reviewing countless thesis chapters thank you for encouraging me and carrying me when I was too weary to even think. In you I have a true friend for life.

Lastly I want to thank my husband Shawn for being my quiet support throughout this and my many endeavors. Thanks for being the stable force of my free spirit life...I love you more than you will ever know for letting be ME!

Juliette Marie Merchant

## Table of Contents

# CHAPTER I: INTRODUCTION

We have them vaccinated, take them for regular checkups, and ensure that they eat a healthy diet. But the number one killer of children in the United States is not disease - it's injury. Unintentional injury claims the lives of more children between the ages of 0 and 18 in the United States, accounting for more deaths than the next 20 causes of mortality combined (Schwebel and Gaines 2007).

The Centers for Disease Control and Prevention (CDC) lists motor vehicle crashes as the leading cause of death among children in the United States. From 2000 to 2013 a staggering 32,044 children from birth to 15 years of age were killed in traffic fatalities (WISQARS 2015) More than 32,000 children lost their lives through no fault of their own.

Children under age 16 spend nearly as much time in motor vehicles as adults, average 3.4 trips for up to 45-50 minutes per day. The more time spent in motor vehicles corresponds to increased crash exposure (Durbin 2011).

Countless research studies show buckling children in age and size appropriate child safety seats and booster seats can significantly reduce the risk of serious and fatal injuries in motor vehicle crashes. Child safety seats and booster seats reduce the risk for death to infants less than 1 years of age by 71%; toddlers aged 1-4 years by 54%; and 45% for children aged 4-8 years in passenger vehicles compared with seat belt use. For older children and adults, seat belt use reduces the risk for death and serious injury by approximately half (Sauber-Schatz, West et al. 2014).

Based on this evidence, CDC recommends using age and size appropriate child restraints systems (CRS) (including child safety seats and booster seats) in the back seat until they are large enough to safely fit into an adult seat belt properly. This means the lap belt lays across the upper thighs, not the abdomen, and the shoulder belt lays across the shoulder and chest, not the neck or face. Based on general development, experts say this typically occurs after a child is at least age 8 years or more than 57 inches (145 cm) tall (Sauber-Schatz, West et al. 2014).

Head injuries are the most common injuries sustained by children in motor vehicle crashes regardless of age, restraint, and crash direction (Arbogast, Wozniak et al. 2012). The abdomen is the second most commonly injured body region in children using adult seat belts (Arbogast, Jermakian et al. 2009). Booster seats reduce the risk of abdominal injuries by improving the fit of the seat belt on young children and encouraging better posture and compatibility with the vehicle seat (Arbogast, Jermakian et al. 2009).

When installed and used properly, CRS can prevent injuries and save lives. Although laws and public awareness campaigns have increased the use of restraints, many children continue to be unrestrained or improperly restrained. Age-appropriate child restraint systems are a vital means to prevent injury and death. The young school-aged child in particular present unique challenges to standardized vehicle restraint systems. As these children outgrow child safety seats, they frequently are placed in lap/shoulder belt systems designed for the adult.

***Cost***

Motor vehicle crash-related injuries among children burden health care resources, with nationwide charges exceeding $2 billion annually (Gardner, Smith et al. 2007). The savings from booster seat use have 2 components: injury prevention and injury severity reduction. (Miller, Zaloshnja et al. 2006).

Despite clear evidence of the effectiveness of CRS and recommendations of their use from CDC, the American Academy of Pediatrics (AAP) and other leading health organizations, more than 32,000 children in the United States lost their lives from 2000 to 2013 in motor vehicle crashes. In 2013, 1,105 children ages 12 years and younger died as occupants in motor vehicle crashes, and more than 127,250 were injured. That is an average of 3 deaths and 349 injuries each day (WISQARS 2015). The National Highway Traffic Safety Administration (NHTSA) statistics show that nearly one-half of deaths and injuries in children occurred because they were not properly restrained.

Every 34 seconds, a child under the age of 13 is involved in a crash and more than a third of children killed in crashes were not in car seats or wearing seat belts (NHTSA 2014).

The purpose of this paper is to identify potential reasons children are still at risk for injury and death as occupants of motor vehicles. The examination of the literature will focus on child passenger policy and legislation; booster seat interventions for school age children between 4 and 8 years old; education program strategies and technology implications affecting child restraint use.

*Definition of Terms*

**Booster Seat**: A child restraint to be used as a transition to lap and 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.

**Car Seat**: Common term for a device, especially designed to secure a child in a motor vehicle. Car seats meet federal safety standards and increases child safety in the event of a motor vehicle collision.

**Child Passenger Restraint System or Child Restraint**: A crash-tested device that is designed to provide infant and child protection in the event of a motor vehicle collision.

**Convertible Car Seat**: A child restraint device that can be used in more than one mode, usually rear-facing for infants and forward-facing for toddlers.

**FMVSS 213**: Federal Motor Vehicle Safety Standard that pertains to all restraint systems intended for use as motor vehicle crash protection for children up to 50 pounds.

**FMVSS No. 225**: Federal Motor Vehicle Safety Standard that pertains to the standardized vehicle anchorage systems for child passenger restraint systems (upper and lower) independent of the vehicle seat belts.

**Forward-Facing Child Restraint**: A restraint that is intended for use only in the forward-facing position for a child aged 2 years and older, weighing 20 to 40 lbs.

**The National Highway Traffic Safety Administration (NHTSA)**: A national organization committed to reducing crash-related injuries and fatalities while ensuring the highest standards of safety on the nation's roadways.

**Rear-Facing Infant Seat**: Type of child restraint system that is specifically meant for use by children from birth up to approximately 20 lbs. used in the rear-facing mode only.

**Unintentional Injury**: Any injury that is unplanned.

# CHAPTER II: REVIEW OF THE LITERATURE

Nearly 250,000 children in the United States are injured every year in car crashes, and approximately 2000 die from their injuries (NHTSA 2013, Bae, Anderson et al. 2014)

In the late 1970s, the U.S. public's increasing awareness of the high rates of morbidity and mortality for child passengers resulted in rapid proliferation of state laws on the issue. Between 1977 and 1985, all 50 states adopted one or more laws aimed at reducing harm to infants and child passengers by requiring the use of some sort of child restraint device. (Bae, Anderson et al. 2014)

Beginning in the 1990s, National Highway Traffic Safety Association (NHTSA), as well as professional associations like American Academy of Pediatrics (AAP), have developed child passenger safety standards and guidelines that cover a wider range of child passenger safety issues and better protect children from injuries. Among other things, they emphasized the importance of three types of safety practices in protecting child passengers: (1) device-based restraints that are tailored to the age/size of individual child passengers; (2) rear seating, and; (3) seatbelt wearing of minors who have outgrown child restraint devices but are still in need of supervision to comply with seatbelt requirements (Bae, Anderson et al. 2014).

### *Historical Overview*

Though child seats were beginning to be manufactured in the early 1930s, their initial purpose was devised as a way to enable small children to look out the windows like a booster seat and then as a way to keep children from moving around while the motor vehicle was in motion causing distraction for the driver (Wikipedia.org 2015).

Given that the first three-point seat belts weren't available in motor vehicles until 1959, it’s obvious safety wasn’t a serious consideration for auto manufacturers. In 1962 two gentlemen designed the first child seats with the idea of safety in mind. British designer Jean Ames presented a rearward-facing seat with a familiar Y-strap, while the other designed by American Len Rivkin buckled the child into a seat surrounded by a metal frame.

By 1968 auto manufacturers capitalized on the popularity with the first car seats designed for crash protection. Ford developed the Tot-Guard and General Motors (GM) developed the Love Seat for Toddlers. GM soon followed with the Infant Love Seat - the first rear-facing only restraint, then the Bobby Mac convertible seat (SafeRideNews 2009). In 1971 the National Highway Traffic Safety Administration (NHTSA) adopts the first federal standards, FMVSS213. Crash tests are not included, but the standards require use of a safety belt to hold the car seat into the vehicle and a harness to hold the child in the car. In 1978, 16 years after the first innovation and 7 years from preliminary regulations, Tennessee is the first state to institute a child restraint law requiring parents to properly secure children under the age of four in a car seat. By 1985 all 50 states had passed child restraint laws (SafeRideNews 2009).

***What role does policy and legislation play in CRS use?***

To help combat child injuries and deaths, all 50 states, the District of Columbia and Puerto Rico have enacted some form of child restraint legislation. Current booster seat laws are thoroughly documented by the Insurance Institute for Highway Safety (IIHS) and the Highway Loss Data Institute (HLDI). Legislative efforts have been directed at reduction of child lives lost to motor vehicle collisions. Although these laws are an important factor for keeping children safe in vehicles, some do not provide comprehensive coverage for all children all the time. In some states, child passenger restraint laws are secondary, meaning the police can cite a driver for passenger restraint violation only if there was an additional reason for the stop. Furthermore, many states do not require children to be restrained in rear seats of the vehicle. As of 2015, only 14 states require rear seating of child passengers of varying ages (IIHS 2015).

Both federal and state governments play critical roles in addressing this policy issue. At the federal level, the NHTSA has developed guidelines designed to maintain consistent safety standards. State legislatures work to ensure established laws for safely transporting children in motor vehicles are followed.

As branch of the U.S. Department of Transportation, NHTSA, works to reduce traffic crashes and fatalities and to educate and inform the public regarding a variety of traffic safety issues. The agency has developed multi-faceted safety programs on child passenger protection, including child safety seats, school bus safety, and bicycling and pedestrian safety.

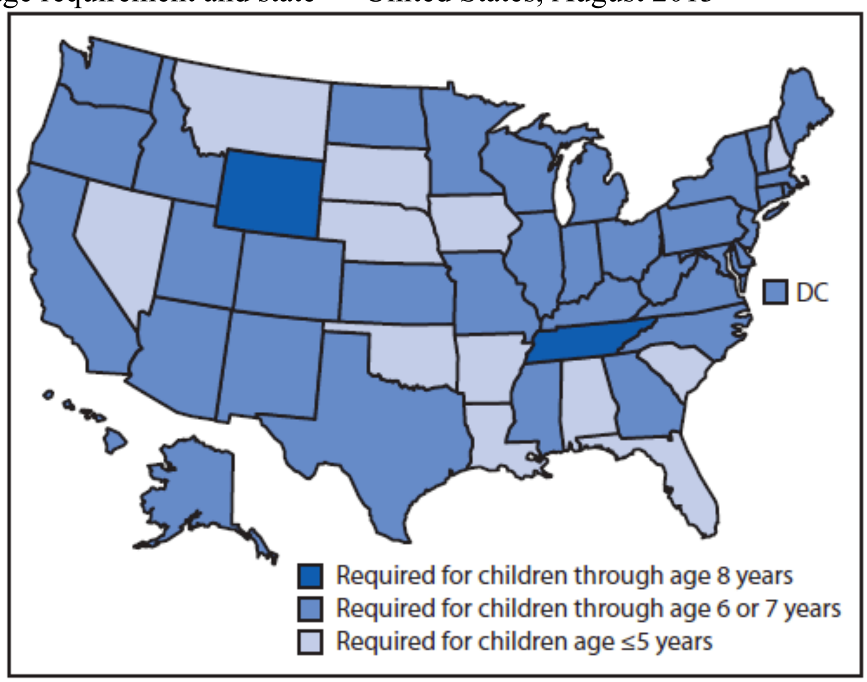
For example, the Transportation Recall Enhancement, Accountability and Documentation (TREAD) Act required that, by November 2002, a safety rating for child restraints be established to create a consumer information program to provide consumers with practical, readily understandable and timely information which can now be used to make informed decisions about purchasing child restraint systems.

Through a legislative mandate under Title 49 of the U.S. Code, Chapter 301, Motor Vehicle Safety, NHTSA is required to issue federal motor vehicle safety standards (FMVSS) and regulations. These standards and regulations are designed to ensure that manufacturers of motor vehicles and equipment are building safe, reliable products. These federal safety standards establish minimum performance requirements for motor vehicles and motor vehicle equipment.

FMVSS 213 covers child restraints. This safety standard outlines requirements for child safety seats used in motor vehicles and airplanes.

To simplify child restraint installation and to reduce the continuing high incidence of misuse and incorrect installation of child safety seats, FMVSS 225 required that, beginning in September 2002, new vehicles and child restraints be equipped with the LATCH child restraint anchorage system. LATCH (Lower Anchors and Tethers for Children) includes two lower anchorage points and upper tether anchorage points in at least two rear seating positions in nearly all cars, minivans and light trucks, and attachments on the child restraints themselves. LATCH was created to simplify how child restraints are attached to vehicles without using the vehicle seat belts.

Figure 1: Child passenger restraint laws requiring use of child safety or booster seats, by age requirement and state — United States, August 2013



Source: MMWR: Morbidity & Mortality Weekly Report, 2/7/2014, Vol. 63 Issue 5, p113-118

Figure 1 above shows child passenger restraint laws requiring use of child safety or booster seats, by age requirement and state in the United States during August 2013. In 2013, only 2 % of children in the United States lived in states with a child passenger restraint law that required child safety seat/booster seat use by children through at least age 8 years.

Although all states instituted some form of child restraint law by 1984, most state laws do not comply with Best Practice recommendations. Passage of booster seat laws increased child restraint use 39% among 4- to 7-year-olds (Durbin 2011). Older children (ages 5 to 15) are not covered by the gap between child and adult restraint laws in several states (Durbin 2011). Children riding in the front seat are 40 to 70% more likely to be injured than children riding in the rear.

The lives of approximately 4,800 children have been saved since 1997 due to improvements in child passenger safety. The American Academy of Pediatrics (AAP) released a revised Child Passenger Safety Policy Statement in 2011

In a retrospective, longitudinal analysis of all motor vehicle occupant crashes involving children 4 to 7 years of age identified in the Fatality Analysis Reporting System from January 1999 through December 2009, Mannix et al (2012) found booster seat laws are associated with decreased fatalities in children 4 to 7 years of age, with the strongest association seen in children 6 to 7 years of age. In 1999, at the start of the study period, 9% of 4 to 5-year-old children involved in a motor vehicle crash with a fatality were properly restrained in a booster seat; by 2009, the rate of proper booster seat restraint increased to 41% in this age group. In 1999, <0.9% of 6-year-olds and 0.1% of 7-year-olds involved in a motor vehicle crash with a fatality were restrained in a booster seat. By 2009, 23% of 6-year-olds and 12% of 7-year-olds were properly restrained in a booster seat. Mannix et all suggest laws should be extend to children aged 6 to 7 years (Mannix, Fleegler et al. 2012). This study demonstrates that state booster seat laws are associated with decreased rates of fatalities and injuries in children 4 to 7 years of age in the United States, with the strongest effects in the older children (Mannix, Fleegler et al. 2012). However, to properly protect a child in a crash both the booster seat and seat belt system must be used correctly (O'Neil, Rouse et al. 2012).

In 2000, Congress passed the TREAD Act that directed the Department of Transportation to reduce the deaths and injuries among 4 to 7-year-olds caused by the failure to use booster seats by at least 25%. In response, NHTSA started the National Survey of the Use of Booster Seats (NSUBS) survey in 2006 to provide a national estimate of booster seat use to target its outreach programs (Pickrell 2014). The NHTSA's National Center for Statistics and Analysis conducts the NSUBS every other year (Pickrell 2014).

Anton's Law is an example of how a tragedy was used to saves lives with legislation. On December 4, 2002 Congress signed Anton's the first booster seat use requirement. The law is named in memory of Anton Skeen, a 4-year-old boy who was tragically killed in a rollover crash in Washington State in 1996. While visiting family in Yakima, Washington, Autumn Alexander Skeen and her 4-year-old son Anton were both buckled up using standard lap/shoulder belts. Autumn became distracted and lost control of her sport utility vehicle. The ensuing crash caused Anton's small body to slip out from under the seat belt, and he was thrown from the vehicle. He died instantly. The belt remained buckled even after Anton had been ejected. Autumn, a local journalist later discovered that she had made a common mistake in thinking Anton was big enough to fit in the front seat with using the lap/shoulder belt without a child safety seat.

After extensive research on booster seats Autumn prompted the Washington State legislature to pass the country's first mandatory booster seat provision, dubbed "Anton's Law and was also instrumental in advocating for the enactment of Federal legislation. Anton's Law requires that children ages 4 and 5 and weighing between 40 pounds and 60 pounds be secured in a booster seat while riding as passengers in motor vehicles. Anton's Law was amended in 2007 to require children up to their eighth birthday - unless they are 4'9" tall to ride in a properly used child restraint (NHTSA 2002) (NHTSA 2009).

The AAP best-practice recommendation for children whose weight or height is above the limit for forward-facing child car seats is to use a belt-positioning booster seat in the rear until the lap/shoulder belt fits properly (Durbin 2011). An indirect positive effect of the booster seat laws might be that fewer children ride in front seats. Research has shown that children younger than 13 are at greater risk of injury in front seats than in rear seats (Durbin, Chen et al. 2005).

Currently all 50 states and the District of Columbia have child passenger seat laws. However these laws vary greatly among states and in many cases do not follow the current AAP recommendations - rear-facing seating in car seats until age 2 years, forward-facing seating in car seats with a harness until the weight/height maximum is reached on car seats, use of booster seats until lap and shoulder belts fit properly, and seating in the back seat for passengers younger than 13 years old.

Primary enforcement allows a citation to be issued whenever a law enforcement officer observes a seat belt violation. Secondary enforcement requires an officer to stop the driver for a separate violation in order to issue a citation for a seat belt violation. Nineteen states do not require primary enforcement of existing seat belt laws (CDC 2014). Criminal enforcement for not having a child properly restrained in a vehicle also varies greatly among states ranging from $0 (no fine) to $2000 (Bae 2014).

In a study of five states that increased the age requirement for car seat/booster seats to age 7 or 8 years, Eichelberger et al (2012) found that the rate of children using car seats and booster seats improved almost three times and that the rate of children who sustained deadly or debilitating injuries decreased by 17%.

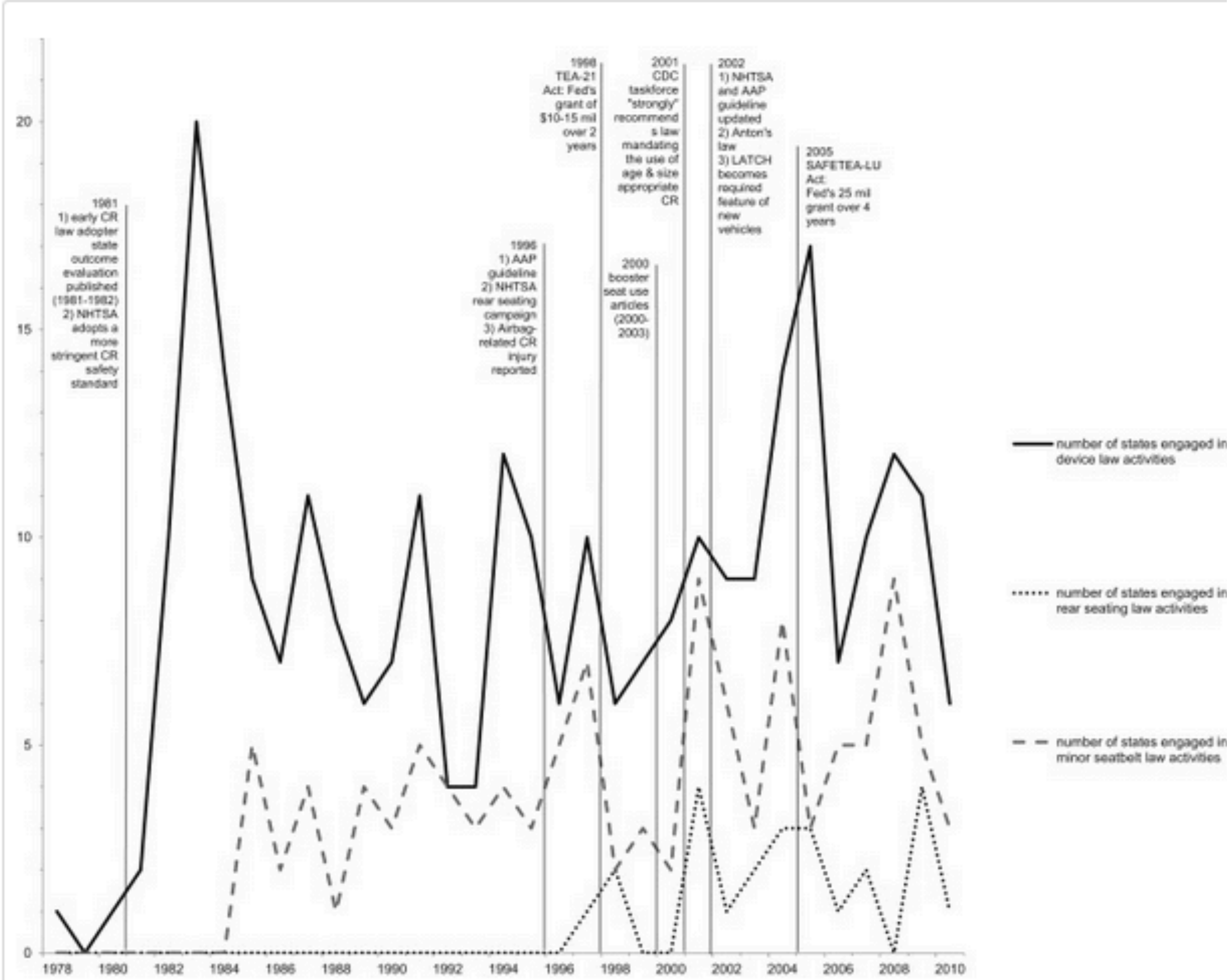
***Georgia Facts***

In 2008, a total of 14,154 children ages 6 to 8 years in Georgia were involved in motor vehicle crashes. Of those children, 1,755 were injured and 10 were killed. Only 12% of these children were reported to be using a supplemental restraint, such as a child safety seat or a booster seat, in addition to the adult seat belt. In the three-year period from 2005 to 2008, hospitalization charges for 248 children who were hospitalized due to motor vehicle traffic related injuries were about $7 million. An additional $5 million in charges was for the 5,111 emergency room visits for the same period (GGOHS 2011).

In 2009, over 140,000 children from birth to 12 years of age sought emergency department (ED) treatment for non-fatal injuries sustained as occupants in motor vehicle collisions (Macy, Clark et al. 2012). Emergency physicians are responsible for the care of children after acute traumatic injuries, with devastating cases often resulting from motor vehicle crashes. The American College of Emergency Physicians has recognized a role of emergency physicians in injury prevention efforts. In the 2008 Policy Statement on Injury Prevention and Control for Adult and Pediatric Patients, emergency physicians are encouraged to incorporate evidence-based injury prevention education into routine clinical practice and to promote interventions that address preventive mechanisms (Macy, Clark et al. 2012).

In an examination of safety laws in the US between 1978 – 2010 (Figure 2) Bae, Anderson et al (2014) found while many states have continued efforts to update their laws to be consistent with latest motor vehicle safety recommendations, there has been a considerable time lag in knowledge diffusion and policy adoption. For instance, despite empirical evidence supporting the protective effect of child restraint devices was available in the early 1970s laws requiring their use were not adopted by all 50 states until 1986 – more than a decade for adoption (Bae, Anderson et al. 2014).

Figure 2: U.S. states engaged in legislative activities relating to child passenger safety laws: 1978–2010



(Bae, Anderson et al. 2014)

Table 1: The First Ten Adopter States for Each Type of Child Passenger Safety Laws

| State | Any child restraint law | Explicit infant seat law | Explicit booster seat law | Rear seating law | Minor seatbelt law | Total |
|---|---|---|---|---|---|---|
| AK | | 1 (1990) | | | | 1 |
| AL | 9 (1982) | 9 (2006) | 10 (2006) | | | 3 |
| AR | | | | | | 0 |
| AZ | | | | | | 0 |
| CA | | | | 9 (2005) | | 1 |
| CO | | 5 (2003) | 6 (2003) | | | 2 |
| CT | | 7 (2005) | | | 6 (1986) | 2 |
| DE | 8 (1982) | | | 2 (1998) | | 2 |
| FL | | | | | 7 (1986) | 1 |
| GA | | | | 7 (2004) | | 1 |
| HI | | | | | | 0 |
| IA | | 6 (2004) | | | | 1 |
| ID | | | | | | 0 |
| IL | | | | | 2 (1985) | 1 |
| IN | | | | | | 0 |
| KS | 4 (1982) | | | | | 1 |
| KY | 10 (1982) | | | | | 1 |
| LA | | | 7 (2004) | | | 1 |
| MA | 4 (1982) | | | | 8 (1987) | 2 |
| MD | | | | | | 0 |
| ME | | | | | | 0 |
| MI | 4 (1982) | | | | | 1 |
| MN | 4 (1982) | | | | | 1 |
| MO | | | | | | 0 |
| MS | | | | | | 0 |
| MT | | | | | | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| NC | | | | | | 0 |
| ND | | | | | | 0 |
| NE | | | | | | 0 |
| NH | | | | | | 0 |
| NJ | | | | 5 (2001) | 1 (1985) | 2 |
| NM | | 2 (2001) | 8 (2005) | 3 (2001) | 2 (1985) | 4 |
| NV | | | | | 2 (1985) | 1 |
| NY | | | | | 2 (1985) | 1 |
| OH | | | | | | 0 |
| OK | | | | | | 0 |
| OR | | 10 (2007) | 3 (2002) | | | 2 |
| PA | | | 5 (2003) | | 9 (1987) | 2 |
| RI | 2 (1980) | | | 1 (1997) | | 2 |
| SC | | | 1 (2001) | 3 (2001) | | 2 |
| SD | | | | | | 0 |
| TN | 1 (1978) | | 1 (2001) | 7 (2004) | | 3 |
| TX | | | | | | 0 |
| UT | | | | | | 0 |
| VA | | | | | | 0 |
| VT | | 4 (2003) | | | | 1 |
| WA | | 3 (2002)a | 4 (2002) | | | 2 |
| WI | | 8 (2006) | 9 (2006) | 10 (2006) | 10 (1987) | 4 |
| WV | 3 (1981) | | | | | 1 |
| WY | | | | 6 (2003) | | 1 |

While tougher legislation and enforcement is important, child-safety advocates say it's equally important to include public education into the language of these laws. A 2011 study which examined booster seat legislation provides evidence that stronger child restraint laws are effective at increasing the use of child safety seats, increasing the placement of children in rear seats, and reducing injuries, especially serious injuries, among children covered by the laws (Brixey, Corden et al. 2011). The study found that parents and caregivers of children are 43% more likely to put children in car booster seats once they learn how important booster seats are to child safety and how easy they are to use. Further, the study found that while offering education and incentives to parents increases the use of booster seats as much as 32%, enforcement alone has no substantial impact whatsoever (Brixey, Corden et al. 2011).

Just as equally important as knowing the importance is consistency of use. Macy et a. (2012) found while the majority of parents (76%) indicated that their 4 to 8-year-old child uses a safety seat, two thirds of parents who carpool children other than their own, admit booster seat use when carpooling is inconsistent. The findings suggest that social norms and self-efficacy for booster seat use may be influential in carpooling situations (Macy, Clark et al. 2012).

Factory installed should-lap seat belts are intended for a body frame over 4’9” weighing more than 50lbs – not the typical 4 to 8 year old child. Booster seats raise children up so the adult designed shoulder-lap belt is properly fitted. Parents often find themselves confronted with a child’s resilient nagging that when fitted into a seat belt it is uncomfortable or hurts, frequently resulting in the shoulder belt thrown behind the back or the lap belt strung across the stomach, a useless approach to the safety belt. Booster seats raise the child to a position that will allow the shoulder belt to fit properly across the chest and shoulders, not the neck, and the lap belt to stretch low across the hips and thigh bones, not the belly. The most extraordinary benefit to the use of booster seats is that they reduce automobile accident injuries by 59%.

Since 2011, Georgia requires that every child under the age of eight be secured in a booster seat appropriate for their height and weight and installed according to the manufacturer's instructions (GGOHS 2011).The law also requires that children under age eight ride in the rear seat per AAP recommendations. There are exceptions to the law if the adult driver can show that the child under age eight is 4'9" in height or are required by medical personnel to avoid safety restraint systems because of preexisting health conditions. Other exemptions include taxi and public transportation.

The law provides that any person transporting a child under age eight and not properly secured in a booster seat receive a first fine of $50 and one point on their driver's license. A second citation will result in a doubled fine and two points. A citation may be written for every child not properly secured within the vehicle.

Though restraint laws are in place and public awareness campaigns and educational interventions have increased, many children are still improperly restrained or not restrained at all. A staggering 40% of all child passengers ride in vehicles unrestrained and nearly 30% are improperly retrained (CDC, 2011). Staunton et al. (2005) collected data on 1,858 children aged between 1 and 12 in 24 different counties in Georgia and found that only 58% of study participants had access to proper child safety restraints and only 48% used those restraints properly.

The age groups with the highest noncompliance were infants and children aged between 5 and 8 (Staunton et al., 2005). Staunton et al. found that nearly 30% of infants were in forward-facing car seats and 22% of infants were passengers in the front seat. Nearly 90% of children in the 5 to 8 age group were restrained by seat belts alone and 4% were completely unrestrained (Staunton et al., 2005). When used correctly, child safety seats defined as a child restraint system (CRS) can reduce the risk of death by as much as 71%. The NHTSA (2010) estimated that CRS including belt positioning boosters for preschoolers and early-elementary-age children, and safety belts-saved the lives of 3,894 children between 1975 and 2010.

NHTSA promotes the correct use of child safety seats at different stages in a child's development. When children outgrow their forward-facing child safety seats - at about 4 years old and approximately 40 pounds, they should ride in belt-positioning booster seats for optimal protection. To ensure their safety, older children should remain in booster seats until they are at least 8 years old, unless they are 4’ 9” tall ([NHTSA] 2008).

***Increased Risk for 4 – 8 Year Olds***

While there have been significant gains in reducing motor vehicle related injuries for infants, school age children remain at risk. Motor vehicle crashes remain the leading cause of death and acquired disability for children between the ages of 4 and 8 years. Safety advocates call this group the “Forgotten Child” because, until recently, public policy did not adequately protect them.

In 2004 nearly half of state laws only required child restraints only through age 4. Belt-positioning booster seats have been shown to reduce injury risk among child passengers ages 4 to 8 in motor vehicle crashes. To encourage the use of booster seats, many states have enacted laws that require the use of either a child restraint with internal harness or a belt-positioning booster seat, but the specific age range covered by the laws varies by state. The AAP and NHTSA have long recommended belt-positioning booster seats for children who have outgrown child safety seats with harnesses, but state laws have led many parents to believe that seat belt restraint is sufficient once the child reaches 4 years. Many parents are not aware of the importance of belt-positioning booster seats in protecting their children. Previous studies have found evidence that booster seat laws are effective in reducing injury risk among children, but these studies primarily have included states with younger age requirements.

Table 2: Georgia Passenger Vehicle Occupant Fatalities Age 5 and Above by Restraint Use and Lives Saved Estimates

| | Fatalities Age 5 and Above* | | | | | Lives Saved Estimates** | |
|---|---|---|---|---|---|---|---|
| Year | Total | Restrained | Unrestrained | Unknown Restraint Use | % Known Restrained* | Lives Saved at Current Belt Use | Potential Additional Lives Savable at 100 % Usage |
| 2008 | 1,064 | 397 | 565 | 102 | 41 | 508 | 135 |
| 2009 | 915 | 350 | 454 | 111 | 44 | 476 | 130 |
| 2010 | 871 | 370 | 424 | 77 | 47 | 469 | 118 |
| 2011 | 866 | 381 | 421 | 64 | 48 | 493 | 96 |

| Year | Fatalities Age 5 and Above* | | | | | Lives Saved Estimates** | |
|---|---|---|---|---|---|---|---|
| | Total | Restrained | Unrestrained | Unknown Restraint Use | % Known Restrained* | Lives Saved at Current Belt Use | Potential Additional Lives Savable at 100 % Usage |
| 2012 | 816 | 384 | 365 | 67 | 51 | 486 | 85 |

* % Based Only Where Restraint Use Was Known
**Lives Saved Estimates (Sum of columns may not equal other published numbers due to rounding)
Source: Fatality Data - NCSA Fatality Analysis Reporting System (FARS): 2008-2011 Final File and 2012 Annual Report File (ARF)

While previous studies have shown proper use of car seats can significantly reduce injury to children, growing evidence suggests most parents and caregivers do not know how to correctly install a child safety seat. According to a NHTSA study 3 out 4 children are not secure as they should be in vehicles because their safety seats are not used correctly; 72% of nearly 3,500 observed car and booster seats were misused in a way that could be expected to increase a child's risk of injury during a crash (NHTSA 2009).

The decline in car seat use may reflect the fact that older children did not like to be restrained or that parents did not have the resources to replace an infant car seat with a toddler seat. In an effort to address this critical problem the Injury Free Coalition for Kids of Atlanta (IFCK-Atlanta) has provided a hospital based child passenger safety education and distribution program for more than ten years.

Interventions that combine educational programs and free or discounted child safety seats show improvement in parental child passenger safety knowledge and practices. Weiss-Laxer et al. (2009)

The rate of CRS misuse in the United States is exceedingly high. Experts believe 73 to 94% of CRS are being used incorrectly significantly decreasing the effectiveness of the restraint in the event of a crash (Bing, Bolte Iv et al. 2015), (Decina L., Lococo K. et al. 2011).

The majority of CRS misuse documented in previous studies is caused by consumers' installation errors and comprehension of instructions. However, Bing et al showed physical incompatibilities between CRS and vehicle models may also cause or exacerbate problems in the installation process. Poor fit of the CRS within the vehicle environment may result in loose CRS-to-vehicle connections or misuse of the top tether or may lead consumers to use a CRS that is improper for a child's size. All of these issues may have unpredictable consequences on the performance of the CRS (Bing, Bolte Iv et al. 2015).

A belt-positioning booster, either with or without a high back, raises the child up to improve the fit of both the lap and shoulder portions of the seat belt. (Durbin, Elliott et al. 2003).

CDC analyzed 2002 to 2011 data from the Fatality Analysis Reporting System to determine the number and rate of motor-vehicle occupant deaths, and the proportion of unrestrained child deaths among children aged <1 year, 1to 3 years, 4 to 7 years, 8 to12 years, and for all children aged birth to 12 years. Age group–specific death rates and proportions of unrestrained child motor vehicle deaths for 2009 to 2010 were further stratified by race/ethnicity.

Motor vehicle occupant death rates for children declined significantly from 2002 to 2011. However, one third (33%) of children who died in 2011 were unrestrained. Compared with white children for 2009–2010, black children had significantly higher death rates, and black and Hispanic children both had significantly higher proportions of unrestrained child deaths (Sauber-Schatz, West et al. 2014).

As shown by Table 2 in 2013, 884 children between the ages of birth to 15 years old were killed in motor vehicle crashes. There were 214 passenger vehicle occupant fatalities among children younger than age 4. Among the 200 fatalities in this age group for which restraint use was known, 53 (25%) of the children were unrestrained. In the age group 4 to 7 years, there were 199 fatalities. Among the 184 fatalities in this age group for which restraint use was known, 77 (42%) were unrestrained. In 2013, the age group13 to 15 years had the highest passenger vehicle occupant fatalities 246. Among the 218 fatalities for which restraint use was known, 13 to 15 years also had the highest percentage age of unrestrained occupants (61%) (NHTSA 2015).

Table 3: Passenger Vehicle Occupants Killed by Age Group and Restraint Use, 2013

**Passenger Vehicle Occupants Killed, by Age Group and Restraint Use, 2013**

| Age (Years) | Restraint Use | | | | | | Total | | Percent "Known" Restrained | Percent "Known" Unrestrained |
|---|---|---|---|---|---|---|---|---|---|---|
| | Restrained | | Unrestrained | | Unknown | | | | | |
| | Number | Percent | Number | Percent | Number | Percent | Number | Percent | | |
| <4 | 147 | 69% | 53 | 25% | 14 | 7% | 214 | 100% | 74% | 27% |
| 4–7 | 107 | 54% | 77 | 39% | 15 | 8% | 199 | 100% | 58% | 42% |
| 8–12 | 113 | 50% | 94 | 42% | 18 | 8% | 225 | 100% | 55% | 45% |
| 13–15 | 84 | 34% | 134 | 54% | 28 | 11% | 246 | 100% | 39% | 61% |
| 16–20 | 944 | 41% | 1,172 | 50% | 208 | 9% | 2,324 | 100% | 45% | 55% |
| 21–24 | 856 | 35% | 1,340 | 55% | 219 | 9% | 2,415 | 100% | 39% | 61% |
| 25–34 | 1,353 | 36% | 2,085 | 55% | 354 | 9% | 3,792 | 100% | 39% | 61% |
| 35–44 | 995 | 38% | 1,367 | 53% | 236 | 9% | 2,598 | 100% | 42% | 58% |
| 45–54 | 1,197 | 45% | 1,243 | 47% | 225 | 8% | 2,665 | 100% | 49% | 51% |
| 55–64 | 1,315 | 55% | 900 | 38% | 179 | 7% | 2,394 | 100% | 59% | 41% |
| 65–74 | 1,085 | 61% | 564 | 32% | 133 | 7% | 1,782 | 100% | 66% | 34% |
| 75+ | 1,574 | 70% | 548 | 24% | 140 | 6% | 2,262 | 100% | 74% | 26% |
| Unknown | 7 | 44% | 3 | 19% | 6 | 38% | 16 | 100% | 70% | 30% |
| Total | 9,777 | 46% | 9,580 | 45% | 1,775 | 8% | 21,132 | 100% | 51% | 49% |

Source: FARS 2013 ARF

NHTSA has estimated that child safety seats reduce the risk of fatal injury by 71% for infants (younger than 1 year old) and by 54% for toddlers (ages 1 to 4 years) in passenger cars. For infants and toddlers in light trucks, the corresponding reductions are 58% and 59%, respectively (NHTSA 2015).

Among children under age 5, an estimated 263 lives were saved in 2013 by restraint use. Of these 263 lives saved, 246 were associated with the use of child safety seats and 17 with the use of adult seat belts. At 100% child safety seat use for children under age 5, an estimated 319 (that is, an additional 56) lives could have been saved in 2013 (NHTSA 2015).

Table 4: Estimated Number of Lives Saved by Restraint Systems 1975-2013

**Estimated Number of Lives Saved by Restraint Systems, 1975–2013**

| Restraint Type | 1975–03 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seat Belts | 179,948 | 15,548 | 15,688 | 15,458 | 15,223 | 13,312 | 12,757 | 12,670 | 12,071 | 12,386 | 12,584 | 317,645 |
| Child Restraints | 7,021 | 455 | 424 | 427 | 388 | 286 | 307 | 303 | 262 | 285 | 263 | 10,421 |
| Frontal Air Bags | 14,258* | 2,660 | 2,752 | 2,824 | 2,800 | 2,557 | 2.481 | 2,403 | 2,341 | 2,422 | 2,388 | 39,886 |

Source: FARS 2013 ARF

Motivating parents to take certain safety precautions when traveling with their children remains challenging for advocates. Caregivers of booster-aged children are particularly difficult to reach because they do not consider their children to be of "safety-seat" age and have inherently low perceptions of vulnerability to crash injury (Will, Dunaway et al. 2012).

*Why Booster Seats?*

Just as a seat belt is the single most effective way of preventing injuries for an adult, using an age-appropriate CRS is the most effective strategy for preventing injury and death in a child in a crash (Kuska 2011). A child aged 4 through 8 years who is restrained in a belt-positioning booster seat in the rear seat of a vehicle is 45% less likely to be injured in a crash, compared with children using seat belts alone. Of those riding in booster seats, children involved in side-impact crashes saw the greatest reduction in injury risk. The rate of booster seat use for children aged 5 years or younger is 76%, but the rate decreases to 40% by age 8 years. This confirms a trend in which older children are less likely to ride in booster seats (Kuska 2011).

Booster seats are designed to improve belt fit by altering the seated position of the child by changing the belt routing. Good belt fit is achieved if the belt is placed in anatomical regions where the restraint forces can be directed onto the skeleton rather than soft tissues (Reed, Ebert-Hamilton et al. 2013). During a frontal crash, the lap portion of the belt should engage with the front of the pelvis and the shoulder portion of the belt should load the clavicle. For this optimal loading pattern to be achieved, the pre-crash position of the lap portion of the belt needs to be below the anterior superior iliac spine (ASIS) landmark on the upper edge of the front of the pelvis bone (Reed, Ebert-Hamilton et al. 2013).

When a vehicle seat belt does not fit properly, a child will typically put the shoulder belt behind him or her, leaving only the lap belt to hold him or her in place. Then to sit comfortably with the legs dangling over the edge of the seat, the child will slouch and scoot forward. This causes the lap belt to ride up on the abdomen. In a crash, the lap belt will compress the abdomen directly against the spinal column, causing high-tension forces in the lumbar spine (Durbin 2011) (Kuska 2011). This group of abdominal injuries, ranging from hip and abdominal contusion and abrasions to pelvic fractures, cervical and lumbar spine injuries, and intra-abdominal injuries to solid and hollow organs, is known as seat belt syndrome. Figure 3. The anatomic characteristics of the pelvis and abdomen of younger children place them at higher risk for these injuries (Kuska 2011).

Figure 3: Improper vs. Proper Positioning of a Lap Belt

Source: Partners for Child Passenger Safety Study

*Image redacted due to copyright restrictions.

See link below to view image illustrating seat belt syndrome caused from improper positioning of lap belt.

https://injury.research.chop.edu/sites/default/files/documents/aap_cps_webinar_slides.pdf slide #23

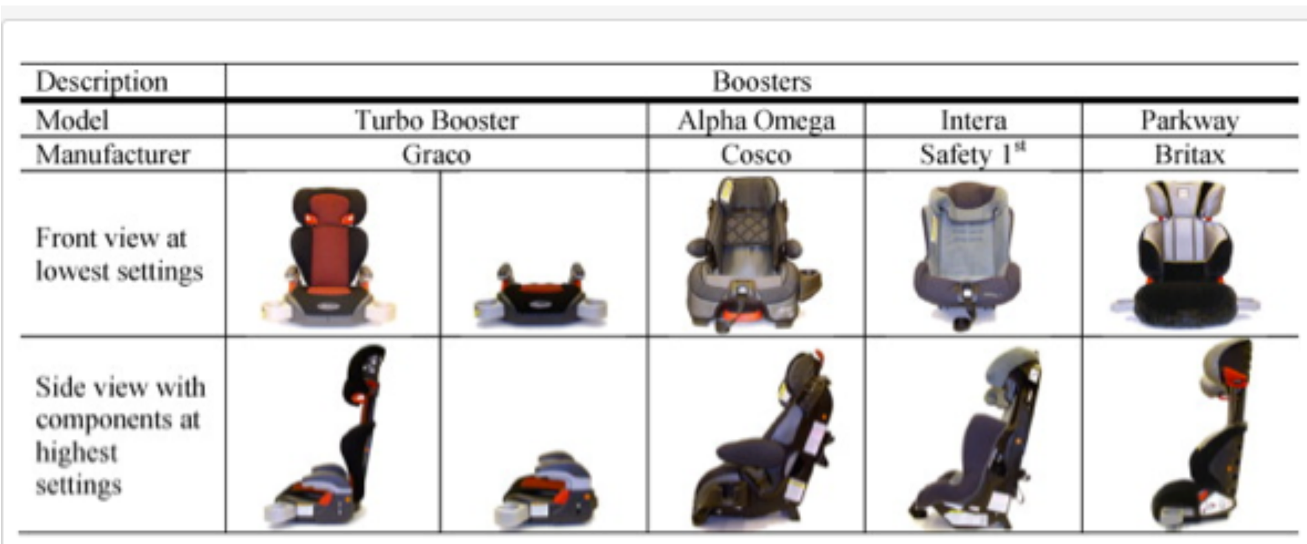
Reed et al (2013) found with one midrange belt configuration, the lap belt was not fully below ASIS landmark on the front of the pelvis for 89% of children in one booster, and 75% of children failed to achieve that level of belt fit in another. In contrast, the lap belt was fully below the ASIS for all but two children in the best-performing booster. Child body size had a statistically significant but relatively small effect on lap belt fit. Overall the data show substantial effects of booster design on belt fit, and quantify the importance of optimizing belt geometry for children (Reed, Ebert-Hamilton et al. 2013). Children who cannot achieve good belt fit with vehicle belts alone should be seated in an appropriately sized harness restraint or in a belt-positioning booster (Reed, Ebert-Hamilton et al. 2013). This study supports Durbin et al. (2003), finding that children 4 to 7 years of age using a belt-positioning booster were 59% less likely to be injured than those using a vehicle belt alone (Reed, Ebert-Hamilton et al. 2013).

Children heavier than 40 pounds seated in a booster with a three-point vehicle belt are considered to be appropriate restrained. NHTSA recommends children should continue to use boosters until they reach age 8 unless they are 57 inches tall (NHTSA 2009). Child restraints and belt-positioning boosters have been shown to be effective in reducing the risk of injury. Elliot et al. (2006) found that the use of child restraints reduces the risk of fatality by about 28% over seat belts alone for children from 2 to 6 years of age. Risk of abdominal injury was significantly lower for children age 4 to 7 using boosters compared with those using vehicle belts alone, (Reed, Ebert-Hamilton et al. 2013).

Nance et al (2004) found that children ages 4-8 who were restrained only in seat belts were 3.5 times more likely to sustain an abdominal injury than children using booster seats Recent studies have found overall injury reductions associated with booster seats ranging from 14% to 45% (Arbogast, Jermakian et al. 2009).

All car seats rated by NHTSA meet Federal Safety Standards and strict crash performance standards. Figure 4. While all rated seats are safe, they do differ in their ease of use in four basic categories: evaluation of instructions, evaluation of labels, vehicle installation features and securing the child.

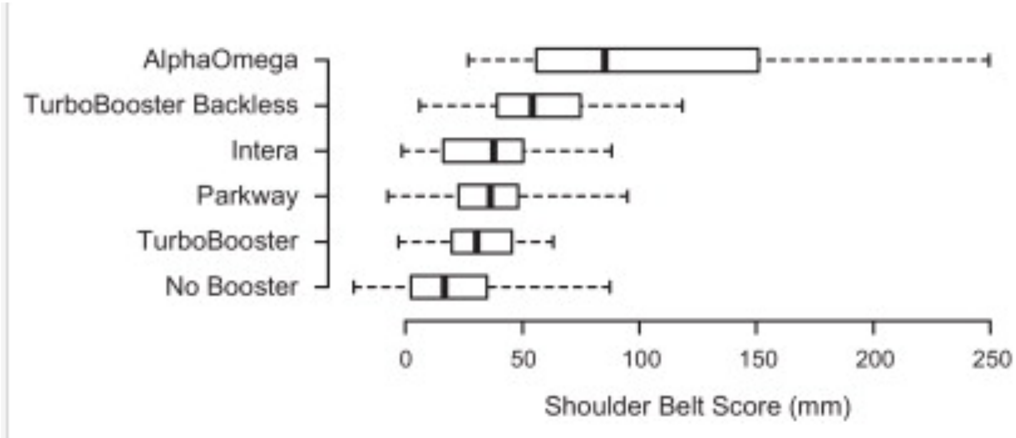
Figure 4: Five Popular Booster Seat Types



| Description | Boosters | | | | |
|---|---|---|---|---|---|
| Model | Turbo Booster | | Alpha Omega | Intera | Parkway |
| Manufacturer | Graco | | Cosco | Safety 1st | Britax |
| Front view at lowest settings | | | | | |
| Side view with components at highest settings | | | | | |

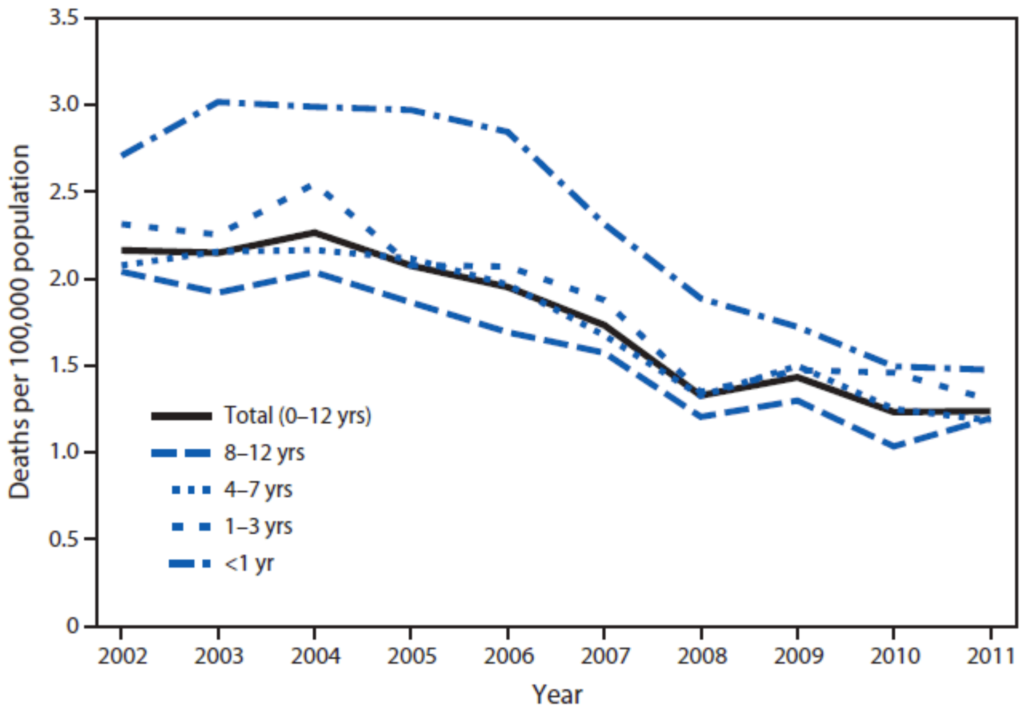
A regression analysis showed the effect of stature on lap belt fit was the same across booster conditions (including no booster), meaning children of all sizes experienced approximately the same improvement in lab belt fit in each booster, relative to the no-booster condition. Statistically significant effect of stature ($p < 0.01$) and no interaction between stature and booster type (Reed, Ebert-Hamilton et al. 2013).

Figure 5: Regression Analysis Comparing of Six Booster Seat Types




Motor vehicle occupant deaths among children in the United States have declined in the past decade, but more deaths could be prevented if restraints were always used. Effective interventions, including child passenger restraint laws (with child safety seat/ booster seat coverage through at least age 8 years) and child safety seat distribution plus education programs, can increase restraint use and reduce child motor vehicle deaths (Sauber-Schatz, West et al. 2014).

Figure 6: Motor vehicle occupant deaths per 100,000 population for children aged birth to 12 years, by age group and year — United States, 2002–2011



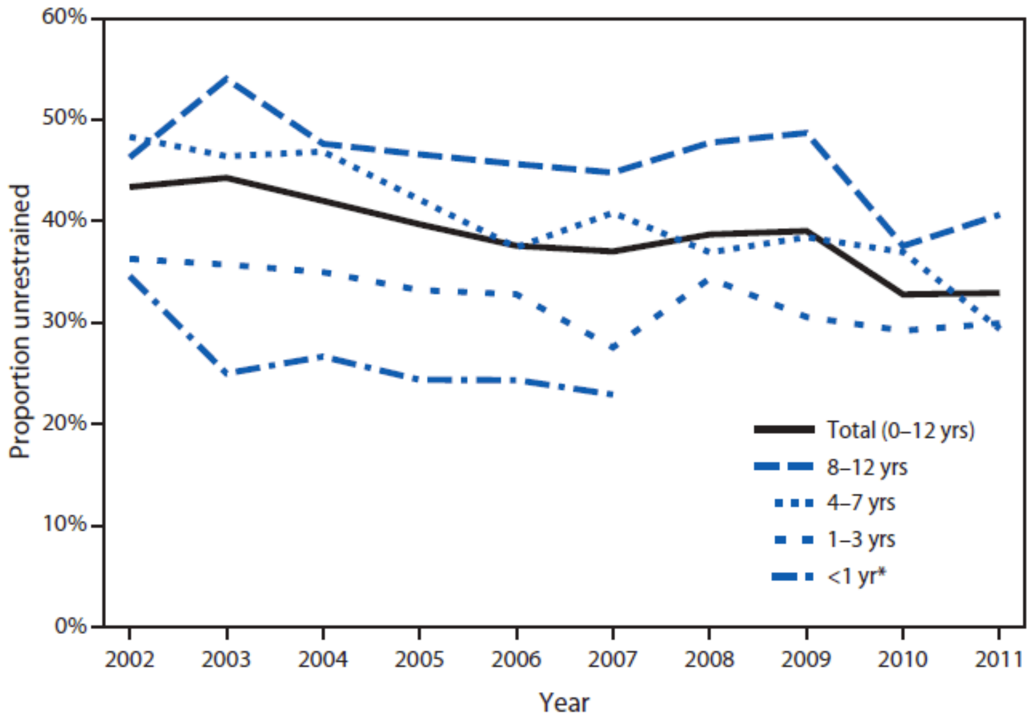

Source: MMWR: Morbidity & Mortality Weekly Report, 2/7/2014, Vol. 63 Issue 5, p113-118

The figure above shows motor vehicle occupant deaths per 100,000 population, for children aged birth to 12 years, by age group and year in the United States during 2002–2011. During 2002–2011, a total of 9,182 children aged birth to 12 years died in motor vehicle crashes in the United States. During this period, motor vehicle death rates among children aged birth to12 years decreased 43%, from 2.2 deaths per 100,000 population in 2002 to 1.2 in 2011 (Sauber-Schatz, West et al. 2014).

Children are not always properly restrained while riding in a motor vehicle, and some are not restrained at all, which increases their risk for injury and death in a crash. Proper car seat, booster seat, and seat belt use among children in the back seat prevents injuries and deaths, as well as averts hospital charges. (Sauber-Schatz, Thomas et al. 2015). However, Sauber-Schatz et al found optimal restraint use in the back seat declined with child's age (1 year: 95.9%, 5 years: 95.4%, 7 years: 94.7%, 8 years: 77.4%, 10 years: 67.5%, 12 years: 54.7%). Child restraint use was associated with driver restraint use;

41.3% of children riding with unrestrained drivers also were unrestrained compared with 2.2% of children riding with restrained drivers.

Figure 7: Proportion of unrestrained child motor vehicle deaths by age group and year — United States, 2002–2011




Source: MMWR: Morbidity & Mortality Weekly Report, 2/7/2014, Vol. 63 Issue 5, p113-118

The figure above shows the proportion of unrestrained child motor vehicle deaths by age group and year in the United States during 2002–2011. During 2002–2011, the proportion of unrestrained child deaths decreased significantly for children aged 1–3 years (by 18%), aged 4–7 years (by 39%), and aged birth to 12 years (by 24%). Restraint use among young children often depends upon the driver's seat belt use. Almost 40% of children riding with unbelted drivers were themselves unrestrained (Sauber-Schatz, West et al. 2014).

Seating in vehicles is designed for adults, not for children. CRS are a crucial component of a child's safety. According to the NHTS, every 34 seconds one child, under age 13, is involved in a crash and 4 out of every 5 car seats are not installed properly (NHTSA 2015).

***Are all children age groups equally at risk?***

Great strides have been made in recent years in protecting child passengers. Among infants and toddlers, restraint use is at the highest levels ever recorded (98% for infants and 93% for toddlers), and crash-related child fatalities have dropped steadily to the lowest number since record keeping began in 1975 (NHTSA 2008). Unfortunately, similar progress has not been achieved where older-child passengers are concerned. Motor vehicle crashes remain the leading cause of death and acquired disability for children between the ages of 4 and 8 years. Safety advocates call this group the "Forgotten Child" because until recently, public policy did not adequately protect them.

In 2004 nearly half of state laws only required child restraints only through age 4. Belt-positioning booster seats have been shown to reduce injury risk among child passengers ages 4 to 8 in motor vehicle crashes. To encourage the use of booster seats, many states have enacted laws that require the use of either a child restraint with internal harness or a belt-positioning booster seat, but the specific age range covered by the laws varies by state. The AAP and the NHTSA have long recommended belt-positioning booster seats for children who have outgrown child safety seats with harnesses, but state laws have led many parents to believe that seat belt restraint is sufficient once the child reaches 4 years.

Many parents are not aware of the importance of belt-positioning booster seats in protecting their children. Previous studies have found evidence that booster seat laws are effective in reducing injury risk among children, but these studies primarily have included states with younger age requirements.

In The National Estimates of Booster Seat Use (NSUBS), survey data is obtained for children newborn to 12 years old in passenger vehicles at a nationwide probability sample of gas stations, day care centers, recreation centers, and restaurants in five fast-food chains. Restraint use is observed by trained data collectors prior to or just as the vehicle comes to a stop, except in the case of observation at fast-food drive-through lanes, where restraint use is observed prior to the vehicle reaching the drive-through window (Pickrell 2014).

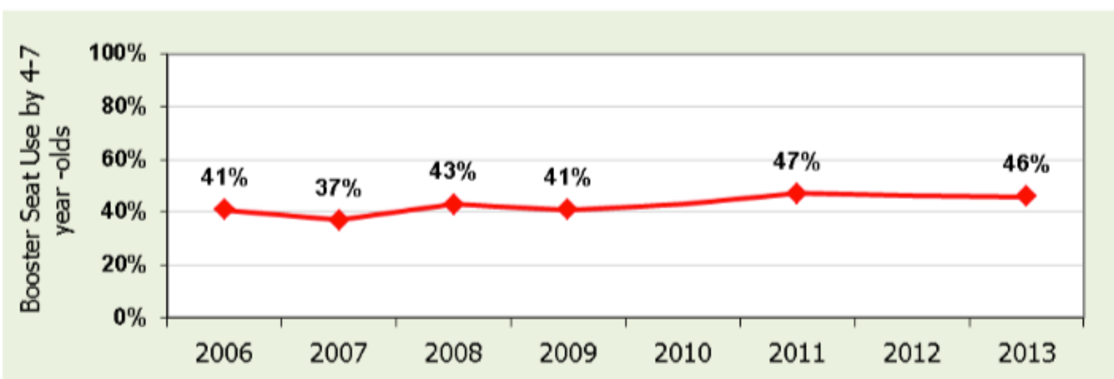
Macy et al (2012) analyzed the 2007, 2008 and 2009 NSUBS and found a decline in child safety seat use and an increase in being unrestrained were observed with increasing child age. The researchers found that age and racial disparities exist as age appropriate restraint use was lower among minority children aged 4 to7 years compared with white children and higher proportions of minority children aged 4 and 5 years were prematurely transitioned to seat belts compared with white children (Macy and Freed 2012).

Findings from the 2013 NSUBS in which 7,229 vehicles were observed at 428 data collection sites shows premature graduation to restraint types that are not appropriate for children’s age, height, and weight continues in 2013. Booster seat use among 4 to 7-year-old children was 46% but 24% were restrained by seat belts and 9% were unrestrained (Pickrell 2014).

***Premature Graduation Among Children 4 to 7 Years Old***

NHTSA's current car seat recommendation for children 4 to 7 years old directs parents to keep their child in a forward- facing car seat with a harness until he or she reaches the top height or weight limit allowed by your car seat's manufacturer. Once your child outgrows the forward-facing car seat with a harness, it's time to travel in a booster seat, but still in the back seat (Pickrell 2014). Therefore, the appropriate restraint types for children 4 to 7 years old should be either forward-facing car seats or booster seats. However, the 2013 NSUBS found that only 66% of children 4 to 7 years old were restrained either in forward-facing car seats (20%) or in booster seats (46%) in 2013. About 24% of children 4 to 7 years old were prematurely graduated to seat belts and 9% were unrestrained. These results indicate that as many as 33% (24% in seat belts and 9% unrestrained) of children 4 to 7 in the United States were not being properly restrained.

Figure 8: Booster Seat Use, National Estimates




Source: The National Survey of the Use of Booster Seats, NHTSA's National Center for Statistics and Analysis, 2013

Table below shows the distribution of restraint types for children 4 to 7 years old in 2011 and 2013 (Pickrell 2014).

Table 6: Distribution of Restraint Types Among Children 4-7 yr, by Sub-Age Groups

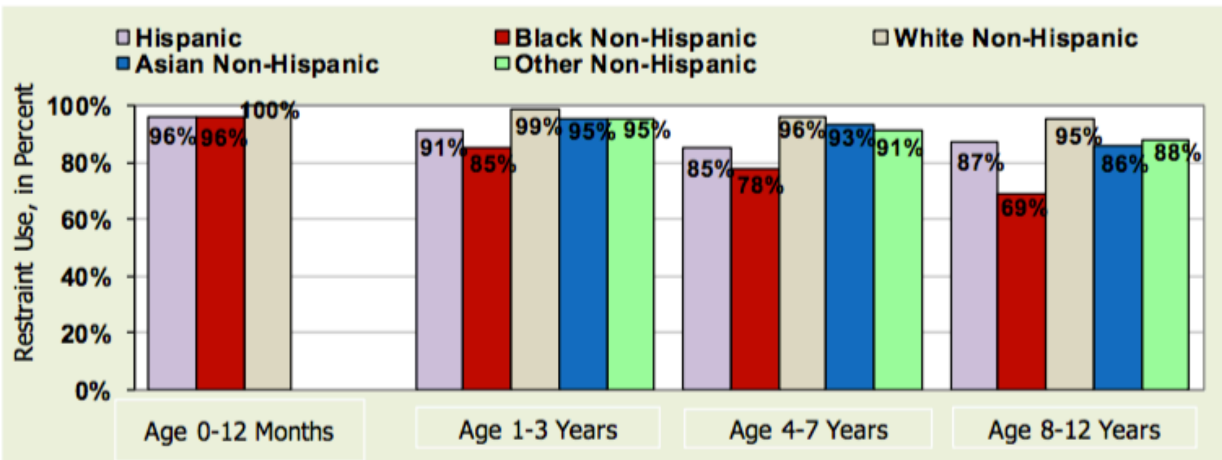
| Restraint Type[1] | 2011 | | 2013 | | 2011-2013 Change | |
|---|---|---|---|---|---|---|
| | Percentage[2] of Children[3] Observed in the Restraint Type | Standard Error | Percentage[2] of Children[3] Observed in the Restraint Type | Standard Error | Change in Percentage Points | Confidence in a Change in Percentage[4] |
| **Children 4 and 5 Years Old** | | | | | | |
| Rear-Facing Car Seat | NA | NA | NA | NA | NA | NA |
| Forward-Facing Car Seat | 27% | 2% | 31% | 2% | 3 | **92%** |
| Booster Seat (Overall) | 49% | 3% | 48% | 3% | -1 | 18% |
| High-Backed Booster Seat | 30% | 1% | 31% | 2% | 0 | 16% |
| Backless Booster Seat | 19% | 2% | 17% | 2% | -1 | 48% |
| Seat Belt | 15% | 2% | 13% | 2% | -1 | 42% |
| No Restraint Observed | 9% | 2% | 8% | 1% | -1 | 47% |
| **Children 6 and 7 Years Old** | | | | | | |
| Rear-Facing Car Seat | NA | NA | NA | NA | NA | NA |
| Forward-Facing Car Seat | 4% | 1% | 6% | 1% | 2 | **97%** |
| Booster Seat (Overall) | 43% | 2% | 44% | 3% | 1 | 23% |
| High-Backed Booster Seat | 18% | 1% | 20% | 3% | 2 | 58% |
| Backless Booster Seat | 25% | 2% | 25% | 2% | -1 | 35% |
| Seat Belt | 42% | 2% | 40% | 3% | -2 | 62% |
| No Restraint Observed | 11% | 1% | 10% | 2% | -1 | 25% |
| **Children 4 to 7 Years Old** | | | | | | |
| Rear-Facing Car Seat | 0% | 0% | NA | NA | NA | NA |
| Forward-Facing Car Seat | 18% | 1% | 20% | 2% | 2 | 87% |
| Booster Seat (Overall) | 47% | 2% | 46% | 2% | 0 | 8% |
| High-Backed Booster Seat | 25% | 1% | 26% | 2% | 1 | 26% |
| Backless Booster Seat | 21% | 1% | 20% | 2% | -1 | 40% |
| Seat Belt | 25% | 1% | 24% | 2% | -1 | 33% |
| No Restraint Observed | 10% | 1% | 9% | 1% | -1 | 40% |

Source: The National Survey of the Use of Booster Seats, NHTSA's National Center for Statistics and Analysis, 2011, 2013

NSUBS data collectors conduct interviews to obtain race and ethnicity of passenger vehicle occupants including all child occupants under 13. As modeling behavior goes, children with an unrestrained driver had a 23 times higher adjusted odds of being unrestrained themselves. For minority children older than 3 years of age, having four or more child passengers compared with one child passenger were also associated with child passengers being unrestrained (Macy and Freed 2012).

Figure 9 shows the overall picture of child restraint use by race and ethnicity across all age groups. Across all age groups, Non-Hispanic White children from birth to 12 months old had the highest restraint use (100 %) while Non-Hispanic Black children 8 to 12 years old had the lowest (69 %).

Figure 9: Child Restraint Use by Age and Race/Ethnicity in 2013




Source: The National Survey of the Use of Booster Seats, NHTSA's National Center for Statistics and Analysis, 2013

The researchers say tailored child passenger safety programs are needed to address the motivations of parents from various cultural and socioeconomic backgrounds, and for drivers who do not use seat belts themselves. Clinic visits can be used to address parental misinformation related to child safety seats, such as concerns that booster seats can cause injury (Macy and Freed 2012).

As previous studies have showed, early child restraint laws in the 1970s and 1980s were effective at increasing child restraint use and reducing injuries among young children (Zaza et al., 2001). In recent years, most states have strengthened their child restraint laws to require older children to be restrained in forward-facing child restraints or belt-positioning booster seats. Currently, the oldest age covered by a booster seat or child restraint requirement varies across states, ranging from 3 in Florida to 8 in Wyoming and Tennessee. Twenty-nine states and the District of Columbia require booster seats or child restraints for children 7 and younger (Insurance Institute for Highway Safety (IIHS), 2011).

In a 2003 study, Durbin found 81% of all 4 to 7-year-olds were using either a seat belt or belt-positioning booster seat. Restraint use of the children varied by age, seat belts were used by 42% of 4-years-olds, 72% of 5-year-olds, and 89% of 6 and 7-year-olds; belt-positioning booster seats were used by 16% of 4-year-olds, 13% of 5-year-olds, and 4% of 6 and 7-year-olds (Durbin, Elliott et al. 2003).

Many parents roll up towels and blankets and use pool noodles just to get their CRS to fit better in their car. It turns out CRS and vehicle seats don't align properly more than 40% of the time, according to a new study. In an effort to improve child car seats' fit and position in vehicles, a team of researchers from the Ohio State University College of Medicine collected dimension samples from 61 vehicles and 59 child car seats currently on the market and identified the most common sources of incompatibility.

Data from nearly 3,600 potential child car seat-vehicle combinations and 34 physical installations were analyzed and showed less than 60% of rear-facing child car seat-vehicle combinations fit properly between the vehicle's seat pan angle and the child car seat manufacturer's required base angle (Bing, Bolte Iv et al. 2015).

Most cars now have a LATCH system. They're dedicated attachment points that are supposed to make it easier for parents to properly install a car seat. But many safety experts argue that hasn't happened. That's why the Insurance Institute for Highway Safety started testing the designs and ease of use. Researchers are specifically looking at how easy it is for parents to find the lower anchors within the seat and maneuver around them and how much force is required to connect a child restraint. Of the 102 cars they studied this year, only three received good, which is the highest rating: a BMW 5 series, Mercedes Benz GL and VW Passat.  More than half were marginal or poor, including the Toyota Sienna, a minivan often used by families (Bing, Bolte Iv et al. 2015).

While all car seats are safe and have passed federal regulations, to really optimize the safety of a child's car seat and provide the best protection for the child, experts say parents have to sure it fits properly in the vehicle. To that end, researchers encourage parents to take measurements of their car in order to make the most informed decision when choosing the safest car seat option for their child

Another goal of the study is to share the specific data points and assist with communication between child car seat and vehicle manufacturers so they can more fully understand compatibility of their products and, ultimately, help improve individual designs. Bing and her research team recommend parents go to the store and ask if they can take the model off the shelf and go out to their car and try it. It might look great on the shelf and have all the greatest safety ratings but, if it doesn't fit in your vehicle, it may not be the best option (Bing, Bolte Iv et al. 2015).

Summary

- Motor vehicle crashes as the leading cause of death among children in the United States.

- Nearly 250,000 children in the United States are injured every year in motor vehicle crashes, and approximately 2000 die from their injuries.
- Belt-positioning booster seats lower the risk of injury to children aged 4-8 years by 45% compared with the use of seat belts alone
- All 50 states have child restraint laws
- Primary enforcement allows a citation to be issued whenever a law enforcement officer observes a seat belt violation. Secondary enforcement requires an officer to stop the driver for a separate violation in order to issue a citation for a seat belt violation. As of 2015, only 14 states require rear seating of child passengers of varying ages

# CHAPTER III: METHODOLOGY

### *Strategy for Searching Literature*

A comprehensive review of the literature was conducted based on the four areas of focus proposed in the research question – child restraint policy and legislation, booster seat interventions for 4 – 8 year olds, education program strategies and technology.

The search was conducted using the Emory School of Medicine PubMed Database. The time frame for study inclusion was the last 15 years (2000 to 2015). No foreign research were included, all studies were conducted in the U.S. The keyword search term car seat safety was combined with the following terms in various orders: injury prevention, law, policy, education, technology, older children, Latino, African American and booster seat.

The term child seat safety was typed in the search queue of the PubMed Database. Then child seat safety was combined with other key terms in the following order:

(car seat safety) AND (injury prevention OR education)

(car seat safety) AND (Law OR Policy)

(car seat safety) AND (injury prevention OR education) AND (technology)

(car seat safety) AND (older children OR booster seat)

(car seat safety) AND (injury prevention OR education) AND (older children OR booster seat)

(car seat safety) AND (injury prevention OR education) AND (African American OR Latino)

(car seat safety) AND (African American OR Latino)

The abstract and conclusion was scanned and qualitative analysis was used to further filter the articles yielded from the initial search. For each of the research question focus areas a at least one of the following key words needed to be contained in the abstract or conclusion to be included in each focus area category.

For Policy/Legislation, at least one of the three major child safety laws had to be mentioned and or positive effect on car seat use. For Booster Seat, the recommended AAP CRS for 4 to 8 year olds had to be mentioned and intervention or misuse or barrier. For Education, any of the keywords program, training, awareness and African American or Latino had to be mentioned. Lastly, for Technology any mention of a tech related term like smart phone, social media or installation was used for selection.

The articles were organized alphabetically by lead author into four tables sub classified as:

1. Child Restraint Policy/Legislation
2. Booster Seat >3 yrs
3. Education
4. Technology

# CHAPTER IV: RESULTS

The selection of research articles yielded from the PubMed Database literature search is summarized in Figure 10. From a potential pool of 177 initial articles approximately 41 articles that satisfied the initial inclusion criteria and subsequent qualitative analysis were selected.

Figure 10: Diagram of Search Query Results of Research Articles

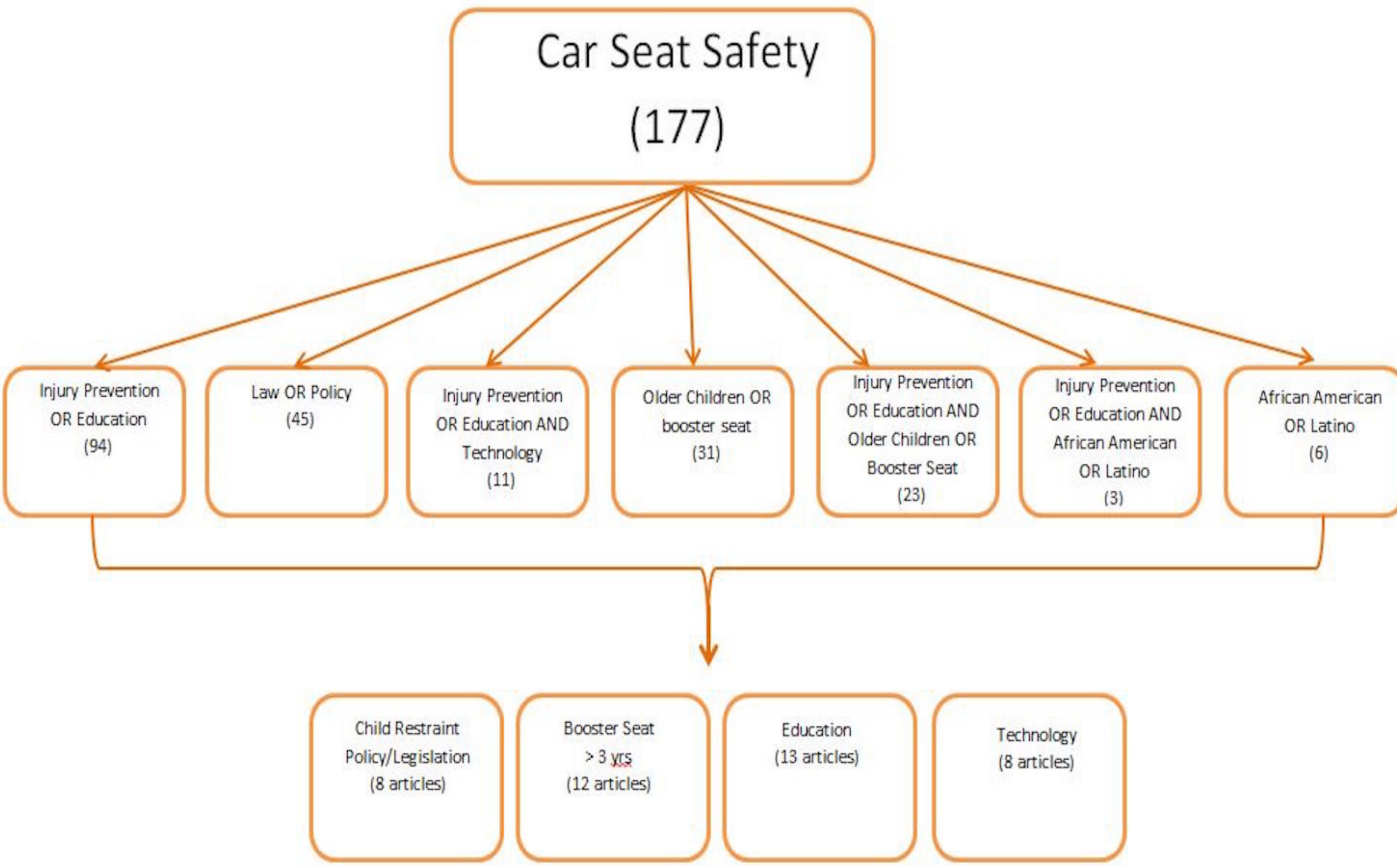
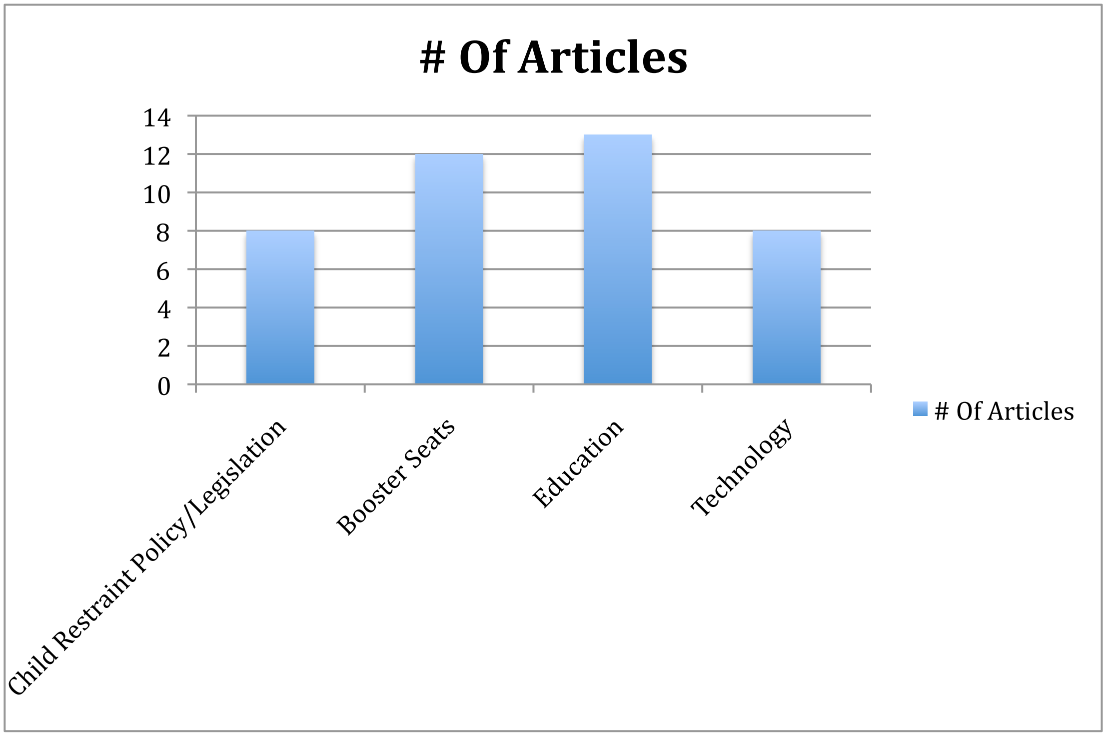


Figure 11 shows the sub-classification breakdown of the selected research articles.

Figure 11: Sub Classification of Selected Research Articles




Tables 7 – 10 show the complete list of selected articles accompanied by the main research findings in the category.

| Table 7: Child Restraint Policy/Legislation |
|---|

| Title & Year | Year | Lead Author |
|---|---|---|
| Child passenger safety laws in the United States, 1978-2010: policy diffusion in the absence of strong federal intervention | 2014 | Bae, J. Y., |
| Booster seat legislation: does it work for all children? | 2011 | Brixey, S. N., |
| Legislating child restraint usage -Its effect on self-reported child restraint use rates in a central city | 2010 | Brixey, S. N., |
| Child passenger safety | 2011 | Durbin,.D. R. |
| Effects of booster seat laws on injury risk among children in crashes | 2012 | Eichelberger, A. H., |
| Booster seat laws and fatalities in children 4 to 7 years of age | 2012 | Mannix, R., |
| Motor Vehicle Crashes, Medical Outcomes, and Hospital Charges Among Children Aged 1-12 Years - Crash Outcome Data Evaluation System, 11 States, 2005-2008 | 2015 | Sauber-Schatz, E. K., |
| Vital signs: restraint use and motor vehicle occupant death rates among children aged 0-12 years - United States, 2002-2011 | 2014 | Sauber-Schatz, E. K., |
| | | |
| Total Articles Reviewed | | 8 |

***Child Restraint Policy/Legislation***

Since 1978, child passenger safety laws have evolved to provide mandated protection for children from birth through late adolescence. Since this initial wave of legislation, states have continuously refined their policies in light of emerging safety research.

While much more work needs to be done to be in line with current AAP and NHTSA guidelines for maximum protection for children, several articles show legislation does increase CRS use in states with primary enforement.

The federal government's direct intervention to promote enactment of child restraint laws has been limited.  While Congress may have power to legislate such law under the Commerce Clause, Bae et al (2014) suggests federal government does not have constitutional power mandate state legislative to enforce it. The federal government can can encourage or pressure states with funding or grants.

For decades, child passenger safety laws have failed to stay current with pertinent research regarding best practices for child safety restraints. Despite clear evidence based data about the effectiveness of CRS to save the lives of children and thus the need for stricter laws regarding child passenger safety, policy change at the federal level has been slow often several years behind science. While Congress can legislate federal laws, Bae et al. (2014) point out under some clauses they are constitutionally unable to enforce state laws (Bae, Anderson et al. 2014).

Currently all 50 states and the District of Columbia have child passenger seat laws. However the these laws vary greatly among states and in many cases do not follow the current AAP recommendations - rear-facing seating in car seats until age 2 years, forward-facing seating in car seats with a harness until the weight/height maximum is reached on car seats, use of booster seats until lap and shoulder belts fit properly, and seating in the back seat for passengers younger than 13 years old (Durbin 2011).

As of 2015, only 14 states require rear seating of child passengers of varying ages (IIHS 2015). Primary enforcement allows a citation to be issued whenever a law enforcement officer observes a seat belt violation. Secondary enforcement requires an officer to stop the driver for a separate violation in order to issue a citation for a seat belt violation. Nineteen states do not require primary enforcement of existing seat belt laws (CDC 2014). Criminal enforcement for not having a child properly restrained in a vehicle also varies greatly among states ranging from $0 (no fine) to $2000 (Bae 2014).

States with booster seat laws had a lower risk of fatalities in 4- to 5-year-olds than states without booster seat laws (Mannix, Fleegler et al. 2012). In a study of five states that increased the age requirement for car seat/booster seats to age 7 or 8 years, Eichelberger et al (2012) found that the rate of children using car seats and booster seats improved almost three times and that the rate of children who sustained deadly or debilitating injuries decreased by 17%. To encourage the use of booster seats, many states have enacted laws that require the use of either a child restraint with internal harness or a belt-positioning booster seat, but the specific age range covered by the laws varies by state (Eichelberger, Chouinard et al. 2012). Current AAP policy recommendations call for booster seat use for children up to age 8. Booster seat laws are effective in increasing the use of child safety seats, increasing the placement of children in rear seats, and reducing injuries, especially severe injuries, among children covered by the laws (Eichelberger, Chouinard et al. 2012).

Brixey et al. (2011) assessed the impact of a booster seat law in Wisconsin on booster seat use in relation to race, ethnicity and socioeconomic status and found while overall booster seat use increased, proper restraint use increased after legislation in white, but not in black or Latino children. (Brixey, Corden et al. 2011). The risks of injury follow a continuum, with unrestrained children faring worse in a crash than improperly restrained children faring worse than restrained.

In 2009, over 140,000 children 0 to 12 years of age sought emergency department (ED) treatment for non-fatal injuries sustained as occupants in motor vehicle collisions (Macy, Clark et al. 2012) Emergency physicians are responsible for the care of children after acute traumatic injuries, with devastating cases often resulting from motor vehicle crashes. The American College of Emergency Physicians has recognized a role of emergency physicians in injury prevention efforts. In the 2008 Policy Statement on Injury Prevention and Control for Adult and Pediatric Patients, emergency physicians are encouraged to incorporate evidence-based injury prevention education into routine clinical practice and to promote interventions that address preventive mechanisms (Macy, Clark et al. 2012).

Table 8: Booster Seat >3 yrs

| Title | Year | Lead Author |
|---|---|---|
| Effectiveness of belt positioning booster seats: an updated assessment | 2009 | Arbogast, K. B., |
| Interventions to increase children's booster seat use: a review | 2006 | Ehiri, J. E., |
| Buckle Up: Every Ride, Every Time | 2013 | Ferguson, R. W., |
| Restraint use and seating position among children less than 13 years of age: Is it still a problem? | 2010 | Greenspan, A. I., |
| Factors influencing booster seat use in a multiethnic community: lessons for program implementation | 2009 | Johnston, B. D., |
| Car seat inspection among children older than 3 years: Using data to drive practice in child passenger safety | 2015 | Kroeker, A. M., |
| Taking care of children: the case for booster seats | 2011 | Kuska, T. |
| Carpooling and booster seats: a national survey of parents | 2012 | Macy, M. L., |
| Driver report of improper seat belt position among 4- to 9-year-old children | 2011 | Macy, M. L., |
| Cost-outcome analysis of booster seats for auto occupants aged 4 to 7 years | 2006 | Miller, T. R., |
| Seat belt misuse by a child transported in belt-positioning booster seat with deadly consequences | 2012 | O'Neil, J., |
| Barriers to booster seat use and strategies to increase their use | 2002 | Simpson, E. M., |
| | | |
| Total Articles Reviewed | | 12 |

**<u>Booster Seat >3 yrs</u>**

Children who are prematurely placed in adult seat belts experience more problems with incorrect shoulder belt position compared with children restrained in high-back boosters, placing them at increased risk for injury in motor vehicle collisions. Safety experts recommend that children use belt-positioning booster seats from the time they outgrow their car seat until an adult seat belt fits properly. Proper seat belt fit is expected when a child is 57 inches tall, which is the average height of an 11-year-old child (CDC 2009). To promote child safety seat use, 47 states have passed laws requiring that children older than 4 years use a child safety seat, but only 2 states require booster seat use beyond a child's 8th birthday. (Macy, Reed et al. 2011).

Macy et al. (2011) found more than three-quarters of drivers reported that improper belt positioning occurs on most trips when their 4- to 9-year-old child passengers use an adult seat belt alone. Children who are prematurely restrained in an adult seat belt that does not fit properly are at increased risk of injury to the head, spine, and abdomen. Although improper lap belt positioning was more common, of greater clinical concern is that almost one-half of children were reported to have improper shoulder belt positioning. Our findings are consistent with laboratory evidence that demonstrates incorrect belt positioning is commonly the result of a mismatch between child body proportions and rear seat belt geometry (Macy, Reed et al. 2011)

The recently updated AAP guidelines for child passenger safety emphasize the importance of child size over child age when making the transition from a belt-positioning booster seat to an adult seat belt (Macy, Reed et al. 2011).

Findings from Safe Kids Worldwide in 2013 there are many parents who do not always take the time to ensure their children are safely secured in vehicles (Ferguson 2013). 21% of parents said it was acceptable to drive with their child not buckled up if they are not driving far. However, buckling up close to home is just as important as staying buckled up on long trips: 60 percent of crashes involving children occur 10 minutes or less from home.(Ferguson 2013).

From the time a child outgrows their forward-facing car seat until a child reaches adult stature, lap and shoulder belt fit can be improved with the use of a belt-positioning booster seat (Macy, Reed et al. 2011). The researchers point out that many newer model forward-facing car seats with 5-point harnesses will accommodate children older than 4 years of age weighing up to 65 pounds, and several booster seats are available for children weighing up to 120 pounds. Thus parents are encouraged to use car seats for as long as possible, followed by belt-positioning booster seats at least until the child reaches a height of 57 inches (Macy, Reed et al. 2011).

Using data from Second Injury Control and Risk Survey (ICARIS-2) - a nationally representative cross-sectional random-digit-dial telephone survey that included child-specific questions on motor vehicle restraint use and seating position, Greenspan et al (2010) found 4% of children less than 4 years of age were reported to ride unrestrained “some or all of the time” during a 30 day period between 2001 to 2003. For those 8-12 years, 9% were reported unrestrained. Based on the findings, Greenspan et al, estimated 618,337 children less than 13 years rode in vehicles without the use of a child safety seat or booster seat or a seat belt at least some of the time between 2001 and 2003. Among children less than 13 years, parents reported an estimated 618,337 who rode unrestrained and more than one million who rode in the front seat of a vehicle at least some of the time and close to 11 million children 8 years and younger reportedly used only adult seat belts. The results of this study highlight the need for continued outreach to parents regarding optimal restraint use and rear seating position for children every trip, every time (Greenspan, Dellinger et al. 2010).

While the effectiveness of booster seats does not vary by the type of booster seat each has its own advantages (Kuska 2011). High-back booster seats have built-in guides to route the lap and shoulder belts so that they fit properly, and offer head support. While backless boosters are generally inexpensive and have built-in lap belt guides, providing a better lap belt fit. Additionally, as Kuska (2011) points out, older children prefer backless booster seats because they look less like toddler child restraint seats, which may contribute to more consistent use. Belt-positioning booster seats reduce the risk for injury in children aged 4 through 8 years compared with seat belts (Arbogast, Jermakian et al. 2009).

It is important to note that many newer model forward-facing car seats with 5-point harnesses will accommodate children older than 4 years of age weighing up to 65 pounds, and several booster seats are available for children weighing up to 120 pounds. Health care providers should strongly encourage parents to use car seats for as long as possible, followed by belt-positioning booster seats at least until the child reaches a height of 57 inches (Macy, Reed et al. 2011).

A booster seat costs an average of $30 dollars this investment saves $1854 dollars per seat, a return on investment of 9.4 to 1(Miller, Zaloshnja et al. 2006).

Macy et a. (2012) found while the majority of parents (76%) indicated that their 4 to 8-year-old child uses a safety seat, two thirds of parents who carpool children other than their own, admit booster seat use when carpooling is inconsistent.

Table 9: Education

| Title & Year | Year | Lead Author |
|---|---|---|
| | | |
| Development, implementation and evaluation of a unique African-American faith-based approach to increase automobile restraint use | 2006 | Falcone, R. A., Jr. |
| Lessons for increasing awareness and use of booster seats in a Latino community | 2003 | Lee, J. W., |
| Emergency physician perspectives on child passenger safety: a national survey of attitudes and practices | 2011 | Macy, M. L. |
| Child passenger safety for inner-city Latinos: new approaches from the community | 2006 | Martin, M., |
| Evaluation of a child passenger safety class in increasing parental knowledge | 2014 | Muller, V. M., |
| Keeping baby safe: a randomized trial of a parent training program for infant and toddler motor vehicle injury prevention | 2013 | Swartz, L., |
| Effectiveness of hands-on education for correct child restraint use by parents | 2010 | Tessier, K. |
| Effects of a booster seat education and distribution program in child care centers on child restraint use among children aged 4 to 8 years | 2009 | Thoreson, S., |
| Community-based programs to promote car seat restraints in children 0-16 years -- a systematic review | 2005 | Turner, C., |
| Promoting correct car seat use in parents of young children: challenges, recommendations, and implications for health communication | 2013 | Weaver, N. L., |
| Evaluating the educational component of a hospital-based child passenger safety program | 2009 | Weiss-Laxer, N. |
| Challenges and opportunities for promoting booster seat use: progressive dissemination of a high-threat message | 2012 | Will, K. E. |
| Evaluation of the Boost 'em in the Back Seat Program: using fear and efficacy to increase booster seat use | 2009 | Will, K. E. |
| Total Articles Reviewed | | 13 |

**Education**

Many studies suggest pediatricians and other physicians have a great opportunity to educate parents and caregivers about child passenger safety during clinical encounters. In a national cross-sectional survey of emergency physicians, responding to two hypothetical clinical scenarios involving pediatric patients injured in motor vehicle crashes, Macy et al. (2011) found regardless of training background, emergency physicians overwhelmingly agreed that they have a role in the education of parents about child passenger safety and that they can make a difference in how a parent restrains their child. Yet the physicians acknowledge that they do not consistently perform this role (Macy, Clark et al. 2012).

Interventions that combine educational programs and free or discounted child safety seats show improvement in parental child passenger safety knowledge and practices. Weiss-Laxer et al. (2009) evaluated participant knowledge retention in a bilingual (English/Spanish) class for Latino parents at a hospital-based safety seat program. They found parents surveyed less than six months after receiving the child passenger safety program displayed less correct safety seat knowledge compared with parents surveyed more than six 6 months after participating in the program. Parents noted multiple barriers to safety seat use. The researchers suggest sending reminders to parents to refresh safety seat transition knowledge, particularly for older children, and revising program, curriculum to address the parental motivators and barriers to correct safety seat use (Weiss-Laxer, Mello et al. 2009).

Families exposed to an educational intervention provided by community health workers trained as child passenger safety technicians were more likely to have their child's seat installed correctly according to the manufacturer's recommended weight/height range, facing the correct direction with the harness straps positioned properly (Martin, Holden et al. 2006).

Will et al (2012) argues that most booster seat programs fail to adequately motivate their intended population because they are primarily informational in nature and rely on caregivers to seek out and attend to the information. The study tested interventions using threat appeal tactics and progressive dissemination methods as ways to effectively target participation among this population. Previous research on risk communication shows threat appeals are supported when they contain high threat and high efficacy components. The intervention resulted in significant increases in knowledge, risk-reduction attitudes, sense of efficacy, and observed booster seat use. Through use of progressive dissemination methods, the intervention has reached an audience of 431,600 people and counting (Will, Dunaway et al. 2012).

Ehiri, et al. (2006) found interventions were generally effective in increasing booster seat use among children aged 4 to 8 years. Education paired with incentive or distribution programs produced more consistent results than education-only interventions that targeted parents, children, or both (Ehiri, Ejere et al. 2006).

Will et al (2009) found that an educational video was effective in increasing parental knowledge of car seat safety. They conclude a longer follow-up period would offer better insight into evaluating knowledge retention from this intervention. 6 months after participating in a child safety class Weiss-Laxer et al (2009) found parents' knowledge decreased.

In comparing a child care center-based booster seat education and distribution program with no intervention when implemented immediately after booster seat legislation, Thoreson et al (2009) found parents received information about booster seats but not booster seat use. The investigators say more research is needed to identify effective methods and messages to promote booster seats effectively and reach high-risk populations (Thoreson, Myers et al. 2009).

Tessier (2010) evaluated whether a hands-on educational intervention makes a significant difference in the proper use of a child passenger restraint by a parent. In the study 111 parents who were at least seven months pregnant were randomly assigned to one of two groups (56 intervention and 55 control). All participants received a free car seat and a standardized education session on the safety and use of child passenger restraints but the experimental group received an additional component consisting of a hands-on demonstration and return demonstration of correct installation and use in their own vehicle. A total of 24 (22%) parents correctly used the car seat; of these, 18 (32%) were in the intervention group and 6 (11%) were in the control group. The researchers found the intervention group was four times more likely to have correct use than the control group and no secondary variable (age, education, income, or help from others) had a significant effect on the outcome (Tessier 2010).

***Cultural Disparities***

Restraint use among African Americans remains below national levels, especially among children. Through a partnership with the African-American faith-based community a unique multigenerational intervention program was developed targeting motor vehicle restraint use. Following program implementation, significant improvements were observed in restraint use compared to control churches. In particular, there was a 72% reduction in unrestrained children, a 25% increase in children being secured in the rear-seat position and a nearly 20% increase in driver restraint use. The development and implementation of a culturally sensitive intervention program can significantly improve restraint use in a minority population. Partnering with the community in all phases of the program is essential to its success (Falcone, Brentley et al. 2006).

As research as shown, Latino children are more likely to be unrestrained passengers in motor vehicles than non-Latino children. To learn more about the barriers for booster seat use Lee et al (2003) conducted two focus groups with Spanish speaking parents. Researchers found as a whole, parents were widely misinformed about recommended guidelines for booster seat use, and the majority of participants did not own a booster seat. A general lack of information, cost, perceived resistance to use by the child as well as limited space in the vehicle were identified as barriers to booster seat use. Lee et al (2003) emphasize that campaigns to promote booster seats in the Latino community need to be should be culturally specific with clear guidelines for booster seat use should be given in Spanish.

| Table 10: Technology | | |
|---|---|---|
| Title | Year | Lead Author |
| Investigation of Child Restraint System (CRS) Compatibility in the Vehicle Seat Environment | 2015 | Bing, J. A., |
| Strength limitations to proper child safety seat installation: implications for child safety | 2009 | Brown, S. H., |
| A smartphone app to communicate child passenger safety: an application of theory to practice | 2015 | Gielen, A. C., |
| A computerized child passenger safety screening program in the emergency department | 2014 | Kiley, K., |
| Effects of child restraint system features on installation errors | 2014 | Klinich, K. D., |
| Harnessing social media for health promotion and behavior change | 2013 | Korda, H., & Itani, Z. |
| Effects of vehicle seat and belt geometry on belt fit for children with and without belt positioning booster seats | 2013 | Reed, M. P., |
| How readable are child safety seat installation instructions? | 2003 | Wegner, M. V., |
| | | |
| Total Articles Reviewed | | 8 |

**Technology**

CRS misuse is common and can have serious consequences to child safety. Bing et al (2015) suggest physical incompatibilities between CRS and vehicles can complicate the installation process and thus worsen CRS misuse rates. The results of this study indicate that forward facing CRS base angles and front row clearance space, as well as forward facing CRS head restraint interference, are frequent compatibility concerns.

In a laboratory study Reed et al (2013) measured the postures and belt fit of 44 children ages 5 – 12 to quantify the effects of belt-positioning boosters on lap and shoulder belt fit. Four highback boosters, one backless booster, and on a vehicle seat without a booster were used in the study. While all boosters produced better mean lap belt fit than was observed in the no-booster condition, the researches found large but differences among boosters types (Reed, Ebert-Hamilton et al. 2013) were relatively large.

Could the actual features of a child restraint system (CRS) contribute to CRS installation errors? Klinich et al (2014) tested 16 convertible CRS, with a wide range of features, with 32 subjects with varying education levels and experience with installing CRS (none or experienced). Each subject was asked to perform four child restraint installations in the right-rear passenger seat of a 2006 Pontiac G6 sedan using a crash dummy as a child surrogate. After each installation, the experimenter evaluated 42 factors for each installation, such as choice of belt routing path, tightness of installation, and harness snugness. In general, subject assessments of the ease-of-use of CRS features were not highly correlated with the quality of their installation, suggesting a need for feedback with incorrect installations. (Klinich, Manary et al. 2014).

Many drivers, especially those who always use seat belts, said they would encourage unbuckled passengers to buckle up and supported auditory and visual belt reminders for passengers, particularly for children sitting in the back seat. Front and rear passenger reminders that last indefinitely would be acceptable to most drivers who transport these passengers. An auditory alert may be especially useful to alert drivers to children unbuckling in the back seat during a trip (Kidd and McCartt 2014).

Correctly used CRS reduce the risk of fatal injury by 71% and hospitalization by 67%. Numerous studies show that improper restraint use is alarmingly prevalent, ranging from 79% to 94% (Wegner and Girasek 2003). Wegner et al (2003) propose possible contributors to misuse could include engineering/design problems, physical difficulty with installation, and poor comprehension of installation instructions. Data from the study indicate that CRS instructions in the US are currently written at a reading level that is too high and should be aimed for fifth-or sixth-grade reading literacy (Wegner and Girasek 2003).

Since 1975, the rate of infant motor vehicle fatalities has been reduced by 75%, yet only 54% for all children younger than 4 years (Arbogast, Jermakian et al. 2009). O’Neil et al. (2012) describes the tragic case of a 5-year-old boy who placed the shoulder portion of the lap-shoulder seat belt behind his back and was killed in a motor vehicle crash. As with all CRS, misuse of seat belts reduces the effectiveness of belt-positioning booster seats. Unfortunately, the misuse can result in severe and fatal consequences when a crash occurs (O'Neil, Rouse et al. 2012).

# CHAPTER V: CONCLUSIONS

Injuries sustained from motor vehicle crashes remain the biggest threat to safety of children. An extensive literature review provides irrefutable evidence that motor vehicle crashes are the leading cause of death for children from birth to14 years old accounting for an average of 2000 deaths and 250,000 hospital visits annually. This is a complex issue that requires a multifaceted approach.

A wealth of best practices safety literature from the NHTSA, AAP, CDC, Safe Kids and other health organizations are widely available to help parents and caregivers make informed safety decisions for children from purchasing the appropriate CRS and its subsequent consistent and proper use. Yet thousands of children remain improperly or completely unrestrained increasing their risk for injury or death. Policy, legislation and empirical evidence show age and size appropriate properly installed CRS in the back seat is the single best way to protect our children. Many of the tragic deaths of young children could have been prevented if they had been properly secured in the vehicle.

For decades, child passenger safety laws have failed to stay current with pertinent research regarding best practices for child safety restraints. Despite clear evidence based data about the effectiveness of CRS to save the lives of children and thus the need for stricter laws regarding child passenger safety, policy change at the federal level has been slow often several years behind science.

While all 50 states and the District of Columbia have child passenger seat laws, the laws vary greatly among states and in many cases do not follow the current AAP recommendations - rear-facing seating in car seats until age 2 years, forward-facing seating in car seats with a harness until the weight/height maximum is reached on car seats, use of booster seats until lap and shoulder belts fit properly, and seating in the back seat for passengers younger than 13 years old.

As of 2015, only 14 states require rear seating of child passengers of varying age, which can cause inconsistent messaging for parents nationwide. Primary enforcement which allows a citation to be issued whenever a law enforcement officer observes a seat belt violation would appear most effective but at least 14 states do not require primary enforcement of existing seat belt laws.

Research has shown in states that increased the age requirement for car seat/booster seats to age 7 or 8 years, the overall rate of children using car seats and booster seats improved significantly thus greatly lowering the rate of children who would sustain sustained deadly or debilitating injuries. Overall, the risks of injury follow a continuum, with unrestrained children faring worse in crashes than improperly restrained children.

Children who are prematurely placed in adult seat belts experience more problems with incorrect shoulder belt position compared with children restrained in high-back boosters, placing them at increased risk for injury and risk of injury to the head, spine, and abdomen in motor vehicle collisions. To ensure optimal safety children who have outgrown their forward facing car seat need to use belt-positioning booster seat until an adult seat belt fits properly. Proper seat belt fit is expected when a child is 57 inches tall, which is not achieved before a child’s eighth birthday. To promote child safety seat use, 47 states have passed laws requiring that children older than 4 years use a child safety seat, but only 2 states require booster seat use beyond a child's eighth birthday.

The recently updated AAP guidelines for child passenger safety emphasize the importance of child size over child age when making the transition from a belt-positioning booster seat to an adult seat belt. While these recommendations are directed for children, proper lap-belt position applies to everyone. Thus a petite adult less than 5” tall would be safer in a motor vehicle by being boosted up with a seat alteration such as cushion. While the effectiveness of booster seats does not vary by the type of booster seat each has its own advantages such as cost and ease of use. Older children may prefer backless booster seats because they look less like toddler child restraint seats, which may contribute to more consistent and longer use.

With continual improvements with CRS, many newer model forward-facing car seats with 5-point harnesses will accommodate children older than 4 years of age weighing up to 65 pounds, and several booster seats are available for children weighing up to 120 pounds.

Pediatricians have a great opportunity to educate parents and caregivers about child passenger safety during clinical encounters. Interventions that use multimedia components and hands-on instruction with the incentive of a free or discounted child safety may help contribute to improved knowledge of the importance of booster seats, but more research is needed to evaluate retention after the intervention.

CSR use among African Americans and Latino children remains below national levels, but research suggest community-based programs with culturally specific messaging maybe effective in narrowing the disparities gap for minority children.

In order to effectively protect a child in a motor vehicle crash, the CRS and seat belt system must be used properly. While human error in installation is main reason cause of misuse the physical incompatibilities between CRS and vehicle in which it is being installed could be a significant factor. A paradigm shift in how CRS are purchased could help address reduce this cause of misuse. Before making committing to specific brand or style, parents should first test the fit of the CRS in their car to minimize need to use propping aids for adjustment and decrease the chance of misuse.

The savings from booster seat use reduce injury and overall societal costs. Thus the savings in medical and other resource costs from a booster seat exceed its purchase price significantly. School aged children 4 to 9 years old are at increased risk for serious injury because they've outgrown their front facing car seats and are too small for seat belts. Even more troubling is the fact that many children in this age group travel completely unrestrained. Lack of knowledge, immune fallacy, affordability, misuse errors, socioeconomic are all factors that associated with barriers to CRS compliance, but understanding the full scope reasons parents put their young children at risk is a complex issue not easily addressed.

Cultural differences and the lack of culturally appropriate messages appear to be the primary factor for the lack of success of generalized intervention programs among African American and Latino communities. Culturally sensitive education programs are needed to help improve passenger safety among minorities and reduce unintentional injury disparities. Multimedia instruction using video elements of emotionally charged images and messaging should also be researched as a means to promote consistent CRS use. Results from such research would provide some insight about reinforcement of injury prevention education and its potential to affect lasting behavioral change.

The literature offers copious clear empirical evidence for CRS in reducing risk of injuries in motor vehicle crashes. However, there is a dearth of research utilizing the technological advances of social media and smart technology and new age design on the impact of child seat safety. Future studies should evaluate the effect of social media and smart phone app technology to remain engaged with parents of small children though the stages different CRS from birth through booster seat age (4 to 8 yrs old) to promote consistent safety behavior.

Though extensive, this literature review has several limitations. By focusing on four areas of interest the methodology and subsequent article selection was bias thus many other factors that affect CRS use were not examined.

The statistical probability of a fatal or nonfatal motor vehicle crash collision is impacted by a multitude of factors including human error, age, driving experience, road/weather conditions, alcohol/drug influence, gender, socioeconomic and a host of others. A child properly secured in an age and size appropriate CRS has better odds of reduced injury versus an unrestrained child, but no vehicle or CRS can ultimately guarantee survival.

This review did not investigate a behavior change theory, which could promote long-term safety awareness and thus reduce potential inconsistent use of CRS among some parents.

Children are our future, and they need our protection to reach their full potential. Reducing the potential barriers to CRS compliance could provide passive and active strategies to ultimately save lives.

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