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**AN EVALUATION OF THE VIRGINIA 2002 CHILD PASSENGER  
SAFETY LAW:  
DETERMINING IF THE LAW REDUCED MOTOR VEHICLE  
CRASH INJURIES AND FATALITIES**

A dissertation submitted in partial fulfillment of the requirements for the degree of  
Doctor of Philosophy at Virginia Commonwealth University.

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## Abstract

AN EVALUATION OF THE VIRGINIA 2002 CHILD PASSENGER SAFETY LAW:  
DETERMINING IF THE LAW REDUCED MOTOR VEHICLE CRASH INJURIES  
AND FATALITIES

By Petra Maria Menzel Connell, Ph.D.

A dissertation submitted in partial fulfillment of the requirements for the degree of  
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In 2002, Virginia increased the age that children needed to be restrained in a child safety seat from age three to age five. Employing a pre and post intervention analysis, this study evaluated the 2002 Virginia child safety restraint law and determined if the number and severity of motor vehicle crash injuries to children ages four and five changed significantly post-law. Two groups of children, children under age four and children ages six and seven, were utilized as control groups.

Motor vehicle crash injury and death data from the Virginia Department of Motor Vehicles police crash report file, Virginia Health Information hospital discharge database, and the Virginia Department of Health death database from January 1, 1995 through June 30, 2007 were analyzed. Only select motor vehicle crash e-codes were included in the analyses.

An independent samples t-test was conducted and rate per 100,000 was calculated for each age group to determine if there was an effect on the numbers of injuries, fatalities, and injury severity post-law. A significant decrease of injuries and mild and moderate injury severity in the target group and both control groups post-law was found. The target group had the greatest reduction post-law.

The 2002 law, along with the interaction of concurrent events and initiatives and possibly spillover effect, may explain why all groups, saw significant reductions post-law. The possibility that education, federal initiatives, enforcement, engineering, public policy changes, and/or enhancements in the medical system may have played a role in the findings is explored.

Future research on motor vehicle crash injuries is recommended if statewide emergency room, urgent care center, or physician office data are ever collected. Also, Virginia amended their child passenger safety law in 2007. The 2007 law required children through the age of seven to be properly secured in a child safety restraint. An analysis of the 2007 law would determine if the two year increase in age had an effect on injuries and fatalities of children when involved in a motor vehicle crash.

## **CHAPTER 1: Background**

### **Introduction**

Today all fifty states and the District of Columbia have some form of child passenger safety law mandating that children be restrained in a child safety restraint while riding in motor vehicles (Advocates for Highway and Auto Safety, February 24, 2007; National Highway Traffic Safety Administration, February 2007). There is great variation with regard to the maximum age that a child must use a child safety device while riding in a motor vehicle. Some states also include weight and/or height requirements for children. The greatest variation exists in the laws that are to protect children between the ages of four and eight.

The average child, when he or she reaches age four, is too big to use a forward-facing child safety seat with an internal harness but is still too small for vehicle lap and shoulder belts to fit properly (American Academy of Pediatrics, 2007; Ebel, Koepsell, Bennett, & Rivara, 2003a; Elliott, Kallan, Durbin, & Winston, 2006; F. K. Winston, Durbin, Kallan, & Moll, 2000). On a child, the adult vehicle lap belt rides up over the stomach and the vehicle shoulder belt cuts across the neck. This lack of fit may cause serious or even fatal injuries if the child is involved in a motor vehicle crash.

Booster seats, a type of child passenger safety seat, have been recommended as the best practice for protecting child occupants between the ages of four and eight years, unless the child is at least 4'9" tall (National Highway Traffic Safety Administration, 2000; F. K. Winston, Chen, Elliott, Arbogast, & Durbin, 2004). In 2002, the Virginia General Assembly increased the age that children needed to be restrained in a child safety seat from age three (through their fourth birthday) to age five (through their sixth birthday). This study attempts to determine if Virginia's law, requiring that children be properly secured in a child safety restraint through the age of five (until their sixth birthday), protects Virginia's booster seat age population when involved in a motor vehicle crash.

### **Motor Vehicle Crash Morbidity and Mortality**

Motor vehicle crashes are a major public health problem. They remain the leading cause of morbidity and mortality for children between the ages of four and eight in the United States (Partners for Child Passenger Safety, July 2004). Fatalities are a relatively small percentage of the motor vehicle crash injuries. Nationwide in 2003 there were 331 fatalities of child passengers between the ages of four and eight (a four percent increase from 2002) and an additional 53,000 in this age group were injured (National Highway Traffic Safety Administration, November 2005).

The short-term and long-term results of the non-fatal injuries are profound. Some children may have less severe injuries, yet there is still a tremendous impact on the financial and emotional stability of their families. These non fatal injuries have a

significant impact on the family and the health of our communities, affecting health care costs, productivity, and quality of life. It is important to remember that motor vehicle crashes are not “accidents,” but are predictable and preventable incidents with identifiable risk factors (Allen, 1998).

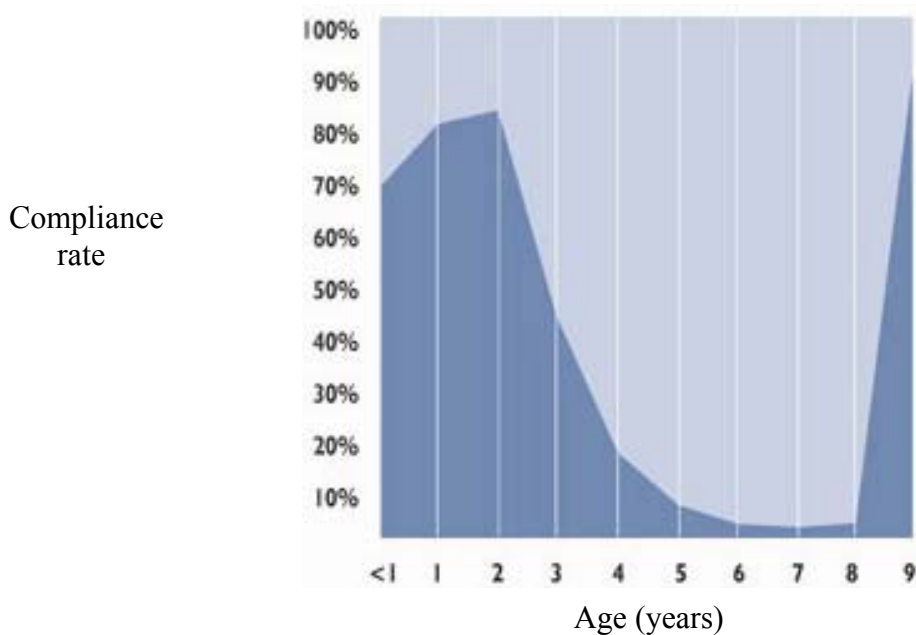
Theoretically, no parent or caregiver intentionally would put a child at risk of injury or death. However, through their ignorance of crash dynamics and child passenger safety, many parents take such a risk. Laws that require correct child restraint systems for all children, in all seating positions, in the care of all drivers, could potentially protect the innocent children and the uninformed parents and reduce injuries to children involved in motor vehicle crashes.

Researchers found that "while parents generally do a good job of restraining children in automobiles who are under age three and over age eight, the number of appropriately restrained children between ages three and eight drops significantly. Instead of using child safety seats or belt-positioning booster seats, many of these children are inappropriately restrained in adult seat belts (Flaura Winston, Moll, Durbin, & Kassam-Adams, 2001)."

Figure 1 presents the percentage of children found to be conforming to the best practice recommendations for child passenger safety restraint by the NHTSA. It is evident from Figure 1 that many children between the ages of three and eight are not optimally restrained for their age. Specifically, premature graduation out of child safety seats becomes common around age three leaving the children vulnerable to injury if involved in a motor vehicle crash.



**FIGURE 1: Compliance with Recommended Restraints by Age**



Source: Winston, et al., *The Premature Graduation of Children from Child Restraints to Vehicle Safety Belts*. DOT HS 809 259, 2001.

### **Rationale for Recommendations**

For over ten years the NHTSA, the American Academy of Pediatrics, and National Safe Kids have recommended booster seats for children who have outgrown child safety seats but are still too small to fit properly in a vehicle safety belt (American Academy of Pediatrics, 2007; CPSafety, 2008; National Highway Traffic Safety Administration, September 2005). The current NHTSA recommendation is that children who have outgrown child safety seats should be properly restrained in booster seats until they are at least eight years old, unless they are at least 4'9" tall (National Highway Traffic Safety Administration, September 2005). A booster seat is a type of child safety seat that raises children up on the vehicle seat so that their height is more like that of an

adult since vehicle seat belts are designed for adult passengers, not children (National Highway Traffic Safety Administration, November 2005).

Correct safety belt fit is not usually achieved until a child is nine years old, the age at which the child's femur length is long enough for the child to sit against the back of the vehicle seat, the anterior superior iliac spines are sufficiently developed to anchor the lap belt, and the child's sitting height is sufficient for the shoulder belt to fit properly over the shoulder and sternum (Morris, Arbogast, Durbin, & Winston, 2000). In the event of a motor vehicle crash, the lap portion of the vehicle seat belt tends to ride up on the abdomen of the child and the shoulder portion of the vehicle seat belt crosses high on the neck of the child if they are not using a booster seat. This can cause intra-abdominal and spinal cord injuries, also known as "seatbelt syndrome," along with possible injuries to the face, neck, and brain (Achildi, Betz, & Grewal, 2007; Arbogast et al., 2007; M. J. Bull & Sheese, 2000; Davies, 2004; Nance et al., 2004; Santschi, Echave, Laflamme, McFadden, & Cyr, 2005; Sokolove, Kuppermann, & Holmes, 2005; F. K. Winston, Durbin, Kallan, & Moll, 2000).

### **The State of Child Passenger Safety**

Media, politicians, health care professionals, injury prevention advocates, parents, and countless others focused their attention on child occupant protection after many states received failing grades in a 2001 report from the National Safe Kids Campaign for their child passenger safety laws. California received an A, Florida received a B, seven states received C's, eighteen states received D's, and twenty-four states received F's (National

Safe Kids Campaign, 2001). Since the 2001 report, states have looked to upgrade their child passenger safety laws.

Healthy People 2010 (HP 2010), a nationwide health promotion and disease prevention plan started by the United States Department of Health and Human Services to be achieved by 2010, also sought to address the problem of motor vehicle crashes and child safety restraints by including objectives to address the problems (U.S. Department of Health and Human Services, 2000). HP 2010 had specific objectives of (1) reducing deaths from motor vehicle injuries (objective 15-15); (2) reducing non-fatal motor vehicle injuries (objective 15-17); and (3) increasing the use of child safety restraints (objective 15-20). Since these goals were published, every state now requires that infants and children up to a certain age be restrained in a child safety device when riding in a motor vehicle (Savage, Kawanabe, Mejeur, Goehring, & Reed, 2002).

As of April 1, 2008, forty states and the District of Columbia had enacted provisions in their child restraint laws requiring the use of a booster seat by children who are still too small to use an adult safety belt system correctly. Table 1 provides a list of states that have booster seat laws, the requirements of the law, the maximum fine for a first time offense, the year the law was enacted, and the year the law took effect. These laws theoretically will reduce injuries in children between the ages of four and eight when involved in a motor vehicle crash. However, the laws vary from state to state, so all children across the nation are not equally protected while in motor vehicles. All state laws include an age limit, but some states also stipulate weight limits and/or height

requirements (National Highway Traffic Safety Administration Occupant Protection Division, April 1, 2008).

**TABLE 1: States with Booster Seat Laws as of April 1, 2008:**

**Requirements, Maximum Fines, Year of Enactment, and Year of Effect**

| STATE                | REQUIREMENT  | MAXIMUM FINE 1 <sup>ST</sup> OFFENSE | YEAR INITIAL BOOSTER SEAT LAW ENACTED | YEAR INITIAL BOOSTER SEAT LAW EFFECTIVE |
|----------------------|--|--------------------------------------|---------------------------------------|---|
| Alabama              | 5 but not yet 6 in a booster seat.   | \$25                                 | 2006                                  | 2006                                    |
| Arkansas             | 5 years and younger and less than 60 pounds  | \$100                                | 2001                                  | 2001                                    |
| California           | 5 years and younger and less than 60 pounds  | \$100                                | 2000                                  | 2002                                    |
| Colorado             | 4 through 5 years and less than 55 inches  | \$50                                 | 2002                                  | 2003                                    |
| Connecticut          | 1 through 6 years who is less than 60 pounds in a child restraint system (booster seats may only be used in a seating position with a lap and shoulder belt) | \$60                                 | 2005                                  | 2005                                    |
| Delaware             | 7 years and younger and less than 66 pounds  | \$25                                 | 2002                                  | 2003                                    |
| District of Columbia | 7 years and younger  | \$75                                 | 2002                                  | 2004                                    |
| Georgia              | 5 years and younger and 57 inches or less  | \$50                                 | 2004                                  | 2004                                    |
| Hawaii               | 4 years through 7 years must be in a booster seat or child restraint   | \$100                                | 2006                                  | 2007                                    |

|           |   |       |      |      |
|-----------|---|-------|------|------|
| Idaho     | 6 years and younger   | \$100 | 2005 | 2005 |
| Illinois  | 7 years and younger   | \$50  | 2003 | 2004 |
| Indiana   | 7 years and younger when driver holds an Indiana license  | \$25  | 2004 | 2005 |
| Iowa      | 1 through 5 years   | \$25  | 2004 | 2006 |
| Kansas    | children 4 through 7 who weigh less than 80 pounds and children 4 through 7 who are less than 57 inches tall must be in a child restraint or booster seat   | \$60  | 2006 | 2006 |
| Louisiana | 4 through 5 years or 40-60 pounds in a child booster seat   | \$50  | 2003 | 2004 |
| Maine     | 40-80 pounds and less than 8 years in a safety system that elevates the child so that an adult seat belt fits properly  | \$50  | 2002 | 2002 |
| Maryland  | 5 years and younger or 40 pounds or less  | \$25  | 2002 | 2003 |
| Michigan  | 7 years and younger and less than 57 inches (effective 07/01/08)  | \$10  | 2008 | 2008 |
| Missouri  | 4 through 7 years who weigh at least 40 pounds but less than 80 pounds and who are 4'9" or shorter must be in either a child restraint or booster seat; children 4 years and older who weigh at least 80 pounds or who are at least 4'9" tall must be in either a booster seat or safety belt | \$50  | 2006 | 2006 |

|                |   |       |      |      |
|----------------|---|-------|------|------|
| Montana        | 5 years and younger and less than 60 pounds   | \$100 | 2003 | 2003 |
| Nebraska       | 5 years and younger   | \$25  | 2002 | 2002 |
| Nevada         | 5 years and younger and 60 pounds or less   | \$500 | 2003 | 2004 |
| New Hampshire  | 5 years and younger who are less than 55 inches tall  | \$25  | 2003 | 2004 |
| New Jersey     | 7 years and younger and less than 80 pounds   | \$25  | 2001 | 2001 |
| New Mexico     | 5 through 6 or less than 60 pounds in a booster seat  | \$25  | 2005 | 2005 |
| New York       | 6 and younger in all seats except all children who weigh more than 40 pounds and all children 4 through 6 years may be in a lap belt if there is no available lap/shoulder belt | \$100 | 2004 | 2005 |
| North Carolina | 7 years and younger and less than 80 pounds   | \$25  | 2005 | 2006 |
| North Dakota   | 6 years and younger and less than 57 inches or less than 80 pounds  | \$25  | 2005 | 2005 |
| Oklahoma       | 5 years and younger   | \$25  | 2004 | 2004 |
| Oregon         | more than 40 pounds but 4 feet and 9 inches or less must be in a safety system that elevates the child so that an adult seat belt fits properly                                 | \$90  | 2001 | 2002 |
| Pennsylvania   | 7 years and younger   | \$100 | 2002 | 2003 |
| Rhode Island   | 6 years and younger and less than 54 inches and less than   | \$75  | 2001 | 2002 |

|                |  |       |      |      |
|----------------|--|-------|------|------|
|                | 80 pounds  |       |      |      |
| South Carolina | 1 through 5 years and 40-80 pounds in a booster seat secured by lap-shoulder belt (lap belt alone is impermissible)                                      | \$150 | 2001 | 2001 |
| Tennessee      | 4 through 8 years and less than 4'9" in a booster seat   | \$50  | 2003 | 2004 |
| Utah           | 7 years and younger and shorter than 57 inches (effective 05/04/08)  | \$45  | 2008 | 2008 |
| Vermont        | 2 through 7 and more than 20 pounds  | \$25  | 2003 | 2004 |
| Virginia       | 7 years and younger unless they have a physician exemption   | \$50  | 2002 | 2002 |
| Washington     | 7 years and younger and less than 4'9"   | \$124 | 2000 | 2001 |
| West Virginia  | 7 years and younger and less than 4'9"   | \$20  | 2005 | 2005 |
| Wisconsin      | children 4 through 7 who both weigh at least 40 pounds but less than 80 pounds and who are less than 57 inches tall are required to be in a booster seat | \$75  | 2006 | 2006 |
| Wyoming        | 8 years and younger  | \$50  | 2003 | 2003 |

Source: National Highway Traffic Safety Administration Occupant Protection Division and Insurance Institute for Highway Safety

While laws are a step in the right direction to protect our children, it is critical to evaluate if the laws have made a difference. If the legislation does not protect children

from motor vehicle crash related injuries and death, or if the legislation does not sufficiently address the situation, additional protective measures should be considered.

### **Prevention: Does it Make a Difference?**

When properly utilized, child passenger safety restraints work. Child safety seats reduce the likelihood of a child under the age of one being killed in a motor vehicle crash by seventy-one percent and child safety seats reduce the likelihood of children between the ages of one and four of being killed by fifty-four percent (National Highway Traffic Safety Administration, 2007). Children between the ages of four and seven who properly use booster seats are fifty-nine percent less likely to be injured in a car crash than children restrained only by a seat belt, according to a study by Children's Hospital of Philadelphia (Durbin, Elliott, & Winston, 2003). Child safety seats are effective in preventing fatalities if they are used properly, but a majority of young children are either not belted properly or they are riding in a child safety seat that is incorrectly installed (Miller-Hobbs, April 15, 2003).

Over eighty percent of the time, parents or caregivers are incorrectly using their child's safety seat, with potentially tragic consequences (Safe Kids Worldwide, 2006). Injury prevention advocates have utilized education, enactment of stricter child passenger safety legislation, enforcement, and environment changes, such as simpler child safety seat installation instructions and new technology to make installation easier, to address the incorrect usage or non-use of child safety seats. What effect does mandating booster



seats have on rates of morbidity and mortality of children involved in motor vehicle crashes?

Having heard or read of booster seats does not necessarily create an understanding or commitment to use them. Studies have also shown that simply having heard or read about booster seats is not enough for people to understand the need for children between the ages of four and eight to use them. The majority of parents and caregivers are unaware of the proper height and age to place a child in the vehicle seat with the regular adult seat belt (Simpson, Moll, Kassam-Adams, Miller, & Winston, 2002).

Some individuals still believe that the failure to use a child safety seat or safety belt only affects the child and their family. The NHTSA indicates that this is not the case. When involved in a motor vehicle crash unbelted occupants frequently injure other occupants in a crash by colliding with them in the vehicle. Unbelted drivers have much less opportunity to control their vehicle in a crash since they may be thrown from behind the wheel of the vehicle. In addition, the cost of increased deaths and injuries associated with failure to use a seat belt or child safety seat is borne by society through decreased productivity, police and emergency medical services costs, hospital costs, rehabilitation costs, insurance administration costs, costs to employers, and years of potential life lost (Beery, April 14, 2003).

### **History of Virginia Legislation**

In Virginia, child safety advocates secured passage of a law in 2002 that increased the age that children need to be restrained in a child safety seat when riding in a motor

vehicle. Children were now required to utilize a child safety seat to the age of five (until their sixth birthday). The two year increase in age was intended to better protect “booster seat” children from injuries and death when involved in a motor vehicle crash. Though the law protected children ages four and five, it still did not meet NHTSA recommendations of keeping children restrained in a child safety seat until they were eight years old, unless they are at least 4’9” tall.

Since Virginia enhanced requirements for child passenger safety, it is important to evaluate the effectiveness of the 2002 Virginia child safety restraint law and to evaluate if the law has significantly reduced the number of motor vehicle crash injuries and fatalities. Systematic reviews are essential if policymakers and practitioners are to know whether their efforts actually reduce injuries and death in children ages four and five. Are the results of the legislation successful in reducing the loss of life and suffering motor vehicle crashes cause, or are other injury interventions and countermeasures necessary?

## **CHAPTER 2: Literature Review**

### **History of Seat Belt Laws**

In December of 1984, New York state introduced the first mandatory seat belt law (Centers for Disease Control and Prevention, 1985). By the end of 1988, thirty-one states and the District of Columbia had enacted some sort of seat belt law. The specifics of the laws varied from state to state but generally front seat occupants of passenger vehicles were required to wear safety belts. People in the rear vehicle seats were, and often still are, exempt from such laws (Campbell, Stewart, & Reinfurt, 1991).

Today, there are mandatory safety belt laws in forty-nine states and the District of Columbia (Insurance Institute for Highway Safety, 2008). In most states, these laws cover front seat occupants only, although seat belt laws in nineteen states and the District of Columbia also cover all rear seat occupants. Seat belt use laws are primary in only twenty-six states and the District of Columbia (Insurance Institute for Highway Safety, 2008). This means no other violation needs to be committed prior to police stopping the vehicle. The vehicle can be pulled over solely for a seat belt law violation. New Hampshire is the only state with no adult seat belt law. The lack of restraint law in New Hampshire may stem from a reluctance to infringe on individual freedoms (Curtis, Rodi, & Sepulveda, 2007). Some believe that seat belt laws have criminalized self-risk and that

has established a dangerous, liberty threatening, principle that licenses the state to proscribe anything or activity of which it might disapprove (Adams, 2007).

In 1978, the first state law requiring mandatory use of a child passenger safety restraint was passed in Tennessee (National Safe Kids Campaign, 2001). Thirty years later, all fifty states and the District of Columbia have child restraint laws (National Highway Traffic Safety Administration, February 2007). These laws require children to travel in approved child passenger safety restraints, and some permit or require older children to use adult safety belts. Variations exist from state to state regarding the age at which vehicle seat belts can be used instead of child restraints (see Table 1) (Angulo-Vazquez & De Santis, 2005; Insurance Institute for Highway Safety, 2008).

Ideally, infants and children in all vehicles should be covered by safety belt laws or child restraint laws. But differences in the way the laws in various states are worded result in many occupants, especially children, not being fully protected. Legislators are working to eliminate existing child passenger safety restraint gaps by amending the child restraint and safety belt laws within their states (Advocates for Highway and Auto Safety, 2007; Insurance Institute for Highway Safety, 2008).

### **Virginia Seat Belt Laws**

Virginia passed their first passenger safety belt law (Code of Virginia Article 12 - Section 46-2) in 1987; it covered people age sixteen and older riding in the front of a vehicle. Minor changes to wording have occurred over the years, but the basic requirements have remained the same. The law is not a primary enforcement law,

meaning the police officer must witness a violation of another traffic law before stopping someone for not buckling up.

For children ages eight through age fifteen (until their sixteenth birthday), the Code of Virginia mandates they must be belted correctly in vehicle safety belts in vehicles manufactured after January 1, 1968. School buses, executive sedans, limousines and school buses are exempt from the law. This safety belt law for children ages eight through fifteen is primary enforcement, meaning no other violation needs to be committed prior to ticketing for failure to have a child correctly buckled up. A \$50 civil penalty fine is imposed for a violation of the law and all fines that are collected go into a fund to purchase safety seats for low-income families ("Acts of Assembly", 2002;; "Acts of Assembly", 2007).

### **Virginia's Child Restraint Law**

The Code of Virginia also protects Virginia's youngest children. The first Virginia child passenger safety restraint law was passed in 1982. The law required that any parent or legal guardian who drives a motor vehicle registered in Virginia and manufactured subsequent to January 1, 1968 shall ensure that their child under the age of four is secured in a child safety restraint. Any person that was not the parent or the legal guardian of a child being transported was exempt from following the law. A few additional exemptions were included, one being that if a child under the age of four weighed more than forty pounds, they could be restrained in a vehicle seat belt ("Acts of Assembly", 1982). Another was that a Virginia licensed physician could exempt a child

from using a child safety seat if medical reasons would make using one impractical. Additionally, the law did not apply if a child was on public transportation, a bus, a school bus, or a farm vehicle.

The original 1982 law carried with it a \$25 fine. The law created a special fund known as the “Child Restraint Device Special Fund” where all collected fines were deposited. The fund was administered by the Virginia Department of Motor Vehicles (VA DMV) that purchased child safety seats and then loaned them out to individuals that were not able to afford them.

Changes occurred over the years to better protect children while riding in motor vehicles. In 1986, the General Assembly revised the Code of Virginia so that any person (not just the parent or legal guardian) regularly transporting children under the age of four would need to restrain the children in child safety seats approved by the United States Department of Transportation ("Acts of Assembly", 1986). Another revision in 1986 was that people who could not afford a child safety seat would either be loaned a seat or furnished with a seat that they could keep through the VA DMV's “Child Restraint Device Special Fund” ("Acts of Assembly", 1986).

In 1992, the General Assembly revised the Code of Virginia so that any person driving on the highways of Virginia (not just people with vehicles registered in Virginia) would need to restrain children under the age of four in a U.S. Department of Transportation approved child safety restraint. In addition, the exemption that allowed children under the age of four and weighing more than forty pounds to not use a child safety seat was stricken ("Acts of Assembly", 1992). Children under age four that

weighed more than forty pounds now also needed to be restrained in a child safety seat. Additionally, the 1992 legislature increased the fine for a violation from \$25 to \$50.

The 2002 legislature mandated that effective July 1, 2002, child passenger safety restraints were required for children through the age of five (until their sixth birthday). All child safety restraints must continue to be properly used and meet standards adopted by the U.S. Department of Transportation except on public transportation (taxis, buses), school buses, and farm vehicles ("Acts of Assembly", 2002).

During the 2007 General Assembly, the Virginia legislature closed the remaining “gaps” in Virginia's Child Safety Seat Law. The legislature changed the law so that effective July 1, 2007 child restraint devices are required for children through the age of seven (until their eighth birthday). Additionally, the legislature mandated that children can no longer ride unrestrained in the rear cargo area of vehicles. The law applies to anyone who provides transportation for a child in any vehicle manufactured after January 1, 1968. The only exemptions are public transportation (taxis, buses), regulation school buses, and farm vehicles or if the child has a medical exemption from a Virginia licensed physician. The child passenger safety restraint law is primary enforcement, so no other violation need be committed prior to ticketing for failure to have a child in an approved seat. The civil penalty remains a \$50 fine for failure to have a child in a child safety seat. All fines collected go into the special fund to purchase safety seats for low-income families (Virginia Department of Health Division of Injury and Violence Prevention, 2008b).

## **Supporting a Change in the Law**

Virginia has a strong injury prevention advocacy network known as the Injury Prevention Network (IPN). This is a group of injury prevention professionals and stakeholders dedicated to reducing unintentional injuries and deaths throughout Virginia. Members of the IPN include the Virginia Department of Health (VDH), VA DMV, Safe Kids of Virginia, universities and colleges, hospitals, health care providers, police, fire and rescue, schools, child care centers, and countless others. This network provides and distributes education on child passenger safety through a variety of methods, including mail, email, lectures, seminars, newsletters, etc. When a change in the law occurs, the network members share the changes immediately through their already established methods of communication.

## **Education**

The lead agency for injury prevention in Virginia is the VDH Division for Injury and Violence Prevention (VDH DIVP). The VDH DIVP offers free educational resources (brochures, video, activity books, posters, etc) to anyone in the community. The VDH DIVP updates its resources and website immediately after a law has changed, and many of its resources are available in both English and Spanish.

Virginia is fortunate to also have a strong Safe Kids Program. The mission of Safe Kids is to prevent accidental injuries to children ages fourteen and under. Virginia has nine Safe Kids Coalitions and two Safe Kids chapters that actively work to prevent unintentional injuries in children. Each coalition or chapter addresses injury risk areas



that are significant in their area of the state. Most Safe Kids coalitions and chapters are involved with car seat safety checks to ensure children are properly restrained.

Education is an important component of injury prevention, but studies have not been successful in demonstrating that education alone increases the rate of booster seat use. One study found that education on booster seats in a pediatric emergency department did not convince parents to purchase and use booster seats. The research found that a combination of education along with the installation of a complimentary seat increased booster seat use (Gittelman, Pomerantz, & Laurence, 2006). Another study also found that education and a free seat being given to the family, if necessary, during a well-child visit significantly improved the rates of use (Quinlan, Holden, & Kresnow, 2007). The two aforementioned studies indicate that education is not enough to change behavior. However, education along with a complimentary booster seat increased the usage rate of booster seats. The question remained if the booster seats were being used appropriately. Pierce et al., evaluated the combination of education and a free booster seat giveaway and found that sixty-six percent of children were still inappropriately restrained even after the free seat was issued (Pierce, Mundt, Peterson, & Katcher, 2005).

### **Child Passenger Safety Seat Inspections**

According to the VDH DIVP and Safe Kids of Virginia, eighty percent of children riding in safety seats are at risk because they are not buckled in correctly (Miller-Hobbs, April 15, 2003; Virginia Department of Health Division of Injury and Violence Prevention, 2008a). Child safety seat inspections are a way to make sure

children are properly restrained. At an inspection, certified inspectors will inspect child safety seats that are installed in a vehicle and then make any necessary modifications so the seat is properly installed. The inspector will explain to the caregiver of the child why the changes were made and will offer best practice recommendations. Literature on child passenger safety, along with verbal education and hands on demonstration, are also provided at child safety seat checks.

### **The Low Income Safety Seat Distribution and Education Program**

An issue that needs to be considered regarding booster seat laws is that there is the possibility for such laws to burden low-income families (Apsler, Formica, Rosenthal, & Robinson, 2003; Cameron, Segedin, Nuthall, & Thompson, 2006). The potential for booster seat laws to impact the economically disadvantaged cannot be ignored and should be addressed in legislation mandating booster seat use (Bingham, Eby, Hockanson, & Greenspan, 2006).

The Commonwealth of Virginia addressed this concern with a low income safety seat distribution and education program that is currently located at the VDH DIVP. The Low Income Safety Seat Distribution and Education Program promotes, purchases, and distributes free child safety seats to eligible low-income families. The child safety seats are purchased using a collection of funds from child safety seat traffic infraction fines. According to the VDH DIVP, more than 102,000 safety seats have been distributed since 1996 at over 135 distribution sites statewide. Ongoing annual training, assistance, and refresher courses are provided to staff to enable the staff to educate safety seat recipients

about correct installation and use of child safety seats (Virginia Department of Health Division of Injury and Violence Prevention, 2008c). To qualify for a free child safety seat, Virginia applicants must meet all of the following conditions:

- Medicaid or FAMIS eligible or proof of meeting program income eligibility requirements
- Resident of Virginia
- Parent, legal guardian, or foster parent of the child
- Last trimester of pregnancy, or seat recipient must have children seven years old or younger who fit within the program safety seat manufacturer's guidelines
- Recipient of seat must be available to attend a safety seat installation and use class
- Sign a waiver of liability release form (Virginia Department of Health Division of Injury and Violence Prevention, 2008c).

## **Enforcement**

Enforcement of traffic safety laws has been effective in influencing the behavior of the public in a number of traffic safety areas, including restraint use (L. E. Decina & Lococo, 2005). The Decina and Lococo study identifies instances where parents and caregivers used the incorrect type of child safety restraint for the child's age, height and/or weight which was a violation of the child safety seat laws in many states. For example, it would be incorrect to use a booster seat for a twenty pound, two year old.

One critical piece to enforce correct restraint use is to have effective programs that make police aware of the importance of correct child restraint use and the age

requirements. Police presence also plays an important role in enforcement. Police and law enforcement agencies must take a role in child passenger safety restraint education programs. Many police officers are certified child passenger safety inspectors and provide car seat installation checks at their police stations or participate in child safety seat checks in their communities. Police presence encourages public compliance with the restraint laws, promotes driver and passenger restraint use, and most likely improves proper child safety seat use while presenting a positive public image of police and strengthening community relationships (L. E. Decina & Lococo, 2005).

There are also practical issues related to the enforcement of booster seat laws that need to be considered. Eligibility for booster seat use will be determined by state legislatures, and will be based on child age, height, weight, or some combination of these variables. The criteria that are selected will influence how police enforce the law. If height and weight are used, it is unlikely that police will carry a scale and measuring tape. If age is used, there is no way for police to know the age of the child since the majority of children do not carry any form of identification. The police will have to rely on the word of the person who is driving the vehicle. These details are important, as they could affect the ability of police to enforce the law (Bingham, Eby, Hockanson, & Greenspan, 2006).

If a state does not have a primary enforcement law, police authority to enforce belt laws is limited. Officers must have some other reason to stop a vehicle before citing an occupant for failing to buckle up. In Virginia, child passenger safety restraint laws are primary, but the seat belt law covering people over the age of sixteen is secondary.

According to a 2003 survey conducted by the National Highway Traffic Safety

Administration (NHTSA), sixty-four percent of the population supports primary enforcement of seat belts (Advocates for Highway and Auto Safety, 2008). In 2004, an Advocates Lou Harris Poll showed that eighty percent of Americans support primary enforcement seat belt laws (Advocates for Highway and Auto Safety, 2007). NHTSA also found that fifty-nine percent of people believe the fine for not using a child safety seat should be \$50 or greater while thirty-nine percent believe the fine should be \$100 or greater (Garrison, Harris, Garrison, Vaca, & McKay, 2005).

Primary enforcement states' seat belt use rates are approximately nine percent higher than their secondary enforcement counterparts (Houston & Richardson, 2005). By upgrading from secondary to primary enforcement it has been estimated that states could increase belt use by ten percent, reducing injuries and fatalities (Houston & Richardson, 2006). One NHTSA study estimated that 5,390 lives could have been saved between 1996-2003 if secondary enforcement states would have been primary enforcement (Advocates for Highway and Auto Safety, 2008). Another study on the effect of changing from a secondary law to a primary enforcement law found that an estimated 696 deaths per year could have been prevented if all secondary enforcement states (twenty-eight existed at the time of the study) had upgraded to primary (Farmer & Williams, 2005).

### **So Why Are Some Children Still Not Restrained Properly?**

NHTSA recommends using booster seats once children have outgrown their child safety seats due to the unquestionable safety benefits booster seats provide (National

Highway Traffic Safety Administration, November 2005). Nevertheless, rates of booster seat use remain low (Durbin, Elliott, & Winston, 2003; Ebel, Koepsell, Bennett, & Rivara, 2003a; Ramsey, Simpson, & Rivara, 2000). Many parents do not realize the importance of changing child safety seats as their children grow, and do not realize the risk that standard, adult-sized seat belts can pose (Berns & Vaca, 2001).

According to one NHTSA study, fewer than half the parents and caregivers (forty-eight percent) reported being aware of booster seats and had no concerns about booster seat safety. This means the majority of parents or caregivers (fifty-two percent) were either unaware of booster seats or had concerns about the safety of booster seats (Berns & Vaca, 2001).

An observational study of 149 children in day cares in the greater Seattle area found that only ten percent of children ages six through eight were in a booster seat (Ramsey, Simpson, & Rivara, 2000). In the study, more than one half of the children's parents who did not use booster seats actually owned booster seats. Although some parents noted that some booster seats were just too difficult to use, the most common reason for lack of booster seat use was parental perception that their child was large enough to use a regular seat belt (Cameron, Segedin, Nuthall, & Thompson, 2006; Kunkel, Nelson, & Schunk, 2001; Ramsey, Simpson, & Rivara, 2000; Rivara et al., 2001; Simpson, Moll, Kassam-Adams, Miller, & Winston, 2002).

Many parents do not know the approximate weight and height of their children when asked, but they know their children's ages (Apsler, Formica, Rosenthal, & Robinson, 2003; Cameron, Segedin, Nuthall, & Thompson, 2006; Ebel, Koepsell,

Bennett, & Rivara, 2003a; Staunton et al., 2005). Recommendations based on weight and height may be ignored since parents may not think the recommendations apply to their children. Recommendations based on age avoid the potential for confusion, but one should remember that age is a crude substitute for height and weight in assessing appropriate use of child passenger safety restraints (Apsler, Formica, Rosenthal, & Robinson, 2003).

Parents also indicated that the cost of purchasing booster seats and resistance from children to use the booster seats were barriers (Medoff-Cooper & Tulman, 2007; Rivara et al., 2001; Simpson, Moll, Kassam-Adams, Miller, & Winston, 2002). Cost of child safety seats has frequently been cited as a reason why low socio-economic and minority children are unrestrained (Apsler, Formica, Rosenthal, & Robinson, 2003; Hendrie et al., 2004; Lee, Fitzgerald, & Ebel, 2003; Rivara et al., 2001).

Availability and affordability of child safety seats could have a significant role in preventing childhood injuries. One challenge is to identify the best way to promote their use. The data reported in one study regarding availability and affordability patterns imply that some children face serious risk as a result of the income level of their household or country (Hendrie et al., 2004). The authors of the study suggest that a moral obligation exists to offer all children a fair chance of surviving to adulthood by providing affordable safety devices, regardless of their ability to pay.

Reasons that can be given to parents to use booster seats include the fact that children who are restrained are better able to see out of the car window and may be more manageable and content passengers (M. J. Bull & Sheese, 2000). In addition, booster

seats can make children more comfortable by reducing the discomfort of poorly fitting shoulder belts and by reducing the risk of injury from ill-fitting lap belts (F. K. Winston, Durbin, Kallan, & Moll, 2000).

### **NHTSA Observational Study**

The National Survey of Use of Booster Seats (NSUBS), conducted by the NHTSA National Center for Statistics and Analysis, is the only probability-based nationwide child restraint survey that observes restraint use and collects age, height, and weight information (Glassbrenner & Ye, January 2008a). While the primary purpose of NSUBS is to estimate booster seat use, it also provides estimates of which children are “prematurely graduated” to restraint types that are inappropriate for their height or weight. The 2007 survey found premature graduation for all types of child restraints from infant seats to booster seats. For example, the 2007 NSUBS findings include:

- About one-fifth (nineteen percent) of children under the age of one were not in rear-facing seats.
- About one-quarter (twenty-three percent) of children less than twenty pounds were not in rear-facing seats.
- Over one-quarter (twenty-eight percent) of children under the age of one or less than twenty pounds were not in rear-facing seats.
- Almost half (forty-four percent) of children twenty to forty pounds were not in front-facing safety seats. Note, however, that some twenty to forty pound



children could be infants who should be in rear-facing safety seats, and some booster seats have weight limits as low as thirty pounds.

- Over half (fifty-six percent) of children age twelve and younger and thirty-seven to fifty-three inches tall were not in child safety seats or boosters seats.
- About eight in ten (eighty-six percent) of children age twelve and younger and fifty-four to fifty-six inches tall were not in child safety seats or boosters seats. It is important to remember that these children are within two inches of the 4'9" minimum height recommendation
- Restraint use dropping from forty-one percent in 2006 to thirty-seven percent in 2007 among children ages four to eight. The decrease could be due to improved training of NSUBS data collectors on what is "use" for forward facing seats and booster seats prior to conducting the 2007 survey (Glassbrenner & Ye, January 2008a).
- In 2007, forty-six percent of children ages four to six years old were restrained in a booster seat. The rate of booster seat use in children ages six and seven decreased from thirty-six percent in 2006 to twenty-five percent in 2007 (Glassbrenner & Ye, January 2008c).

The 2007 NSUBS survey also found that child passenger safety restraint use rates tended to be higher among white and Asian non-Hispanic children, compared to other racial and ethnic groups. The survey found that Hispanic children under the age of thirteen have lower restraint use rates than non-Hispanic children. A decrease in restraint

use, from ninety-two percent in 2006 to seventy-five percent in 2007, among Hispanic four to eight year olds was found (Glassbrenner & Ye, January 2008b). Again, the decrease could be due to NSUBS data collectors receiving additional training on what is “use” for forward facing seats and booster seats prior to conducting the 2007 survey (Glassbrenner & Ye, January 2008a).

The NSUBS survey is an observational study of child passenger safety restraint use and therefore does not have to address the concern of self-reported booster seat use and ownership. The differences sometimes found between observational studies and self report studies are significant. One such study found that almost twenty-eight percent of self-report participants said they used booster seats, yet only ten percent were observed to have their child or children restrained at the time of the interview (Ramsey, Simpson, & Rivara, 2000). It could be that part-time booster seat users contribute to differences between observed and self-reported use because they may be observed not using a booster seat, but respond affirmatively when asked if they use booster seats (Bingham, Eby, Hockanson, & Greenspan, 2006). Another difference in observations and self reports may be that people want others to think that they are doing all they can do to protect their children when in reality they knowingly may not be doing what is recommended as the safest.

### **Health impact**

The injuries associated with children using vehicle seatbelts can be associated with significant health care costs and hospitalizations (Arbogast et al., 2007). Children

restrained with safety belts are three and a half times more likely than children placed in booster seats to be injured and over four times more likely to experience head trauma (F. K. Winston, Durbin, Kallan, & Moll, 2000). Proper use of child passenger safety restraints is capable of reducing the extent of child injuries and fatalities on highways (Corden, 2005; F. K. Winston, Durbin, Kallan, & Moll, 2000; Zaza, Sleet, Thompson, Sosin, & Bolen, 2001). The literature indicates that laws are an effective and immediate way of increasing the use of child restraints (E. B. Desapriya, Iwase, Pike, Brussoni, & Papsdorf, 2004; F. K. Winston & Durbin, 1999).

### **Implications for Legislation**

Findings from one study indicate that booster seat legislation would be effective across the entire population of parents with booster seat aged children (Bingham, Eby, Hockanson, & Greenspan, 2006). A statewide random sample study of 350 Michigan households with children between the ages of four and eight found that booster seat legislation was a key determinant of the level of use and the motivation to use booster seats (Bingham, Eby, Hockanson, & Greenspan, 2006). In the study, almost seventy percent of part-time booster seat users said they believed it was mandated, while almost sixty percent of part-time and non-booster seat users said they would be more likely to use booster seats if legally required. Over ninety percent of part-time and non-booster seat users said it would be simpler for them to use booster seats if a law required it, and non-users were almost six times more likely than part-time users to agree that a law would make it easier to use booster seats.

The conclusion that legislation would increase booster seat use is also supported by the effect of legislation on the use of other safety restraints. Safety belt use increases when legislation requiring that they be used is passed, and is especially effective if the legislation allows for primary enforcement of the law (Eby, Molnar, & Olk, 2000; Eby, Vivoda, & Fordyce, 2002). Increased restraint use has also followed the passage of legislation requiring the use of infant and toddler passenger safety restraints (Phelan et al., 2002; Rock, 1996).

### **Booster Seat Age Children and Restraint Use**

From 2000-2003, nearly half of the children between the ages four and eight killed in crashes were completely unrestrained (National Highway Traffic Safety Administration, November 2005). Data collected from the Partners for Child Passenger Safety study, an on-going child focused crash surveillance system, identified adult seat belts as the most common form of restraint for children ages five through nine years old (F. K. Winston, Chen, Elliott, Arbogast, & Durbin, 2004). Wearing an adult seat belt or using a booster seat greatly reduces the risk of fatality to children between the ages of four and eight (National Highway Traffic Safety Administration, 2002b) when compared to riding unrestrained. A survey of parents of 4,243 children involved in crashes found that among four to seven year olds, the odds of injury were fifty-nine percent lower when riding in belt positioning booster seats than when using a seat belt alone (Durbin, Elliott, & Winston, 2003).

Premature graduation of children to adult seatbelts, failure to use booster seats, and absence of any restraints increases with children ages four to eight as they grow older (Apsler, Formica, Rosenthal, & Robinson, 2003). One study found that nearly all (ninety-five percent) of the 8,344 children in the study sample were restrained, according to their parents, but many children were prematurely graduated from a child safety seat and placed in a booster seat or vehicle seatbelt. Use of booster seats in this study reached their maximum at age three (twenty-nine percent of parents reported use) and then decreased with each following year of age to the point where less than one percent of the children in the crashes ages five through eight were reported to have been restrained properly in booster seats when injured (F. K. Winston, Durbin, Kallan, & Moll, 2000).

### **Disparities**

Studies have documented that Hispanic and African American children and teenagers are at greater risk from motor vehicle crash fatalities than Caucasian children (Baker, Braver, Chen, Pantula, & Massie, 1998). Socioeconomic status also has an affect on safety restraint usage. Children from lower income families are less likely to be secured in age appropriate child passenger safety restraints. An explanation for this may be related to the cost of the child safety seat or booster seat since the seat is not included in the vehicle and would require additional funds that a low income family may not be able to afford (Angulo-Vazquez & De Santis, 2005).

As policymakers seek to improve health outcomes and access to effective preventive interventions and to reduce disparities in health as part of Healthy People

2010 (U.S. Department of Health and Human Services, 2000), childhood injury remains an important and often underemphasized component. One study estimated the cost of a booster seat at \$30 plus \$167 for maintenance and time spent on installation and use. The \$197 investment in a booster seat is estimated to save \$1,854 in medical spending, work loss, quality of life lost, and other resource costs per seat. The cost-benefit analysis above demonstrates that preventing injuries costs less than treating them. The 9.4 to 1 rate of return demonstrates that booster seats are worth the investment to protect children while in a motor vehicle (T. R. Miller, Zaloshnja, & Hendrie, 2006). For example, programs like the VDH DIVP Low Income Safety Seat Distribution and Education Program realize that the provision of a child safety seat for a child who cannot afford one is less expensive than the injuries that might be sustained if the child were in a motor vehicle crash without a child safety seat.

### **Impact of Legislation on Injuries and Fatalities**

#### 1991 Virginia Seat Belt Study

Many studies have been conducted to see if seat belt legislation reduces injuries and fatalities from motor vehicle crashes. A 1991 study of motor vehicle crash injury patterns before and after Virginia's seat belt law took effect on January 1, 1988 found a significant reduction in nonfatal injuries post-law (Lestina, Williams, Lund, Zador, & Kuhlmann, 1991). Police records were used to obtain information about the crash and a follow up call was made to the driver or owner of the vehicle involved in the crash. Additionally, University of Virginia (UVA) Hospital Emergency Department records,

UVA Hospital discharge records, and Office of the Medical Examiner death records were utilized for information regarding injuries. The study had several limitations.

One concern is that hospital discharge data may contain misleading information. Hospital discharge data may have multiple records for a patient for the same injury (Division of Injury and Violence Prevention, 2006; Du, Finch, Hayen, & Hatfield, 2007; Lyons et al., 2008). An injured person may have been admitted and discharged from a hospital on several occasions for the same injury. For example, the individual may be transferred from a different hospital, have a readmission for follow up care, or have unexpected complications after discharge requiring readmission. As a consequence the count of hospital discharges may be inflated (Du, Hayen, Finch, & Hatfield, 2008). Du et al., suggest that a unique identifier and a date of injury field be added to hospital datasets, but those variables may not be provided to researchers because of confidentiality issues. Another potential problem with hospital data, whether emergency room or discharge, is incomplete coding (Division of Injury and Violence Prevention, 2006; Lyons et al., 2008). Complete, consistent, and accurate coding is critical if the data within the database is to be considered reliable.

Another limitation acknowledged by the Virginia study authors was that the injured occupants self-reported seat belt use, which may draw into question the reliability of the study. People are more likely to over report restraint use than under report it since they would be confessing to a violation of the law. Therefore, the increase in seatbelt use of thirty-five percent one year pre-law and fifty-seven percent one year post-law is potentially inaccurate. A longer time frame would have provided results that were more

credible since additional time post-law would help separate rival causes that could have produced the results. Based on estimates from NHTSA on seatbelt effectiveness of reducing injuries, the 1991 Virginia seat belt study change in seat belt use, if accurate, would predict an eleven percent decrease in fatal injuries, a thirteen percent decrease in moderate to critical injuries, and a two percent decrease in minor injuries (Lestina, Williams, Lund, Zador, & Kuhlmann, 1991). Another limitation is that the study results were from a narrowly defined population. The study evaluated only front seat occupants ages five and older, in a car less than eight years old, involved in a crash where the car needed to be towed away in the Charlottesville, VA area. We may not be able to generalize these results to all crashes statewide.

#### 1991 Multi-state Seat Belt Study

The 1991 multi-state seat belt study subjected nine statewide crash databases to time series analyses to detect if there were changes in injuries associated with the passage of seat belt laws in their respective states (Campbell, Stewart, & Reinfurt, 1991). The authors indicate that advantages accrue from using a statewide database since there are a large amount of data. Having a large dataset offers a better chance to detect a significant change in the number of injuries that occur after a law is implemented (Campbell, Stewart, & Reinfurt, 1991). One disadvantage of using the nine state databases was that data elements varied from state to state, as did reporting practices. The authors selected data from large states that had many years of post-law data and had found an increase of seat belt use post-law. However, seat belt status was not analyzed since the authors state



that with the onset of seat belt laws and the threat of a ticket, they find it inappropriate to rely on self reported seat belt status in crash data since there is evidence that people often claim they were belted when they were not (Campbell, Stewart, & Reinfurt, 1991). The authors explain that different analyses, primarily injury percentages but sometimes injury frequencies, had to be conducted for different states based on what data was available. Tests were conducted on “covered drivers,” those subject to the belt law once in effect, and compared them with those “not covered by the law” (i.e. pedestrians, cyclists, and rear seat occupants). The overall findings of the Campbell study were that after the seat belt law was enacted, states generally saw a significant reduction in motor vehicle injuries, beginning in the same month that the law or its enforcement went into effect.

#### Multiple Michigan Child Safety Restraint Studies

Michigan implemented a mandatory seat belt law for children under the age of four in April, 1982 with the goal of increasing restraint use and decreasing motor vehicle crash injuries to children. Children under the age of four were required to be restrained by a child safety seat when traveling in a motor vehicle. The vehicle seat belt was a permissible substitute for a child safety seat for children ages one, two, or three as long as children were in the rear seat of the vehicle. A series of three studies were conducted by Wagenaar to examine if Michigan achieved its goal of protecting children less than age four. The 1984, 1986, and 1987 studies measured the degree to which restraint use and injury post-law were different from the expected values, based on the pre-law data.

Each of the three studies included six comparison age groups (ages 4-15, ages 16-17, ages 18-24, ages 25-34, ages 35-54, and ages 55+) of occupants in motor vehicle crashes to increase confidence that observed changes in restraint use or injuries were a result of the law and not due to coincidental factors. If observed changes in restraint use and injuries were due to the law, the main effects of the law should have been limited to the target population, children under age four with the possibility of a spillover effect in older children (Wagenaar, Maybee, & Sullivan, 1987).

A limitation of the Wagenaar studies is that restraint use was based on police records. In January 1982, three months before the Michigan law went into effect, the police added a separate code for child restraint use to their existing seat belt use codes on their crash report form. The addition of the child restraint use code may have increased police officers awareness of child safety seats and may have caused an increase in police reported child passenger safety restraint use, independent of any change in actual usage rates (Wagenaar, 1984). Police officers, if not sure about restraint use, may have relied on the drivers self reporting use or non-use of child safety seats which is a potential problem of the study. One effect of the restraint laws is an increase in the number of drivers that report that they and their passengers were restrained when in fact they had not been, since reporting non-use of restraints would be admitting to a violation of the law, as discussed previously. Additionally, correct versus incorrect use of child safety seats is not documented on police reports. Police reports only record if a child safety seat was used. At the time of the studies, up to seventy percent of all child safety seats were being used incorrectly (Wagenaar, 1984).

The 1984 study evaluated the initial short-term effectiveness of the child passenger safety restraint law in the state of Michigan utilizing data from January 1978 through December 1982, fifty-one months pre-law and only nine months post-law. The analyses revealed a significant increase from twelve to thirty-six percent in restraint use for the one, two, and three year olds group and a seventeen percent decrease in motor vehicle crash injuries after implementation of the law. For children less than age one the sample was too small to determine if there was a change in restraint use, but the authors did claim to find a fifty percent decrease in injuries for children less than age one. The only comparison group with significant injury reduction findings was the thirty-five through fifty-four year old age group, which the authors state may just be “random fluctuations” (Wagenaar, 1984). Significant increases, although much smaller than in children ages one, two, and three, in restraint use were also found in three comparison groups (ages 4-15, ages 18-24, and ages 55+). The authors acknowledge the possibility of spillover creating the significant findings in the comparison groups but also state that the findings could again just be “random fluctuations.”

The 1986 follow-up study included twenty-one months post-law data, an additional twelve months post-law data than the 1984 study used. The 1986 study found the number of children less than age four restrained while injured in a motor vehicle crash increased almost three hundred percent, from twelve percent before the law to fifty-one percent after the law went into effect (Wagenaar & Webster, 1986). Along with the increase of restraint use, injuries decreased twenty-five percent in motor vehicle occupants less than age four after the law was implemented (Wagenaar & Webster,

1986). The comparison group of children ages four to fifteen revealed a spillover effect in restraint use. The authors called the 131 percent increase, from six percent pre-law to fourteen percent post-law, in restraint use for the four to fifteen year old comparison group “small compared to the change found in the children less than age four.”

In the 1986 study, it was also found that the child passenger safety restraint law was more effective in reducing the number of mild and moderate injuries to children less than age four than those having severe or fatal injuries. Several explanations were offered. One explanation was that the post-law increase in child restraint use was greater in children in less severe crashes than those in more severe crashes. Another explanation was the high rate of improper child restraint use. It was hypothesized that an improperly used child restraint may offer protection in minor crashes but fail to protect children from injury in more severe crashes. The authors also indicate that there is some evidence that child safety restraint laws may be associated with a decrease in the number of children riding in the front seat (Wagenaar & Webster, 1986). This possible change in seating position from the front seat, which is considered more dangerous than the rear seat, was also offered as a potential explanation for the reduction in injuries.

In 1987, the long term effect of the Michigan child passenger safety law on injuries was analyzed. Michigan State Police injury data from January 1978 through December 1985, which included fifty-one months of pre-law data and forty-five months of post-law data, were used. The study found a twenty-eight percent reduction (from 180 to 133 per month) in the frequency of injured children less than age four along with a smaller percentage spillover in the group of children ages four to fifteen. Based on these

results, the authors estimated the law prevented injuries to 552 children less than age four per year.

#### 1985 California Child Safety Restraint Study

In 1983, California passed a Child Passenger Restraint Law that required children less than age four to be restrained in child safety seats. Utilizing monthly motor vehicle crash data from the California Highway Patrol Public Affairs Office, a time series analysis was conducted to evaluate the impact of the law on the number of children injured or killed by motor vehicle crashes before and after the law went into effect (Guerin & MacKinnon, 1985). The study used a comparison group of California children ages four through seven and a comparison group of Texan children less than age four since Texas did not have a child passenger safety restraint law at the time. Sixty months of pre-law data and twelve months of post-law data, 1978-1983, revealed an eight percent decrease in the number of motor vehicle injuries to the California children less than age four but no change in the control California group of four through seven year olds or the control Texan children less than age four. The number of fatalities in both California groups and the Texas group did not change after the law went into effect. A possible explanation could be that the time series analysis used a short time frame and the number of monthly fatalities for the children less than age four was approximately four per month. The study authors cautioned that laws may not lead to reduction in injuries in other states, as found in California, since California had strict requirements and penalties.

In considering the Guerin and MacKinnon study, some of the limitations must be discussed. As in previously reviewed studies, a limitation is the use of police records. A concern is that the impact of the child passenger safety law on the severity and patterns of injury is not reflected in the police records (Agran & Wehrle, 1985). Police in almost every state use the same classification system for injury on their crash records (T. Miller, Zaloshnja, & Sheppard, 2002). Research has demonstrated that the police report injury classification system is coarse and inconsistently coded between states and over time (T. Miller, Zaloshnja, & Sheppard, 2002). For example, in California the crash report form calls only for a very basic measure of injury. There could be a complaint of pain to visible injury based on the individual judgment of the police officer. Although it is expected to see fewer serious injuries and generally less severe injuries as more children travel restrained, police reports may not reflect all the specifics of the injury.

Another limitation of the study is that “it is assumed that all fatal and injury accidents were reported” to the police. Research indicates that not all motor vehicle crash injuries are reported to the police (Lyons et al., 2008). A trauma study conducted in Ohio hospitals found that the injury rate from motor vehicle crashes was almost one and a half times higher than the official police statistics (Barancik, Chatterjee, Greene, Michenzi, & Fife, 1983). Another study analyzed a sample of 1,200 motor vehicle crash patients treated in a hospital in Birmingham, England, and found that approximately one-sixth of serious injuries and one-third of minor injuries did not appear in the official police statistics (J. Bull & Roberts, 1973). An additional study found that thirty-six percent of the children involved in motor vehicle crashes and treated at one of eleven

emergency rooms in Montreal had not been reported to police (Stulginskis, Pless, & Frappier, 1983).

The eight percent decrease in injuries reported by Guerin and MacKinnon could have been attributed to factors other than the child safety restraint laws. During the time of the Guerin study, there had been a decrease in the number of overall motor vehicle traffic injuries in California (Agran & Wehrle, 1985). Agran and Wehrle suggest it is possible that the decrease in child passenger injuries could be a trend or due to an increase in restraint use. However, at the time of the 1985 study, California traffic crash report forms did not include restraint use, so it was not possible to determine the degree of use.

#### 1987 Multi-state Child Safety Restraint Study

In a 1987 multi-state study, Wagenaar et al., evaluated the effects of child passenger safety restraint laws on traffic fatalities in eleven states. To avoid the problem of a small number of fatalities, the study aggregated fatalities from eleven states that implemented child passenger safety restraint laws between July 1980 and January 1983. The data was summed across the eleven states for fifty-four months before the state law went into effect and twelve months after the law went into effect. Therefore, the monthly fatality count does not correspond to an actual month of time but represents a month relative to the implementation of the law in each state (Wagenaar, Webster, & Maybee, 1987). The authors utilized time series analysis methods to address trend and seasonal patterns. However, it is not explained how this was possible since time was represented

by a month relative to the implementation of the law and did not correspond to an actual month of time across all states.

To build confidence in the findings, the 1987 multi-state study included control groups of older motor vehicle occupants not affected by the child safety restraint law. The authors of the study had concern about spillover effect of the law on the control group, children ages five to fifteen. To address the concern, an additional control group of people ages sixteen and older was included.

Another concern was that the size of the population at risk may have changed over the study time frame. The study controlled for a possible change in the population by analyzing the monthly rate of fatalities per 100,000 (Wagenaar, Webster, & Maybee, 1987). U.S. Census Bureau population estimates were used to calculate rates of fatalities per 100,000. The study found no statistically significant decrease in the number of fatalities to children covered by the law after the implementation of a child safety restraint law.

The finding of no reduction in the number of fatalities is consistent with other studies of child fatalities after a law was implemented (Guerin & MacKinnon, 1985; Wagenaar & Webster, 1986). Wagenaar et al., hypothesized that the low frequency and high variation of fatalities, an average of almost nine per month per state ranging from two to eighteen, was the primary reason no significant effect of child safety restraint laws on fatalities in the eleven states was found (Wagenaar, Webster, & Maybee, 1987). The authors advised that evaluations of child safety restraint laws should include analyses of



motor vehicle crash injuries, as well as fatalities, to determine the effectiveness of the laws.

In the 1987 Wagenaar multi-state fatalities study, California accounted for almost half of the cases and may have skewed the findings. Previous research on the California child safety restraint law found that motor vehicle crash injuries decreased only eight percent for children less than age four after the law went into effect (Guerin & MacKinnon, 1985). Wagenaar et al., did not find the California eight percent decrease as much of a success as the authors of the California study did. The eight percent decrease is significantly less than the twenty-five percent decrease in injuries found in the 1986 study of Michigan children less than age four (Wagenaar & Webster, 1986; Wagenaar, Webster, & Maybee, 1987). Authors speculated that the California law may have been less effective than in other states due to socio-demographic factors in the state, the level of restraint use prior to the law being implemented, the type and publicity about the law, and enforcement of the law (Wagenaar, Webster, & Maybee, 1987). The small change in fatalities may also be due to children not using restraints or using them inappropriately even after the law went into effect. Child safety restraints may protect children in minor crashes even if the restraints are used incorrectly but the restraints may not adequately protect children in severe crashes that cause a fatality (Wagenaar, Maybee, & Sullivan, 1987).

As indicated in the 1987 Wagenaar study, analyses of motor vehicle injuries and fatalities must take into account the factor of possible misuse of child restraints. Study findings of up to eighty percent child safety restraint misuse have been published (L. E.

Decina & Lococo, 2005; Eby, Bingham, Vivoda, & Rangunathan, 2005; Howard, Beben, Rothman, Fiissel, & MacArthur, 2006; Kunkel, Nelson, & Schunk, 2001; Lesire, Cuny, Alonzo, Tejera, & Cataldi, 2007; Morris, Arbogast, Durbin, & Winston, 2000; Quinlan, Holden, & Kresnow, 2007; Rangel, Martin, Brown, Garcia, & Falcone, 2008; Shepherd, Hamill, & Segedin, 2006; Vesentini & Willems, 2007; F. K. Winston, Durbin, Kallan, & Moll, 2000). For example, children are often improperly harnessed into the child safety restraint or the restraint is not properly secured to the vehicle with the vehicle seat belt. The implications of child restraint system misuse in terms of injury have been demonstrated in crash testing and in real life crashes. Many inappropriately restrained children have been injured. Although the injuries often tend to be minor, the full benefit of increased child safety restraint use is not achieved.

#### 1986 New Mexico Child Safety Restraint Study

The 1986 New Mexico study evaluated the New Mexico child passenger safety restraint law that went into effect June 1983. The law required the use of a child passenger restraint for children less than age five while riding in a vehicle registered in New Mexico. Children older than age one could be restrained by a seat belt in the rear of the vehicle. Utilizing traffic crash data from January 1981 through September 1984, thirty months pre-law and fifteen months post-law, injury and fatality rates were calculated. A comparison group of children ages five through twelve, those not protected by the law, was used as a control group. For children less than age five, there was a thirty-three percent reduction in fatality rates and a thirteen percent reduction in injury

rates after the restraint law went into effect. The control group of children ages five through twelve had an almost forty-four percent increase in fatality rates and an almost four percent increase in injury rates (Sewell, Hull, Fenner, Graff, & Pine, 1986). The authors indicate that the large increase in fatalities was not statistically significant (Sewell, Hull, Fenner, Graff, & Pine, 1986). Authors reviewed total number of reported traffic crashes, vehicle miles traveled, and population estimates for the children during the study time frame and found little change over the four years.

Limitations included possible uncontrolled temporal changes in the nature of crashes, unexpected effects of the law, and possible unreported crashes. New Mexico transportation authorities estimate unreported crashes in New Mexico to be less than five percent since those crashes involve only minor personal property damage or occur on private property and therefore are not required to be reported to police (Sewell, Hull, Fenner, Graff, & Pine, 1986). Also, the New Mexico law allows children over the age of one to utilize the vehicle seat belt. This requirement of the law does not fully protect children. New Mexico has updated their law and now requires children younger than age one to use a rear-facing infant seat; children ages one through four or less than forty pounds to use a child safety seat; and children ages five and six or less than sixty pounds to use a booster seat (Insurance Institute for Highway Safety, 2008).

#### 1996 Illinois Child Safety Restraint Study

In a 1996 study, the impact of the Illinois child passenger restraint law that went into effect July 1983 was evaluated. The law required parents to restrain children less

than age four in a child safety seat and children ages four and five in seat belts or child safety seats. A monthly time series analysis was conducted using forty-two months of pre-law data and forty-two months of post-law data (1980-1986). Due to the low number of fatalities, fatalities and injuries were combined to obtain more meaningful results. The study found that the Illinois child safety restraint law significantly reduced injuries in children less than age five (Rock, 1996). Comparison control groups did not show any change in injuries making it appear that the law reached the target age group and that there were no rival causes. The authors wanted to expand the scope of the study but were hindered since only total injuries were available by age bracket and injury severity information was not known (Rock, 1996).

#### 2004 and 2008 Japanese Child Safety Restraint Studies

A 2004 Japanese study did a preliminary evaluation of the effect the April 2000 Japanese child passenger safety legislation on injuries of child passengers ages one through five. The Traffic Crash Database maintained by the Traffic Bureau of the National Police Agency and the Institute for Traffic Accident Research and Data Analysis of Japan, was used for the study since it contains all reported traffic crashes, injuries, and fatalities. Although not mentioned as a shortcoming, one can presume the Japanese study had similar limitations of incomplete and inaccurate data as found in similar United States studies. The study used data from 1997-2002, three years pre-law and three years post-law. The law required children from birth through age five to be restrained in a child safety seat. Children less than age one were omitted from the study

since they are required by the law to be rear facing until they are at least one year old and at least nine kilogram, approximately twenty pounds (E. B. Desapriya, Iwase, Pike, Brussoni, & Papsdorf, 2004).

The 2004 study found that serious injuries and fatalities among children ages one through five involved in a motor vehicle crash did not decrease after a child safety restraint law went into effect in April 2000 (E. B. Desapriya, Iwase, Pike, Brussoni, & Papsdorf, 2004). An unexpected finding was that minor injury rates among child passengers increased after the legislation. As a control, the study used pedestrian casualties, ages one through five, since the legislation should not have made an impact on this group. The study did not measure the same thing by using a control group of pedestrians for a study evaluating injury of motor vehicle crash occupants. There was no significant change in the pedestrian casualties before and after the legislation.

The 2004 study found an overall increase in the use of child safety seats. The lack of injury and fatality rate reduction was explained as being due to incorrect use of the seats. The authors suggested that educational and promotional activities along with stricter enforcement of the law might assist with reducing injuries. Additionally, Japan has minor penalties for incorrect use of or failing to use a child safety restraint. If a violation occurs, there is usually no monetary fine and only one demerit point is given. Authors also noted that child restraints cost approximately \$400 U.S. dollars which is expensive and could deter the purchase of a seat. Another limitation was that the time frame was short (1997-2002). Additional analysis may help explain the increase in minor injuries to child passengers after the law went into effect.

As a follow-up to the 2004 Japanese study, Desapriya et al., conducted a study utilizing data from 1994-2005, six years pre-law and six years post-law, and included all children from birth through age five. As in the 2004 study, it was found that the April 2000 child safety restraint law did not result in any significant reduction of child injuries and fatalities in Japan post-law (E. Desapriya, Fujiwara, Scime, Babul, & Pike, 2008).

The 2008 study identified a limitation related to the data that was used that was not mentioned in the 2004 study. The data was provided by calendar year not by month or quarter. Since the law went into effect April 1, 2000, the study decided to make the pre-law data time frame January 1, 1994 - December 31, 1999 and the post-law time frame January 1, 2000 - December 31, 2005. Another detail was that the law does not require children to be in the rear seat of the vehicle, which has long been established as the safest place for children (Reeve, Zurynski, Elliott, & Bilston, 2007). The research found that children are still riding in the front seat of vehicles either incorrectly restrained or not restrained, and dangerously close to airbags.

#### Partners for Child Safety project/Children's Hospital of Philadelphia

Much child passenger safety research has come out of the Children's Hospital of Philadelphia demonstrating that child safety seats reduce injury and save lives (Arbogast et al., 2007; Durbin, Elliott, & Winston, 2003; Nance et al., 2004; F. K. Winston, Chen, Arbogast, Elliott, & Durbin, 2003; F. K. Winston, Chen, Smith, & Elliott, 2006). Several studies utilize a unique dataset from the Partners for Child Safety project. The Partners for Child Safety project is a large scale, child specific crash surveillance system utilizing

State Farm Insurance claims as a source of subjects and on-site crash investigations with telephone surveys as the primary source of data. Only State Farm insured vehicles, model years 1990 or newer, and having an occupant less than age 16 are included in the dataset. Data are limited to crashes that occurred in 15 states and the District of Columbia, representing 3 large regions of the United States (F. K. Winston, Kallan, Elliott, Xie, & Durbin, 2007). If policyholders consent to be included in the database, then limited information related to them and their crash is electronically transferred for inclusion in the Partners for Child Safety project database (Nance et al., 2004; F. K. Winston, Chen, Arbogast, Elliott, & Durbin, 2003; F. K. Winston, Kallan, Elliott, Xie, & Durbin, 2007).

While the Partners for Child Safety project is an exceptional source of data, there are some limitations. Older vehicles and uninsured vehicles are not included in the data so any results found may not be generalizable to occupants of older uninsured vehicles. Additionally, surveillance information is collected by telephone interview of the parent or driver and there is a potential for recall bias or incorrect report of restraint use.

#### 2007 Multi-state Partners for Child Safety project Child Safety Restraint Study

One study utilizing the Partners for Child Safety project database compared age appropriate restraint use for children ages four through seven involved in a motor vehicle crash in states with booster seat laws versus states without booster seat laws. The study included data from December 1, 1998 through December 31, 2004 and included only vehicles with children ages four through seven with a driver at least sixteen years of age

(F. K. Winston, Kallan, Elliott, Xie, & Durbin, 2007). A total of 16,433 subjects completed the full telephone survey, representing an inclusion rate of fifty-two percent of eligible subjects (F. K. Winston, Kallan, Elliott, Xie, & Durbin, 2007). Researchers created two variables about booster seat law status at the time of the crash. The first variable was if a booster seat law was or was not in effect at the time of the crash. The second was a three level variable indicating if the law applied to children ages four through seven, if the law applied to children ages four and five, or if no law was in effect (F. K. Winston, Kallan, Elliott, Xie, & Durbin, 2007). The study found that during the time frame appropriate restraint use increased for children involved in a motor vehicle crash. Findings included that children ages four through seven in states with booster seat laws were thirty-nine percent more likely to be reported as appropriately restrained than children ages four through seven in states with no booster seat law. The effect of the law varied depending on the age of the children. Children ages four and five were twenty-three percent more likely to be appropriately restrained and children ages six and seven were twice as likely to be appropriately restrained if the state had a law (F. K. Winston, Kallan, Elliott, Xie, & Durbin, 2007). Overall, the study found that the effect of a booster seat law was stronger when the law included children ages four through seven than when the law included only children ages four and five.

Winston et al., acknowledge the limitations discussed above related to the use of the Partners for Child Safety project database. Additionally, since the study was voluntary, only half of the cases meeting the inclusion criteria chose to participate, which could potentially lead to selection bias and incorrect self-reporting of restraint use (F. K.



Winston, Kallan, Elliott, Xie, & Durbin, 2007). Another concern related to Winston's 2007 booster seat law study is that the authors incorrectly identified the effective date of Virginia's law. The authors have Virginia's booster seat law going into effect January 1, 2004 when the law really went into effect July 1, 2002, eighteen months earlier than the authors documented in the study.

Child passenger safety restraint laws that support the best practice guidelines have been shown to be one of the most effective ways for increasing child restraint use (Cameron, Segedin, Nuthall, & Thompson, 2006; E. B. Desapriya, Iwase, Pike, Brussoni, & Papsdorf, 2004; Staunton et al., 2005; Zaza, Sleet, Thompson, Sosin, & Bolen, 2001). Evaluation of the effectiveness of a mandatory child restraint use law is complex and requires a variety of measures and methods. It has been suggested that utilizing multiple datasets would provide more reliable data, with respect to numbers, types of injuries, and severities of injuries, than just police reports and death records (Agran & Wehrle, 1985; Du, Finch, Hayen, & Hatfield, 2007; Lyons et al., 2008). To date, no study has analyzed Virginia's 2002 child safety restraint law. The goal of this study is to evaluate the 2002 Virginia child safety restraint law and determine if the number and severity of injuries and fatalities of booster seat age children involved in motor vehicle crashes has changed significantly post-law.

## **CHAPTER 3: Methodology**

### **Rationale**

The goal of child passenger safety policy in the United States has been to reduce the number of infant and child injuries and fatalities due to motor vehicle crashes. In 2002, the Virginia General Assembly increased the age that children needed to be restrained in a child safety seat from age three (through their fourth birthday) to age five (through their sixth birthday). The increase in age was intended to better protect “booster seat” children from injuries and death when involved in a motor vehicle crash. Since Virginia updated its requirements for child passenger safety, it is important to evaluate the effectiveness of the 2002 Virginia child passenger safety restraint law and to evaluate if the law has significantly reduced motor vehicle crash injuries and fatalities. Systematic reviews are essential so that policymakers and practitioners will better know how to protect children from injuries and death. Did the legislation help reduce the loss of life and injury? Are other injury interventions and countermeasures necessary to better protect booster seat age children from injuries and death when involved in a motor vehicle crash?

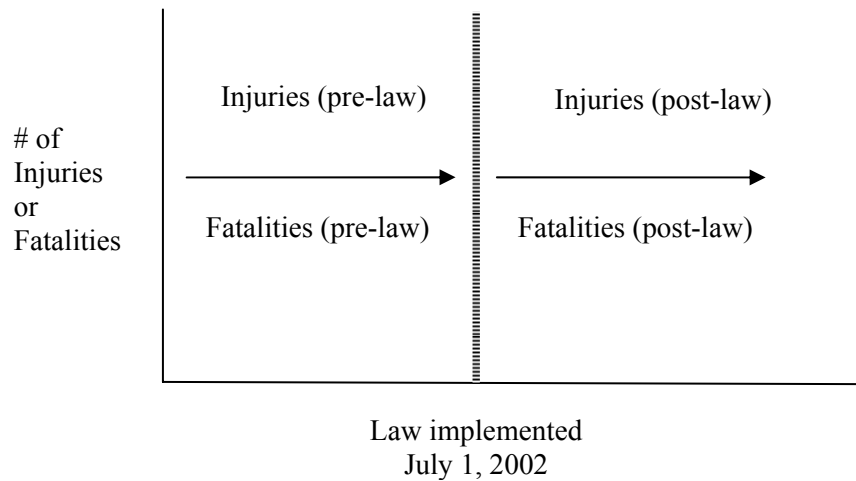
## **Research Design**

This study employed a pre and post intervention analysis of three datasets, Virginia police crash reports, Virginia injury hospitalization discharge data, and Virginia death records. Time series analyses, including pre and post analysis, play an important role in research on effects of law or policy changes (Biglan, Ary, & Wagenaar, 2000). The analysis allows research to be conducted where randomized assignment of subjects to control or experimental groups cannot happen since all subjects are affected by a “change” at the same time (Ross, Campbell, & Glass, 1970). The key characteristic of this form of analysis is repeated observations of a variable before and after the intervention, as shown in Figure 2. The variables of interest in this study are injuries and fatalities, and the intervention is the 2002 child passenger safety law. The analyses determined if there was a significant change in the mean number of injuries and fatalities of booster seat age children before and after the child passenger safety legislation of 2002.

Injury prevention advocates across Virginia knew that the 2002 law would increase the age of children required to be restrained in a child passenger safety restraint, also known as a booster seat, to age five (until their sixth birthday). This change in the law was a step towards the National Highway Traffic Safety Administration (NHTSA) recommendation that booster seats be used by children until they are at least eight years old, unless they are at least 4’9” (National Highway Traffic Safety Administration, September 2005). The advocates anticipated that the booster seat age children’s parents,

once they purchased and used a booster seat, would use the seat longer than the Virginia law required.

**FIGURE 2: Model of Pre-Post Study**



### **Research Questions**

The primary research question for this study is:

- Has there been a statistically significant decrease in the number of children ages four and five injured or killed in Virginia as a result of motor vehicle crashes since the Virginia child passenger safety law (Code of Virginia Article 13-Section 46.2) went into effect on July 1, 2002?

The expectation is that the legislative impact would be limited to the law's target age group of children ages four and five. The researcher did not expect the law to change the number of injuries pre and post legislation in children under the age of four and children over the age of five. Therefore, two groups of children, children under the age

of four and children ages six and seven, were selected as control groups. The additional questions that were explored include:

- Has there been a statistically significant decrease in the number of children under the age of four injured and killed in Virginia as a result of motor vehicle crashes since the Virginia child passenger safety law went into effect on July 1, 2002?
- Has there been a statistically significant decrease in the number of children ages six and seven injured or killed in Virginia as a result of motor vehicle crashes since the Virginia child passenger safety law went into effect on July 1, 2002?

Another hypothesis that was tested is whether there had been a decrease in injury severity from motor vehicle crashes in children ages four and five after the Virginia child passenger safety law went into effect on July 1, 2002. The law may not completely stop any injuries from occurring, but the law may reduce the severity of injuries sustained from motor vehicle crashes.

### **Databases Used**

The databases utilized were from the Virginia Department of Motor Vehicles (VA DMV) police crash report file, Virginia Health Information (VHI) database, and the Virginia Department of Health Center for Health Statistics (VDH CHS) vital records death database.

## VA DMV Data

Police crash reports have long been used as a source of data to study motor vehicle crash injuries. In Virginia, VA DMV houses and analyzes the police crash data. The police crash reports capture a variety of information including total number of crashes, fatalities, and injuries. Another variable of interest that VA DMV collects is the number of vehicle miles traveled (VMT) per year. The vehicle miles traveled are represented in millions and it is important to note that starting in 2002 vehicle miles traveled was based on vehicle count instead of gasoline consumption (Virginia Department of Motor Vehicles, 2008). VA DMV police crash annual data for the years 1995 through 2007 were obtained.

While the VA DMV data provides much valuable information, there are some limitations. The data is limited to what is captured in the police crash report. This report requires the police officer to document information regarding any crash. Information on every driver is collected regardless of injury. For passengers, the officer only documents data if the passenger is injured or killed. So if a passenger in a crash is not injured the passenger will never be recorded by the police officer on the police crash form. Therefore, VA DMV could not provide an accurate total number of crashes, both with and without injuries, involving children less than age eight (Venable, October 29, 2008). VA DMV did provide data on the number of children less than age eight injured or killed in a crash involving a motor vehicle since police officers document injured occupants.

VA DMV extracted crash data by age for the study population, children less than age eight, but the data are not reliable and are not included in this study. When data are

pulled by age from the VA DMV database, typically there are as many or more injuries and fatalities than total crashes due to the police crash report limitations noted above.

Moreover, when multiple same aged children are in a motor vehicle crash the children count only once as one crash, regardless of how many same aged children are in the vehicle. These same aged children, although counting only once as a crash, would count multiple times as an injury or fatality. However, if two children of different ages were in the same car crash it would count as two crashes (Venable, October 29, 2008). For example, if a one year old, a four year old, and a seven year old were all in one vehicle involved in a crash these three children in the one vehicle would count as three crashes. This makes the crash data misleading and again, it is not included in the study.

Another limitation encountered with the VA DMV data is that VA DMV codes any case with an “unknown” or “unstated” age as age being “0” (Venable, October 29, 2008). Therefore, if the police report does not include an age it will be a “0.” In this study, children less than age one, also coded by VA DMV as “0,” are included making the count for children less than age one unreliable.

An additional limitation encountered is that the VA DMV data includes all injuries involving a motor vehicle. For example, if a motor vehicle strikes and injures or kills a four year old pedestrian (or bicyclist, scooter rider, etc) that individual is captured in the VA DMV dataset. This study identified certain e-codes of interest to exclude pedestrian, bicyclist, etc. injuries whereas the VA DMV data includes all motor vehicle traffic e-codes.

### U.S. Census Bureau Population Data

To determine if there was a change in the number of children for the years of the study, U.S. Census Bureau population estimate data were used to identify how many children under age four, ages four and five, and ages six and seven were living in Virginia each year of the study. Additionally, the population data were used to calculate rates per 100,000.

### VHI Injury Hospitalization Data

The VHI dataset was selected since it is a comprehensive source of Virginia hospitalization discharge data utilized by injury prevention advocates and researchers across the Commonwealth. The VHI database contains all licensed Virginia hospital discharges. The analyses utilized hospitalization discharge data from January 1, 1995 through June 30, 2007, thirty quarters pre-law and twenty quarters post-law. The time frame was selected because children ages four through sixteen were not required to use a child safety seat prior to 2002, only children under age four were required to be in a child safety restraint. In 2002, legislation increased the age that children had to be restrained in a child safety seat from age three (through their fourth birthday) to age five (until their sixth birthday). The study only used data through June 30, 2007 because effective July 1, 2007, the Virginia General Assembly updated the law and required children through the age of seven (until their eighth birthday) to be properly secured in a safety restraint.

VHI's database includes a variety of patient demographic (i.e. race, gender), clinical, administrative, and hospital information (i.e. length of stay, total charges) on



every discharge that occurs in Virginia licensed hospitals (Virginia Health Information, 2007). See Appendix 1 for a complete listing of VHI's patient level database variables. When hospital admissions occur due to an injury in Virginia, International Classification of Diseases (ICD)-9 External Cause of Injury Codes (e-codes) are recorded to reflect the cause and intent (unintentional, self-inflicted, undetermined, etc.) of the injury (Sloan, 2007).

The ICD code is the international standard diagnostic classification used to classify diseases and other health problems recorded on many types of health and vital records, including hospital records and death certificates (World Health Organization, 2008). The injury mechanism, represented by the e-code, is defined as the external object or circumstance that caused the injury, such as a motor vehicle crash. Motor vehicle crash e-codes are three digit numbers that range from E810 to E819 and are described below in Tables 2 and 3 (Centers for Disease Control and Prevention, 2001; Injury Surveillance Workgroup, 2003). Each e-code additionally has a decimal point and a number following that identifies the individual that was injured or killed. It is important to know that the VHI data does not include decimal points in their e-codes to identify the injured person (as seen in Table 3). The VHI data removes the decimal point making the e-code a four digit number. For example, e-code E810.1 is represented in the VHI data as E8101. Only cases with e-codes 810 through 816 and e-code 819 with a fourth digit of the e-code being either .1 (passenger) or .9 (unspecified person) were included in this study.

**TABLE 2: E-codes, Definitions, and Whether Included or Excluded from this Study**

| <b>E-code</b> | <b>DEFINITION</b>   | <b>Included/Excluded</b> |
|---------------|---|--------------------------|
| E810          | Motor vehicle traffic crash involving collision with train                            | Included                 |
| E811          | Motor vehicle traffic crash involving re-entrant collision with another motor vehicle | Included                 |
| E812          | Other motor vehicle traffic crash involving collision with motor vehicle              | Included                 |
| E813          | Motor vehicle traffic crash involving collision with other vehicle                    | Included                 |
| E814          | Motor vehicle traffic crash involving collision with pedestrian                       | Included                 |
| E815          | Other motor vehicle traffic crash involving collision on the highway                  | Included                 |
| E816          | Motor vehicle traffic crash due to loss of control, without collision on the highway  | Included                 |
| E817          | Noncollision motor vehicle traffic crash while boarding or alighting                  | Excluded                 |
| E818          | Other noncollision motor vehicle traffic crash  | Excluded                 |
| E819          | Motor vehicle traffic crash of unspecified nature                                     | Included                 |

**TABLE 3: E-code 4<sup>th</sup> Digit Decimal Subdivisions to Identify Injured Person and Whether Included or Excluded from Study**

| <b>MECHANISM/CAUSE</b>                                   | <b>E-code</b>           | <b>Included/Excluded</b> |
|--|-------------------------|--------------------------|
| <b>Motor Vehicle Traffic Crashes</b>                     |                         |                          |
| Driver of motor vehicle:<br><i>Other than motorcycle</i> | E810-E816 and E819 (.0) | Excluded                 |
| Passenger in motor vehicle:<br>other than motorcycle     | E810-E816 and E819 (.1) | Included                 |
| Motorcyclist   | E810-E816 and E819 (.2) | Excluded                 |
| Passenger on motorcycle                                  | E810-E816 and E819 (.3) | Excluded                 |
| Occupant of Streetcar                                    | E810-E816 and E819 (.4) | Excluded                 |
| Rider of animal:<br>occupant of animal drawn vehicle     | E810-E816 and E819 (.5) | Excluded                 |
| Pedal cyclist  | E810-E816 and E819 (.6) | Excluded                 |
| Pedestrian   | E810-E816 and E819 (.7) | Excluded                 |
| Other specified person                                   | E810-E816 and E819 (.8) | Excluded                 |
| Unspecified person                                       | E810-E816 and E819 (.9) | Included                 |

The VHI database contained 1,902 children less than age eight injured severely enough to require a hospital admission from January 1, 1995 through June 30, 2007.

There were thirty quarters of data before the law went into effect on July 1, 2002 and twenty quarters of data after the law went into effect. After selecting children with the motor vehicle crash e-codes of interest 1,092 cases remained. Out of the 1,092 children, 745 injuries occurred before the law went into effect and 347 injuries occurred after the law went into effect. The cases were then separated into the three age groups of interest, under age four, ages four and five, and ages six and seven, for analysis.

There was concern that the injury hospitalization data may include multiple counts of an individual involved in a crash. The individual may have been transferred from a different hospital, may have had a readmission for follow up care, or had unexpected complications after discharge requiring readmission. VHI reviewed the data and acknowledged that less than one percent of children ages four through seven are duplicates each year. VHI also indicated that there is not a way to de-duplicate for children less than age four because VHI does not collect the data elements needed for de-duplication on this population. VHI stated that they felt the data file provided was reasonably de-duplicated (Delcher, June 23, 2008).

Because the VHI dataset only included information on patients that were severely injured enough to be hospitalized, it was important to also analyze death records to better understand the burden of injury from motor vehicle crashes.

#### VDH CHS Death Data

The VDH CHS vital records data were used for the death analyses. VDH CHS provided data from January 1, 1992 through December 31, 2007, forty-two quarters pre-

law and twenty-two quarters post-law. The third and fourth quarters of the year 2007 were not included in this study since the 2007 Virginia child passenger safety law had gone into effect July 1, 2007 that required children through the age of seven (until their eighth birthday) to be properly secured in a child safety restraint.

The VDH CHS death records include variables such as individual demographics (i.e. gender, race, date of birth and date of death), geographic information (i.e. residence, place of death), and ICD e-codes. A complete list of available VDH CHS variables is included in Appendix 1.

The VDH CHS death data included ICD-9 codes for the years 1992 through 1998 and then in 1999 through 2007 the records included ICD-10 codes. For the years 1992-1998 only cases with e-codes 810 through 816 and e-code 819 with a fourth digit of the e-code being either .1 (passenger) or .9 (unspecified person) were included in the study. The comparable ICD-10 codes were included in the study for the years 1999-2007.

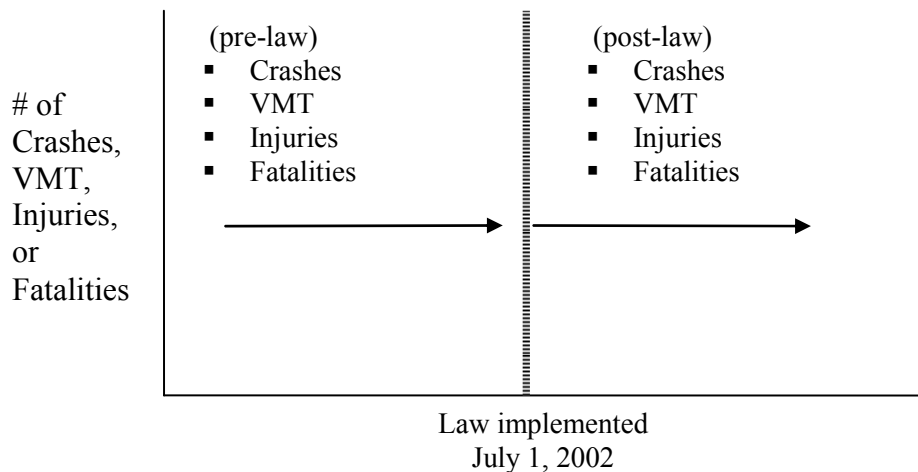
After selecting children with the motor vehicle crash e-codes of interest, 223 cases of children under age eight remained from January 1, 1992 through June 30, 2007. Out of the 223 children, 166 died before the law went into effect and 57 died after the law went into effect. The cases were then separated into the three age groups of interest, children under age four, children ages four and five, and children ages six and seven for analysis.

## Data Analysis

### VA DMV

The total number of crashes per year for all ages, not just children, and the number of vehicle miles traveled (VMT) was reviewed for the years 1995-2007. Additionally, despite the VA DMV police crash report data limitations, the number of children less than age eight injured or killed in a motor vehicle crash was analyzed to see if there were any significant changes pre and post-law for the target age group, children ages four and five, and the two control groups (see Figure 3).

**FIGURE 3: Virginia Department of Motor Vehicle Crash Facts (1995-2007)**



Independent samples t-test were run on each variable to determine if there was a statistically significant difference between the two means of the variable pre-law and post-law. T-tests for crashes and VMT were conducted. VA DMV provided thirteen

years of data, seven and a half years pre-law, and five and a half years post-law. To account for the six months in 2002 before the law went into effect the 2002 cases were divided in half.

The VA DMV number of fatalities comprised only a small number of cases, so the injuries and fatalities were combined. For the target group and the two control groups, t-tests were run and rates were calculated per 1,000 crashes, 10,000 VMT, and 100,000 population.

#### VHI AND VDH CHS Data Analysis

Analyses were conducted on the VHI hospitalization discharge records and the VDH CHS death data for measures of injuries and fatalities due to motor vehicle crashes. Initially, the VHI and VDH CHS datasets were analyzed separately and then merged due to the small number of fatalities.

First, data files were created for the quarters of data and then the data was merged, labeled, and analyzed. Only variables of interest were imported. From the VHI data, the variables that were included in the analysis were age in days, age in years, sex, race, quarter/year admission and discharge, admission source, admission type, patient zip code, length of stay, patient discharge status, pre-operative and post-operative length of stay, diagnostic related group, major diagnostic category, all patient refined diagnostic related group codes, total charges and the categorical breakdown of the total charges, payer type, county code, state, e-code, readmission and transfer, and the VHI unique record identifier. From the VDH CHS data, the variables that were included in the

analysis were gender, date of birth and death, age, race, hospital status, zip code of residence, accident code, date record filed, underlying cause code (in ICD format), and multiple cause codes. A complete list of available variables for both datasets is included in Appendix 1.

After importing the data, only children less than age eight were retained from each of the datasets for analysis. The next step was to specify and select which e-codes were included in the analysis. As shown in Tables 2 and 3, motor vehicle e-codes E810-E816 and E819, ending in either .1 (representing passenger) or .9 (representing unspecified person), were included in the study.

After the selected cases were identified for each dataset, they were saved under a new file name. Next, variable labels and values were assigned. Since every dataset contains some errors, the data in both datasets were reviewed and “cleaned.” There were some cases with missing data, and some with “not applicable” answers that were excluded from the analyses.

Once the datasets were “clean,” the data were coded to identify the quarter and year in which they occurred. Next, a new variable labeled “Child Passenger Safety Law” was created and identified cases as occurring before or after July 1, 2002 when the Virginia law went into effect. Each case was either assigned a “1” and labeled “Before Law,” identifying it as occurring before the law or a “2” and labeled “After Law,” identifying it as occurring after the law went into effect.

To evaluate the study research question, independent samples t-tests were run and rates were calculated on the VHI injury and the VDH CHS death data. The independent



samples t-test determined if there was a statistically significant difference between the two means of the number of children injured (or killed) due to a motor vehicle crash pre-law and post-law (Garson, 2008). The two sample groups analyzed were the “Before Law” and “After Law” cases and the variable was number of children per quarter year. Similar t-tests were run for the two control groups, children under four and children ages six and seven.

#### Merged VHI and VDH CHS Data

To obtain more meaningful results the hospital injury discharge data were merged with the injury death data. Only data from January 1, 1995 through June 20, 2007 were utilized. Three years of death data (1992-1994) were discarded, eliminating fifty-four death cases, so the two datasets would have matching time frames. The injury hospital discharge data had 1,092 cases (504 children under age four, 284 children ages four and five, and 304 children ages six and seven) and the death data for the time frame of study had 169 cases (91 children under age four, 44 children ages four and five, and 34 children ages six and seven) making a total of 1,261 cases for the merged file. There were 857 cases before the law and 404 cases after the law. Again, an independent samples t-test was conducted for each age group to determine if there was an effect on the numbers of injuries and fatalities post-law.

### Injury Severity

To determine if there was a reduction in the severity of injuries sustained from motor vehicle crashes two categories of injury severity were created using a VHI variable called "All Patient Refined Diagnostic Related Code"(APR-DRG) (see Table 4). The APR-DRG variable contains five characters. The first three characters are the actual APR-DRG. The fourth character is an assigned severity index and the fifth is the risk of mortality subclass. For the severity index and the risk of mortality subclass, values range from one to four. A value of "1" indicates the less severe or lower risk cases, while a "4" indicates the most severe or higher risk cases (Virginia Health Information, 2007).

**TABLE 4: Categorization of Injury Severity**

| <b>Injury Group</b> | <b>Injury Severity</b>         |
|---------------------|--------------------------------|
| 1                   | Severe Injuries and Fatalities |
| 2                   | Mild and Moderate Injuries     |

Category 1, representing the severe or fatal injuries, contains all deaths and any APR-DRG that had a value of "4" in either the fourth or fifth APR-DRG character. Category 2 contains all remaining mild or moderately injured children. Out of the 1,261 merged death and injury hospitalization cases, 169 were fatalities. Of the remaining hospitalization cases, one child had an APRDRG that was not categorizable since it had the value of zero for both the APRDRG fourth and fifth character and therefore was not included in the analysis leaving 1,260 cases. There were 237 severe or fatally injured

children in category 1 and 1,023 mild or moderately injured children in category 2. Again, t-tests were conducted to determine if mild and moderate or severe and fatal injury severity decreased post-law for children under age four, ages four and five, and ages six and seven.

#### Rate/100,000 population

Utilizing the merged hospital injury discharge and death data, rates per 100,000 were calculated for the target group and the two control groups using the U.S. Census Bureau population data. Additionally, rates/100,000 for each injury severity category age group were calculated.

#### **Limitations**

As with any study, there are some limitations that need to be discussed. One issue is determining the laws impact versus other factors on reducing injuries and fatalities among children ages four and five. By utilizing the two control groups confidence in the findings will be strengthened. If there was a decrease in injuries after the law went into effect in the target group of children ages four and five, but not in the two control groups, it is suggestive that the law was effective. Additionally, crash data for the years of study was reviewed and analyzed to strengthen confidence in the findings.

Another concern that could be raised regarding this study is that the datasets do not include a variable that indicates use or non-use of a restraint. Ideally, one would like to know restraint use, but with the passage of legislation and the threat of a ticket, there is

evidence that often people claim to be belted when they are not (Campbell, Stewart, & Reinfurt, 1991). The Campbell study states that with the onset of seat belt laws, it is inappropriate to rely on restraint status reported in crash data. Even if the datasets did include a variable indicating restraint use, there would be no way of determining if a child safety restraint was appropriate for the child's age, height, and weight or if the seat was properly installed.

Another potential problem was that the fatality data included a small number of cases. The number of fatalities was too small to reliably assess the effects of the new law. Since the fatality data comprised only a small number of children, the fatality data was merged with the injury data to obtain more meaningful results.

Analyses of individual states' laws can be complicated by the need for accurate statistics on restraint use. Since it was already known that this data is not available in Virginia, it was important to separate out the impact of the law change from other factors that could affect the analyses. This is challenging because motor vehicle injuries and fatalities can exhibit monthly variability and yearly cyclicalities (Rock, 1996). For example, the data could be affected by weather, alcohol consumption, speed, highway and vehicle design and features, as well as a variety of public policies. To address these factors, the data were reviewed for seasonal cycles, autocorrelations, and trends.

The VHI and VDH CHS datasets, while good sources of data, can only provide us with some answers to better understand the burden of injury and death caused by motor vehicle crashes. This study utilized a total of fifty quarters of data, thirty quarters of data before the law went into effect, and twenty quarters of data after the law went into effect.

Additional data points would strengthen the study since each additional data point would allow for a better assessment of the data trend (Robson, 1993). However, VHI could only provide data starting in 1995 and with the 2007 law going into effect July 1, 2007, the data was limited to twenty quarters of data post-law.

Another concern is with regard to the implementation of the policy. The Virginia legislature passed the bill in February of 2002 but the law did not go into effect until July 1, 2002 ("Acts of Assembly", 2002). The data analysis could reveal a "premature" or "delayed" effect on injury. A "premature" effect could be due to parents and caregivers preparing for the law change prior to the law actually going into effect. A "delayed" effect could be observed since parents and caregivers may not be aware of the law until after it goes into effect. Ideally, a reduced number of injuries and fatalities would be observed immediately after the law went into effect demonstrating a correlation between the law and a reduction of motor vehicle crash injury and death.

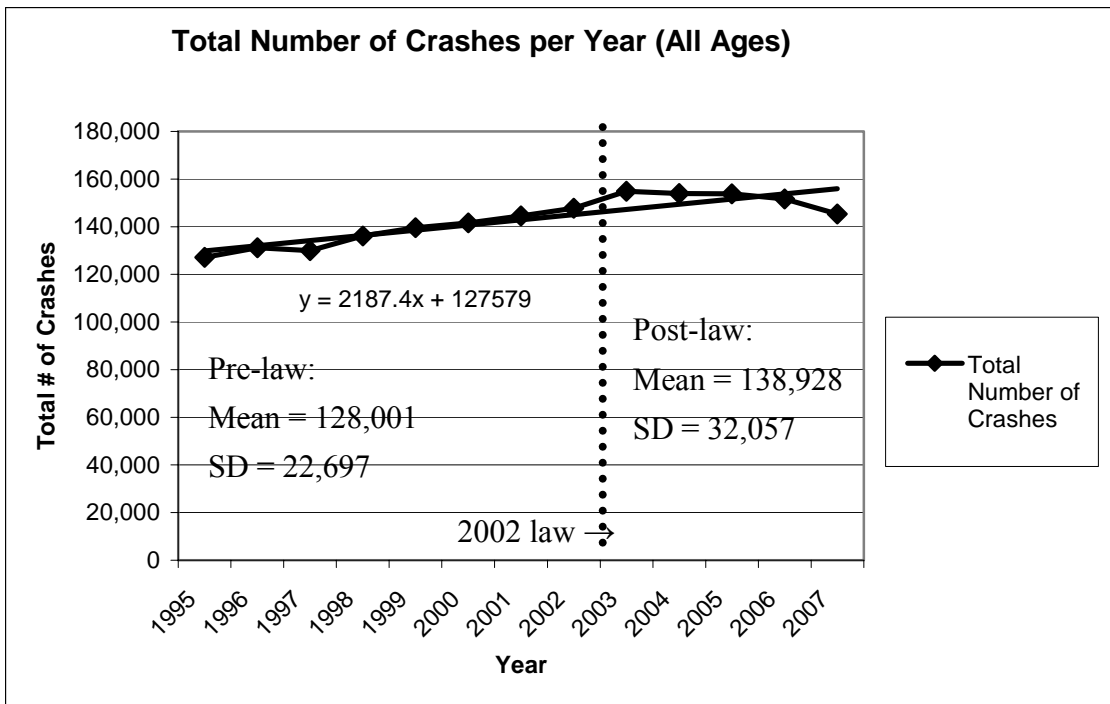
Another concern was that hospitalization discharge data and death data may not provide the complete picture of motor vehicle crash injury. The VHI and VDH CHS datasets only include those children so severely injured that they were admitted to a hospital or died. A large group of children that may have been in a motor vehicle crash but were seen by their private physician or in an emergency department or urgent care center and then released will not be included in this analysis. Virginia does not collect statewide emergency room data or information from physician practices regarding injuries.

## CHAPTER 4: Results

### Virginia Department of Motor Vehicles (VA DMV) Police Crash Report Data

In Figure 4, the total number of crashes per year for all ages, not just children, are presented for the years 1995-2007. Overall, there was a slight upward trend in the years 1995-2007. However, when evaluating the total number of crashes for all ages before and after the 2002 law, the independent samples t-test revealed no significant difference ( $t = -.750$ ,  $df = 12$ ,  $p = 0.47$ ). Before the 2002 law went into effect, there were an average of 128,001 crashes per year with a standard deviation of 22,697. Post-law there were 138,928 average crashes per year with a standard deviation of 32,057.

**FIGURE 4: VA DMV Total Crashes for All Ages 1995-2007**

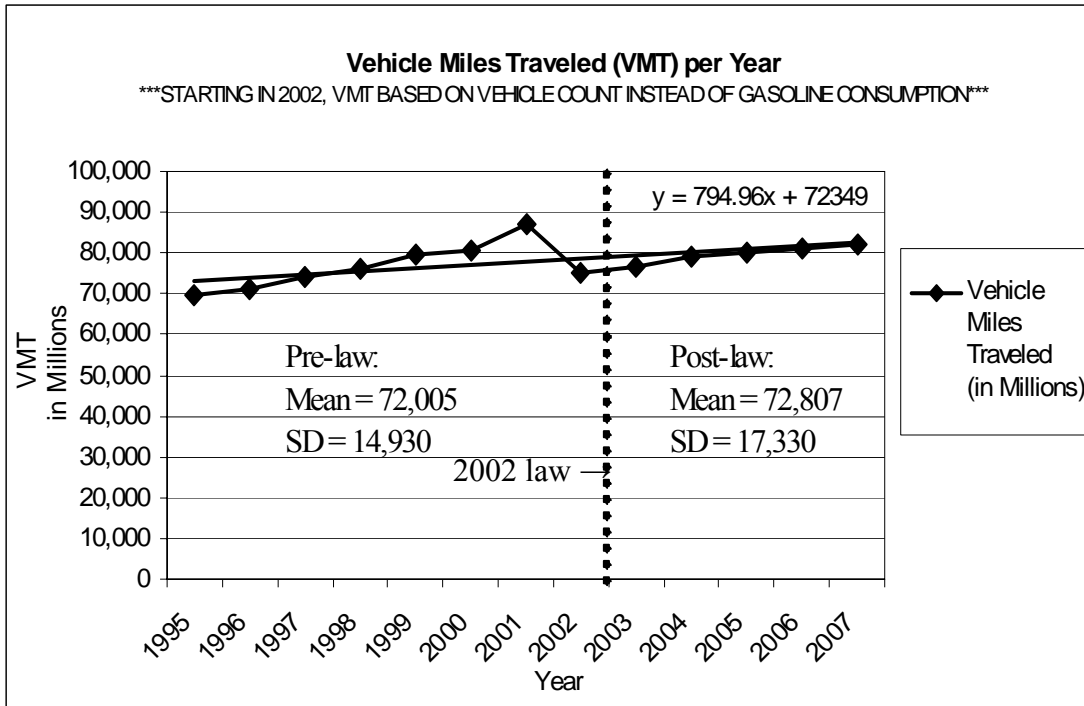


In Figure 5 the number of vehicle miles traveled (VMT) per year is presented for the years 1995-2007. As mentioned in Chapter 3, the VMT is represented in millions and starting in 2002 VMT was based on vehicle count instead of gasoline consumption (Virginia Department of Motor Vehicles, 2008). This likely explains the discontinuity in the VMT trend progression. Over the thirteen years reviewed, there was a gradual increase in the number of VMT in Virginia.

The independent samples t-test confirms that there was no significant difference in the number of VMT pre and post-law ( $t = -0.093$ ,  $df = 12$ ,  $p = 0.93$ ). Prior to the 2002 law, there were an average of 72,005 million VMT per year with a standard deviation of

14,930 million VMT. Post-law there were 72,807 million VMT per year with a standard deviation of 17,330 million VMT.

**FIGURE 5: VA DMV Vehicle Miles Traveled 1995-2007**

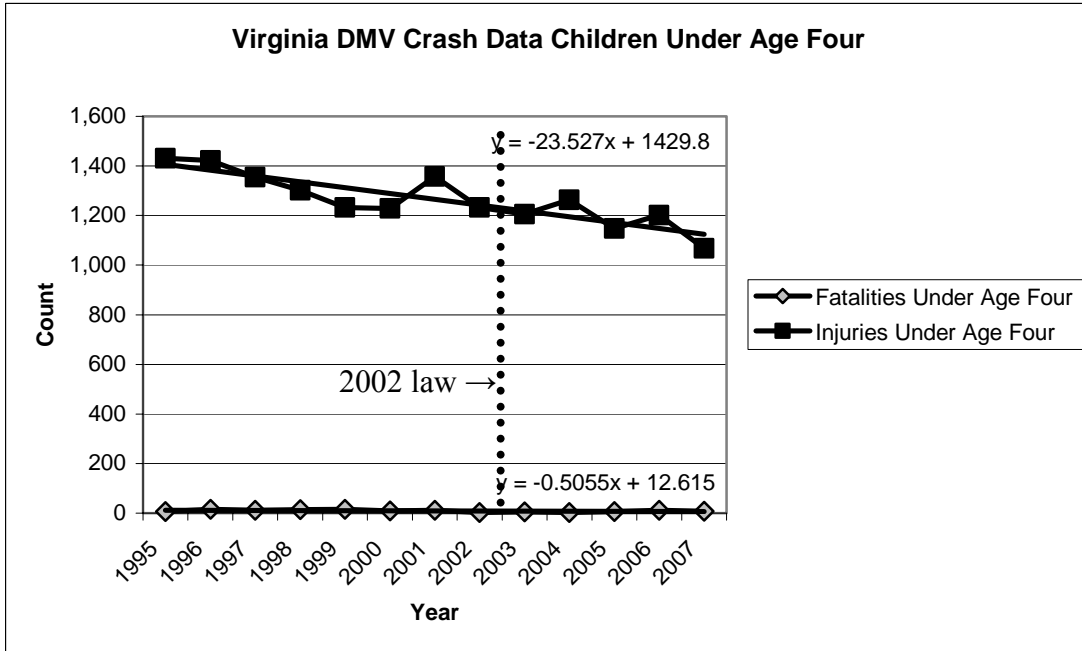


The police crash report data is a useful source of data but not without limitations when analyzing children involved in motor vehicle crashes. The Virginia Department of Motor Vehicles (VA DMV) provided data on the number of children less than age eight injured or killed in a motor vehicle crash and the data is presented below in Figures 6 through 8 by age group of interest for this study.



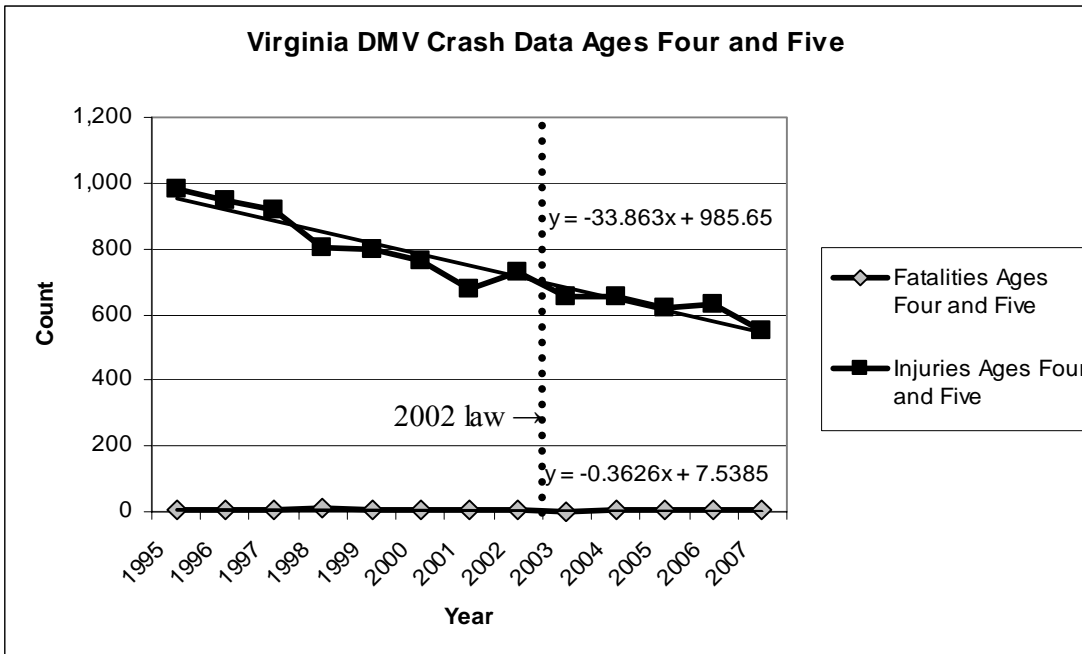
**FIGURE 6: Virginia Department of Motor Vehicle Crash Facts:**

**Injuries and Fatalities to Children Under Age Four (1995-2007)**



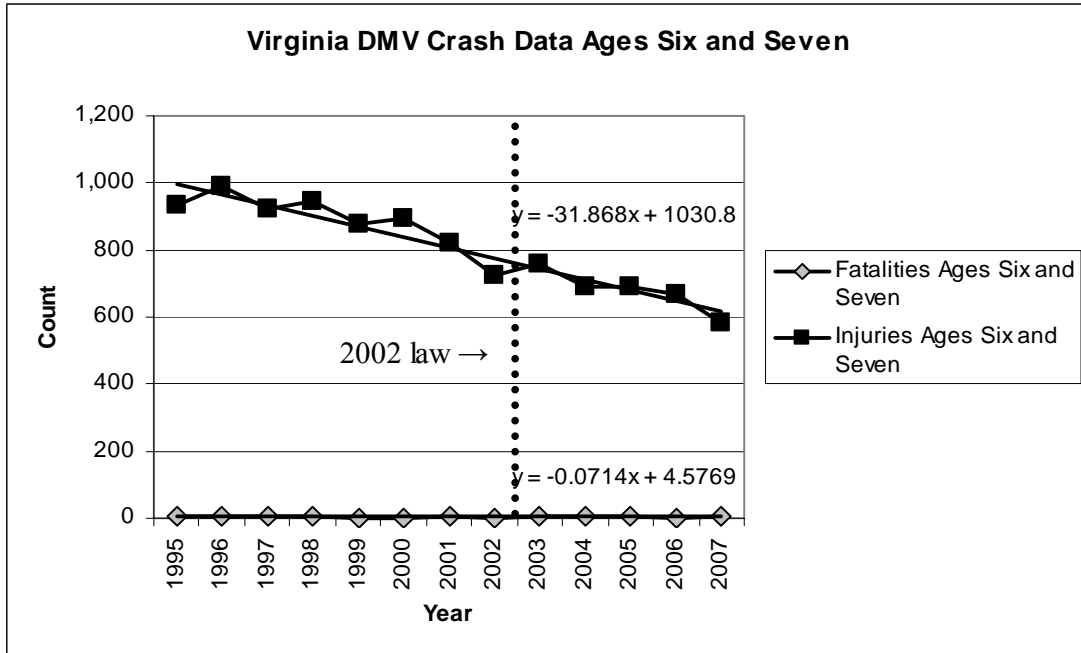
**FIGURE 7: Virginia Department of Motor Vehicle Crash Facts:**

**Injuries and Fatalities to Children Ages Four and Five (1995-2007)**



**FIGURE 8: Virginia Department of Motor Vehicle Crash Facts:**

**Injuries and Fatalities to Children Ages Six and Seven (1995-2007)**



Figures 6 through 8 above indicate that there was a downward trend in the number of injuries per age group from 1995 - 2007. The target group, children ages four and five, and the two control groups, children under age four and children ages six and seven, all had a decrease in the number of injuries.

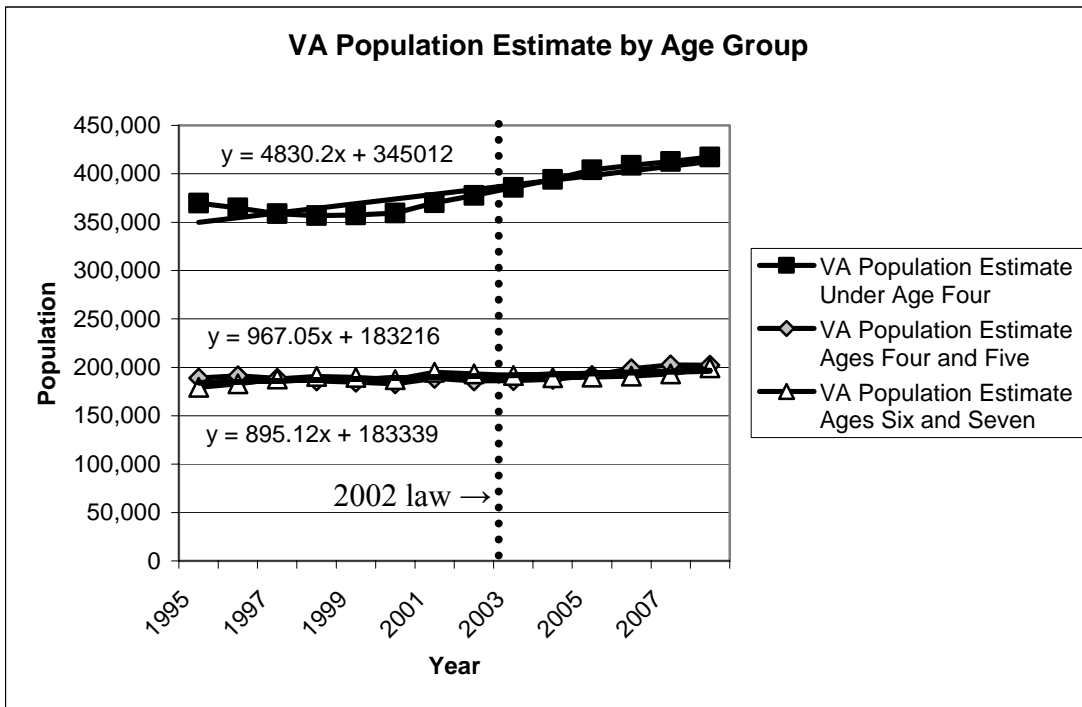
The number of fatalities was small making it difficult to reliably assess any trend over the years. Since the data on fatalities comprised only a small number of cases, anywhere from two to fifteen per year for any one age group, no further analysis was conducted on the fatalities since death counts of less than twenty are considered to be unreliable (Centers for Disease Control and Prevention, 2008). The VA DMV data

fatalities and injuries were combined and rates were calculated per 1,000 crashes, 10,000 VMT, and per 100,000 population.

U.S. Census Bureau Population Data

U.S. Census Bureau population estimate data were used to identify how many children under age four, ages four and five, and ages six and seven were living in Virginia each year of the study. Figure 9 below indicates that only the group of children under age four saw a slight upward trend over the years. The other two age groups (children ages four and five and children ages six and seven) populations stayed relatively constant over the time frame of study.

**FIGURE 9: VA Population Estimates by Age Group 1995-2007**



### VA DMV Data Rates

Utilizing the merged VA DMV injury and fatality data, rates per 1,000 crashes, 10,000 VMT, and 100,000 population were calculated for the target age group (children ages four and five) and the two control groups (children under age four and children ages six and seven). The results are displayed below in Table 5. All rates indicate a decrease in the number of injuries/fatalities post-law. Additionally, all independent samples t-tests were significant indicating that there was a significant decrease in the number of injuries and fatalities post-law.

**TABLE 5: VA DMV Data Rates**

|   | <b>Mean Rate/ Year<br/>pre-law<br/>Jan 1, 1995- June 30, 2002</b> | <b>Mean Rate/Year<br/>post-law<br/>July 1, 2002- June 30, 2007</b> | <b>Difference/Year<br/>(Pre – Post)</b> | <b>T-test<br/>(for rates pre-post)</b> |
|---|---|--|---|--|
| <b>Rate of VA DMV Injuries &amp; Fatalities/ 1,000 Crashes (All ages)</b>                                     |   |  |   |  |
| <b>Under Age Four</b>   | 9.84  | 7.84   | 2.00                                    | t = 4.51<br>(df = 9.2, p = 0.00)       |
| <b>Ages Four and Five</b>   | 6.21  | 4.18   | 2.03                                    | t = 4.39<br>(df = 9.0, p = 0.00)       |
| <b>Ages Six and Seven</b>   | 6.65  | 4.53   | 2.12                                    | t = 5.65<br>(df = 9.3, p = 0.00)       |
| <b>Rate of VA DMV Injuries &amp; Fatalities/ 10,000 Vehicle Miles Traveled (All ages) (*VMT in Millions*)</b> |   |  |   |  |
| <b>Under Age Four</b>   | 175.28  | 149.85   | 25.43                                   | t = 2.48<br>(df = 12, p = 0.03)        |
| <b>Ages Four and Five</b>   | 110.86  | 80.05  | 30.81                                   | t = 3.33<br>(df = 10.4, p = 0.01)      |
| <b>Ages Six and Seven</b>   | 118.50  | 86.76  | 31.74                                   | t = 3.85<br>(df = 12, p = 0.00)        |
| <b>Rate of VA DMV Injuries &amp; Fatalities/ 100,000 Population (Per age group)</b>                           |   |  |   |  |
| <b>Under Age Four</b>   | 36.67   | 29.35  | 7.32                                    | t = 4.77<br>(df = 12, p = 0.00)        |
| <b>Ages Four and Five</b>   | 44.97   | 32.52  | 12.45                                   | t = 4.30<br>(df = 12, p = 0.00)        |
| <b>Ages Six and Seven</b>   | 47.67   | 35.76  | 11.91                                   | t = 4.63<br>(df = 12, p = 0.00)        |

### **Virginia Health Information (VHI) Hospital Discharge Data t- tests**

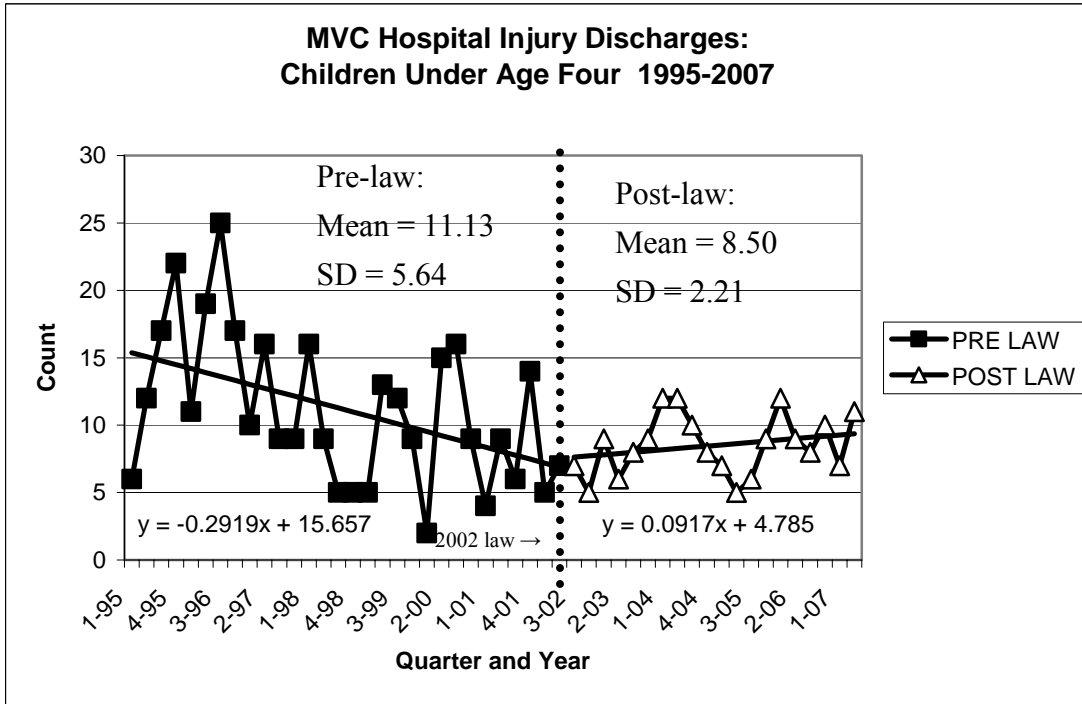
An independent samples t-test was conducted for each age group to determine if there was an effect on the numbers of injuries post-law. The t-test determines if there was a statistically significant difference between the two groups (count per quarter) of the children injured due to motor vehicle crashes before the law and after the law.

#### **Under Age Four**

Out of the 504 children under age four, 334 children were hospitalized before the child passenger safety law went into effect and 170 children were hospitalized after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law ( $M = 11.13$ ,  $SD = 5.64$ ) with the mean case count per quarter post-law ( $M = 8.50$ ,  $SD = 2.21$ ). The alpha level was 0.05. This test was found to be statistically significant,  $t = 2.30$ , ( $df = 40.6$ ,  $p = 0.03$ ). This indicates that equality of means pre and post-law cannot be assumed. There was a significant decrease in the number of injures post-law.

Figure 10 below represents the injury hospitalization data for children under age four. There is a downward trend pre-law and then a slight upward trend post-law. The t-test confirmed that there was a significant decrease in the number of injures post-law.

**FIGURE 10: Motor Vehicle Crash (MVC) Hospital Injury Discharges:  
Children Under Age Four 1995-2007**



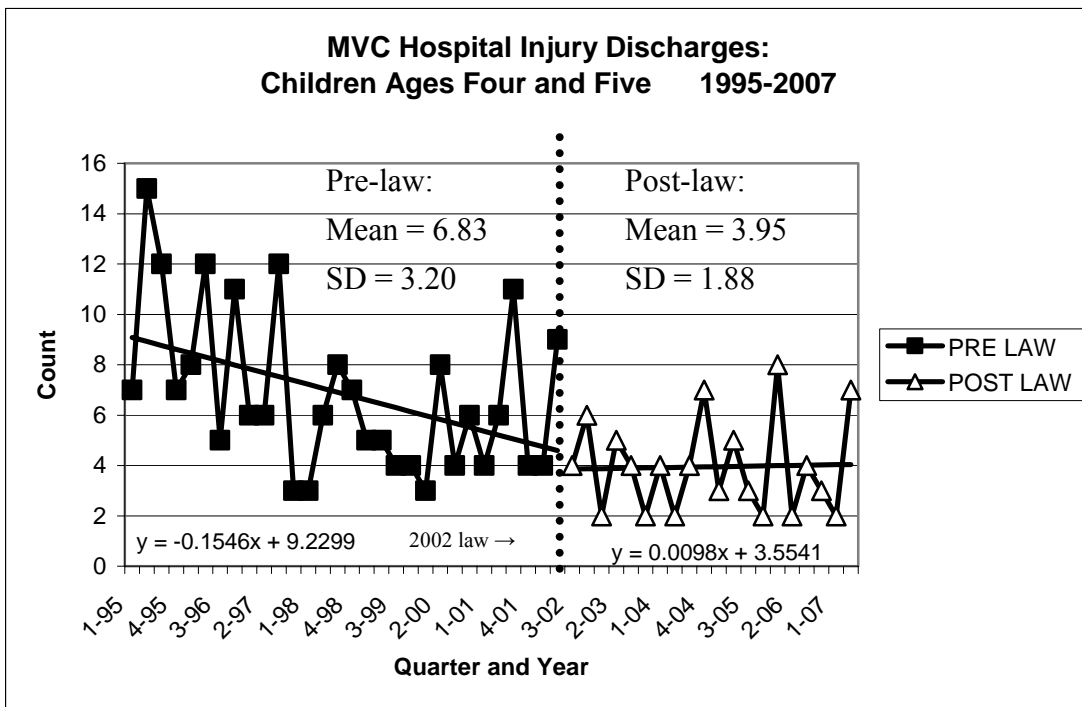
Ages Four and Five

Out of the 284 children ages four and five, 205 children were hospitalized before the child passenger safety law went into effect and 79 children were hospitalized after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law (M = 6.83, SD = 3.20) with the mean case count per quarter post-law (M = 3.95, SD = 1.88). This test was found to be statistically significant,  $t = 4.01$ , ( $df = 47.4$ ,  $p = 0.00$ ). This indicates that equality of means pre and post-law cannot be assumed. There was a significant decrease in the number of injuries post-law.

Figure 11 below represents the injury hospitalization data for children ages four and five. There is a downward trend pre-law and then a leveling off post-law. The t-test confirmed that there was a significant decrease in the number of injures post-law.

**FIGURE 11: Motor Vehicle Crash (MVC) Hospital Injury Discharges:**

**Children Ages Four and Five 1995-2007**



Ages Six and Seven

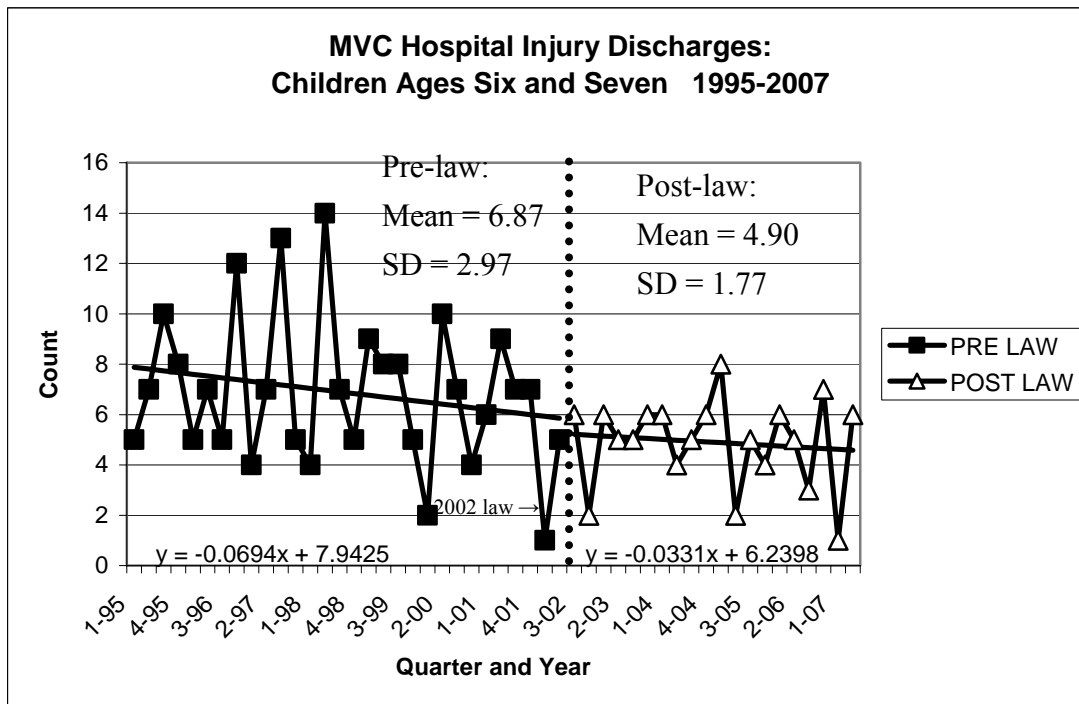
Out of the 304 children ages six and seven, 206 children were hospitalized before the child passenger safety law went into effect and 98 children were hospitalized after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law (M = 6.87, SD = 2.97) with the mean case count per



quarter post-law (M = 4.90, SD = 1.77). This test was found to be statistically significant,  $t = 2.66$ , ( $df = 48$ ,  $p = 0.01$ ). This indicates that equality of means pre and post-law cannot be assumed. There was a significant decrease in the number of injuries post-law.

Figure 12 below represents the injury hospitalization data for children ages six and seven. There is a downward trend pre-law that continues downward post-law. The t-test confirmed that there was a significant decrease in the number of injuries post-law.

**FIGURE 12: Hospital Discharge Motor Vehicle Crash Injuries:  
Children Ages Six and Seven 1995-2007**



## **Virginia Dept. of Health Center for Health Statistics (VDH CHS) Death Data t-tests**

As with the injury hospitalization discharge data, an independent samples t-test was conducted for each age group to determine if there was an effect on the numbers of fatalities post-law.

### **Under Age Four**

Out of the 122 children under age four, 94 children died before the child passenger safety law went into effect and 28 children died after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law ( $M = 2.24$ ,  $SD = 1.57$ ) with the mean case count per quarter post-law ( $M = 1.40$ ,  $SD = 1.31$ ). The alpha level was 0.05. This test was found to be statistically significant,  $t = 2.06$ , ( $df = 60$ ,  $p = 0.04$ ). This indicates that equality of means pre and post-law cannot be assumed. There was a significant decrease in the number of fatalities post-law.

### **Ages Four and Five**

Out of the fifty-seven children ages four and five, forty-two children died before the child passenger safety law went into effect and fifteen children died after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law ( $M = 1.00$ ,  $SD = 1.15$ ) with the mean case count per quarter post-law ( $M = 0.75$ ,  $SD = 0.91$ ). This test was not found to be statistically

significant,  $t = 0.853$ , ( $df = 60$ ,  $p = 0.40$ ). This indicates that there was no significant difference of the means pre and post-law.

### Ages Six and Seven

Out of the forty-four children ages six and seven, thirty children died before the child passenger safety law went into effect and fourteen children died after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law ( $M = 0.71$ ,  $SD = 0.89$ ) with the mean case count per quarter post-law ( $M = 0.70$ ,  $SD = 0.86$ ). This test was not statistically significant,  $t = 0.060$ , ( $df = 60$ ,  $p = 0.95$ ). This indicates that there was no significant difference of the means pre and post-law.

The number of fatalities was small making it difficult to reliably assess the effects of the new law. Since the data on fatalities comprised only a small number of cases, the fatality data were combined with the hospital injury discharge data to obtain results that are more meaningful.

### **Merged Injury Hospital Discharge Data and Death Data t-tests**

To obtain more meaningful results, the hospital injury discharge data were merged with the injury death data for the time frame January 1, 1995 through June 20, 2007. Again, an independent samples t-test, along with rates/100,000 population, was

conducted for each age group to determine if there was an effect on the numbers of injuries and fatalities post-law.

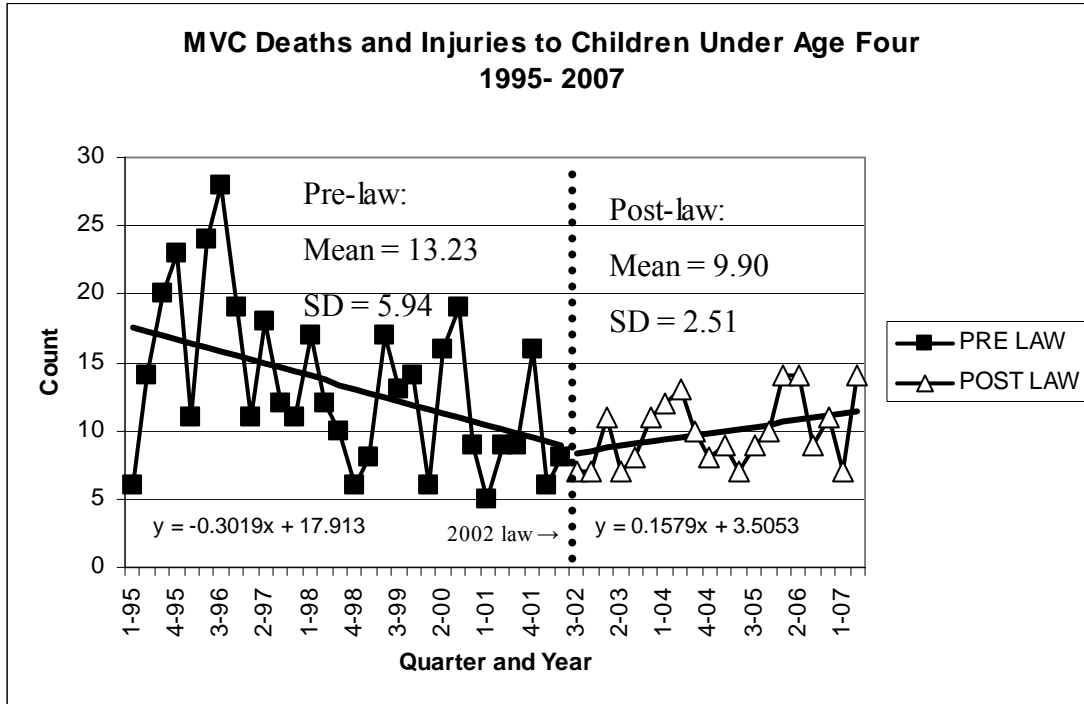
#### Under Age Four

Out of the 595 children under age four, 397 children were injured or died before the child passenger safety law went into effect and 198 children were injured or died after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law ( $M = 13.23$ ,  $SD = 5.94$ ) with the mean case count per quarter post-law ( $M = 9.90$ ,  $SD = 2.51$ ). The alpha level was 0.05. This test was found to be statistically significant,  $t = 2.73$ , ( $df = 42.02$ ,  $p = 0.01$ ). This indicates that equality of means pre and post-law cannot be assumed. There was a significant decrease in the number of injuries and fatalities post-law.

Figure 13 demonstrates that there was a trend downwards pre-law and then post-law there was a slight upward trend. Overall, the t-test confirms, there was a decrease in the number of injuries and deaths of children under age four post-law.

**FIGURE 13: Motor Vehicle Crash Deaths and Injuries:**

**Children Under Age Four 1995-2007**



Rates per 100,000 population were also calculated for the merged data and results for all three age groups are displayed in Table 6.

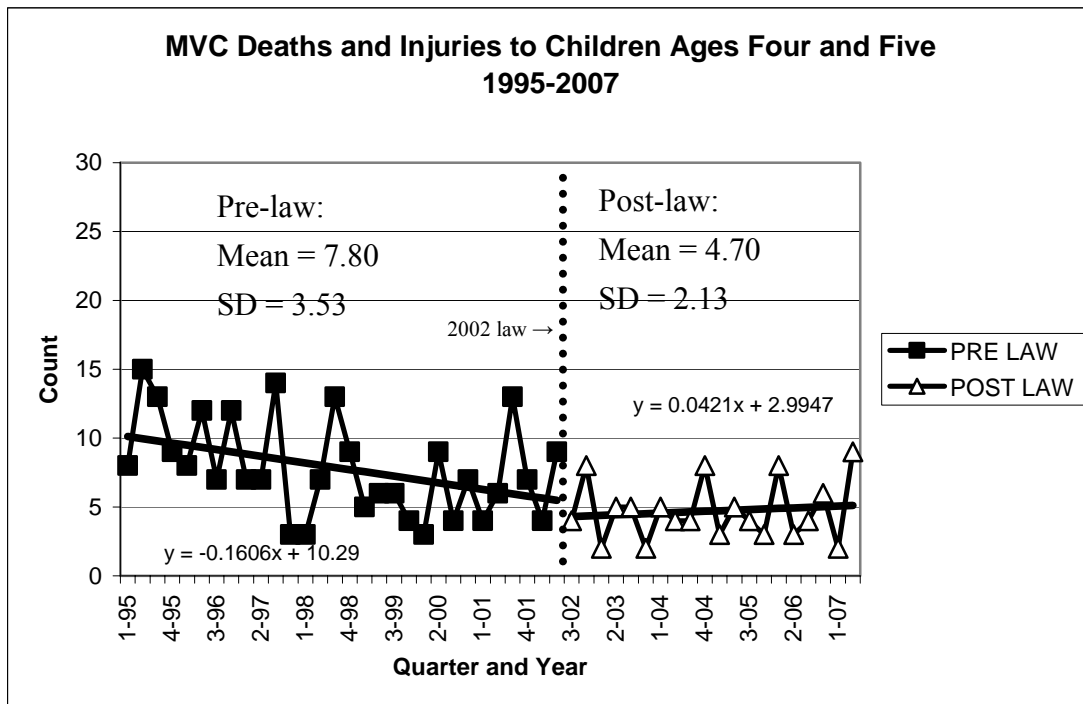
Ages Four and Five

Out of the 328 children ages four and five, 234 children were injured or died before the child passenger safety law went into effect, and 94 children were injured or died after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law (M = 7.80, SD =3.53) with the mean

case count per quarter post-law ( $M = 4.70$ ,  $SD = 2.13$ ). This test was found to be statistically significant,  $t = 3.87$ , ( $df = 47.64$ ,  $p = 0.00$ ). This indicates that equality of means pre and post-law cannot be assumed. There was a significant decrease in the number of injuries and fatalities post-law.

Figure 14 demonstrates that there was a trend downwards pre-law and then post-law it leveled off. Overall, as the t-test indicates, there was a decrease in the number of injuries and deaths of children ages four and five post-law.

**FIGURE 14: Motor Vehicle Crash Deaths and Injuries:  
Children Ages Four and Five 1995-2007**



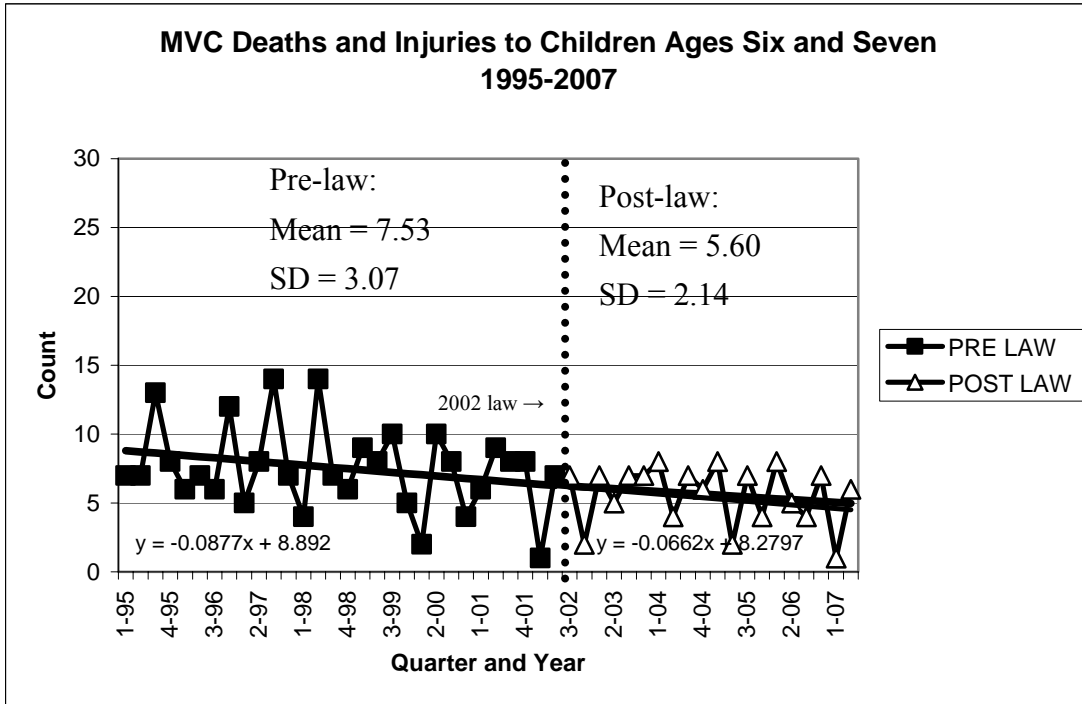
### Ages Six and Seven

Out of the 338 children ages six and seven, 226 children were injured or died before the child passenger safety law went into effect and 112 children were injured or died after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law ( $M = 7.53$ ,  $SD = 3.07$ ) with the mean case count per quarter post-law ( $M = 5.60$ ,  $SD = 2.14$ ). This test was found to be statistically significant,  $t = 2.45$ , ( $df = 48$ ,  $p = 0.02$ ). This indicates that equality of means pre and post-law cannot be assumed. There was a significant decrease in the number of injuries and fatalities post-law.

Figure 15 demonstrates that there was a trend downward pre-law and the downward trend continued post-law. Overall, as the t-test indicates, there was a decrease in the number of injuries and deaths of children ages six and seven post-law.

**FIGURE 15: Motor Vehicle Crash Deaths and Injuries:**

**Children Ages Six and Seven 1995-2007**



**Injury Severity**

To determine if there was a reduction in the severity of injuries sustained from motor vehicle crashes the two created injury severity categories, category 1 representing severe and fatal injuries and category 2 representing mild and moderate injuries, were analyzed. An independent samples t-test, along with rate/100,000 population, was conducted for each injury severity category and age group to determine if there was an effect on injury severity post-law.



## **Category 1 (Severe and Fatal Injuries) t-tests**

### **Severe and Fatal Injuries Under Age Four**

Out of the 128 severe or fatally injured children under age four, 87 children were injured or died before the child passenger safety law went into effect and 41 children were injured or died after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law ( $M = 2.90$ ,  $SD = 2.26$ ) with the mean case count per quarter post-law ( $M = 2.05$ ,  $SD = 1.23$ ). The alpha level was 0.05. This test was not found to be statistically significant,  $t = 1.71$ , ( $df = 46.51$ ,  $p = 0.09$ ). No significant difference of the means pre and post-law was found.

### **Severe and Fatal Injuries Ages Four and Five**

Out of the sixty-one severe or fatally injured children ages four and five, thirty-nine children were injured or died before the child passenger safety law went into effect and twenty-two children were injured or died after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law ( $M = 1.30$ ,  $SD = 1.42$ ) with the mean case count per quarter post-law ( $M = 1.10$ ,  $SD = 1.17$ ). This test was not found to be statistically significant,  $t = 0.52$ , ( $df = 48$ ,  $p = .60$ ). No significant difference of the means pre and post-law was found.

### **Severe and Fatal Injuries Ages Six and Seven**

Out of the forty-eight severe or fatally injured children ages six and seven, twenty-seven children were injured or died before the child passenger safety law went

into effect and twenty-one children were injured or died after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law ( $M = 0.90$ ,  $SD = 1.09$ ) with the mean case count per quarter post-law ( $M = 1.05$ ,  $SD = 1.10$ ). This test was not found to be statistically significant,  $t = -0.47$ , ( $df = 48$ ,  $p = 0.64$ ). No significant difference of the means pre and post-law was found.

Charts were not included for the severe and fatal category since the findings were not significant. Rates per 100,000 population were also calculated for severe and fatal injuries and results for all three age groups are displayed in Table 6.

## **Category 2 (Mild and Moderate Injuries) t-tests**

### **Mild and Moderate Injuries Under Age Four**

Out of the 466 mild and moderately injured children under age four, 309 children were injured before the child passenger safety law went into effect and 157 children were injured after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law ( $M = 10.30$ ,  $SD = 5.52$ ) with the mean case count per quarter post-law ( $M = 7.85$ ,  $SD = 2.21$ ). The alpha level was 0.05. This test was found to be statistically significant,  $t = 2.19$ , ( $df = 40.99$ ,  $p = 0.04$ ). This indicates that equality of means pre and post-law cannot be assumed. There was a significant decrease in the number of mild and moderate injuries post-law.

**FIGURE 16: Mild and Moderate Motor Vehicle Crash Injuries:  
Children Under Age Four 1995-2007**

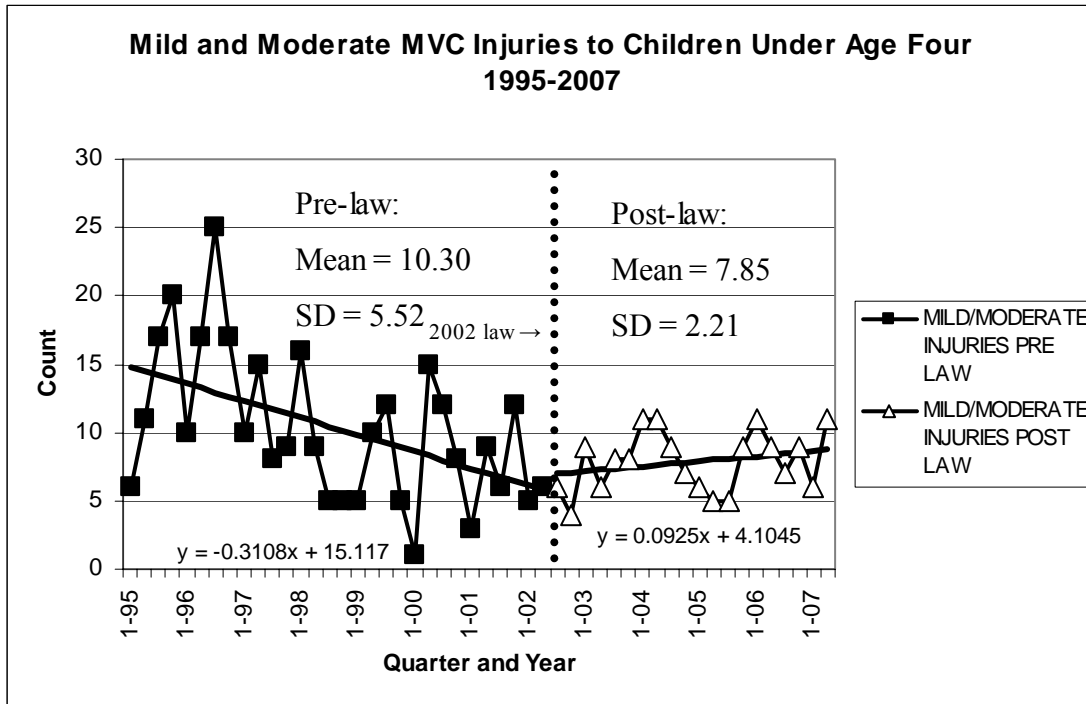


Figure 16 demonstrates that there was a trend downwards pre-law and then a slight increase upwards post-law. The t-test indicates that there was a significant decrease in the number of mild and moderate injuries of children under age four post-law.

Mild and Moderate Injuries Ages Four and Five

Out of the 267 mild and moderately injured children ages four and five, 195 children were injured before the child passenger safety law went into effect and 72 children were injured after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law (M = 6.50, SD =3.18) with

the mean case count per quarter post-law ( $M = 3.60$ ,  $SD = 1.67$ ). This test was found to be statistically significant,  $t = 4.20$ , ( $df = 49.92$ ,  $p = 0.00$ ). This indicates that equality of means pre and post-law cannot be assumed. There was a significant decrease in the number of mild and moderate injuries post-law.

**FIGURE 17: Mild and Moderate Motor Vehicle Crash Injuries:  
Children Ages Four and Five 1995-2007**

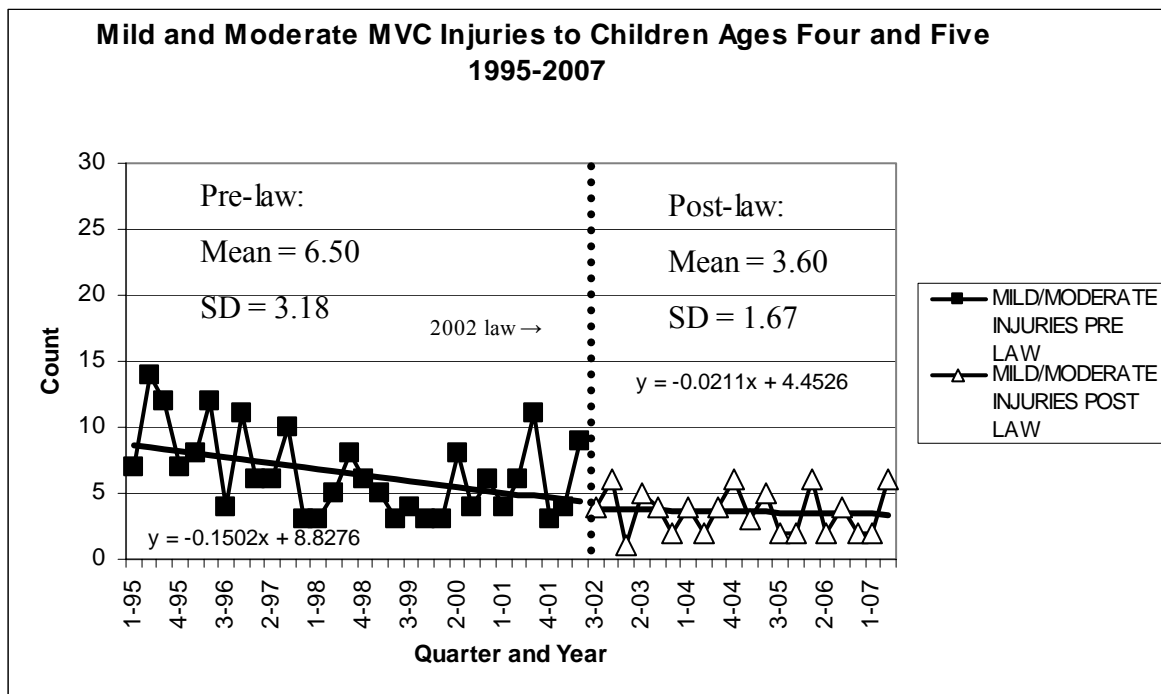


Figure 17 demonstrates that there was a trend downwards pre-law and then a slight decrease in the trend post-law for the target group, children ages four and five. Overall, the t-test indicates, there was a decrease in the number of mild and moderate injuries of children ages four and five post-law.

### Mild and Moderate Injuries Ages Six and Seven

Out of the 290 mild and moderately injured children ages six and seven, 199 children were injured before the child passenger safety law went into effect and 91 children were injured after the law went into effect. The independent samples t-test was performed comparing the mean case count per quarter pre-law ( $M = 6.63$ ,  $SD = 2.87$ ) with the mean case count per quarter post-law ( $M = 4.55$ ,  $SD = 1.82$ ). This test was found to be statistically significant,  $t = 2.88$ , ( $df = 48$ ,  $p = 0.01$ ). This indicates that equality of means pre and post-law cannot be assumed. There was a significant decrease in the number of mild and moderate injuries post-law.

**FIGURE 18: Mild and Moderate Motor Vehicle Crash Injuries:**

**Children Ages Six and Seven 1995-2007**

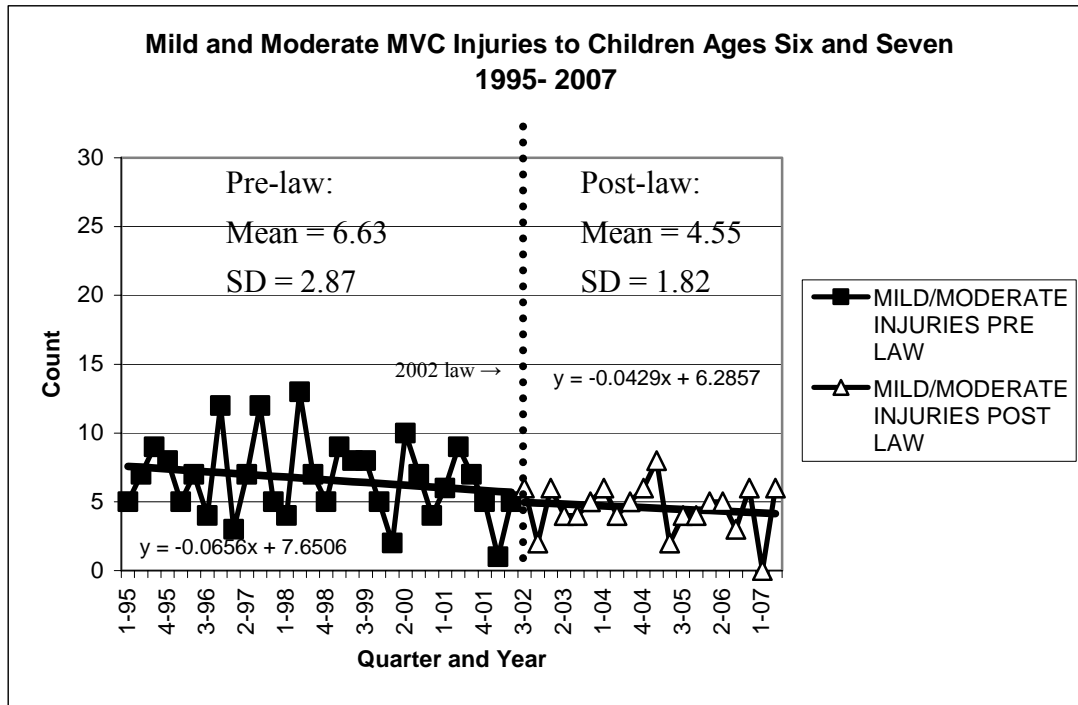


Figure 18 demonstrates that there was a trend downwards pre-law and that downward trend continued post-law for children ages six and seven. It is clear that there was a decrease in the number of mild and moderate injuries of children ages six and seven post-law.

Rates/100,000 population

Utilizing the merged hospital injury discharge and death data, rates per 100,000 were calculated for the target group and the two control groups using the U.S. Census Bureau data previously displayed in Figure 9. Additionally, rates per 100,000 for each

injury severity category were calculated and can be found in Table 6 below. An independent samples t-test was also conducted on the mean rate/100,000 per quarter for each of the three age groups in each of the three categories, merged injury and death data, mild and moderate injuries, and severe and fatal injuries.

#### Merged Hospital Discharge Injuries and Deaths / 100,000 Population

The target group, children ages four and five, and both control groups experienced a reduced rate of injuries and fatalities per 100,000 post-law. The independent samples t-tests conducted on the merged hospital injury discharge and death data rates per 100,000 for all three age groups were statistically significant indicating that equality of means pre and post-law cannot be assumed.

#### Mild and Moderate Injuries / 100,000 Population

Each of the three age groups found a significant reduction in the rate of mild and moderate injuries post-law. The independent samples t-tests conducted on the mild and moderate injuries rate per 100,000, for all three age groups, were statistically significant indicating that equality of means pre and post-law cannot be assumed.

#### Severe and Fatal Injuries / 100,000 Population

The analysis of the severe and fatal injuries did not provide significant findings for the target group or for the control group of children ages six and seven. The only age

group of severe and fatal injuries that had a significant rate reduction was the control group of children under age four.

The independent samples t-test on the rate per 100,000 confirmed the results. Only the control group of children under age four was statistically significant indicating that equality of means pre and post-law cannot be assumed.



**TABLE 6: Merged Hospital Discharge Injury and Death Data Rates / 100,000 and Injury Severity Rates / 100,000**

|   | <b>Mean Rate /Quarter<br/>Year<br/>pre-law<br/>Jan 1, 1995 –<br/>June 30, 2002</b> | <b>Mean Rate /Quarter<br/>Year<br/>post-law<br/>July 1, 2002-<br/>June 30, 2007</b> | <b>Difference/<br/>Quarter</b> | <b>Difference/<br/>Quarter x 4 =<br/>Difference /<br/>Year<br/>(estimate)</b> | <b>T-test<br/>(for rates pre-post)</b> |
|---|--|---|--------------------------------|---|--|
| <b>Merged Hospital Discharge Injuries and Deaths / 100,000 Population</b> |  |   |                                |   |  |
| Under Age Four  | 3.64   | 2.45  | 1.19                           | 4.76  | t = 3.60<br>(df = 39.2, p = 0.00)      |
| Ages Four and Five  | 4.16   | 2.42  | 1.75                           | 6.99  | t = 4.18<br>(df = 47.3, p = 0.00)      |
| Ages Six and Seven  | 3.98   | 2.93  | 1.06                           | 4.23  | t = 2.52<br>(df = 48, p = 0.02)        |
| <b>Mild and Moderate Injuries / 100,000 Population</b>                    |  |   |                                |   |  |
| Under Age Four  | 2.83   | 1.94  | 0.89                           | 3.56  | t = 2.92<br>(df = 38.6, p = 0.01)      |
| Ages Four and Five  | 3.47   | 1.86  | 1.61                           | 6.45  | t = 4.46<br>(df = 45.7, p = 0.00)      |
| Ages Six and Seven  | 3.51   | 2.38  | 1.13                           | 4.52  | t = 3.23<br>(df = 47.9, p = 0.00)      |
| <b>Severe and Fatal Injuries / 100,000 Population</b>                     |  |   |                                |   |  |
| Under Age Four  | 0.80   | 0.51  | 0.29                           | 1.16  | t = 2.20<br>(df = 44.5, p = 0.03)      |
| Ages Four and Five  | 0.70   | 0.56  | 0.14                           | 0.55  | t = 0.68<br>(df = 48, p = 0.50)        |
| Ages Six and Seven  | 0.48   | 0.55  | -0.07                          | -0.29   | t = -0.43<br>(df = 48, p = 0.67)       |

## **CHAPTER 5: Discussion and Recommendations**

Motor vehicle crash injury and death data from the Virginia Department of Motor Vehicles (VA DMV), Virginia Health Information (VHI), and the Virginia Department of Health Center for Health Statistics (VDH CHS) were analyzed and presented in the previous chapter. This chapter will provide a recap of the study, discussion about the study findings, possible reasons for the study findings, public policy recommendations, and potential future areas of study about child passenger safety.

### **Overview of the study**

Since Virginia enhanced requirements for child passenger safety, it is important to evaluate the effectiveness of the 2002 Virginia child safety restraint law and to evaluate if the law significantly reduced the number of motor vehicle crash injuries and fatalities in booster seat age children. Did the legislation reduce the loss of life and suffering motor vehicle crashes cause, or are other injury interventions and countermeasures necessary?

## **Study Purpose and Research Questions**

The primary research question for this study was:

- Has there been a statistically significant decrease in the number of children ages four and five injured or killed in Virginia as a result of motor vehicle crashes since the Virginia child passenger safety law (Code of Virginia Article 13- Section 46.2) went into effect on July 1, 2002?

In addition, analyses were conducted to determine whether there had been a decrease in injury severity from motor vehicle crashes in children ages four and five after the Virginia child passenger safety law went into effect on July 1, 2002. Two additional groups of children, children under the age of four and children ages six and seven, were selected as control groups.

## **Study Methodology**

Utilizing VA DMV data, the total number of crashes per year for all ages, not just children, and the number of vehicle miles traveled (VMT) were reviewed for the years 1995-2007. The number of children less than age eight injured and killed in a motor vehicle crash were analyzed to see if there were significant changes pre and post-law for the target age group, children ages four and five, and the two control groups.

Independent samples t-tests were run on each variable to determine if there was a statistically significant difference between the two means of the variable pre-law and

post-law. In addition, for the target group and the two control groups, rates were calculated per 1,000 crashes, 10,000 VMT, and 100,000 population.

The VHI and VDH CHS data were initially analyzed separately and then merged due to the small number of fatalities. An independent samples t-test was conducted for each age group to determine if there was an effect on the numbers of injuries, fatalities, and injury severity post-law. Rates per 100,000 population were also calculated.

### **Discussion of Findings**

The researchers' expectation that the 2002 Virginia child passenger safety law would be limited to the law's target age group, children ages four and five, was not found to be true. A decrease of injuries and fatalities after the law went into effect was found in target group of children, ages four and five, and in both control groups. Though the results for the target group were not significantly different than the two control groups, it should not be assumed that the law had no impact. In fact, results were favorable in all age categories perhaps due to spillover effect of the law.

### **VA DMV and U.S. Census Bureau Population Data**

The VA DMV data revealed that there was a slight upward trend in the number of crashes and VMT over the years of the study. However, independent samples t-tests indicate that there were no significant changes for either variable pre and post-law.

The U.S. Census Bureau population estimate data showed that only the control group of children under age four saw a slight upward trend over the years. The other two

age groups (children ages four and five and children ages six and seven) populations stayed relatively constant over the time frame of study.

The police crash report data demonstrated that the target group of children and both control groups, had a downward trend in the number of injuries from 1995 - 2007. The number of fatalities were small making it difficult to reliably assess any trend over the years and to conduct significant analyses. The VA DMV fatalities and injuries were combined and used to calculate rates per 1,000 crashes, 10,000 VMT, and per 100,000 population. VA DMV rates are discussed below and can also be found on Table 5 in Chapter 4.

#### VA DMV Rate of Merged Injuries and Fatalities per 1,000 crashes (all ages)

The target age group (children ages four and five) and both control groups saw a significant decrease in the rate of merged injuries and fatalities per 1,000 crashes post-law. Each age group saw a difference of approximately two injuries/fatalities per 1,000 crashes annually after the law went into effect based on the VA DMV data. The independent samples t-tests were significant for each age group indicating that there was a significant decrease in the number of injuries/fatalities per 1,000 crashes post-law.

#### VA DMV Rate of Merged Injuries and Fatalities per 10,000 VMT (all ages)

The target age group and both control groups saw a significant decrease in the rate of merged injuries and fatalities per 10,000 VMT post-law. The target group saw a difference of approximately thirty-one injuries/fatalities per 10,000 VMT annually after

the law went into effect based on the VA DMV data. Children under age four saw a difference of approximately twenty-five injuries/fatalities per 10,000 VMT and children ages six and seven saw a difference of approximately thirty-two injuries/fatalities per 10,000 VMT after the law went into effect. The independent samples t-tests were significant for each age group indicating that there was a significant decrease in the number of injuries/ fatalities per 10,000 VMT post-law.

#### VA DMV Rate of Merged Injuries and Fatalities per 100,000 Population (Per age group)

The target age group and both control groups saw a significant decrease in the rate of merged injuries and fatalities per 100,000 post-law. The target group saw a difference of approximately twelve injuries/fatalities per 100,000 annually after the law went into effect based on the VA DMV data. Children under age four saw a difference of approximately seven injuries/fatalities per 100,000 and children ages six and seven saw a difference of approximately twelve injuries/fatalities per 100,000 after the law went into effect. The independent samples t-tests were significant for each age group indicating that there was a significant decrease in the number of injuries/fatalities per 100,000 population post-law.

#### VHI Hospital Discharge Data

Independent samples t-tests on the hospital injury discharge data for the control group and both control groups were statistically significant indicating that equality of means pre and post-law cannot be assumed. There was a significant decrease in the

number of motor vehicle crash injures post-law for all three age groups. Again, these results may indicate that the law had a spillover effect on the control groups of children or some other cause could be responsible.

Because the VHI dataset only includes information on patients that were hospitalized, it was important to also analyze death records to obtain a more complete understanding of the burden of injury from motor vehicle crashes.

#### Virginia Department of Health Center for Health Statistics (VDH CHS) Death Data

Independent samples t-tests on the death data found a significant decrease post-law for the control group of children under age four. For the target group of children ages four and five and the control group of children ages six and seven, no significant decrease in the mean count per quarter was found post-law.

The low frequency and high variation of fatalities is presumed to be the primary reason no significant effect of the child safety restraint law on fatalities was found. To obtain results that were more meaningful the fatality data were combined with the hospital injury discharge data.

#### Merged Injury Hospital Discharge Data and Death Data

Independent samples t-tests on the merged hospital injury discharge data and death data for all three age groups were statistically significant indicating that equality of means pre and post-law cannot be assumed. The target group, children ages four and five, and both control groups experienced a reduction in injuries/fatalities post-law.

The law may not completely stop motor vehicle crash injuries from occurring, but it may reduce the severity of injuries sustained from motor vehicle crashes. To determine if there has been a decrease in injury severity from motor vehicle crashes in children ages four and five, since the Virginia child passenger safety law went into effect on July 1, 2002, additional analysis regarding severity of injury was conducted.

### Injury Severity

#### Category 1 t-tests (Severe and Fatal Injuries)

The three t-tests conducted by age group on the severe and fatally injured children did not demonstrate a significant decrease post-law in the target group of children ages four and five, or the two control groups. There was no significant decrease in the number of severe and fatal injuries post-law.

#### Category 2 t-tests (Mild and Moderate Injuries)

The three t-tests conducted by age group on the mild and moderately injured children were statistically significant indicating that equality of means pre and post-law cannot be assumed. There was a significant decrease in the target group, children ages four and five, and both control groups, in the number of mild and moderate injuries post-law.



### Merged Injury Hospital Discharge Data and Death Data Rates /100,000 population

The rates per 100,000 population for the merged injury and death data found similar results as the t-tests. The target group, children ages four and five, and both control groups experienced a reduced rate of merged injuries and fatalities per 100,000 post-law as was shown on Table 6 in Chapter 4. The target group of children ages four and five saw the greatest reduction post-law, from a rate of 4.16/100,000 per quarter pre-law to 2.42/100,000 per quarter post-law. This reduction of 1.75/100,000 per quarter roughly equates to seven fewer children injured or killed/100,000 each year post-law. The control group of children under age four saw a reduction 4.76/100,000 annually post-law and the control group of children ages six and seven saw a reduction of 4.23/100,000 annually.

The independent samples t-tests conducted on the merged hospital injury discharge and death data rates per 100,000 for all three age groups were statistically significant indicating that equality of means pre and post-law cannot be assumed. There was a significant decrease in the target group, children ages four and five, and both control groups, in the rate per 100,000 post-law.

### Severe and Fatal Injuries / 100,000 Population

The analysis of the severe and fatal injuries did not provide significant findings for the target group or for the control group of children ages six and seven. The only age group of severe and fatal injuries that had a significant rate reduction was the control

group of children under age four. This group saw a reduction of 1.16/100,000 severe or fatal injuries per year post-law.

The independent samples t-test confirmed the results. Only the control group of children under age four was statistically significant indicating that equality of means pre and post-law cannot be assumed.

#### Mild and Moderate Injuries / 100,000 Population

All three age groups found a significant reduction in the rate of mild and moderate injuries post-law. The target group of children, ages four and five, had the greatest reduction of mild and moderate injuries post-law, approximately 6.45/100,000 per year. The control group of children ages six and seven had a difference of 4.52/100,000 fewer mild and moderate injuries post-law and children under age four had a difference of 3.56/100,000 fewer mild and moderate injuries post-law.

The independent samples t-tests conducted on the mild and moderate injuries rate per 100,000, for all three age groups, were statistically significant indicating that there was a significant decrease in the number of injuries for each age group post-law.

#### **Implications**

The study found a reduced number of injuries and fatalities in the target group of children and both control groups after the 2002 Virginia child passenger law went into effect. The age group comparisons were particularly important in assessing the effects of the child restraint law, given that any changes in injuries and fatalities due to the law

should only be seen for those children covered by the law, with the exception of the possible spillover effects on the other children.

The study results demonstrate that the target group of children had the greatest reduction in injuries and fatalities (seven fewer injuries and fatalities annually) and the greatest reduction in mild and moderate injuries (approximately six and a half fewer mild and moderate injuries) post-law. A significant reduction of injuries and fatalities in the target group and not in the two control groups would have built confidence that the law was solely responsible for the findings. However, decreased injuries and fatalities for all age groups post-law is a favorable finding and could be partially due to spillover effect on the two control groups.

The VA DMV data suggests that the law, or some other cause, reduced the number of injuries and fatalities for the target group and both control groups. All three age groups for all three calculated rates (per 1,000 crashes, per 10,000 VMT, and per 100,000 population) found significant reductions in injuries and fatalities. The findings could be spillover from the law or some other reason may be responsible, and will be explored.

The merged VHI injury hospitalization discharge data and VDH CHS death data also suggest that a spillover effect may have occurred. All three age groups had significant t-test findings indicating there was a statistically significant decrease in the number of injuries and fatalities post-law.

It was hypothesized that the 2002 child passenger safety law may not completely stop any injuries from occurring, but that the law may reduce the severity of injuries

sustained from motor vehicle crashes. No significant t-test results were found for the severe and fatal injuries. The rate per 100,000 calculation did show a significant reduction of approximately one severe or fatal injury per 100,000 annually post-law for children less than age four.

A significant reduction in the number of mild and moderate injuries was found for each of the three age groups. The target group of children had the greatest reduction in the number, seven annually, of injuries and fatalities, followed by both control groups having approximately five fewer injuries and fatalities annually post-law.

### **Possible Explanations of Findings**

The 2002 law, along with a combination of additional injury prevention initiatives and possibly spillover effect, may explain the reason that both control groups, and the target group, saw significant reductions in injuries and fatalities post-law. The high level of statistical significance desired in this study may not have been achieved due to the interaction of many concurrent events and initiatives. The possibility that education, federal initiatives, enforcement, engineering, public policy changes, and/or enhancements in the emergency care system may have played a role in the overall reduced injuries and fatalities are explored below.

#### Education

Many organizations and government agencies in the United States implemented public health and educational campaigns to promote appropriate restraint of children in

motor vehicles. In March of 1998, the National Highway Traffic Safety Administration (NHTSA) began a standardized child passenger safety training and certification program. Over 16,000 people had been certified as child passenger safety technicians by the year 2000 (F. K. Winston, Chen, Arbogast, Elliott, & Durbin, 2003). NHTSA also made booster seat use the primary focus of its annual Child Passenger Safety Week in February 2000. In addition, NHTSA also launched a campaign called “4 Steps for Kids” which promotes proper use of child safety seats through the ages.

At the same time that NHTSA was actively educating about child passenger safety, insurance companies and car manufacturers became involved and developed their own educational campaigns. State Farm Insurance Company, prior to 2003, did a mass mailing on booster seats to its thirty-five million policyholders. Ford Motor Company, General Motors, and Daimler-Chrysler all created child passenger safety programs. Each had their own unique booster seat campaign which educated the public on the importance of using age appropriate child safety seats. Ford Motor Company, through its Boost America Campaign, in addition to educating the public distributed one million booster seats across the nation (F. K. Winston, Chen, Arbogast, Elliott, & Durbin, 2003). The promotion of age appropriate child safety seat use by federal, non-profit, corporate, and other organizations, was cited as a reason one study found a thirty-three percent increase in child safety seat use (F. K. Winston, Chen, Arbogast, Elliott, & Durbin, 2003).

In Virginia, there already were strong partnerships between a variety of organizations and agencies that were working on educating the public about best practice recommendations for child passenger safety. The 2002 Virginia law, while targeted

towards children ages four and five, was the impetus for massive statewide child passenger safety education for children of all ages. Two of the leading child passenger safety and injury prevention agencies in Virginia indicated that the 2002 law was used to educate about best practice recommendations for all ages (Funkhouser Board, December 23, 2008; Miller-Hobbs, October 23, 2008). Educational influences during the post-law period included educational messages, media, and activities sponsored by the Virginia Department of Health Division of Injury and Violence Prevention (VDH DIVP), VA DMV, Virginia SAFE KIDS, Drive Smart Virginia, State police, and a multitude of other agencies. These activities that were targeted for all ages of children, not just four and five year olds, probably increased child safety seat use, and could explain some of the favorable results found in the two control groups.

Prior to the law going into effect July 1, 2002, agencies took the opportunity to educate the public about child passenger safety for all ages. VDH DIVP coordinated a Ford Boost America program in the spring of 2002 in Norfolk, Virginia (Funkhouser Board, December 23, 2008). Partners for this event included United Way of South Hampton Roads, Virginia Association of Chiefs of Police, American Automobile Association (AAA), Drive Smart of Hampton Roads, VA DMV, and Ford Motor Company. Ford awarded 10,600 booster seats to VDH DIVP to disseminate to the public. The one-day event distributed over 250 booster seats, inspected and correctly installed approximately 120 child safety seats, and distributed an additional twenty child safety seats. VDH DIVP coordinated the distribution of the remaining booster seats to various agencies and organizations in all of the health districts to ensure distribution to

income eligible families throughout the state (Funkhouser Board, December 23, 2008).

The project was timely in that it was a great opportunity to provide booster seats to families that could not afford them, but were going to be required to use them under the new law starting July 1, 2002.

Additionally, VDH DIVP commemorated Buckle Up America Week, May 20-27, 2002 by coordinating an 11,000 targeted mailing of information packets about the new child passenger safety law and general child passenger safety information (Funkhouser Board, December 23, 2008). Information packets were sent to all licensed daycare centers (home and centers), Children's Health Insurance Program (CHIP) contacts, Head Start centers, pediatricians, family care physicians, all health departments/districts, SAFE KIDS coalitions, VA DMV Community Transportation Safety Program (CTSP) managers, Virginia National Highway Traffic Safety Administration instructors, hospital pre-natal educators, public elementary schools, sheriff offices, police departments, law enforcement training academies, churches, public libraries, schools implementing the National Fire Protection Association Risk Watch injury prevention curriculum, and Drive Smart Virginia members.

The mass educational efforts across Virginia for all ages of children, not just children ages four and five, almost certainly made a significant impact on the number of children using child safety seats. The increase in the use of child safety seats would explain the decrease in the number of injuries seen when children were involved in a motor vehicle crash. Other studies have shown that education does increase usage rates

(King, Monroe, Applegate, & Cole-Farmer, 2007; F. K. Winston, Chen, Arbogast, Elliott, & Durbin, 2003) and that utilizing a child safety seat reduces the risk of injury. Child safety seats reduce the likelihood of a child under the age of one being killed in a motor vehicle crash by seventy-one percent and child safety seats reduce the likelihood of children between the ages of one and four of being killed by fifty-four percent (National Highway Traffic Safety Administration, 2007). Children between the ages of four and seven who use booster seats are fifty-nine percent less likely to be injured in a car crash than children restrained only by a seat belt (Durbin, Elliott, & Winston, 2003). An increase in use of child safety seats would explain the reduction of overall injuries and mild and moderate injuries seen for all three age groups of this study.

The lack of reduced severe and fatal injuries could be explained by non-use, or serious installation error, of child passenger safety restraints. It is possible that an improperly used child restraint may offer protection in minor crashes but fail to protect children from injury in more severe crashes.

Additionally, through educational initiatives, parents learned that the safest place for a child is the rear seat of the vehicle. There is evidence that child safety restraint laws may be associated with a decrease in the number of children riding in the front seat (Wagenaar & Webster, 1986). The change in seating position from the front seat to the rear seat, which is considered safer, may play a part in the reduction in injuries for all ages of children.



## Federal Grants

Starting in 1998, NHTSA provided state incentive grants that were designed to improve traffic safety in the states. In 1999, NHTSA provided funds to support states to educate on occupant safety, improve existing seat belt and child passenger safety legislation, and provide training and services designed to improve appropriate use of child safety restraints. In 1998, Virginia received almost seven and a half million dollars. In 2002, Virginia received almost twenty-two million dollars and the support from NHTSA to this day, has continued to support transportation safety initiatives (National Highway Traffic Safety Administration, 2009). Over the years, these federal funds have been used to support many initiatives to improve child passenger safety across Virginia.

In addition to the NHTSA funds, the United States Maternal and Child Health Bureau funded Virginia in 1998 with a three year Virginia Emergency Medical Services for Children (VA EMSC) program implementation grant. EMSC is an initiative designed to reduce child disability and death due to illness or injury. The initial purpose of the program is to prevent childhood illness or injury. When prevention fails, the goal is to ensure that all ill or injured children and adolescents receive state-of-the-art emergency medical care from prehospital professionals, emergency department personnel, and rehabilitation specialists, if needed.

The VA EMSC program utilized over seventy thousand dollars from its 1998 implementation grant to focus on preventing the leading causes of injury and death of children. The primary focus was on child passenger safety. The VA EMSC program, which was located at Virginia Commonwealth University, continued to support injury

prevention initiatives until the program relocated to the VDH in March of 2007. The federal funds targeted towards improving child passenger safety unquestionably play a role in the findings of this study.

### Police Education and Enforcement

State police, since they are the responsible party to collect crash data, must have knowledge regarding child passenger safety. All state police are required to complete eight hours of training on child passenger safety (Geller, March 24, 2008). In addition to the required training, many officers partner with other child passenger safety advocates to work on child safety seat inspections and community educational events across Virginia to ensure proper use of seats in accordance with the law.

When a new traffic safety law is passed, all Virginia state police officers are provided with a memo about the upcoming changes, are provided a notepad detailing the new laws and any amendments, and are required to watch a video about the new laws. The state police aggressively enforce all child passenger safety laws and use each violation as a teachable moment to educate caregivers about proper use of child safety seats (Geller, March 24, 2008). As mentioned earlier, police presence and enforcement are a critical piece of child passenger safety. However, enforcement alone does not increase booster seat use (King, Monroe, Applegate, & Cole-Farmer, 2007). A multi-faceted approach, as was seen in Virginia, combining legislation, education, and enforcement is best at achieving a reduction of motor vehicle injuries and fatalities (Ehiri et al., 2006; King, Monroe, Applegate, & Cole-Farmer, 2007). The combination of the

legislation, education, and enforcement definitely are partly responsible for all age groups of this study having a reduction in the number of injuries and fatalities post-law.

In addition to the enforcement and education by police, in 2002 Virginia adopted the NHTSA “Click It or Ticket” campaign without being part of the national evaluation (National Highway Traffic Safety Administration, 2002a). “Click It or Ticket” is a NHTSA mobilization campaign to increase the use of seat belts among young people and is primarily aimed at teens and young adults. Through partnerships of law enforcement agencies, State police, and traffic safety advocates, the 2004 Virginia “Click It or Ticket” campaign resulted in Virginia exceeding its goal of increasing the safety belt use rate from seventy-five percent to seventy-seven percent. After the campaign, the annual safety belt observational survey found the State’s rate was almost eighty percent. More than 3,300 drivers received citations for not using seat belts, 362 were cited for not having children in child safety restraints, and over 15,000 traffic citations were written during the campaign (National Highway Traffic Safety Administration, 2004). The high profile campaign increased the number of people buckling themselves up and restraining their children so they would avoid receiving a citation. The “Click It or Ticket” campaign is just one additional education component that could explain the overall decrease in injuries and fatalities observed in this study.

### Speed Limit Changes

Over the duration of the study time frame, 1995 through 2007, speed limits on a few major interstate highways were raised to improve safety and traffic flow (Virginia

Department of Transportation, 2009). In 1994, the Virginia General Assembly had passed a bill to provide for a uniform sixty-five mile per hour speed limit for all vehicles on rural interstate highways ("Acts of Assembly ", 1994).

The areas of Virginia impacted during the study time frame by the legislative changes are nominal when viewing all of Virginia's highways. The researcher believes that the changes in speed limits to improve safety and traffic flow had a minimal, if any effect, on reducing the number of injuries in all three age groups of children in the study.

Prior to the 2002 child passenger safety law, bills were passed that increased the maximum allowable speed limit on the Dulles Greenway, limited access highways in Frederick County, on Virginia Route 288, and on high occupancy vehicle (HOV) travel lanes that are physically separated from normal travel lanes, from fifty-five miles per hour to sixty-five miles per hour ("Acts of Assembly", 1996; , "Acts of Assembly", 1998; , "Acts of Assembly", 1999; , "Acts of Assembly", 2001).

After the 2002 child passenger safety law was passed, a few changes in speed limits occurred. In 2004, the Virginia General Assembly mandated that the maximum speed limit will be sixty-five miles per hour on interstate highways, multi-lane, divided, limited access highways, and HOV lanes that are physically separated from regular travel lanes and sixty miles per hour on U.S. Route 360 where it is a non-limited access, multilane, divided highway ("Acts of Assembly", 2004). In the 2005 General Assembly session, the speed limit was increased to sixty miles per hour on U.S. Route 17 between Port Royal and Saluda, on U.S. Route 29, U.S. Route 460, and U.S. Route 58 ("Acts of Assembly", 2005). During the 2006 session the maximum speed limit on Interstate 85

was set at seventy miles per hour ("Acts of Assembly", 2006). Again, it is presumed that these speed limit changes had only a minimal, if any, effect.

### Traffic Violations/Fines

Over the study time frame there were no major changes in the fines associated with traffic violations. Effective July 1, 2007, the end of the study time frame, Virginia began issuing traffic fines as high as \$3,550 per violation (TheNewspaper.com, 2007). Virginia's 2007 traffic fines were expected to raise funds to improve the state's roads without raising taxes. In addition, it was anticipated that the new law would help reduce traffic injuries and deaths. The House of Delegates voted to repeal the high fees on Virginia residents for various traffic offenses during the 2008 General Assembly (Fiske, 2008). Since the law began July 1, 2007, which was the end of the study, traffic violation fines had no impact on the findings of this study.

### Engineering: Highway Safety Design

Engineering plays an important role in the multi-faceted approach in the prevention of motor vehicle crashes. Enhancing safety on Virginia's roads has been achieved through a variety of improvements in roadway safety features including roadway design. It is estimated that roadway design is an important factor in approximately one-third of fatal motor vehicle crashes (The Road Information Program, 2004). Roadway improvements such as adding lanes, removing obstacles, adding or improving medians, widening lanes, widening and paving shoulders, improving

intersection design, upgrading road markings and traffic signals, the separation of traffic from oncoming vehicles, gentler curves, paved shoulders and rumble strips, all contribute to reducing traffic injuries, fatalities and crashes (The Road Information Program, 2004).

Since 1998, federal legislation have provided federal funding for Virginia's transportation program, including funds to support highway safety improvements and other traffic safety initiatives in Virginia (Virginia Department of Transportation, 2006). The reduction of injuries and fatalities found in this study are probably due in part to the roadway improvements that occurred across Virginia since 1998.

#### Engineering: Vehicle Safety Design

Another key factor in motor vehicle safety is vehicle design. During the 1990s, vehicle manufacturers, NHTSA, and other motor vehicle safety experts realized considerable advances in vehicle safety technology. Vehicles have been made safer through the addition of front and side airbags, seat belt pretensioners and load limiters, knee bolsters, safety belt reminder systems, enhanced vehicle stability technology, and anti-lock braking systems, crumple zones, side impact protection beams, and padding of the instrument panel and other interior parts of the vehicle likely to be struck by the occupants during a crash (Wikipedia, 2009; F. Winston, Xie, Durbin, & Elliott, 2007). Many additional safety features have also been added that protect both the driver and the passengers. The enhancement of vehicle safety features are one possible explanation for the reduction in injuries ad fatalities that were found in this study.

## Installation Issues and Improvements

When not used correctly, the effectiveness of child safety seats is greatly reduced. Research has shown that approximately eighty percent of child safety seats are misused in some form (Miller-Hobbs, April 15, 2003; Virginia Department of Health Division of Injury and Violence Prevention, 2008a). The individuals, usually the parents, installing the child seats certainly are not making such errors due to a lack of motivation to install the seats and to secure the child within the system correctly. Therefore, it is possible that the physical demands and ease of installation of child safety seats are too challenging to allow many people to perform this important task correctly.

To address the high rate of child safety seat misuse, NHTSA required new child safety seats to have a specialized way of attaching to a vehicle seat beginning September 1, 2002. The system, called “Lower Anchors and Tethers for Children” (LATCH), is a restraint system created to work independently of the vehicle seat belt system to make child safety seat installation easier and reduce misuse (National Highway Traffic Safety Administration, 2002c).

In conjunction with the new child safety seat requirement, all new passenger vehicles manufactured after Sept. 1, 2002 have the anchors for the child seat lower anchors and tethers so the child safety seats can be installed using the LATCH system. Together, the two lower attachments and an upper tether on a child safety seat and the lower anchors and a top tether anchor built into a vehicle’s back seat make up the LATCH system. NHTSA estimated that the LATCH system would eliminate half of the misuse due to incorrect installation and when used properly, LATCH was expected to

save up to fifty lives annually and prevent close to 3,000 injuries in a motor vehicle crash (National Highway Traffic Safety Administration, 2002c).

NHTSA conducted a survey in 2005 to collect information about the types of child restraint systems that were being used to keep children safe while riding in motor vehicles. A primary focus of the study was whether drivers with LATCH equipped vehicles were using LATCH to secure their child safety seats to the vehicle, and if so, were these seats properly installed (L. Decina, Lococo, & Doyle, 2006). The survey found that forty percent of parents were unaware of either the existence or the importance of the LATCH system and still relied on the vehicles' seat belts when installing their car seat. The LATCH system was supposed to simplify child safety seat installation for parents and caregivers but the study found that the LATCH system has not solved as many installation problems as NHTSA originally anticipated (National Highway Traffic Safety Administration, 2006).

Proper use of child safety restraints is the most effective way to protect children involved in a motor vehicle crash. Despite many parents still not using LATCH, those individuals utilizing the LATCH system could be a reason for the reduced number of child injuries and fatalities found in this study for the target group and both control groups.

### Medical Care System

In 1974, Virginia's Board of Health was given authority as a result of the Federal Emergency Medical Services Act of 1973 to develop "a comprehensive, coordinated



emergency medical care system of the Commonwealth.” A coordinated emergency medical care system is critical to favorable health outcomes of individuals sustaining an injury. The Commonwealth’s trauma system development began voluntarily in the early 1980s with a trauma designation program and the creation of a statewide trauma registry (Joint Legislative Audit and Review Commission, 2004).

The Virginia trauma center designation and periodic verification process is administered by the Virginia Office of Emergency Medical Services (VA OEMS) within the Department of Health. Part of the trauma center designation process involves a commitment to injury prevention through community education and research. Multiple studies have examined whether improvements in mortality and morbidity occurred after the implementation of a trauma system, and nearly all found a positive effect on both measures. A review of motor vehicle crash deaths, the most common source of traumatic injuries nationally, revealed an eight percent decrease in mortality when a trauma system was available (Joint Legislative Audit and Review Commission, 2004).

VA OEMS is also responsible for the statewide trauma registry and for all Virginia emergency medical services (EMS) personnel. In 1997, statewide triage protocols were established to provide criteria by which EMS providers could assess whether an injured patient should be transported to a trauma center (Joint Legislative Audit and Review Commission, 2004).

In addition to improvements being made by VA OEMS, the VA EMSC program provided over two hundred thousand dollars, starting in 1998, for pediatric training and supplies to the EMS Regions in Virginia. Appropriate pediatric equipment and pediatric

focused education for EMS providers is critical when administering emergency medical care to children who have sustained an injury.

Another key component of a well coordinated and comprehensive emergency care system is emergency departments. One of the most frequent causes of injury to patients treated by emergency physicians is motor vehicle crashes. Starting in 1997, the American College of Emergency Physicians (ACEP) realized that a multi-faceted approach involving collaborative efforts between public and private organizations was essential to improve motor vehicle safety and reduce injury, death, and costs related to motor vehicle crashes (American College of Emergency Physicians, 2009). ACEP answered this call to action and members became involved in motor vehicle safety initiatives at the local, state, and national levels.

Well trained EMS providers, capable emergency department staff, and highly skilled trauma center personnel create better outcomes for injured people. Having these talented health care providers educating on injury prevention to their local communities is an integral part of decreasing, the occurrence of motor vehicle injury. The comprehensive and well coordinated Virginia emergency care system certainly is an integral part of the explanation as to why all ages, the target group and both control groups, saw a reduced number of motor vehicle crash injuries and fatalities post-law.

### **Recommendations/ Future Areas of Study**

The VHI hospitalization discharge data and VDH CHS death data, while reliable sources of data, can only provide us with some answers to better understand the burden of

injury and death caused by motor vehicle crashes. The VHI and VDH CHS datasets only include those children severely injured enough that they were admitted to a hospital or those that sustained fatal injuries. The majority of children involved in a motor vehicle crash visit their private physician, an emergency department, or urgent care center and then are released. These children, since they are not severely injured enough to require a hospital admission, are not captured in this analysis.

Currently, Virginia does not collect statewide emergency room data, urgent care center data, or data from physician practices. Additionally, the long-term post-hospitalization outcomes and expenses of the patients within the VHI dataset are not known and the years of potential life lost for the fatalities are not known.

If statewide emergency room, urgent care center, or private physician office data ever are collected it would be an excellent source of data to further evaluate the impact that motor vehicle crashes have on children's health.

Another area of future study that would assist in evaluating the changes in motor vehicle crash injuries and fatalities is to evaluate whether the child safety seat is properly installed and used. The passage of a law does not imply the child safety seats will be used properly. It is not possible to determine if the injury or fatality sustained from a motor vehicle crash is in part due to incorrect installation or issue of the child safety seat. Currently, police crash report forms do not capture data on proper use of a child safety seat in Virginia and it is not anticipated that the data will be captured in the near future.

The Virginia police crash report data is a useful source of data but not without limitations when analyzing children involved in motor vehicle crashes. Virginia is not

the only state that has encountered problems with their police crash report data and other states have also had research hindered due to limitations with police crash report data. If Virginia could improve their capability of capturing data on all crashes, on all individuals involved in a crash, the coding of the data, and the ability to parse out the data by specific age, additional research could be conducted to evaluate the impact of all passenger safety laws.

As mentioned earlier, the Virginia General Assembly amended the child passenger safety law in 2007 and required children through the age of seven (until their eighth birthday) to be properly secured in a safety restraint. An analysis of the age increase would be worthwhile to determine if the increase in age had an effect on injuries and fatalities of children when involved in a motor vehicle crash.

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## **APPENDIX A**

### Available Data Variables from VHI and VDH CHS

#### Virginia Health Information Data Variables:

Medicare Provider Number

Provider Number (National Provider Identifier for the hospital)

Age in Days

Age in Years

Patient Sex

Patient Race

Quarter/Year of Admission

Quarter/Year of Discharge

Admission Source

Admission Type

Patient Zip Code

Length of Stay

Patient Discharge Status

Principal Diagnosis

Secondary Diagnosis Codes

Principal Procedure Code

Secondary Procedure Codes

Preoperative Length of Stay

Postoperative Length of Stay

Diagnostic Related Group

Major Diagnostic Category  
All Patient Refined Diagnostic Related Group  
Total Charges  
Room and Board Charges  
Routine Care Charges  
Special Care (Intensive Care) Charges  
Anesthesiology Charges  
Pharmacy Charges  
Radiology Charges  
MRI/CT Charges  
Nuclear Medicine Charges  
Clinical Lab Charges  
Labor/Delivery Room Charges  
Operating Room Charges  
Oncology Charges  
Med/Surg Supplies Charges  
Other Charges  
Payer Type  
U.S. Postal Service County Code  
Health Planning Region Codes  
Health Planning District Codes  
Complication Code  
Cancer Co-morbid  
Chronic Cardiovascular Disease  
Chronic Liver Disease  
Chronic Renal Disease  
Chronic Diabetes  
Chronic Pulmonary Disease  
Cerebrovascular Degeneration

Patient State  
External Injury Codes  
Infant Birth Weight  
VHI Unique Record Identifier  
Attending Physician Identification Number  
Operating Physician Identification Number  
Other Physician Identification Number  
Readmission and Transfer

\* Virginia Health Information (VHI) has provided non-confidential patient level information used in this file, report, publication, or database which it has compiled in accordance with Virginia law but which it has no authority to independently verify. By using this file, report, publication, or database, the user agrees to assume all risks that may be associated with or arise from the use of inaccurate data. VHI cannot and does not represent that the use of VHI's data was appropriate for this file, report, publication, or database or endorse or support any conclusions or inferences that may be drawn from the use of VHI's data.

VDH Center for Health Statistics Data Variables:

Certificate Number  
Name of Deceased  
Gender  
Date of Death  
Age of Deceased  
Race

Hospital Code  
Hospital Status (DOA, Outpatient, Inpatient, etc)  
Place of Death (3 digit city/county code)  
Planning District of Place of Death  
Place of Residence (3 digit city/county code)  
Planning District of Place of Residence  
Address of Residence  
Zip code of Residence  
Marital Status  
Social Security Number  
Birthplace of Deceased (State or country)  
Autopsy Performed? (yes/no)  
Pregnancy? (yes/no)  
Accident Code (uses standard National Safety Council codes)  
Attendant Code  
Transcript Code  
Census Tract (Newport News and Richmond only)  
Date Record Filed  
Underlying Cause Code (in ICD format)  
Multiple Cause Codes (up to 20 codes in ICD format)  
Annual Report Cause Code  
Date of Birth  
Name of Father  
Maiden Name of Mother  
Name of Spouse (given first name only)  
Initials of Spouse (initials for first and middle name only)  
Hispanic Origin Code  
Education Level

## VITA

Petra Maria Menzel Connell was born on August 14, 1968, in Royal Oak, Michigan, and is an American citizen. She earned her baccalaureate degree in science from Michigan State University in 1991 and her master's degree in public health from Virginia Commonwealth University in 1998. During her doctoral studies, she worked as the Program Director, Principal Investigator, and as a consultant for the Virginia Emergency Medical Services for Children (VA EMSC) Program. She continues to serve as a consultant for both the National EMSC program and VA EMSC program.

During her time with VA EMSC, she was awarded 1.6 million dollars in grant funding to support injury prevention, systems development, school health, and data enhancement throughout Virginia. She has been the recipient of numerous honors and awards, including the Maternal and Child Health Bureau National Heroes EMSC Project Coordinator of Distinction Award in 2004 and the Virginia Governor's Award for Outstanding Contribution to EMSC in 2003.

Ms. Connell has served on multiple national committees including the Health Resources and Services Administration (HRSA) EMSC Partnership Stakeholder Group, the National EMSC Grantee Meeting Planning Committee, the Mid-Atlantic Annual EMSC Symposium Planning Committee, and the National EMSC Public Information and

Education Information Task Force. In Virginia, she has served on the Virginia Department of Health (VDH) Child Passenger Safety Awareness Week Planning Committee, the Virginia Injury Community Planning Group, the VA EMSC Committee, the VDH Risk WATCH Champion Management Team, the VDH Trauma System Oversight Committee, and countless other committees.

Ms. Connell has delivered seven invited addresses at national meetings and numerous invited presentations at Virginia conferences ranging in topic from injury prevention to creating effective products for target publics. She has authored a chapter on injuries in children, co-authored the VDH Pediatric Disaster Life Support course, and coordinated and developed educational training tapes for EMS professionals including pediatric trauma care, children with special health care needs, neonatal resuscitation, and pediatric triage.