

**Virginia Commonwealth University  
Transportation Safety Training Center  
Crash Investigation Team**

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## **ABSTRACT**

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During March, April and May of 2006, seven small children riding as passengers in motor vehicles died as a result of crashes. These children, all between the ages of 22 months and 4 years, 8 months, were required by Virginia law to be secured in safety seats that meet United States Department of Transportation standards. This special report, entitled “Child Safety Restraint Study”, examines this series of fatal crashes. The purpose of this report is to address issues related to child safety restraint use, including: (1) failure to use any restraint, even though it is required by state law, (2) using an inappropriate type of restraint for the child’s height, weight and age, (3) incorrect installation of the seat itself, and (4) incorrect use of the child safety seat’s restraint system. Additionally, the effectiveness of child safety restraints in different types of collisions is considered.

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## INTRODUCTION

In 1982, the Virginia General Assembly enacted the Commonwealth's first child safety restraint law. In 1991, the Virginia Multi-disciplinary Crash Investigation Team released "Special Report Number 8—Child Safety Seats", in response to an increase in child fatalities in motor vehicle crashes that occurred in 1990. Of the sixteen children who died, only four had been properly restrained. Nine were not restrained by any method and a few had been fatally injured while improperly restrained. In 1992, the General Assembly amended the law to require that any child under the age of four be properly secured in a child restraint device which meets the standards adopted by the United States Department of Transportation (USDOT). The General Assembly again amended the law in 1997 to cover older children, stating that any child at least four but less than 16 years of age must be restrained by an appropriate safety belt system. The 2002 session introduced an age change, requiring that any child through the age of five is provided with and properly secured in a child restraint device which meets the standards adopted by the USDOT. This session also made an allowance to allow a child, who is at least four years of age but less than six, and whose weight and size is such as to make the use of child restraint device impractical and to make the use of seat belts practical be secured in the seat belt, which is standard equipment in the vehicle. These changes reflected an acknowledgement that vehicle safety restraint systems installed by the manufacturer, while acceptable for older, larger children, could not provide enough protection to the developing bodies of very young children and that belt systems, when used alone, did not usually fit appropriately when worn by children shorter than four feet nine inches tall.

The number of children dying as passengers in motor vehicle crashes has declined significantly since the passage of these laws, especially when law enforcement is combined with the efforts of pediatricians, government and private groups educating parents about the benefits of child safety restraints. However, to meet the demands of customers, the numbers and types of restraints has proliferated. As with any product line, these devices vary in their design and application. Some are easier to use while others may fit better in one vehicle than in another. Some systems are designed to use only with infants; others have more versatility. The options and information on installation and use can be confusing. If child safety restraints are to perform effectively, they must be installed correctly in the vehicle and the child must be placed and belted correctly within them. Misuse can lead to harmful, sometimes fatal, consequences.

During the months of March, April and May, 2006, seven young children were killed when the vehicles in which they rode crashed. A member of the Virginia Multi-disciplinary Crash Investigation Team (VMCIT) had assisted in the investigation of the second of these crashes (Case Study Number 1). One concern that came up was how the child involved had been fatally injured, since she had been in a child safety seat and there had been no intrusion into her occupant area during the crash. While the VMCIT was looking into this crash in more depth, five other child passengers were killed in crashes across the state. Only one child had been unrestrained. The VMCIT decided to pursue investigations into these crashes, focusing specifically on the use of child safety restraints. This special report is the product of those investigations.

The six case studies presented illustrate the following problems with regard to child safety restraint use: (1) failure to use any restraint, even though it is required by state law, (2) using an inappropriate type of restraint for the child's height, weight and age, (3) incorrect installation of the seat itself, and (4) incorrect use of the child safety seat's restraint system.

As mentioned above, any child through the age of five must be properly restrained in an appropriate child restraint device. Those who are not become free-moving projectiles during a crash, striking the interior of the vehicle and other occupants. Often, they are ejected. Lack of restraint use is usually easy to identify.

If a child was restrained in a safety seat, however, the investigation becomes more complex. When it comes to restraint systems, one size does not fit all. Based on recommendations from the American Academy of Pediatrics, infants less than 12 months old or weighing less than 20 pounds should be secured in a semi-reclining position facing the rear of the vehicle. They can be placed in an infant seat especially designed for babies, or they may be placed in the rear-facing position in a convertible seat designed to accommodate a range of sizes, from infants to toddlers. In the event of a frontal crash, babies who are correctly restrained by the seat's internal harness would remain in place and the energy forces of the impact would be spread out across the entire back of their tiny bodies, greatly reducing their likelihood and severity of injury.

Once a child has reached one year and surpassed 20 pounds, the convertible seat may be adjusted to an upright position and turned around to face forward. Another option is to place them in a high back combination seat designed for children of their weight and height. The combination seat has an internal harness for smaller forward facing children and can be used as a

high back belt positioning booster as they grow beyond the capacity of the internal harness. The harness system on both convertible and combination seats will include shoulder straps, lap belts which fit across the pelvis and a crotch strap, forming a five point internal restraint system. These webbed straps, in addition to keeping a child from flying about during a collision, help to spread the energy forces across the child's entire torso.

Convertible and combination seats vary on how large a child they can support and protect. Once a child has reached four years and grown to about 30 to 50 pounds, they are usually able to move into a booster seat that does not utilize the internal harness. Instead, these seats raise the child to a height where the vehicle's lap and shoulder belts fit correctly across their bodies and provide sufficient protection. Such boosters, whether they have high backs or are backless, should only be used with lap and shoulder restraints, never lap belts alone. The American Academy of Pediatrics and the National Highway Traffic Safety Administration (NHTSA) recommend that their use continue until a child is at least eight years old or reaches four feet nine inches in height. Parents should always check the weight and height limitations for the child safety seat they choose, making sure that they move a child to a different seat or change from using an internal harness to using the vehicle lap and shoulder restraints when the height and weight limitations on the seat are exceeded.

In addition to choosing the best child safety restraint for an individual child and ensuring that the child is restrained properly within the seat, parents and guardians must also install the seat correctly in the vehicle. Newer vehicles may have a LATCH system that uses anchors and tethers designed specifically for this purpose. In other vehicles, the regular safety belts can be used, but these may require careful attention to belt routing paths and the use of special devices, such as locking clips, to keep the belt tight. Parents can contact local law enforcement agencies, fire departments and rescue squads which have trained specialists to assist in checking their child safety seats.

The following six case studies can be helpful in identifying many of the problems associated with child safety restraint use, as well as the unfortunate truth that no device will protect all children in every situation. While these are examples of the most tragic outcomes, readers should be aware that safety restraint use is just one factor in reducing the number of children dying in highway crashes.

## **CASE STUDY NUMBER 1**

<b>Type of Crash:</b>	Single vehicle, run off the road and fixed object collision
<b>Day, Time, Season:</b>	Friday, 6:40 p.m., Spring
<b>Road/Weather:</b>	Straight, rural, four lane interstate highway; dry and clear
<b>Vehicles Involved:</b>	1994 Chevrolet conversion van
<b>Occupants:</b>	Driver: 38 year old male, unrestrained Front passenger: 19 year old male, restrained Left rear passenger: 28 month old female, in convertible child safety seat Right rear passenger: 16 year old male, restrained
<b>Severity:</b>	Two fatalities: child and front passenger Two injured, property damage

### **SUMMARY:**

The vehicle in this crash was a full size conversion van with high-backed, “captain” type chairs in the first two rows of seating. The vehicle departed the roadway on the left side, leaving no skids or scuffs on the pavement. Its path was identified from tracks in the grass median leading to the vehicle’s final resting position. The vehicle traveled from the pavement edge to impact with a tree without any evidence of braking. The vehicle struck the tree full force in a frontal collision, with the main impact occurring directly in line with the passenger seat. The impact collapsed the front approximately three feet, and the width of the damage was approximately 1½ feet, consistent with the diameter of the tree. The vehicle rebounded off the tree and rotated approximately five degrees in a clockwise direction and came to rest approximately two feet from the tree.

The crushing forces of the collision caused the engine compartment and the firewall to intrude into the front passenger’s occupant space, pushing the dash and floorboard into the seat. He died instantly from massive blunt force trauma to his chest. Seated behind him, the 16 year old passenger remained in his captain’s seat and was not seriously injured. On the driver’s side, the airbag deployed. There was no evidence that the driver was wearing a safety restraint, and he suffered serious injuries as a result of the collision.

Behind the driver, the 28 month old female was projected forward and to the right, in the direction of the collision forces. Despite wearing the internal harness, she was thrown over the tray shield of her child safety seat. The shoulder straps caught and twisted around her neck, jerking her back toward the seat. She landed in a semi-kneeling, semi-dangling position, facing the seat in which she had been riding. Although she was alive at the scene, she died shortly after being transported to a local hospital.



*Photo 1: Side view of van after impact. Note the lack of damage to the left side of the vehicle behind the driver, where the fatally injured child was seated.*

## DISCUSSION:

The child killed in this crash was riding in a convertible safety seat with a tray shield. Because of the design of the captain's chair, the safety seat could not be installed tightly against the back and bottom of the chair. This allowed for more forward and lateral movement to the safety seat during the crash sequence, and it tilted forward toward the point of impact. No longer in an upright position during the crash sequence, the toddler's upper body was thrown forward as the seat tipped.



*Photo2: Convertible seat with tray shield. Straps were cut to disentangle and release the 28 month old girl.*

From the upper section of the safety seat back, shoulder straps passed through guides and attached to the bottom of the tray shield. A crotch strap was also attached to the bottom of the tray. This piece passed between the child's legs and buckled into a receiver at the base of the seat. The shoulder straps did not have a harness retainer clip, a piece that connected the two belts at the level of the child's chest. This clip is essential to centering the belts across a child's upper body, preventing the belts from slipping off the shoulders and over the arms, and

providing the best location for energy dissipation across the chest in the event of a crash. The rescue worker who first attended this child at the scene indicated that there was no harness retainer clip. Even if the clip had broken during the crash, at least one side is likely to have remained attached to a strap. When the vehicle and seat were examined, there was no physical evidence that the clip had been present. The Medical Examiner's report revealed that the child had abrasions on the top of both shoulders, an indication that the shoulder straps of the harness exerted pressure upon the child's upper body at least initially. Without the retainer clip, however, her left shoulder slid free from one strap while the other strap caught on her right shoulder and twisted around her neck as she was ejected over the tray shield. After cutting her from the strap, rescue workers attempted to resuscitate her and transported her to a local hospital. She died shortly thereafter and her organs were donated for transplant.

## **CASE STUDY NUMBER 2**

<b>Type of Crash:</b>	Single vehicle, run off the road and fixed object collision
<b>Day, Time, Season:</b>	Sunday, 11:27 a.m., Spring
<b>Road/Weather:</b>	Straight, rural, four lane interstate highway; dry and clear
<b>Vehicles Involved:</b>	1998 Toyota 4-Runner Sport Utility Vehicle (SUV)
<b>Occupants:</b>	Driver: 40 year old male, restrained Front passenger: 23 year old female, restrained Left rear passenger: 30 month old male, in a high back belt-positioning booster seat Right rear: 9 month old male, in convertible seat
<b>Severity:</b>	Two fatalities: driver and left rear passenger, One injured, property damage

### **SUMMARY:**

The SUV in this crash slid off the right side of the roadway after an aborted lane change attempt due to traffic conditions. The driver swerved right to avoid the traffic in the left lane and lost control. The vehicle began to rotate clockwise, slid off the pavement and down into a drainage ditch located approximately 15 feet from the pavement edge. The right front of the vehicle struck a small tree, which increased the rotation. With the left side leading and lower than the right side, the SUV started to roll. The top left side of the vehicle struck a large tree and the roof collapsed inward, striking the driver and the 30 month old child seated behind him, restrained in a belt-positioning booster seat. Both suffered fatal blunt force head trauma and died at the scene. The driver's wife, seated in the front right seat and wearing her lap/shoulder restraint, suffered fractures to her ribs and arm, a lacerated liver, and she lost several teeth. Her nine month old son, seated behind her on the right side of the bench seat, remained in his convertible safety seat and was not injured.



*Photo 3: Damage to SUV from rollover. Both fatal victims were seated on the left side.*

## **DISCUSSION:**

Even though he had not reached three years, the child killed in this crash weighed approximately 38 pounds and was considered large for his age. He was about 36 inches tall. Based on American Academy of Pediatrics recommendations, he should have been secured with an internal harness in either a forward facing convertible seat or a high back combination seat, instead of a belt-positioning booster seat. Family members stated that at a medical check up, he had weighed 31 pounds and clinic personnel told the mother that he was too big for a convertible seat. They suggested he be moved to a booster. Unfortunately, due to his seating location, being in a seat with an internal harness is not likely to have changed the outcome of the crash. The crushing intrusion of the roof, as the SUV rolled, is likely to have been unsurvivable for anyone seated at that position.

The 9 month old seated behind the driver was not properly placed in his safety seat. According to family members, he weighed between 20 and 22 pounds and was also big for his age. They indicated that clinic personnel had also told the parents to seat this infant facing forward in a convertible seat. However, despite his size, he should have been seated facing the rear of the vehicle, in a reclined position, rather than facing forward and sitting upright.



*Photo 4: Convertible seat in which 9 month old survivor was seated.*

This would have afforded his developing bones and organs the greatest protection against the forces in a crash. Fortunately for this child, he did not suffer any serious injury. Shortly after the crash, an off duty firefighter arrived. He unbuckled the restraints and pulled the child from the seat without difficulty.

The family involved in the crash was Latino and the mother, who took her children to the clinic, did not speak English well. It is possible that the language difference played a role in her understanding of how her children should have been secured in the vehicle. Both children were in safety seats. She may have believed that any type of booster seat would be satisfactory for her older son, failing to understand the distinction between one with an internal harness and one that positioned the SUV's shoulder restraint across the little boy's chest. She may also have been told to put her infant son into a convertible seat because he was too large for an infant seat, but may not have understood that he still needed to be facing to the rear until he reached 12 months. An interview with family members revealed that the parents were conscientious about the health and well-being of their two boys, and it appears that the incorrect use of restraints was unintentional.

### **CASE STUDY NUMBER 3**

<b>Type of Crash:</b>	Offset head-on collision
<b>Day, Time, Season:</b>	Tuesday, 1:15 p.m., Spring
<b>Road/Weather:</b>	Winding, rural, two lane primary highway; clear and dry
<b>Vehicles Involved:</b>	1989 Chevrolet Blazer Sport Utility Vehicle (SUV) 1996 Ford F-350 truck
<b>Occupants:</b>	Blazer driver: 47 year old female, restrained Left rear passenger: 32 month old male, unrestrained Right rear passenger, 8 month old female, restrained in infant seat Truck driver: 54 year old male, restrained Front passenger, male of unknown age, restrained
<b>Severity:</b>	Two fatalities: Blazer driver and 32 month old left rear passenger Injuries to 8 month old right rear passenger, Severe property damage

#### **SUMMARY:**

The SUV in this crash had negotiated a series of curves and entered a straight-away that exceeded 600 feet in length. The vehicle crossed the center lines as it neared a left curve at the end of the straight section. The truck was coming out of the curve, traveling in the opposite direction. The truck driver, with only seconds to react, pulled to his right, putting both right wheels in a rock-lined ditch that bordered a bluff. The bluff prevented the vehicle from going further to the right. As the ditch deepened, the upper right side of the truck struck the bluff and the left wheels no longer made contact with the ground. The left front corners of the vehicles collided, and the heavier truck pushed the left side of the Blazer's engine compartment backward. The SUV rotated clockwise and the truck continued forward, crushing into the driver's occupant space and the area just behind it. The two vehicles separated and the SUV came to rest straddling the center lines, facing the bluff. The truck rotated slightly and continued across the opposite lane of travel and the shoulder. It came to rest at the edge of a sharp drop-off, with the rear tires in the travel lane.



*Photo 5: Damage to the driver's side of the SUV. The unrestrained child seated behind the driver was thrown forward into the area just behind the driver's seat.*

Neither the truck driver nor his passenger was injured during the crash. However, the SUV driver suffered massive fatal head injuries due to the impact. The unrestrained 32 month old male seated behind her was thrown in the direction of the collision forces, landing on the floor with his head beside the anchors for the driver's seat. He too died at the scene of massive head trauma. An infant seat positioned on the right of the rear bench seat contained his eight month old sister. Her seat was thrown forward and to the left, landing upside down on the floor in the space behind the two front seats. Her head and upper body rested on her brother's legs and she suffered a broken clavicle.

After the crash, witnesses stopped to aid the victims. An off duty nursing assistant, upon learning that a baby was inside, crawled through the rear window. She could see the inverted seat and heard the infant crying. She determined that the child was breathing and noted that the shoulder strap of the seat harness was tight across her neck. After requesting a knife from other bystanders, she cut the baby's harness straps and pulled the seat off from the back. She checked the infant more closely for injuries, identifying a cut on her forehead but saw no other signs of bleeding. She noted that the driver was dead and, when she pulled away the infant seat, she

could see that another child, apparently also dead, was lying on the floorboards. The woman soothed the infant and sang to her to calm her down. When the baby appeared to begin to have trouble breathing, she decided to move her. Another bystander passed a flat windshield into the SUV and they placed the infant upon it, keeping her as immobile as possible as they removed her from the vehicle. The rescue squad arrived immediately thereafter.

## **DISCUSSION:**

Family members reported that the SUV driver often transported the two children, who were her grandchildren. She was wearing her lap/shoulder belt that day. However, the 32 month old boy seated directly behind her was not restrained in any way at the time of the crash. The Medical Examiner estimated that he was about 35 inches tall and approximately 45 pounds, a weight above the 99<sup>th</sup> percentile for a child his age. If he had been restrained in compliance with state law, and his estimated weight was correct, he would have been secured in a booster seat and wearing the SUV's lap and shoulder belts. Since he was unrestrained, he was projected forward during the collision into the impact area, causing his fatal injuries. Even if he had been wearing only a lap/shoulder belt, without the booster seat, he may have survived this collision, because the area in which he was sitting was relatively undamaged.

His infant sister, while secured into an infant seat, was improperly restrained because the seat was faced forward. The lap portion of the vehicle belt was threaded through the guides on the seat. When facing to the front, the lap belt became a pivot point for the entire seat. During the collision, the seat rotated forward and came free from the lap belt. Both the child and the seat were thrown into the back of the driver's chair and then fell to the floor behind it, with the child face down, her collarbone broken. Had the infant been properly restrained, facing backwards in the infant seat, the seat would have remained in place on the bench and she would have had few, if any, injuries.



*Photo 6: This infant seat was faced forward and flipped out of the safety belt during the crash*

The driver was reported to have been in the habit of making sure the children were both restrained when she transported them in her vehicle. The reason for her failure to use the toddler's seat is unknown. Although his parents had a convertible seat for him in the family vehicle, this child was considered large for his age and his grandmother may have assumed he no longer required a child safety seat. She may have used the vehicle's lap/shoulder belt instead, which would not have fit comfortably across his shoulder and neck. Witnesses following the SUV stated that they could see the driver turned partially in her seat, looking into the back seat, perhaps talking to the little boy. Her apparent distraction is likely to have played a role in her allowing the vehicle to drift into the oncoming lane, which led to the crash. Instead of turning and dealing with the child while trying to drive, she should have pulled the car off the road at the nearest safe place, stopped the vehicle, and resolved the issue when she could safely give it her full attention.

## **CASE STUDY NUMBER 4**

<b>Type of Crash:</b>	Angle collision followed by head-on collision
<b>Day, Time, Season:</b>	Friday, 11:32 a.m., Spring
<b>Road/Weather:</b>	Urban, three lane primary road; dry and clear
<b>Vehicles Involved:</b>	2005 Mercury Sable 4 door sedan 1990 Ford Ranger pickup truck 1999 Plymouth Voyager van
<b>Occupants:</b>	Sable driver: 38 year old female, unrestrained Front passenger: 21 year old female, unrestrained (30 weeks pregnant) Left rear passenger: 22 month old female in a backless belt positioning booster seat Pickup driver: 33 year old male, restrained Van driver: 73 year old male, restrained
<b>Severity:</b>	Three fatalities, all Sable occupants Two injured, property damage

### **SUMMARY:**

The Sable and the Ranger were stopped side by side in westbound left turn lanes and began to proceed north together when the traffic signal turned green. The roadway they turned onto narrowed from two lanes to one, with the right lane merging into the left. Both drivers continued to accelerate, jockeying for the lead. The Sable, which was on the right, began to pass the Ranger. As the right lane narrowed, the Sable cut left into the pick-up's path. The left rear of the Sable struck the right front of the Ranger, causing both to lose control. The Ranger skidded off the right side of highway, where it struck a light pole with its right front bumper and stopped. The Sable began to rotate counter-clockwise and crossed the center lines of the roadway. As the Sable driver began steering to the right to straighten her vehicle, she pulled into the path of the oncoming Voyager, which was making its way down the hill. The Sable and Voyager struck front to front with heavier damage to the left side of the Voyager and right side of the Sable. The Sable rotated counter-clockwise off the east edge of the pavement and came to rest. The van rotated clockwise and came to rest off the east edge of the pavement just south of the Sable.

Neither the driver nor the front seat passenger in the Sable wore their lap/shoulder restraints. During the head-on collision with the van, the airbags deployed for both front seating positions; however, the force of the crash and the failure to use the belt restraints resulted in both front seat occupants suffering fatal blunt force injuries. The driver died at the scene and her passenger was pronounced dead at a nearby hospital less than an hour later.

The 22 month old female was seated behind the driver in a belt positioning backless booster seat. In this type of seat, the lap portion of the lap/shoulder combination threads through two molded plastic routers. The shoulder portion of the belt should rest across the child's shoulder, but not over the neck or face. In this case, both the lap and shoulder portions of the combination belt were routed through the molded guides for the vehicle's belts. As a result, when the collision occurred, the toddler was flung forward with only the lap portion of the belt to hold her in place. This placed severe strain on her spine and upper body, and her head struck the back of the driver's seat. She received fatal injuries, including fractures to her skull and the first vertebra in her neck. She was transported to a local hospital and then sent to another hospital where she was removed from life support and her organs were donated for transplantation.



*Photo7: Backless booster seat with shoulder and lap portions of the belt threaded through the lap belt guides. Note that occupant area was relatively unaffected.*

Although he was belted and his airbag deployed, the elderly van driver received life-threatening injuries. He survived the crash, however, as did the pickup driver, who had worn his belt and received minor injuries.

## **DISCUSSION:**

At 22 months and weighing only 28 pounds, this child should have been seated in a forward-facing convertible seat or a high backed combination seat with an internal harness. A five point harness would have kept her upper body restrained, dispersing the energy forces of the crash across the entire area and keeping her from striking any other parts of the Sable's interior. With a correctly used belt-positioning backless booster, she would have had her pelvic area belted and one strap diagonally across her chest, providing less protection and less energy dispersion. Additionally, at 31 inches, she was too short for a belt positioning booster seat to be effective. Despite the booster height, her shoulder strap is likely to have been positioned too high across her shoulder and neck area, which may have been why the adults threaded that portion of the belt through the guides along with the lap portion of the belt. During the collision, this caused the energy forces of the crash to concentrate on her pelvic area, while the rest of her body was free to flail. Developmentally, her skeletal structure did not have the integrity to withstand those forces and her spinal cord was traumatized. As she was flung forward, her head struck the back of the driver's seat, resulting in a basilar skull fracture and a fracture to the first vertebra of her neck. The occupant area the toddler sat in was relatively undisturbed by the collision—she may have survived this crash if she had been in a child safety seat with a 5 point harness to disseminate the forces across a greater area of her body.

This child was initially put at risk because of the aggressive driving actions taken by the drivers of the pickup and the Sable. Their actions, combined with the failure to properly restrain this child, led to her death. It is significant to note that the driver and the front passenger, who was the child's mother, were both unbelted. They had fastened the restraints behind the seats, preventing the seat belt warning light and signal from activating when the car was started. The front passenger was 30 weeks pregnant when she died.

## **CASE STUDY NUMBER 5**

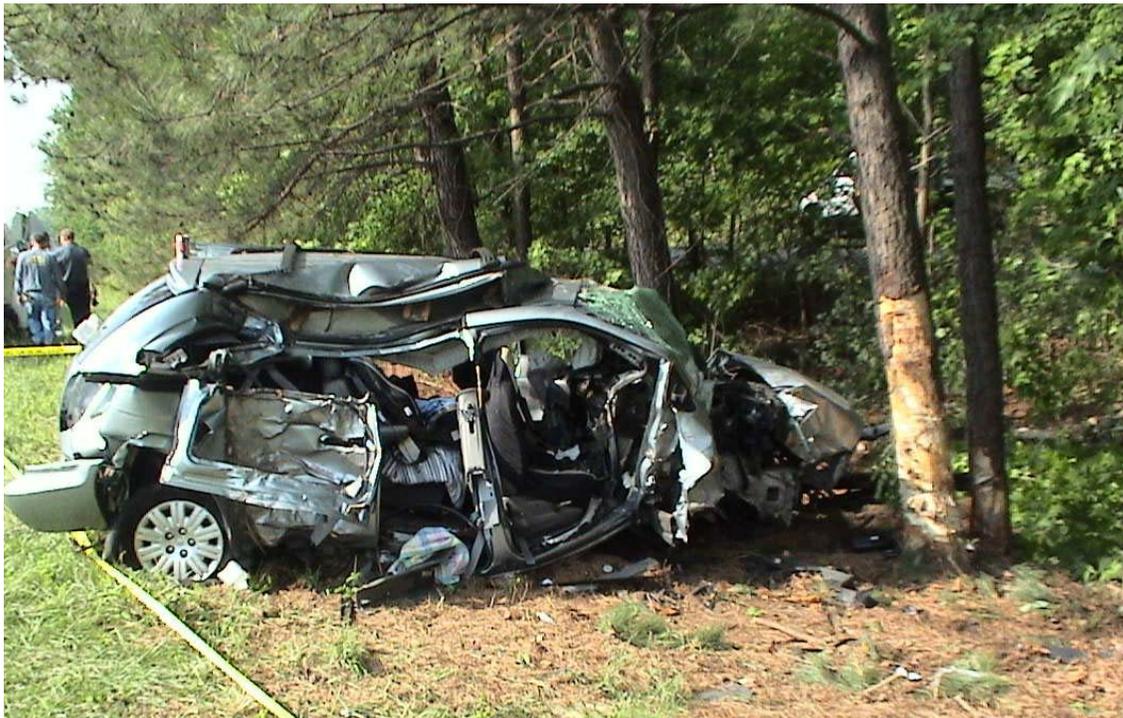
<b>Type of Crash:</b>	Single vehicle, run off the road and fixed object collision
<b>Day, Time, Season:</b>	Thursday, 5:06 a.m., Spring
<b>Road/Weather:</b>	Rural four lane interstate highway; clear and dry
<b>Vehicles Involved:</b>	2005 Chrysler Town & Country van
<b>Occupants:</b>	Driver: 34 year old male, restrained Front passenger: 33 year old female, restrained Right rear passenger: 26 month old male in a combination seat
<b>Severity:</b>	One fatality: child in right rear seat, Two injured, property damage

### **SUMMARY:**

The van in this crash traveling at an excessive speed, drifted off the left edge of the pavement and with the left wheels in the grass traveled along the median for over 200 feet. Rumble strips were present at the edge of the pavement and the van passed over them. The driver, in an attempt to reenter the roadway, swerved to the right and lost control. The vehicle began to rotate clockwise and side-slipped across both travel lanes and onto a paved shoulder. When the vehicle slid off the pavement edge and into the grass, the driver made another attempt to steer hard to the left and the vehicle began to rotate counter clockwise, slid down through the grassy area and struck several trees. After the van struck the first tree with its right front corner, its rotation was accelerated and it slammed into two additional trees with the right side of the vehicle. The initial collision dislodged the engine from its mountings and collapsed much of the engine compartment back, intruding into the occupant space for the front passenger, causing life-threatening, crushing injuries to her lower extremities. The driver, who was wearing his lap/shoulder restraints, received only minor injuries, lacerations to his hand and knee. His injuries were less severe because he was further from the point of initial contact, he wore his safety belts, and he had two airbags deploy: one in the steering wheel and one from the lower dash. These airbags absorbed much of the energy that would have been exerted on his body during the worst of the collision.

The secondary collisions caused the sidewall to crush inward and the roof of the van to buckle down, striking the 26 month old male seated behind the front passenger, his mother. This child was belted into a forward facing combination child safety seat. The seat appeared to have been installed correctly in the middle bench seat of the van, using the lap/shoulder restraint to anchor it in place. The child was then belted into the seat with a 5 point harness. However, the buckling metal of the roof caused fatal head injuries.

After the crash, the driver got out of the vehicle. He could not help his wife, who was pinned in her seat. He removed his young son from the seat and laid him on the ground near the wrecked vehicle before any other help arrived. When the first state trooper arrived, the father informed him that his son was dead.



*Photo 8: Damage to right side of minivan from impact with trees. Note intrusion into occupant area for both front passenger and child in middle seat.*

## DISCUSSION:

It appears that this child was restrained correctly in the appropriate type of child safety seat for his age and size. The bench seat located in the middle of the van was slightly shorter than the rear seat, to allow passengers to access the rear seat more easily. This middle seat is designed to hold two occupants, and the toddler was seated in the right side, which was closer to the middle of the occupant area. However, if the rear seat had been moved forward and the child placed in the middle seat on that bench, he would have been sitting at least 9 inches further to the left, even more centrally located. The roof did not buckle much beyond the point where his seat was initially installed. As a consequence, if he had been in a more centralized location, he might not have been fatally injured in this tragic crash.



*Photo 9: Combination type seat with internal harness for smaller children or used as a high back booster for larger children.*

## **CASE STUDY NUMBER 6**

<b>Type of Crash:</b>	Single vehicle, tire failure, run off the road and fixed object collision
<b>Day, Time, Season:</b>	Sunday, 10:23 a.m., Spring
<b>Road/Weather:</b>	Rural, straight, four lane interstate highway; clear and dry
<b>Vehicles Involved:</b>	1987 Nissan Pathfinder SUV
<b>Occupants:</b>	Driver: 23 year old female, restrained Front passenger: 28 year old female, unrestrained, ejected. Left rear passenger: 4 years and 9 month old female, restrained in a convertible seat Center rear passenger: 7 year old female, restrained in lap belt Right rear passenger: 39 month old female, restrained in a convertible seat
<b>Severity:</b>	One fatality: child in left rear seat Four injured, property damage

### **SUMMARY:**

The older model SUV in this case was in the left lane passing other traffic in a rural interstate facility when a tire failure (tread separation) occurred at the right rear wheel. The driver was belted, but her front seat passenger was not. Three children sitting in the back bench seat were restrained. The seven year old female sat in the middle seat, wearing a lap belt. To her right, her 3 year old sister was buckled into a convertible child safety seat, using a 5 point harness. On her left, her four year old sister was buckled into the same type of child safety seat. As the tire deflated, the SUV swerved violently to the right and began to roll over. Halfway through the first complete rotation, the top of the vehicle came down onto a metal guardrail, crushing the roof above the driver and left side passenger, and actually cutting through the metal just to the rear of the left rear seat position. The child in this seat was bisected. The lower part of her body remained strapped into the seat, while the upper half of her body was ejected through the left rear window. The ejected portion came to rest on the embankment leading down from the road approximately twenty feet from the impact with the guard rail. The vehicle continued to

roll and came to rest on its top some 80 feet further north, on the side of the road. The front passenger was ejected; the driver and the other two children in the rear seat remained in their positions within the vehicle. Witnesses to the crash stopped, notified authorities using their cell phones, and assisted the occupants until rescue, fire and police personnel arrived.



*Photo 9: Damage to the SUV from rollover. Note indentation on roof from contact with guard rail. Fatally injured child was seated behind the driver.*

## DISCUSSION:

At four years and nine months, with an estimated weight of 80 pounds, the child killed in this crash was too large for the convertible seat in which she was secured. The lower half of her body was restrained by the lap belts and the crotch strap. Her head would have extended above the top of the seat. The shoulder straps for the internal harness were threaded through the lowest set of guides, which are designed for securing infants in the rear-facing position. Due to her height and the improper setting for the shoulder restraints, this child was most likely not wearing the shoulder straps of the harness. As a consequence, when the SUV began to roll, her upper body was free to flail about the interior and was thrown to the left as the vehicle rotated to the right. Her head, arms and upper torso were hanging outside the left rear window as the Nissan roof bounced down onto the guardrail. The broken glass around the window edges, combined with the pinching action of the edges of the frame, was sufficient to sever the child's upper torso from the rest of her body, above the waist. She died instantly.



*Photo 10: Convertible seat in which fatally injured child was seated.*

This child should have been secured in a booster seat, with either an internal harness or a lap and shoulder belt positioned correctly across her abdomen and upper body. This would have kept her upper body within the interior of the vehicle. Due to her location, she may still have suffered serious, potentially fatal, injuries when the vehicle rolled and the roof collapsed inward. The restrained driver, however, survived with greater intrusion into her occupant space.

The three year old seated behind the front passenger was restrained in a convertible seat identical to her sister's. Like the other seat, the shoulder straps were threaded through the lowest guides, which are designed for use with infants. Despite this, she did have those straps positioned over her shoulders and was secured by the lap and crotch straps as well. The harness kept her in her seat throughout the crash sequence. She was found suspended upside down in the overturned vehicle by a Good Samaritan. He reported that she spoke coherently and did not appear to be injured, although she was frantic to get out. After talking with her briefly, he was able to reach into the SUV interior and release the straps. She fell down onto the ceiling and crawled out of the vehicle. He picked her up and carried her away from the vehicle while others attempted to help the remaining occupants. The little girl remained with him until noticed by rescue workers.

The seven year old sister, seated in the center rear position and wearing her lap belt, also remained in place during the rollovers. She suffered non-life threatening injuries when her legs and feet were pinned inside the vehicle. After she was extricated by emergency responders, she was transported to a local hospital where she was treated and released several days later.

## CONCLUSIONS

These tragic crashes illustrate the importance of children being properly secured in child safety devices designed for their age, weight and height. Since the passage of child restraint laws in the Commonwealth, we have experienced fewer deaths of unrestrained children. Only one child in these crashes was unrestrained; the others were in child safety devices. However, child safety seats can be complicated to select, install and use. Parents and caretakers have to ensure that the seat is appropriate for the individual child, compatible with the vehicle and that it is installed correctly. Each issue requires time, thought and sometimes testing prior to purchase. The increasing variety of restraint devices from different manufacturers can add to the complexity of knowing what to buy and how to use a child safety seat.

The fact that only one child killed in these case studies was properly restrained in an appropriate safety seat reveals that the next level of improving children's safety must go beyond simply getting children into safety seats—they must emphasize securing children correctly. Public information campaigns and educational efforts by health care providers and social workers focused on individual parents and caregivers, combined with visible law enforcement, can all play a role to increase awareness and full compliance with the Code of Virginia. Media campaigns, including printed materials and radio and television spots can reach a mass audience, easily crossing cultural barriers, and lay the foundation for further education. As pediatricians and clinic providers see infants and toddlers for wellness checks and illness, they can take the opportunity to discuss child safety seat use and help to educate adults to the best type of seat and its use. In addition to focusing on child development issues, they can stress the value of keeping children safe and protected from more than viruses and infections. These individuals are often highly trusted and credible sources, and they reach patients from diverse cultural backgrounds, so their value as educators should not be underestimated. To support these approaches, publicized child safety seat checks within localities give drivers an opportunity to have an expert check their vehicle, seat type and installation. Throughout the Commonwealth of Virginia, a variety of individuals have been trained as Child Passenger Safety Technicians to assist drivers, parents and care providers in the proper selection and installation of child safety devices. Police, fire and rescue personnel, along with other state and local agencies often sponsor these safety check events and will set individual appointments to inspect seats when requested. In addition to improving child occupant protection, these events foster better community relations.

During the course of investigating the crashes in this report, members of the Team discovered that police officers are not all trained to differentiate between correct and incorrect child safety restraint use. Although they are charged with enforcing the law, which specifies that the child must be in an appropriate type of restraint, many go by the rule of thumb that “if the child is in a plastic seat”, they are in compliance with the law. As demonstrated in the case studies in this report, this approach is not sufficient to enforce the law or implement its intent—protecting child passengers. It may not be feasible to have every police officer certified as a Child Passenger Safety Technician, which requires 32 hours of specialized training and testing. However, incorporating some basic child safety restraint information into the basic and in-service training curricula would improve their ability to appropriately enforce the Code. Simply knowing when a child should be rear facing and in a harness, compared to forward facing and in a harness, as opposed to in a booster and wearing a lap and shoulder belt can be enough to get them used to taking a closer look at child passengers in vehicles and evaluating their restraint device. They don’t have to determine what type of seat is used and try to remember a massive amount of configuration information, but they know that “being in a plastic shell” is not enough.

The six case studies in this report represent many of the problems associated with transporting children safely in motor vehicles. These crashes occurred during a short time span in 2006, but they do not include all young passengers who died this year. Early in March, a three year old female who appeared to have been properly restrained in a safety seat died during a collision with a tree. The vehicle in which she rode ran off the road and struck a tree, causing intrusion into her occupant area. In July, another three year old was killed when the tractor-trailer his mother drove ran off the road and hit a bridge abutment. The child had been in the sleeping compartment of the tractor with his father and older brother. He was ejected during the crash and fatally injured by cargo that flew out of the trailer. In these cases, as in the studies presented in this report, driver error played an important role in crash causation. Excessive speed, inattention and fatigue are among the initial causal factors that put children at risk.

As a final note, members of the Team worked closely with the Office of the Chief Medical Examiner to determine the cause of fatal injuries to these children. In some cases, the medical examiner who reviewed that fatality wrote a thorough report that clearly documented the height and weight of the victim, identified injuries and was specific as to cause of death. In other cases, however, weight and height were only estimated, if noted at all. At times, the description of fatal injury was so broad that it was difficult to pinpoint whether or not the child safety seat

played a role in the fatal injury, if intrusion into the vehicle was a factor, if the child struck the interior of the vehicle or was struck by flying debris. In the first case study, the cause of death was cited as “blunt force trauma” and the mechanism of the fatal injury was not clear from the medical examiner’s reports or from information gleaned from hospital records regarding the death. After interviewing emergency responders, Team members were able to discern that hanging by the shoulder strap was the mechanism of injury. While an accidental death may not carry the legal ramifications of a homicide, and thus may not require a full autopsy, having more specific information is essential to understanding the biomechanics of occupants and their injury patterns. With regard to child passenger safety, such information can be invaluable for determining correct seat use and for improving seats and other devices designed to protect children more effectively in crash situations.

## RECOMMENDATIONS

1. The Virginia Department of Health, the Department of Motor Vehicles and the Department of State Police presently work with other state and local agencies to inform and educate those who transport children about appropriate child safety restraint use. Beyond stressing the importance of using restraints, these groups should continue to emphasize correct selection and installation of seats, along with proper use of internal harnesses and vehicle lap and shoulder belts. Methods for creating greater awareness and improving understanding as well as compliance across all populations should be explored, including working with pediatricians, child advocacy groups, and local communities.
2. The Virginia Department of State Police and local law enforcement agencies should include child safety seat information in their basic training and in-service curricula. While not designed to make every officer a specialist, this training should include enough basic information to provide a quick method of visual assessment with regard to whether or not a child appears to be in the correct type of safety device. Officers could then decide whether to look at the restraints more closely and/or take further action if they suspect a violation of the law.
3. The Office of the Chief Medical Examiner should request that individual medical examiners provide more precise injury information on motor vehicle crash fatalities. The importance of more complete information, including height and weight, specific location of injuries, as well as mechanism of injury, if known, would increase the value of the reports for safety research, injury prevention and reduction in severity.