U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

NHTSA
www.nhtsa.gov

DOT HS 812 142 **May 2015**

Results of the National Child Restraint Use Special Study

Suggested APA Format Reference:

Greenwell, N. K. (2015, May). *Results of the national child restraint use special study.* (Report No. DOT HS 812 142). Washington, DC: National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 812 142		

4. Title and Subtitle	5. Report Date
Results of the National Child Restraint Use Special Study	May 2015
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Nathan K. Greenwell	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Office of Vehicle Safety National Highway Traffic Safety Administration Washington, DC 20590	11. Contract or Grant No.

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
National Highway Traffic Safety Administration 1200 New Jersey Avenue SE. Washington, DC 20590	NHTSA Technical Report
	14. Sponsoring Agency Code

15. Supplementary Notes

Acknowledgement to Robert Sivinski and his work on the Sampling Methodology of the National Child Restraint Use Special Study.

16. Abstract

NHTSA conducted the National Child Restraint Use Special Study (NCRUSS) in 2011, observing the use of car seats and booster seats for child passengers (birth to 8 years old) in 4,167 vehicles. The study also interviewed drivers on their attitudes and beliefs about car seats and booster seats as well as their confidence with installing them. The NCRUSS is a nationally representative survey.

Results showed that 94 percent of children were restrained in car seats or booster seats, 4 percent were restrained in seat belts, and 2 percent were unrestrained. By car seat or booster seat type, 50 percent of children were restrained in forward-facing car seats, 31 percent were restrained in booster seats, 9 percent were restrained in rear-facing infant car seats, and 4 percent were restrained in rear-facing convertible car seats.

"Misuse" of car seats and booster seats is defined as a characteristic of installing the car seat/booster seat to the vehicle, or of restraining the child in a car seat/booster seat that may reduce the protection of the car seat/booster seat in the event of a crash. Not every divergence from a perfect installation was considered "misuse" for this study. Results showed that estimated overall car seat and booster seat misuse was 46 percent. By car seat or booster seat type, estimated misuse rates were 61 percent for forward-facing car seats, 49 percent for rear-facing infant car seats, 44 percent for rear-facing convertible car seats, 24 percent for backless booster seats, and 16 percent for highback booster seats.

The NCRUSS also provides data on lower anchor connectors and tether strap installations (LATCH installations). Results showed that rear-facing car seats (both infant and convertible car seats) equipped with lower anchor connectors in seating positions equipped with lower anchors were more likely installed with lower anchor connectors (87%) than seat belts (22%). Similarly, forward-facing car seats equipped with lower anchor connectors and tether strap in seating positions equipped with lower anchors and tether anchor were more likely installed with lower anchors connectors and tether strap (48%) than the seat belt (27%).

17. Key Words	18. Distribution Statement
Car seat, car seat misuse, car seat use, child passenger safety (CPS), data collection, field observations, booster seats, lower anchors, Lower Anchors and Tethers for Children (LATCH), tether anchor	Document is available to the public from the National Technical Information Service www.ntis.gov.

19. Security Classif. (Of this report)	20. Security Classif. (Of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	66	

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List of Abbreviations

ALR	automatic locking retractor
CPS	Child Passenger Safety
CPST	child passenger safety technician
ELR	emergency locking retractor
FMVSS	Federal Motor Vehicle Safety Standard
LATCH	Lower Anchors and Tethers for Children
LTV	light trucks and vans (includes pickup trucks, SUVs, minivans, and full-sized vans)
NASS	National Automotive Sampling System
NCRUSS	National Child Restraint Use Special Study
NHTSA	National Highway Traffic Safety Administration
NOPUS	National Occupant Protection Use Surveys
NSUBS	National Survey of the Use of Booster Seats
PSU	primary sampling unit
SUV	sport utility vehicle

Definitions of Terms

automatic locking retractor	A safety belt retractor that locks and maintains a fixed seat belt (lap belt) length during use.
booster seat	Device intended to be used as a transition to lap and shoulder belts by older children who have outgrown car seats. The device meets Federal safety standards and increases child safety in a crash.
car seat	Common term for a specially designed device that secures a child in a motor vehicle, meets Federal safety standards, and increases child safety in a crash. Includes rear-facing infant car seats, rear-facing convertibles, and forward-facing car seats (includes forward-facing convertibles and combination type).
convertible seat	A car seat that converts from rear-facing for babies and smaller children to forward-facing for older and larger children.
emergency locking retractor	Allows the belt to move freely, locks only when the vehicle or occupant slows quickly/abruptly or stops suddenly. An ELR may be switchable, converting from an emergency locking retractor to automatic locking retractor.
locking clip	A flat, H-shaped metal clip intended to fasten together seat belt webbing (lap and shoulder portion) at a sliding latch plate, to prevent the webbing from sliding through.
lockoff	A clamp attached to the car seat that is affixed to the vehicle seat belt to (1) prevent movement of the belt relative to the latch plate, (2) maintain an applied tension on the belt from the floor anchorage through the latch plate to the lockoff, and (3) prevent movement of the car seat relative to the belt webbing.
lower anchors	Horizontal bars in the vehicle seat bight where lower anchor connectors are anchored to the vehicle structure**.**
lower anchors connectors	Hardware on flexible strap or rigid structure that connect the child's car seat to the lower anchors in the vehicle.
latch plate	The part of the buckle mechanism that slides into the buckle receptor; usually it is the part that affects the length of the seat belt.
locking latch plate	A latch plate that holds the lap belt snug after it has been adjusted. Type of latch plate that contains a metal bar on the underside of the hardware that locks the seat belt in position.

rear-facing infant car seat	A car seat designed for use only by a young child in a rear-facing position.
seat bight	The intersection between the bottom of the seat back cushion and the back of the seat cushion.
tether anchor	Attachment point in the vehicle for a car seat tether strap.
tether strap	An additional belt that anchors the car seat top to the vehicle; reduces the amount the car seat tips forward on impact. A tether is typically available on most child car seats manufactured after September 1, 1999.

Executive Summary

The National Highway Traffic Safety Administration conducted the National Child Restraint Use Special Study in 2011, observing the use of car seats and booster seats for child passengers from birth to 8 years old in 4,167 vehicles. NHTSA also interviewed drivers on their attitudes and beliefs about car seats and booster seats and their confidence with installing them. The NCRUSS is a nationally representative survey that was conducted at the sites where NHTSA also collects data from its National Automotive Sampling System (NASS).

In the weighted data of child passengers (birth to age 8) in 4,167 vehicles, 50 percent of children used forward-facing car seats, 31 percent of children used booster seats, and 13 percent of children used rear-facing car seats. A total of 6 percent of children did not use car seats or booster seats. The majority of children were observed sitting in the second row of the vehicles, with 37 percent of them sitting at the second row left seat, 12 percent in the center seat of the second row, and 47 percent at the right seat of the second row.

NCRUSS also studied misuse rates of car seats and booster seats. NHTSA assembled a group of internal subject matter experts to determine how "misuse" should be defined for purposes of this study. Not every divergence from a perfect installation was considered misuse; instead misuse was identified as characteristics of installing the car seat/booster seat to the vehicle, or of restraining the child in a car seat/booster seat, that may reduce the safety of the car seat/booster seat for the child occupant.

Analysis of overall misuse estimated that one or more misuses existed in 46 percent of all car seats and booster seats. By seat type, calculated percentages were: forward-facing car seats (61%), rear-facing infant car seats (49%), rear-facing convertible car seats (44%), backless belt-positioning boosters (24%), and highback belt-positioning boosters (16%).

NCRUSS also studied use of the child restraint anchorage system required by Federal Motor Vehicle Safety Standard No. 225. Data showed that, in seating positions equipped with lower anchors and tether anchor, more forward-facing car seats equipped with lower anchor connectors and tether strap were installed with lower anchors connectors and tether strap (48%) than seat belts (27%). Total lower anchor connectors use by rear-facing car seats in seating positions equipped with lower anchors amounted to 87 percent. For the rear-facing car seats that were not installed with lower anchors connectors, 83 percent were placed in seating positions equipped with lower anchors and tether anchor.

NHTSA recommends using a tether strap with a forward-facing car seat regardless of whether the car seat is installed with seat belt or lower anchor connectors. It is not necessary to install a rear-facing car seat with a tether strap, although some car seat manufacturers do recommend them. In NCRUSS, total tether strap use by forward-facing car seats in seating positions equipped with lower anchors amounted to 61 percent. However, for forward-facing car seats that did not install with tether straps, 97 percent were placed in seating positions equipped with lower anchors and tether anchors.

1. Introduction

Research on the protection by car seats and booster seats as actually used in crashes has found them to reduce the risk of fatal injury by 71 percent for infants (younger than 1 year old) and by 54 percent for toddlers (1 to 4 years old) in passenger cars. For infants and toddlers in light trucks and vans, the corresponding reductions are 58 percent and 59 percent, respectively.[1]

Past studies on car seats and booster seats have observed high rates of seats being installed incorrectly and/or children being restrained in car seats and booster seats incorrectly. However, these studies used a type of convenience sample at the primary sampling unit level. Although valuable information can be learned from such surveys, such surveys cannot be relied upon to be truly nationally representative. Those that could be reasonably nationally representative (such as the data collected at child passenger safety seat check events) may have a strong selection bias in that the respondents are essentially volunteers for the survey rather than randomly selected subjects.

The NCRUSS was designed to be a large-scale nationally-representative survey that contains both an inspection of the child passenger's restraint system (or lack thereof) by a certified child passenger safety technician and a detailed interview of the driver conducted by a highly trained investigation specialist. The information in NCRUSS covers behavioral factors, demographic information, and quantitative measurements. These factors will be explored in more detail throughout the report.

2. Sampling and Data Collection Methodology

The NCRUSS was a nationally representative survey, with data collected at 24 PSUs across the country. The PSUs were established previously by a separate ongoing survey, the National Automotive Sampling System. The PSUs are defined geographically and can be thought of as cities, counties, or groups of adjacent counties. The PSUs include urban, rural, and suburban environments and are located in 17 States.

The survey design was complex and required several stages of sampling within PSUs. Further sampling took place at the site, vehicle, and child-passenger case level. The complex design resulted in sampling weights, which adjust the results to be nationally representative; the weights are used in all tables and analyses of this report. The sample design and weight development are described in detail in Appendix A. Details of the data collection procedures are provided in Appendix B.

[1] Hertz, E. (1996, December). *Revised estimates of child restraint effectiveness.* Washington, DC: National Highway Traffic Safety Administration.

3. The NCRUSS Data

The NCRUSS contains a large amount of information on the behavioral factors of caregivers and on children seated in car seats and booster seats. Data collection involved physical measurements providing objective information on issues such as the amount of slack of the harness straps to the lateral movement of an installed car seat at its belt path.[2]

In this section and Appendix C, the weighted percentages of the NCRUSS illustrate the characteristics of the survey sample as a whole. These results provide characteristics on how the car seat/booster seat was installed into the vehicle, and on how the child was restrained into the car seat/booster seat. The results also give specifics regarding the different installation methods of car seat/booster seat to vehicle seat.

Due to rounding, summations of percentages may not equal 100 percent. The values provided in the report refer to the weighted percentages. After Table 1, all weighted percentages are calculated over the subgroup sample size, n, provided under the column headers. Finally, it is important to note that as the subgroup sample size decreases, the corresponding weighted percentages may become less reliable. The overall NCRUSS sample size was chosen for the full sample reliability as described in Appendix A; tables showing results by different subgroup sizes are presented for descriptive purposes only, and are not tested for statistically significant differences or other inferences.

3a. Overall Survey Sample

The NCRUSS inspected the use of restraint systems for 4,167 child passengers. Only one child was inspected when multiple children were present in the vehicle. Table 1 provides the seat type use, seating position, age, weight, and height of the inspected child passengers. Throughout the report, rear-facing infant car seats and rear-facing convertibles were grouped together under rear-facing car seats; where relevant the data will be presented independently. For further information on the overall survey sample, see Appendix C, which outlines tables of age, weight, and height that are broken down by restraint types.

Out of the 4,167 children inspected, 106 children (weighted percentage of 2) were observed to be unrestrained in vehicles, and 242 children (weighted percentage of 4) used only seat belts. The 106 were identified as children using nothing in the vehicles to be restrained and not sitting in car seats or booster seats. (Besides being unrestrained, 12 of these 106 already-at-risk children were located on the floor, on the laps of other occupants, or another unspecified location within the vehicles. Out of the seat belt users, 2 percent did not buckle the seat belts, technically meaning that the child is truly unrestrained.) The majority of children (96%) were observed sitting in the second row of the vehicles, with 37 percent of them sitting at the second row left seats, 12 percent in the center seats of the second row, and 47 percent at the right seats of the second row.

[2] The belt path is the path that the seat belt or lower anchor connectors passes around or through the car seat. Some seats have multiple belt paths. The lateral movement at the belt path measurement is not relevant and not recorded for booster seats.

Table 1: Overall Survey Sample Characteristics		
	Count	**Weighted Percentage**
Seat Type		
Rear-Facing infant car seat	299	9%
Rear-facing convertible/all-in-one	143	4%
Forward-Facing car seat	1,992	50%
Booster seat	1,380	31%
Other/unknown device	5	<1%
Seat belt only	242	4%
Unrestrained	106	2%
Seating Position		
Front row center	6	<1%
Front row right	94	2%
Second row left	1,483	37%
Second row center	611	12%
Second row right	1,874	47%
Third row left	40	1%
Third row center	6	<1%
Third row right	52	1%
Fourth row left	1	<1%
Age Range of Child		
Under 1 year	309	10%
1-3 years	1,866	45%
4-7 years	1,825	42%
8 years	138	3%
Refused/unknown/missing/other	29	<1%
Weight Category of Child		
Less than 20 lbs	237	6%
20 – 29 lbs	938	25%
30 – 39 lbs	1,373	32%
40 – 60 lbs	1,349	31%
Greater than 60 lbs	157	3%
Refused/unknown/missing	113	3%
Height Category of Child		
Less than 20 inches	25	1%
20 – 29 inches	605	16%
30 – 36 inches	1,384	33%
37 – 49 inches	1,570	36%
50 – 56 inches	174	5%
Greater than 56 inches	13	<1%
Refused/unknown/missing	396	10%

3b. Car Seat and Booster Seat Hardware

From the data collected, 98 percent of all rear-facing and forward-facing car seats are equipped with 5-point harnesses. Ninety-three percent of all car seats are also equipped with retainer/chest clips. With regard to the lower anchor connectors of rear-facing and forward-facing car seats, 76 percent of them were equipped with flexible straps, 2 percent were equipped with rigid connectors, and 8 percent were equipped with no lower anchor connectors (1% of car seats with no lower anchor connectors were from rear-facing infant car seats installed with no base). The car seats equipped with lower anchor connectors consisted of 56 percent hook-on connectors, 26 percent push-on connectors, and the remaining unknown or missing. In addition, 46 percent of the lower anchor connectors used latch plate adjustment, while 29 percent used button-release adjustment. Finally, with regard to the tether straps of rear-facing and forward-facing car seats, 42 percent of them were equipped with latch plate tether adjustment, 8 percent were equipped with button-release tether adjustment, and 20 percent were equipped with no tether straps.

Of 1,380 booster seats inspected, only 4 percent were equipped with lower anchor connectors. Thirteen percent of booster seats were situated in a seating position with adjustable d-rings on the shoulder belts, while 10 percent of children restrained by seat belts only had adjustable d-rings on the shoulder belts.

3c. Car Seat to Vehicle Installation

This section focuses on observations of how rear-facing and forward-facing car seats are installed in vehicles. “Not applicable” is used in the following tables to denote not applicable criteria for specific variable such as seat position not having shoulder belt or to signify when zero observations were observed for the criteria.

Table 2 shows that most rear-facing (96%) and forward-facing (99%) car seats were installed in correct directions. Only 11 percent and 9 percent of rear-facing and forward-facing car seats, respectively, were observed to be longer than the vehicle seats showing an overhang. Sixty percent of rear-facing convertibles did not move laterally at the belt path, while 40 percent and 42 percent for rear-facing infant car seats and forward facing car seats, respectively, did not move laterally.

Table 2: Car Seat to Vehicle Installation by Seat Type			
	Rear-Facing Infant (n=299)	**Rear-Facing Convertible (n=143)**	**Forward-Facing (n=1,992)**
Installation Direction			
Direction is rear-facing	95%	99%	<1%
Direction is forward-facing	5%	n/a	99%
Direction is supine (facing up)	n/a	n/a	<1%
Direction is other	n/a	n/a	<1%
Missing/unknown direction	n/a	1%	<1%
Car Seat Overhang			
Car seat does hang over the vehicle seat	15%	1%	9%
Car seat does not hang over the vehicle seat	83%	97%	87%
Missing/unknown if car seat hangs over vehicle seat	2%	2%	3%
Lateral Movement[3]			
Does not move laterally	40%	60%	42%
Moves 1 inch laterally	22%	18%	15%
Moves 2 inches laterally	19%	13%	17%
Moves 3 inches laterally	10%	5%	15%
Missing/unknown for lateral movement	8%	4%	12%

3d. Installation Methods of Car Seat to Vehicle

A car seat is designed to be installed in a vehicle by connecting to the lower anchors of the vehicle's child restraint anchorage system (using the car seat's lower anchor connectors) or by a seat belt. There is no distinct "best" installation method of car seat to vehicle, but NHTSA does recommend that forward-facing car seats use the tether straps when installed by either the lower anchor connectors or the seat belts.[4] Table 3 provides the observed installation methods used to install the car seat to the vehicle.

Data show that overall installation using the lower anchor connectors in rear-facing car seats is 65 percent and 76 percent for rear-facing infant car seats and rear-facing convertible car seats, respectively. Overall installation using the lower anchor connectors is 52 percent in forward-facing car seats. Only 42 percent of forward-facing car seats were installed using the tether strap. Out of total tether strap use, 80 percent of forward-facing car seats were installed with lower anchors connectors and tether strap while 28 percent of forward-facing car seats were installed with seat belts and tether strap.

[3] The lateral movement of the installed car seat was measured by holding the car seat at the belt path, pushing and pulling the car seat side to side with a moderate force. If the car seat was very loose, the car seat was not moved more than 3 inches. The lateral movement was sometimes checked with the child in the car seat.
[4] www.safercar.gov/parents/How-To-Install-Car-Seat-Tips.htm

Table 3: Installation Method of Car Seat to Vehicle by Seat Type			
Installation Method	**Rear-Facing Infant (n=299)**	**Rear-Facing Convertible (n=143)**	**Forward-Facing (n=1,992)**
Lower anchor connectors only	57%	60%	16%
Seat belt only	34%	22%	36%
Tether strap only	n/a	n/a	<1%
Lower anchor connectors and seat belt	8%	9%	2%
Lower anchors connectors and tether strap	n/a	7%	30%
Seat belt and tether strap	n/a	1%	8%
Lower anchors connectors and tether strap and seat belt	n/a	n/a	4%
Unknown	1%	1%	3%
Total lower anchor connectors use	65%	76%	52%
Total seat belt use	43%	31%	50%
Total tether strap use	n/a	8%	42%

Tables C-10 to C-19 in Appendix C go into further detail with regard to specific installation methods of car seat to vehicles. Data is provided on how the car seat lower anchor connectors, seat belt, and tether straps are used in the installation of the car seat to the vehicle.

3e. Restraining of a Child in a Vehicle

In this section, tables will provide statistics on how children were restrained into the vehicle, i.e., whether the child was using a car seat, booster seat, or just a seat belt. Since using a booster seat requires the seat belt to be used to restrain the child, Table 4 looks at children using booster seats and children using only seat belts.

Table 4 indicates that the majority of children restrained in booster seats had the lap/shoulder belts snug with no slack (72% with shoulder belt and 70% with lap belt were not loose). Children restrained only using the vehicle seat belts had 47 percent with shoulder belts and 48 percent with lap belts not loose. Regarding correct belt fit, data indicates that children restrained in booster seats had 58 percent of shoulder belts centered on the children's shoulders and 79 percent of lap belts across the hips or thighs of the children. For children restrained only using the seat belts, 15 percent of shoulder belts were centered on the children's shoulders and 36 percent of lap belts were across the hips or thighs of the children. In terms of incorrect belt fit, 12 percent of children had the shoulder belts at neck or face level, 4 percent had the shoulder belts placed behind their arms or backs, and 9 percent of lap belts were over the abdomens when using booster seats. When using seat belts alone, 34 percent of children had the shoulder belts at neck or face level, 17 percent had the shoulder belts placed behind their arms or backs, and 37 percent placed the lap belts over the abdomens.

Table C-20 in Appendix C examines shoulder belt fit of children using highback and backless booster seats. Data shows that 63 and 52 percent of children using highback and backless boosters, respectively, had the shoulder belts positioned centered on the shoulders.

Table 4: Restraining of Child in Booster or Vehicle Seat by Seat Type		
	Booster Seat (n=1,380)	**Seat Belt Only (n=242)**
Seat Belt Buckling		
Seat belt is buckled	93%	88%
Seat belt is not buckled	2%	2%
Missing/unknown for buckling of seat belt	5%	10%
Shoulder Belt Loose/Slack		
Shoulder belt is not loose	72%	47%
Shoulder belt is loose	16%	19%
Not applicable/No shoulder belt	3%	8%
Missing/unknown for shoulder belt	10%	25%
Lap Belt Loose/Slack		
Lap belt is not loose	70%	48%
Lap belt is loose	17%	22%
Not applicable/lap belt not used	1%	n/a
Missing/unknown for lap belt	12%	30%
Shoulder Belt Position		
Shoulder belt over body – centered on shoulder	58%	15%
Shoulder belt over body – touching shoulder	11%	6%
Shoulder belt over body – below shoulder/around arm	5%	1%
Shoulder belt over body – above shoulder at neck/face	12%	34%
Shoulder belt behind arm or back	4%	17%
Not applicable/no shoulder belt	2%	5%
Missing/Unknown shoulder belt position	9%	23%
Lap Belt Position		
Lap belt across hips/thighs	79%	36%
Lap belt across abdomen/ribcage	9%	37%
Not applicable/lap belt not used	1%	n/a
Missing/unknown lap belt position	10%	27%

Table 5 examines the restraining of children in rear-facing and forward-facing car seats. The majority of children restrained in rear-facing and forward-facing car seats were using buckled harnesses. About half of them used the retainer/chest clips at chest/armpit level. In 39 percent of rear-facing car seats, the harnesses had no slack, 28 percent had about 1 inch of slack,[5] and 18 percent had between 1 and 2 inches of slack. In 34 percent of forward-facing car seats, the

[5] The harness slack measurement is the amount of slack in harness straps when pinched at the shoulder when the child is installed.

harnesses had no slack, 22 percent had about 1 inch of slack, and 17 percent had between 1 and 2 inches of slack. In most rear-facing car seats, the children's heads were below the tops of the car seats (90%). About 3 percent of rear-facing car seats had the children's heads at or above the tops of the car seats.

Table 5: Restraining of Child in Car Seat by Seat Type		
	Rear-Facing (n=442)	**Forward-Facing (n=1,992)**
Harness Use		
Harness in use	96%	94%
Harness not in use	2%	2%
Missing/unknown harness use	2%	5%
Retainer Clip Use/Position		
Retainer/chest clip used at chest/armpit	52%	50%
Retainer/chest clip used at abdomen	37%	33%
Retainer/chest clip used at neck level	<1%	<1%
Retainer/chest clip not used	n/a	1%
Missing/unknown use of retainer/chest clip	7%	10%
Harness not used/Missing/unknown harness use	4%	6%
Harness Slack/Tightness		
No slack in harness straps	39%	34%
Less than or equal to 0.50 inch	11%	4%
0.51 – 1.00 inch	17%	18%
1.01 – 2.00 inches	18%	17%
2.01 – 3.00 inches	2%	4%
3.01 – 4.00 inches	2%	3%
Greater than 4.00 inches	<1%	2%
Missing/unknown snugness of harness straps	6%	11%
Harness not used/Missing/unknown harness use	4%	6%
Harness Twisting		
Harness strap is twisted	11%	30%
Harness strap is not twisted	78%	62%
Missing/unknown if harness strap is twisted	11%	8%
Child Height Landmark for Rear-Facing		
Child's head at the top of the car seat	3%	n/a
Child's head above the top of the car seat	<1%	n/a
Child's head below the top of the car seat	91%	n/a
Missing/unknown where's child's head in relation to top of car seat	5%	n/a

3f. Interviewed Drivers' Response

Even if the driver was not the person who installed the car seat/booster seat in the vehicle or restrained the child in the car seat/booster seat, the driver was considered in this study to be the responsible party and was asked where the driver got information about car seats/booster seats, how confident the driver was that the seat was installed correctly, and other questions about child passenger safety. Drivers were asked to rate their confidence on a scale from 1 to 5, with 1 being "not at all confident" and 5 being "very confident." Drivers provided their confidence on the correct type of car seats/booster seats used (Table 6) and correct installation of car seat/booster seat (Table 7).

Table 6: Drivers' Confidence on Correct Type of Car Seat/Booster Seat Used (n=3,814)

	Weighted Percentage
Not confident (1)	1%
Slightly confident (2)	1%
Somewhat confident (3)	7%
Confident (4)	27%
Very confident (5)	56%
Missing/Refused/Unknown	8%

Table 7: Drivers' Confidence on Correct Installation of Car Seat/Booster

	Rear-Facing Infant (n=299)	**Rear-Facing Convertible (n=143)**	**Forward-Facing (n=1,992)**	**Booster Seat (n=1,380)**	**All Car Seat/Booster Seat (n=3,814)**
Not confident (1)	1%	<1%	2%	1%	1%
Slightly confident (2)	2%	3%	2%	1%	2%
Somewhat confident (3)	13%	16%	12%	9%	11%
Confident (4)	34%	42%	35%	26%	32%
Very confident (5)	43%	32%	37%	49%	41%
Missing/ Refused/ Unknown	7%	7%	12%	14%	12%

From the responses collected for both confidence questions, the majority of drivers responded that they were confident or very confident that they chose the correct car seat/booster seat and installed the car seat/booster seat correctly.

There are many possible sources of information about proper car seat/booster seat installation. All drivers were asked if they had read the instructions from any or all of the four following

sources: the car seat box, car seat label, car seat's manual, or the vehicle's owner manual. The results are shown in Table 8.

Table 8: Drivers' Knowledge (n=3,814)				
Has Read Instructions	**Car Seat's Box**	**Car Seat's Label**	**Car Seat's Manual**	**Vehicle's Manual**
Yes	23%	29%	61%	13%
No	71%	65%	33%	81%
Missing/ Refused/ Unknown	6%	6%	6%	6%

In response to this question (Table 8), drivers could select multiple sources. It was determined that 15 percent of the drivers claimed that they did not read any instruction on how to properly install the car seat/booster seat.

Drivers were also asked if they had the seats checked or inspected at seat checks or by certified CPSTs.

Table 9: Car Seat/Booster Seat Been Inspected					
Car Seat/Booster Seat Has Been Inspected	**Rear-Facing Infant (n=299)**	**Rear-Facing Convertible (n=143)**	**Forward-Facing Car Seat (n=1,992)**	**Highback Booster (n=708)**	**Backless Booster (n=682)**
Yes	19%	15%	16%	5%	3%
No	80%	82%	80%	91%	90%
Missing/ Refused/ Unknown	2%	3%	4%	4%	7%

Table 9 indicates that for each type of car seat/booster seat, the majority of drivers responded that the seats were never been inspected at seat checks or by certified CPSTs.

4. Car Seat and Booster Seat Misuse

NCRUSS studied misuse rates of car seats and booster seats. To determine how "misuse" should be defined for purposes of the study, NHTSA assembled a group of internal subject matter experts. The experts decided that not every divergence from a perfect installation should be considered "misuse" for this study. Instead, misuse was assigned based on characteristics of installing the car seat/booster seat to the vehicle, or of restraining the child in a car seat/booster seat, that may reduce the protection of the car seat/booster seat in the event of a crash.[6] Such derived characteristics of real-world use will be identified as "misuse" in this report.[7] The defined misuses were not collected data points, but derived from the observed data points presented in Section 3 and Appendix C. Appendix D provides the list of defined misuses for car seats and booster seats.

Using the above criteria, the NCRUSS focuses on car seat and booster seat installation and use, given that a car seat or booster seat was present. A circumstance that does not fit into the categories of seat installation or child positioning in a seat is the situation of a child being completely unrestrained, or using only a seat belt. These children are not considered in the calculation of misuse, due to the nonuse of car seats or booster seats.

In the previous section, the data is presented as a whole, including responses not collected or known. However, in this section, the corresponding percentages of the defined misuses are calculated with respect to those who provided responses. Table 10 provides the list of defined booster seat misuses and the corresponding percentages of booster seats exhibiting the misuse. Two percent and 4 percent of highback and backless booster seats, respectively, were observed to have the seat belts unbuckled, which essentially left the children unrestrained. A booster seat does not restrain the child; it positions the child so that the seat belt may restrain the child correctly.

[6] Some of the characteristics of car seat installation and restraining the child in the car seat that were considered as misuse in previous surveys were not considered as misuse by the group. The group considered and weighed various sources of information, including field data, simulations, and sled test data to determine the characteristics that are likely associated with a higher risk of injury and fatality to children restrained in car seats.

[7] This NCRUSS report uses this defined list in analyzing misuses in relation to the installation of the car seat/booster seat to the vehicle or the restraining of a child in a car seat/booster seat. NHTSA notes that, if technical data or other information become available that indicates that different use characteristics should be considered, interested people may use the NCRUSS data presented in this report to analyze use characteristics of car seats/booster seats as they prefer.

Table 10: Booster Seats Misuse by Seat Type		
	Highback Booster (n=708)	**Backless Booster (n=672)**
Restraining of Child in Booster Seat		
Child seated in front row, with an active air bag	<1%	2% (n=671)
Location of booster seat not on vehicle seat	<1%	0%
Booster seat is cracked/broken shell	<1% (n=692)	<1% (n=655)
Booster seat has broken/frayed harness	1% (n=692)	0% (n=655)
Booster seat uses aftermarket product, belt tightener	0% (n=692)	0% (n=656)
Seat belt is not buckled	2% (n=671)	4% (n=629)
Child's head above vehicle seat back	2% (n=683)	3% (n=642)
Shoulder belt behind arm or back	4% (n=645)	6% (n=584)
Lap belt across abdomen/ribcage	9% (n=629)	12% (n=576)
Lap belt not used	1% (n=629)	2% (n=576)

Table 11 provides the misuses for rear-facing and forward-facing car seats with respect to installing the car seat to the vehicle and then restraining the child to the car seat. For the installation of the car seat to the vehicle, 17 percent of forward-facing car seats, 11 percent in rear-facing infant car seats, and 5 percent in rear-facing convertibles moved 3 inches or more laterally at the belt path. Sixteen percent of children less than one year of age were in rear-facing infant car seat with a recline angle up to 30 degrees. Similarly, thirteen percent of children less than one year of age were in rear-facing convertible car seats with a recline angle up to 30 degrees.

A child may be placed in a car seat, but still be unrestrained. Data revealed that 3 percent, 1 percent, and 2 percent of children in rear-facing infant car seats, rear-facing convertible, and forward-facing car seat, respectively, did not use the harness and were therefore unrestrained. Harness with more than 2 inches of slack was observed in 6 percent in rear-facing infant car seats, 2 percent of rear-facing convertible car seats, and 11 percent of forward-facing car seats.

Table 11: Car Seats Misuse by Seat Type			
	Rear-Facing Infant (n=299)	**Rear-Facing Convertible (n=143)**	**Forward-Facing (n=1,992)**
Car Seat to Vehicle Installation			
Direction is rear-facing	n/a	n/a	<1% (n=1,987)
Direction is forward-facing	5%	0% (n=142)	n/a
Direction is supine (facing up)	n/a	n/a	<1% (n=1,987)
Direction is other	n/a	n/a	<1% (n=1,987)
Moves 3 inches laterally	11% (n=269)	5% (n=136)	17% (n=1,707)
Other method of attachment of car seat to vehicle	<1% (n=292)	1% (n=140)	<1% (n=1,956)
Car seat not attached to vehicle	1% (n=292)	0% (n=140)	3% (n=1,956)
Car seat not against vehicle back	n/a	n/a	3% (n=1,940)
Child less than 1 years old and car seat is upright	3% (n=258)	0% (n=138)	n/a
Child less than 1 years old and car seat angle is up to 30 degrees	16% (n=258)	12% (n=139)	n/a
Recline of more than 45 degrees	3% (n=258)	1% (n=130)	n/a
Restraining a Child in Car Seat			
Child seated in front row, with an active air bag	<1%	0%	<1% (n=1,990)
Car seat is cracked/broken shell	0% (n=286)	0% (n=134)	<1% (n=1,920)
Car seat has broken/frayed harness	3% (n=286)	0% (n=134)	1% (n=1,920)
Car seat uses aftermarket product, belt tightener	0% (n=290)	1% (n=132)	<1% (n=1,908)
Location of car seat not on vehicle seat	0%	0%	0% (n=1990)
Harness not in use	3% (n=292)	1% (n=137)	2% (n=1,915)
Given harness in use, harness strap not buckled	1% (n=287)	0% (n=134)	1% (n=1,838)
Given harness in use, one or more harness straps behind arm/back/leg	1% (n=284)	1% (n=134)	5% (n=1,786)
Given harness in use, harness slack is greater than 2 inches	6% (n=269)	2% (n=128)	11% (n=1,701)
Given direction is rear-facing, both harness slot position above the child's shoulder by more than 2 inches	<1% (n=267)	1% (n=133)	n/a
Given direction is forward-facing, both harness slot position below the child's shoulder by more than 2 inches	n/a	n/a	3% (n=1,701)
Child's head is above the top of car seat	<1% (n=280)	0% (n=132)	n/a

Table 12 and 13 provide misuses specifically related to installing the car seat by attaching to the lower anchor connectors or with the seat belt, respectively. The subsamples of these tables represent situations where a car seat was installed using either the lower anchor connectors or seat belt. The last defined misuse of both Table 12 and 13 is only applicable to rear-facing convertible seats and forward-facing car seats. In addition, the defined misuse is dependent upon whether the car seat is facing the right direction. Finally, incorrect routing consist of

unconventional routing and routing through slots/channels that are opposite of the correct direction of the car seat.

Table 12: Misuse of Car Seats Installed to Lower Anchors by Seat Type			
	Rear-Facing Infant (n=160)	**Rear-Facing Convertible (n=96)**	**Forward-Facing (n=934)**
Both lower anchor connectors attached to something other than anchor	1% (n=156)	<1% (n=93)	1% (n=914)
One of the connectors not attached to anything or attached to something other than anchor	<1% (n=156)	0% (n=93)	1% (n=914)
Multiple car seats or boosters attached to lower anchors used by inspected car seat	4% (n=149)	<1% (n=91)	4% (n=897)
Incorrect lower anchor strap routing	n/a	33% (n=95)	26% (n=924)

Table 13: Misuse of Car Seats Installed with Seat Belt by Seat Type			
	Rear-Facing Infant (n=157)	**Rear-Facing Convertible (n=52)**	**Forward-Facing (n=1,109)**
Seat belt is not buckled	5% (n=153)	3%	5% (n=1,082)
Vehicle model years prior to 1996 and locking clip used on lap/shoulder, greater than 1 inch/used only on lap/ used only on shoulder	0%	0% (n=51)	<1% (n=1,102)
ELR mode and latch plate is not switchable-locked or locking	50% (n=139)	26% (n=48)	50% (n=1,025)
Car seat lockoff is available and not in use and seat belt is in ELR mode and latch plate is not switchable-locked or locking	3% (n=142)	0% (n=47)	1% (n=1,051)
Incorrect seat belt routing	n/a	27%	33% (n=1,089)

4a. Misuse by Installation Method

In this section, the following tables provide misuses for specific types of installation methods including lower anchor connectors only, seat belt only, lower anchor connectors and tether strap, and seat belt and tether strap. The data provided in Tables 14 to 16 are not their own individual defined misuse, but a subsample of the defined misuses from Tables 11 to 13. Table 14 and 15 present misuses by lower anchor connectors only and seat belt-only installations for both rear-facing and forward-facing car seats. Table 14 and 15 show 11 percent of forward-facing car seats and 2 percent of rear-facing car seats installed only with lower anchor connectors with lateral

movement of 3 inches. For seat belt-only installations, 27 percent of forward-facing car seats and 22 percent of rear-facing car seats move 3 inches laterally.

Table 14: Installation Misuse of Forward-Facing Car Seat by Installation Method		
	Lower Anchor Connectors Only (n=262)	**Seat Belt Only (n=765)**
Moves 3 inches laterally	11% (n=239)	27% (n=654)
Uses rear-facing slots/channels for routing	32% (n=259)	32% (n=750)
Uses other unconventional routing	1% (n=259)	3% (n=750)

Table 15: Installation Misuse of Rear-Facing Car Seat by Installation Method		
	Lower Anchor Connectors Only (n=211)	**Seat Belt Only (n=171)**
Moves 3 inches laterally	2% (n=201)	22% (n=160)
Given rear-facing convertible, uses forward-facing slots/channels for routing	29% (n=78)	38% (n=42)
Given rear-facing convertible, uses other unconventional routing	0% (n=78)	1% (n=42)

Table 16 examines the installation methods of forward-facing car seats by lower anchor connectors and tether strap or by seat belt and tether strap. Eight percent of forward-facing car seats installed by lower anchor connectors and tether strap and 21 percent of forward-facing car seats installed by seat belt and tether strap had lateral movement of more than 3 inches.

Table 16: Installation Misuse of Forward-Facing Car Seat by Installation Method		
	Lower Anchor Connectors and Tether Strap (n=529)	**Seat Belt and Tether Strap (n=201)**
Moves 3 inches laterally	8% (n=492)	21% (n=182)
Uses rear-facing slots/channels for routing	21% (n=526)	26% (n=198)
Uses other unconventional routing	1% (n=526)	1% (n=198)

4b. Overall Misuse

An individual car seat or booster seat can have multiple misuses; misuses are not mutually exclusive. For this report "overall misuse" is considered as having at least one defined misuse present in the car seat or booster seat – the seat may have one or multiple misuses, where one misuse has the same contribution as multiple misuses. The defined misuses listed in Tables 10 to 13 are the components of overall misuse. These misuses can be considered applicable to all car seats and booster seats; they are not manufacturer-specific.

In a survey, there are usually missing/unknown values for some observations. In NCRUSS, with respect to car seat/booster seat misuse, incomplete information in some variables can lead to uncertainty as to whether or not the seat should be classified as an overall misuse or no misuse. Table 17 provides the percentages for unknown misuse status, no misuse, and misuse from the information collected. In Appendix E, more information and tables are provided specific to car seats and booster seats observed with a misuse in NCRUSS.

Table 17: Overall Misuse Percentages of Car Seats and Booster Seats Including Unknowns

	Number of Observed	Unknown	No Misuse	Misuse
Total	**3,814**	**14%**	**44%**	**42%**
Rear-facing infant car seat	299	19%	37%	44%
Rear-facing convertible	143	13%	44%	43%
Forward-facing car seat	1,992	14%	29%	57%
Highback booster	708	10%	74%	15%
Backless booster	672	14%	65%	21%

In the NCRUSS data, 14 percent of car seats and booster seats did not have enough information available to classify overall misuse. For the single misuses of the preceding section, it was possible to drop the unknowns and calculate the single misuse rate from the known data for that specific misuse, with the assumption that the unknown observations would have the same distribution as the known misuse rate; but with overall misuse, potentially multiple unknowns in single misuse information could complicate the assumption, and accepting all unknowns as "no misuse" could incorrectly treat potential misuse as no misuse. To provide a better estimate of the overall misuse, multiple imputations were conducted in order to estimate overall misuse rates of car seats or booster seats including cases with missing data.

For simplification and to match the approach of single misuse (which essentially assumed the missing misuse was proportional to the known misuse), the imputation approach taken was simple random imputation, which imputes missing values at random but proportionally to the observed weighted distribution for a specific variable.[8] Once all missing values have been imputed, the data set is analyzed for overall misuse in the same fashion as before.

Using principles of multiple imputations, the simple random imputation was conducted five separate times to capture the variability due to imputation. A single set of results can be obtained

[8] Gelman, A., & Hill, J. (2006). *Data analysis using regression and multilevel/hierarchical models*. New York: Cambridge University Press.

from combining results from a data analysis performed *m* times, once for each of *m*=5 imputed data sets.[9] Table 18 provides the overall misuse obtained from combining results from the 5 imputed data sets.

Table 18: Imputed Overall Misuse Percentages of Car Seats and Booster Seats

	Misuse
Total	**46%**
Rear-facing infant car seat	49%
Rear-facing convertible	44%
Forward-facing car seat	61%
Highback booster	16%
Backless booster	24%

When performing an analysis of multiply imputed data, the variation in results across the imputed data sets reflects statistical uncertainty due to missing data. From the multiple simple random imputations, the overall misuse of 46 percent has a 95 percent confidence interval ranging from 39 percent to 52 percent. The following diagnostic measures indicate how strongly the estimated overall misuse is influenced by missing data: The relative increase in variance due to nonresponse is was found to be 3.20 percent, and the estimated rate of missing information was 3.15 percent. These parameters indicate that only a small percentage of missing data contributed to the inferential uncertainty about the overall misuse. Details of these calculations are shown in Appendix F.

[9] Rubin, D. B. (1987). *Multiple imputation for nonresponse in surveys*. New York: J. Wiley & Sons.

5. Manufacturer Weight and Height Recommendations

There is a large amount of variability between car seats/booster seats offered. Each seat provides a recommendation of height and weight limits formulated by the manufacturer, specific to the seat. NHTSA does not issue global guidelines for height and weight, but recommends that one follows the recommendation given by the manufacturer with regard to height and weight.[10] Determining whether the seat is a good fit is not as simple as looking at the child's height or weight. According to car seats/booster seats manuals, a good fit is a combination of multiple factors, ranging from age, weight, height, location of child's ears in relation to seat shell, and location of harness strap/shoulder belt in relation to child's shoulder.

Tables 19 and 20 provide percentages of child weight/height or weight/height category in comparison to the seat manufacturer recommended weight and height lower and upper limits. When possible, data was gathered from the available child seat's labels that provided lower and upper weight and height limits. However, these variables had high rates of missing data due to the inability of the seat inspectors to manipulate the installed restraints in order to observe labeling. Inspectors were trained to not maneuver the seats, so if the location of the labels that contains the manufacturer's recommendation were not visible, then the information was unavailable.

Table 19: Child's Weight Relation to Manufacturer Limit by Car Seat/Booster Seat Type

Weight Relation to Limit	Rear-Facing Infant (n=299)	Rear-Facing Convertible (n=143)	Forward-Facing (n=1,992)	Highback Booster (n=708)	Backless Booster (n=672)
Under	n/a	n/a	3%	4%	4%
Within	62%	66%	46%	54%	46%
Above	4%	2%	3%	n/a	2%
Unknown child weight	<1%	1%	1%	2%	2%
Unknown lower & upper limits	35%	29%	41%	39%	46%
Unable to determine	<1%	1%	7%	2%	2%

[10] www.safercar.gov/parents/Right-Car-Seat-Age-Size.htm

Table 20: Child's Height Relation to Manufacturer Limit by Car Seat/Booster Seat Type					
Height Relation to Limit	**Rear-Facing Infant (n=299)**	**Rear-Facing Convertible (n=143)**	**Forward-Facing (n=1,992)**	**Highback Booster (n=708)**	**Backless Booster (n=672)**
Under	n/a	n/a	5%	12%	5%
Within	47%	27%	12%	28%	29%
Above	2%	3%	2%	<1%	1%
Unknown child height	1%	3%	5%	3%	5%
Unknown lower & upper limits	49%	67%	58%	40%	48%
Unable to determine	1%	<1%	19%	17%	12%

Table 19 and 20 provide three types of unknowns when comparing the child's height and weight to the manufacturer's recommended height and weight. The first two types of unknowns, "unknown child weight/height" and "unknown lower and upper limits," are self-explanatory. The last one, "unable to determine," contains several scenarios: Height and weight are missing from both sources, child's height or weight is given within a range (not specific) and this range falls within and outside the recommended range and either the lower or upper recommended limit is unknown.

The total missing rates for weight and height are 45 and 72 percent, respectively. The known children's weight and height that were observed to fall outside the manufacturers' recommendations were 9 and 23 percent, respectively. Due to the larger amount of missing data, and the dependent relationships between variables such as upper limit and lower limit, imputation was not conducted for this subject area.

6. Child Restraint Anchorage System (LATCH[11]) Use

Lower Anchors and Tethers for Children, a system created to help make installation easier by eliminating the use of the seat belt, has been in the marketplace since the NHTSA-promulgated regulation (FMVSS No. 225) became fully effective on September 1, 2002.[12]

There are two items in the vehicle that comprise the vehicle part of the LATCH system. First, there are a minimum of two "lower anchor-equipped" seating positions in the rear of the vehicle; each has two small bars/anchors found in the space between the seat back and the seat cushion (the area is sometimes referred to as the seat bight). Second, there are a minimum of three tether anchors for the tether straps. Two of the three tether anchors are in the same designated seating position as the lower anchors. In sedans, these are usually located behind the vehicle's rear seat on the rear shelf. In some larger vehicles such as vans, pickup trucks, and SUVs, these anchor points may be found on the rear of a vehicle seat itself, on the floor, the roof, or another location. Convertibles are excluded from the tether anchor requirement. The vehicle owner's manual explains where they are in the vehicle and helps the owner to avoid confusing them with other vehicle hardware such as luggage tie-downs.

NHTSA recommends using a tether anchor with a forward-facing car seat whether the car seat is installed with the vehicle seat belt or the lower anchors. The lower anchors or vehicle seat belt are designed to work along with the tether anchor to assure the highest level of safety for child passengers restrained in forward-facing configurations. Also, rear-facing infant and rear-facing convertible car seats in the United States do not normally use the tether anchors for installation. However, some manufacturers of rear-facing car seats recommend use of the tether anchor.

6a. LATCH Use in the NCRUSS

Data collected from the NCRUSS can determine LATCH system use of child occupants in a rear-facing or forward-facing car seat. Table 21 provides the breakdown of rear-facing and forward-facing car seats into "qualified" and "not qualified" car seats. Specifically, rear-facing car seats must be equipped with lower anchor connectors and forward-facing car seats must be equipped with both lower anchor connectors and tether strap, which this report refers to as "qualified car seats."[13] Table 21 provides the weighted percentage and subsample population per car seat type. Table 22 presents installation methods used to attach rear-facing and forward-facing car seats to vehicles. The difference between the data presented in Table 3 and 22, is that in Table 22 the car seats must be equipped with lower anchor connectors and tether strap and be positioned in a designated seating position equipped with lower anchors and tether anchor.

[11] "LATCH" is a term that was developed by child restraint manufacturers and retailers to refer to the standardized child restraint anchorage system required by FMVSS No. 225, Child Restraint Anchorage Systems. FMVSS No. 225 requires new passenger vehicles to be equipped with LATCH systems in rear seating positions.

[12] In addition, FMVSS No. 213 requires car seats to have permanently-attached components that enable the car seat to connect to a LATCH system on a vehicle.

[13] Qualified car seats are defined as rear-facing car seats with available lower anchor connectors and forward-facing car seats with available lower anchor connectors and tether straps.

Table 21: Car Seat With Available Lower Anchor Connectors and Tether Strap or Only Lower Anchor Connectors[14] by Seat Type				
	Rear-Facing Infant (n=299)	**Rear-Facing Convertible (n=143)**	**Forward-Facing (n=1,992)**	**Total (n=2,434)**
Qualified car seat	84%	92%	69%	73%
Not qualified car seat	7%	4%	11%	10%
Unknown status for qualified car seat	8%	4%	20%	17%

There were a total of 2,434 rear-facing and forward-facing car seats; however, 10 percent of the car seats were not qualified car seats (no available lower anchor connectors and tether strap or only lower anchor connectors) while 17 percent were indeterminable in whether the car seat was equipped with lower anchor connectors and tether strap or only lower anchor connectors. Out of the known qualified car seats, 12 percent of the car seats were in vehicles not equipped with the lower anchors and tether anchor while 2 percent of car seats were in vehicles that were deemed indeterminable in whether the vehicle was equipped with lower anchors and tether anchor, leaving the remaining qualified car seats in vehicles where it is confirmed that the vehicle is equipped with lower anchors and tether anchors in the vehicle.

Table 22: Observed Car Seat Attachment to the Vehicle for Qualified Car Seats With Lower Anchors and Tether Anchor Available at the Car Seat's Particular Seating Position		
Installation Method	**Rear-Facing Car Seat (n=249)**	**Forward-Facing Car Seat (n=1,001)**
Lower anchor connectors only	75%	23%
Seat belt only	12%	12%
Tether strap only	n/a	1%
Lower anchor connectors and seat belt	9%	3%
Lower anchor connectors and tether strap	3%	48%
Seat belt and tether strap	<1%	6%
Lower anchor connectors and tether strap and seat belt	n/a	6%
Unknown	n/a	1%
Total lower anchor connectors use	87%	80%
Total seat belt use	22%	27%
Total tether strap use	3%	61%

Table 22 shows that rear-facing car seats (both infant car seats and convertibles) equipped with lower anchor connectors in seating positions equipped with lower anchors were more likely

[14] Car seats with available lower anchor connectors and tether strap apply only to forward-facing car seats. Car seats with only available lower anchor connectors apply only to rear-facing car seats.

installed with lower anchor connectors only (75%) than with the seat belt only (12%). Similarly, forward-facing car seats equipped with lower anchor connectors and tether strap in seating positions equipped with lower anchors and tether anchor were more likely installed with lower anchors connectors and tether strap (48%) than the seat belt only (12%). From these installation methods by car seat, Table 23 provides the percentage of qualified car seats in a vehicle that has lower anchors and tether anchor exhibiting a misuse.

Table 23: Misuse of Qualified Car Seats With Lower Anchors and Tether Anchor Available at the Car Seat's Particular Seating Position by Installation Method

	Misuse Percentage
Installation of rear-facing car seat	
Lower anchors connectors only (n=179)	20%
Seat belt only (n=33)	80%
Installation of forward-facing car seat	
Lower anchor connectors and tether strap (n=449)	34%
Seat belt only (n=172)	87%

The data from Table 23 shows that car seats installed with lower anchor connectors only or lower anchor connectors and tether strap showed a low rate of misuse in comparison to car seats that were installed with the seat belts only.

Not all vehicles equipped with lower anchors and tethers have them in all seating positions. It was important to determine whether drivers who were transporting children in lower anchor connectors and tether-strap-ready car seats were taking advantage of lower anchors and tether anchors in their vehicles to attach the car seats. Table 24 shows the same comparison of methods used to attach the car seats to vehicles, but is now limited to cases where lower anchors and a tether anchor are available somewhere in the vehicle but not at the car seat's seating position. Due to the information provided, it is not always clear whether the car seat's seating position was or was not equipped with lower anchors and tether anchor, so it is assumed that if the car seat is connected to lower anchors, then those lower anchors were designated for a different seating position than the one where the car seat was located (e.g., the car seat was installed in the center-rear seat using the right anchor of the left outboard seat and the left anchor of the right outboard seat).

Table 24: Observed Car Seat Attachment to the Vehicle for Qualified Car Seats as a Function of Lower Anchors and Tether Anchor Availability in the Vehicle but Not at Car Seat's Seating Position		
Installation Method	**Rear-Facing Car Seat (n=55)**	**Forward-Facing Car Seat (n=153)**
Lower anchor connectors only attached to lower anchors from another seating position	43%	14%
Seat belt only	43%	13%
Lower anchor connectors attached to lower anchors from another seating position and seat belt	14%	1%
Lower anchor connectors attached to lower anchors from another seating position and tether strap	n/a	50%
Seat belt and tether strap	n/a	12%
Lower anchor connectors attached to lower anchors from another seating position and tether strap and seat belt	n/a	10%
Unknown	n/a	<1%

Twelve percent of qualified car seats are not riding at lower anchors and tether-anchor-equipped seating positions. From this 12 percent of qualified car seats, it was observed that 89 and 77 percent of qualified rear-facing and forward-facing car seats, respectively, were positioned in the second row center seat instead of the second row outboard seats. Parents and caregivers are placing the safety seat in the center rear-seat of the vehicle, which is generally considered the safest position,[15] instead of placing it in one of the lower anchors and tether-anchor-equipped rear-outboard seats.

6b. Nonuse of Lower Anchors or Tethers

In the NCRUSS, there were a total of 383 car seat models equipped with lower anchor connectors that were not used in the installation of the car seats in vehicles equipped with lower anchors (48 rear-facing car seats and 335 forward-facing car seats). Table 25 provides the seating position of car seats equipped with lower anchor connectors in vehicles where lower anchors were available for that seating position. It shows that 83 percent of the car seats equipped with lower anchor connectors not in use had been placed on seats that were equipped with lower anchors.

[15] Kahane, C. J. (2004, October). *Lives saved by the Federal Motor vehicle Safety Standards and other vehicle safety technologies, 1960-2002 – Passenger cars and light trucks – With a review of 19 FMVSS and their effectiveness in reducing fatalities, injuries and crashes*. (Report No. DOT HS 809 833). Washington, DC: National Highway Traffic Safety Administration. Available at www.nhtsa.gov/cars/rules/regrev/evaluate/pdf/809833Part1.pdf and www.nhtsa.gov/cars/rules/regrev/evaluate/pdf/809833Part2.pdf

Table 25: **Seating Positions of Vehicles With Lower Anchors in the Seating Position, for Lower-Anchor-Connectors-Equipped Car Seats Where the Lower Anchors Connectors Were Not in Use**	
	Forward-Facing Car Seats (n=324)
Second row left	39%
Second row center	7%
Second row right	54%
Third row right	<1%
Total[16]	83%

There were 584 forward-facing car seats equipped with tether straps but not used in the installation of the car seat in vehicles equipped with tether anchors. Table 26 provides the seating position of the forward-facing, tether equipped car seats (for which the tether strap was not in use) in vehicles where a tether anchor was available for that seating position. Table 26 shows that 97 percent of the forward-facing car seats with tether straps not in use had been placed in seating positions that were equipped with tether anchors.

Table 26: **Seating Positions of Vehicles With a Tether Anchor in the Seating Position, for Tether-Equipped Forward-Facing Car Seats Where the Tether Was Not in Use**	
	Forward-Facing Car Seats (n=574)
Front row center	<1%
Front row right	<1%
Second row left	37%
Second row center	13%
Second row right	47%
Third row left	2%
Third row right	1%
Total[17]	97%

[16] The sample size is the 383 car seats equipped with lower anchor connectors but not used in the installation of the car seat in vehicles equipped with lower anchors.

[17] The sample size is the 584 forward-facing car seats equipped with tether straps but not used in the installation of the car seat in vehicles equipped with tether anchors.

7. Summary

Over the years the safety regulations, manufacturers' types, and the recommended procedures for installing car seats and booster seats to vehicles have changed. As a result, research has found that car seats and booster seats are effective in reducing the risk of fatal injury for children.

The NCRUSS contains data providing dual perspectives from the driver viewpoint to the inspection of the car seat or booster seat. Quantitative measurements were collected to provide a more precise understanding of the sample population. The NCRUSS was also designed as a nationally representative sample so that any observations made upon the sample population may be weighted to represent the nation's population of child passengers up to 8 years old.

Results showed that 94 percent of children were restrained in car seats or booster seats, 4 percent were restrained in seat belts, and 2 percent were unrestrained. By car seat or booster seat type, 50 percent of children were restrained in forward-facing car seats, 31 percent restrained in booster seats, 9 percent restrained in rear-facing infant car seats, and 4 percent restrained in rear-facing convertible seats.

Misuse is defined as characteristics of installing the car seat/booster seat to the vehicle, or of restraining the child in a car seat/booster seat, that may reduce the protection of the car seat/booster seat in the event of a crash. The defined list of misuses used in NCRUSS corresponds to the type of car seat/booster seat used. These misuses can be considered applicable to all car seats and booster seats; they are not manufacturer-specific.

Overall misuse is considered as having at least one defined misuse present in the car seat or booster seat – the seat may have one or multiple misuses, where one misuse has the same contribution as multiple misuses. The overall misuse is estimated to be 46 percent with a 95 percent confidence interval ranging from 39 percent to 52 percent. By car seat or booster seat type, estimated misuse rates were 61 percent for forward-facing car seats, 49 percent for rear-facing infant car seats, 44 percent for rear-facing convertible car seats, 24 percent for backless booster seats, and 16 percent for highback booster seats.

In the evolving area of car seat safety regulations, the types of car seats that are manufactured, and the recommended procedures for installing car seats to vehicles came the introduction and availability of LATCH. LATCH created an installation system to help make installation easier by creating an alternative to seat belts. The NCRUSS data revealed that, in seating positions equipped with lower anchors and tether anchors, more forward-facing car seats equipped with lower anchor connectors and tether straps were installed with lower anchors connectors and tether straps (48%) than the seat belts only (12%). Similarly, rear-facing car seats (both infant car seats and convertibles) equipped with lower anchor connectors in seating positions equipped with lower anchors were more likely installed with lower anchor connectors only (75%) than the seat belts only (12%).

Appendix A: Sampling Methodology

A1. Sample Size

Design effects were estimated using results from the 2009 National Survey of the Use of Booster Seats (NSUBS). The 2009 NSUBS survey used similar site types and sampling methods, but only 16 PSU's. Design effect was computed for a simple characteristic; the use of the incorrect type of restraint for a child based on age, size and weight. The design-based estimate of the design effect (the ratio of the true variance of estimate of misuse to the variance of an estimate derived from a simple random selection) for this survey was 13.55. The model-based estimate was 20.78. In determining the likely design effect for the NCRUSS survey, the larger model-based estimate was considered so that it can be adjusted for differences in proposed number of PSUs and overall sample size. The model-based design effect is given by:

$$DEFF_m = (1 + cv_w^2)\{1 + (\bar{b} - 1)\hat{\rho}\} \quad (1)$$

Where cv_w^2 is the squared coefficient of variation of the sampling weight, $\hat{\rho}$ is the estimated intraclass correlation within PSUs and $\bar{b}$ is the simple average of the cluster sizes. The results from the 2009 NSUBS give:

$$DEFF_m = (1 + 1.465)\{1 + (398.375 - 1)0.0187\} = 20.78$$

Although it was difficult to predict changes to cv_w^2 and $\hat{\rho}$ resulting from the differences in the NSUBS and the NCRUSS methodologies, it is possible to adjust $\bar{b}$. Since the number of PSUs is fixed at 24 and there is an upper limit of 3,000 on overall sample size imposed by available funds, the adjusted average cluster size $\bar{b}^*$ is 3,000/24, or 125. Substituting gives:

$$DEFF_m^* = (1 + cv_w^2)\{1 + (\bar{b}^* - 1)\hat{\rho}\}$$

$$DEFF_m^* = (1 + 1.465)\{1 + (125 - 1)0.0187\} = 8.18$$

To find the desired sample size to estimate a population proportion with a margin of error of 5% and 95% certainty we begin with:

$$n = p(1 - p)\left(\frac{z_c}{E}\right)^2 * DEFF_M^* \quad (2)$$

Where p, the rate of incorrect type of restraint, is estimated by the 2009 NSUBS as .413, z_c is the z-score associated with our desired 95% level of certainty, and E is the desired margin of error. The overall sample size is therefore:

$$n = .413(.587)\left(\frac{1.96}{.05}\right)^2 * 8.18$$

$$n = 373 * 8.18 = 3{,}047$$

There were two factors that suggested that a smaller sample size would be sufficient to obtain the desired level of accuracy. It has been asserted that Kish's formula for design effect (1) gives the upper bound of the design effect, and in the case of the NSUBS this seems plausible given the large difference between the model-based design effect given by Kish's formula (20.78) and the design-based effect (13.55).

The second factor was the estimate of misuse used in these calculations. The NSUBS definition is a simplified version of the definition to be used by the NCRUSS survey, which is similar to the misuse definition used in a 2003 NHTSA misuse study that found the rate of misuse to be 0.726. If this rate of misuse is substituted for p in (2), then the resulting desired sample size is only 2,503.

In order to ensure that an overall rate of misuses can be estimated with the desired accuracy, this study proposed to collect the maximum number of observations allowed by funding; 3,000 child passengers from age 0-8. Due to additional funding, the final number of complete observations collected by the NCRUSS was 4,167. The observed design effect for the variable identifying critical misuse was 6.19, well below the predicted design effect of 8.18.

A2. Sampling

The first stage of sampling (PSU level) was taken from a series of ongoing surveys, and details of the process can be found in the NASS-GES Analytical User's Manual. Briefly, the country was divided into 1,195 PSUs (geographic areas) that were stratified by type (large central city, large suburban area, and all others). Twenty-four PSUs were then selected using PPS with the number of reported car accidents within each PSU as the measure of size. PSU weights are available in the NASS-GES data files.

A3. Site Sampling

The second stage of sampling (site) was accomplished through joint effort by the statistical consultant and the NHTSA research team. The sites for survey were stratified by type of establishment, allowing researchers to focus on sites that are likely to provide access to child passengers. The types of sites that were selected for survey were large discount or "big box" stores, national chain fast food restaurants, daycare centers, public libraries, and recreation centers. A sampling frame was constructed that contained all of the eligible sites within each PSU. This was done by the statistical contractor using a NAVTEQ software package that is continually updated from several sources.

The types of sites selected for the study were based on several factors including those relating to safety of the data collectors, candidate drivers and child occupants, site or community cooperation and efficiency of data collection (i.e., volume of child passengers). This selection was made based on information in a contracted report from a statistical contractor with experience in child safety seat surveys that described benefits, impediments, and past experiences of different site types.

Site or community cooperation was critical. Permission was solicited directly from candidate site property managers or owners. For sites under community jurisdiction, government and police agencies were notified. The site level response rates are given in table A-1.

Table A-1: Site Level Response Rates for the NCRUSS

Site Type	Participated in the Survey	Expressly Declined Survey Participation	Were Ineligible for Survey Participation[18]	Unable to Contact	Total
Daycare centers	435	114	365	78	914
Fast food	155	118	98	53	371
Libraries	173	29	52	14	254
Recreation centers	57	15	13	3	85
Big box Stores	28	12	1	1	41
Total	848	288	529	149	1665

The number of sites necessary to collect the desired number of observations was calculated prior to data collection. This was done by assuming a 75 percent vehicle response rate (the same rate given by NSUBS). Accordingly, it was estimated that approximately 4,000 interview attempts would be necessary to reach the desired sample size of 3,000 child passengers. NSUBS was able to administer 14 vehicle interview attempts per 2-hour site observation period, and assuming that the NCRUSS observations will take about half again as long to conduct (based on pilot data), approximately 270 participating sites each with 3-hour observation blocks were needed in order to reach our target sample size (270 sites * 14 vehicle attempts * 0.75 response rate * = 2,835).

The 270 sites were distributed equally across the PSUs, resulting in 11 sites being selected for 18 of the 24 PSUs and 12 sites being selected for the remaining 6 PSUs. The 6 PSUs with 12 sites were randomly selected. The sites selected within each PSU were a stratified random sample, which ensured inclusion of less common site types. The site type strata are:

- Large discount stores and fast food restaurants,
- Libraries and recreation centers, and
- Daycare centers.

The sites were sampled using the following sampling plan to ensure inclusion of less common site types:

- Three libraries or recreation centers were selected randomly per PSU,
- Seven daycare centers were randomly selected per PSU, and

[18] Reasons that these sites were found to be ineligible included that the establishment had gone out of business or had changed to another type of business.

- The remaining 4 or 5 sites were selected randomly from the fast food restaurants and big box stores with relative frequency determined by proportion of frame count.

The resulting site selection probabilities will require the establishment of some notation. Let $1 \leq i \leq 24$ and $1 \leq j \leq 4$ denote integers. Let M_{ij} denote the total number of sites in the sampling frame for stratum j of PSU i, and let $1 \leq k \leq M_{ij}$ be the k^{th} site in the j^{th} stratum of the i^{th} PSU.

The initial sample of 270 sites was selected as described above, and a supplemental sample was taken to account for site refusals by taking the next member of the sorted sampling frame following the sites selected in stage 1. Let the number of initially sampled sites that are included in the final sample from the j^{th} stratum of the i^{th} PSU be denoted by m_{1ij}, and let the number of supplemental sites included in the final sample from the j^{th} stratum of the i^{th} PSU be denoted by m_{2ij}

Using this notation we can represent the probability that site k in stratum j of PSU i was included in the NCRUSS probability sample using the following formula:

$$P'_{ijk} = \delta_i \frac{m_{1ij} + m_{2ij}}{M_{ij}} \quad for\ 1 \leq k \leq M_{ij}$$

where δ_i denotes the selection probability for the i^{th} PSU (inverse of the PSU weight from the NASS database).

A4. Vehicle Sampling

The third stage of sampling (vehicle) was conducted on site by the data collection researchers. The researchers were not able to approach every vehicle containing a child occupant in the population of interest. This level of selection was largely based on convenience of the data collection researchers, and it was considered pseudo-random and unlikely to bias any estimates. A census of vehicles was taken at regular intervals during the data collection to provide estimates of total traffic volume during the collection period.

Let N_{ijk} be the total number of vehicles containing at least one child passenger under the age of 9 that entered the k^{th} site in the j^{th} stratum of the i^{th} PSU during the three-hour observation period and let $1 \leq l \leq N_{ijk}$ be an integer. Let n_{ijk} be the subset of N_{ijk} that was successfully sampled by the research staff. The vehicle (driver interview) weight of the l^{th} vehicle can then be given by the following formula:

$$P'_{ijkl} = \delta_i \frac{m_{1ij} + m_{2ij}}{M_{ij}} \frac{n_{ijk}}{N_{ijk}} \quad for\ 1 \leq k \leq M_{ij}\ and\ 1 \leq l \leq N_{ijk}$$

A5. Person-Level Sampling

The fourth stage of sampling was conducted in cases of multiple children within a single vehicle. In such cases the data collection staff used a 6-sided die to decide which of the children to collect

data on. Data was only collected on one child per vehicle to prevent observations that lasted much longer than driver interviews and to minimize the design effect at this stage of sampling.

If we let Q_{ijkl} denote the total number of children in the l^{th} vehicle at the k^{th} site in the j^{th} stratum of the i^{th} PSU, then the child (observation) weight can be given by the following formula:

$$P'_{ijklr} = \delta_i \frac{m_{1ij} + m_{2ij}}{M_{ij}} \frac{n_{ijk}}{N_{ijk}} \frac{1}{Q_{ijkl}} \quad for\ 1 \le k \le M_{ij}, 1 \le l \le N_{ijk}, 1 \le r \le Q_{ijkl}$$

There was an implicit sampling level for the time of day and day of week of data collection. Collection took place 7 days a week, in 3-hour intervals usually from 6 a.m. to 8 p.m. Effort was be made to balance collection at the site type level across time of day and day of week, with due consideration for traffic volume at these sites. For example, nearly all of the traffic at daycare sites was in the mornings and late afternoons, and therefore data collection teams were not sent to these sites during the middle of the day.

A6. Adjustments

A non-response bias analysis did not reveal bias due to non-response large enough to require an adjustment to the weights. Accordingly, the weights appended to the survey data have not been adjusted or trimmed.

Appendix B: Data Collection Methodology

B1. Data Collection Teams

Each PSU had its own data collection team usually consisting of three members, a driver interviewer, a child seat inspector (usually a certified child passenger safety technician [CPST]), and an assistant/counter.

Each team brought required materials to the data collection sites including interview forms, educational hand-outs, large signs with information about the survey, DOT identification badges, survey procedures manuals, and miscellaneous items such as clip boards, watches, measuring tapes, and digital cameras.

B2. Data Collection Schedule

Data collection began on June 1, 2011 and ended on July 29. Data was collected during week days, normally from 6:30 a.m. to 6 p.m., but some data collection started as early as 5:45 a.m. or ended as late as 8 p.m. The exact time that data collection was scheduled at a specific site or site type was based upon what was considered the best time to find vehicles with children at that location (for example during morning drop-off hours at a daycare center). Data was collected for 3 hours at each of two sites, with the rest of the day reserved for set-up, break-down, checking information on the completed survey forms, and travel.

At the start of the day, the team would develop an overall strategy for collecting data at this site, including setting up a command center where extra survey forms and materials were kept, positioning the two 3' by 5' signs prominently so drivers were alerted to the fact that a child restraint study was being conducted that day, establishing the best place to position the assistant/counter, and selecting a safe pullover zone for the interviews/inspections. After 3 hours of data collection, the team would pack up and move to the second site. A child care center normally would be the first site type scheduled, since early morning was a good time to find a concentrated pool of drivers dropping off children under 9 years old. The other four site types (i.e., fast food, big box stores, libraries, and recreation centers) would normally be scheduled around lunch time (fast food restaurants) or in the afternoon (stores, libraries, recreation centers).

At each site type for the day, the researchers approached vehicles as the driver came to a stop to drop passengers off at a facility, as the driver entered the parking lot, or as the driver parked. The researcher would give the driver a letter of introduction and ask the driver to participate in the study. Once a driver agreed to participate, one researcher interviewed the driver, recording information on the interview forms, while the second researcher inspected the child seat and recorded data on the inspection forms. At some sites, Spanish-speaking interviewers were available for drivers who only spoke Spanish, and, at one site, interviews were conducted in Chinese.

At the conclusion of each interview the participant was given a Child Passenger Safety Resource Card. This card contained contact information (i.e., a NCRUSS study e-mail address, DOT hotline telephone number) so that the drivers could contact someone in case they had any further

questions. Also included on the courtesy card were the Internet addresses for NHTSA's Facebook page and Twitter feed, as well as two Web sites containing NHTSA child passenger safety information. The drivers were also given a hand-out listing locations nearby where child safety seats could be checked, a brochure with additional information about child passenger safety, and a coloring book with child passenger safety information.

B3. Survey Forms and Variables

Data collected during the NCRUSS included information on the sites at which data was collected, the vehicles that stopped at these sites, and the drivers and child passengers up to 8 years old. This data was recorded on seven data collection forms (i.e., OMB Form Approval No. 2127-0642) and were collected via observation, inspection and interview. In total, over 300 unique variables were collected for each observation.

B4. Observational Data

Observational data was collected on two forms, the Daily Site Form-Tallies (NHTSA 1105) and the Observation Form-Non-Response (NHTSA 1109).

The Daily Site Form-Tallies did not require any interaction with the drivers of the vehicles. One form per site location was filled out by the "counter," who would count the number of eligible vehicles (i.e., passenger vehicles with one or more child passengers 8 or younger) that entered the collection site, as well as the number of children 8 or younger who were riding in these vehicles. In addition, the area around the data collection site was characterized by the observer as being urban, suburban or rural in nature. The purpose of this form was to collect site specific information and to collect data to be used to adjust estimates of eligible vehicles that were at the site but did not participate in the survey.

The Observation Form-Non-Response was used by the CPSTs to collect observational data on vehicles and their occupants for use in later investigations of non-response bias—bias that is introduced by drivers who refuse to participate in the survey. This data was collected whether or not drivers agreed to cooperate in the study. When the interviewer approached the driver to obtain the driver's cooperation, the CPST would observe the interaction and log information about it, the driver, the number of passengers in the vehicle, and the vehicle body type.

B5. Inspection Data

The inspection data was collected on two forms, the Inspection Form-Restraints (NHTSA 1110) and Inspection Form-Vehicle Restraints (NHTSA 1111). Both forms were completed by the CPST while the interviewer conducted an in-person interview with the driver.

Once cooperation of the driver was obtained, the Inspection Form-Restraints form was used to obtain information about one child 8 or younger, who was randomly selected to be the "target" child. Specifics were collected about the safety restraint in use (type, location in the vehicle), how the child was restrained in it, and how the safety restraint was installed in the vehicle.

The Inspection Form-Vehicle Restraints form was used to obtain information about the equipment (e.g., seat belts, lower and tether anchors) and the safety restraint systems (e.g., infant child safety seats, booster seats) in each vehicle. Collected data included (1) the number and location of seating positions in the vehicle, (2) the seating positions that had someone sitting in them when the interviewer approached the vehicle, and (3) the vehicle equipment and safety restraints available, and in use, at each seating position.

B6. Interview Data

Interview data was collected on three forms, the Interview Form-Vehicle (NHTSA 1106), the Interview Form-Children by SP (NHTSA 1107), and the Interview Form-Restraints (NHTSA 1108). Drivers were asked the questions on the interview forms while the CPSTs inspected the vehicles.

The Interview Form-Vehicle was used to collect the drivers' knowledge about different restraint systems, whether LATCH is available in the vehicle, and from what sources have the drivers obtained information regarding child safety seats.

The Interview Form-Children by SP was used to collect demographic information (e.g., birth date or age, gender, origin, race, height, weight) on the vehicle's occupants who 13 or younger, regardless of the seating position and type of restraint use.[19] In addition, the driver's relationship to the child was collected.

The Interview Form-Restraints was used to collect information regarding the driver's general knowledge about and experience with restraints in the vehicle, as well as the driver's knowledge about one specific car seat/booster seat in the vehicle. In addition, demographic information about the driver was collected.

B7. Data Entry

Data from the seven paper forms used in the survey was entered manually by the data collectors into an application developed specially for the TPMS-SS survey. This data application contained automated edit checks, skip patterns, and other features to help insure that the data were entered correctly. In addition, staff at the NASS Zone Centers checked the data that were entered, including checking the images that had been taken.

B8. Quality Control

After the data was entered, checks were run by NHTSA staff to identify outliers, discrepancies between two similar variables, and other such inconsistencies via automated logic checks and data runs. While information about data elements that flagged these edit checks was sent to the

[19] This standard was established by the Office of Management and Budget in the October 30, 1997, Federal Register Notice, Volume 62, Number 210, pages 58781-58790. Categories for ethnicity are Hispanic or Latino or neither Hispanic nor Latino. The minimum categories for race are: White, Black or African-American, Asian, Native Hawaiian or Other Pacific Islander, and American Indian or Alaska Native.

NASS Zone Centers to be reviewed and, if necessary, corrected, no statistical editing was performed to alter the recorded values of outliers.

After data reconciliation, a final file was translated into SAS data sets. In addition, database reconciliation of these final SAS data sets was conducted.

Appendix C: The NCRUSS Data

C1. Overall Survey Sample

This section provides further information on the overall survey sample.

Tables C-1 to C-4 provides a breakout of restraint type by different characteristics.

The sample of the NCRUSS was limited to child occupants 8 and younger; however, two children were observed who were 9 and 10 years old. A child was randomly selected for observation based on the assumption of the researcher that the children available for random selection were 8 or younger.

Table C-1: Restraint Type by Age in Years

	Rear-Facing Infant (n=299)	Rear-Facing Convertible (n=143)	Forward-Facing Car Seat (n=1,992)	Booster Seat (n=1,380)	Seat Belt (n=242)
Under 1 year	90%	29%	1%	<1%	0%
1 year old	8%	54%	20%	1%	2%
2 years old	<1%	14%	33%	2%	3%
3 years old	<1%	<1%	23%	11%	6%
4 years old	1%	2%	18%	27%	5%
5 years old	<1%	0%	4%	28%	20%
6 years old	0%	0%	1%	16%	16%
7 years old	0%	0%	1%	11%	14%
8 years old	0%	0%	<1%	4%	34%
9 years old	<1%	0%	0%	0%	0%
10 years old	0%	0%	<1%	0%	0%
Refused/unknown/missing	<1%	1%	1%	1%	<1%

Table C-2: Restraint Type by Age Range

	Rear-Facing Infant (n=299)	Rear-Facing Convertible (n=143)	Forward-Facing Car Seat (n=1,992)	Booster Seat (n=1,380)	Seat Belt (n=242)
Under 1 year	90%	29%	1%	<1%	0%
1-3 years	8%	68%	74%	12%	11%
4-7 years	1%	2%	25%	83%	55%
8-9 years	<1%	0%	<1%	5%	34%
10-12 years	0%	0%	<1%	0%	0%
Refused/unknown/missing	<1%	1%	1%	<1%	<1%

Table C-3: Restraint Type by Weight Category					
	Rear-Facing Infant (n=299)	**Rear-Facing Convertible (n=143)**	**Forward-Facing Car Seat (n=1,992)**	**Booster Seat (n=1,380)**	**Seat Belt (n=242)**
Less than 20 lbs	62%	7%	<1%	<1%	0%
20 – 29 lbs	35%	87%	35%	2%	9%
30 – 39 lbs	2%	5%	48%	22%	7%
40 – 60 lbs	0%	0%	13%	68%	48%
Greater than 60 lbs	0%	0%	1%	6%	30%
Refused/unknown/missing	1%	1%	2%	2%	7%

Table C-4: Restraint Type by Height Category					
	Rear-Facing Infant (n=299)	**Rear-Facing Convertible (n=143)**	**Forward-Facing Car Seat (n=1,992)**	**Booster Seat (n=1,380)**	**Seat Belt (n=242)**
Less than 20 inches	5%	4%	<1%	0%	0%
20 – 29 inches	87%	39%	12%	1%	2%
30 – 36 inches	4%	50%	50%	15%	14%
37 – 49 inches	1%	1%	27%	63%	45%
50 – 56 inches	0%	0%	<1%	11%	26%
Greater than 56 inches	0%	0%	0%	1%	3%
Refused/unknown/missing	3%	6%	11%	8%	10%

Tables C-5 to C-8 provides similar information to Tables C-1 to C-4, but differs now by providing the row percentages.

Table C-5: Age in Years by Restraint Type					
	Rear-Facing Infant	Rear-Facing Convertible	Forward-Facing Car Seat	Booster Seat	Seat Belt
Under 1 year (n=309)	85%	11%	4%	1%	0%
1 year old (n=503)	6%	15%	77%	1%	1%
2 years old (n=649)	<1%	3%	93%	3%	1%
3 years old (n=721)	<1%	<1%	76%	22%	2%
4 years old (n=741)	1%	<1%	50%	48%	1%
5 years old (n=554)	<1%	0%	19%	74%	7%
6 years old (n=259)	0%	0%	8%	82%	11%
7 years old (n=171)	0%	0%	10%	77%	13%
8 years old (n=123)	0%	0%	1%	48%	51%
9 years old (n=1)	100%	0%	0%	0%	0%
10 years old (n=1)	0%	0%	100%	0%	0%
Refused/unknown/missing (n=24)	7%	5%	44%	41%	2%

Table C-6: Age Range by Restraint Type					
	Rear-Facing Infant	Rear-Facing Convertible	Forward-Facing Car Seat	Booster Seat	Seat Belt
Under 1 year (n=309)	85%	11%	4%	1%	0%
1-3 years (n=1,843)	2%	6%	83%	9%	1%
4-7 years (n=1,752)	<1%	<1%	30%	64%	6%
8-9 years (n=129)	<1%	0%	2%	49%	49%
10-12 years (n=1)	0%	0%	100%	0%	0%
Refused/unknown/missing (n=22)	9%	7%	58%	23%	3%

Table C-7: Weight Category by Restraint Type					
	Rear-Facing Infant	Rear-Facing Convertible	Forward-Facing Car Seat	Booster Seat	Seat Belt
Less than 20 lbs (n=237)	92%	4%	4%	<1%	0%
20 – 29 lbs (n=927)	13%	13%	70%	3%	1%
30 – 39 lbs (n=1,350)	1%	1%	76%	22%	1%
40 – 60 lbs (n=1,294)	0%	0%	22%	71%	7%
Greater than 60 lbs (n=145)	0%	0%	12%	52%	37%
Refused/unknown/missing (n=103)	3%	2%	52%	32%	11%

Table C-8: Height Category by Restraint Type					
	Rear-Facing Infant	Rear-Facing Convertible	Forward-Facing Car Seat	Booster Seat	Seat Belt
Less than 20 inches (n=25)	62%	22%	15%	0%	0%
20 – 29 inches (n=597)	50%	9%	38%	3%	1%
30 – 36 inches (n=1,358)	1%	6%	77%	14%	2%
37 – 49 inches (n=1,516)	<1%	<1%	38%	56%	5%
50 – 56 inches (n=169)	0%	0%	4%	74%	23%
Greater than 56 inches (n=12)	0%	0%	0%	66%	34%
Refused/unknown/missing (n=379)	3%	2%	61%	29%	5%

C2. Car Seat to Vehicle Installation

Table C-9 shows that 90 percent of forward-facing car seats were against the vehicle seat backs, while only 4 percent had interference with the vehicle seat back contours. Out of the rear-facing infant car seats and convertibles that had a recline in the car seat, 60 percent and 50 percent of the infant car seats and convertibles, respectively, used the car seat's angle adjustor to adjust the amount of recline in the car seats.

Table C-9: Car Seat to Vehicle Installation by Seat Type

	Rear-Facing Infant (n=299)	Rear-Facing Convertible (n=143)	Forward-Facing (n=1,992)
Car Seat Overhang Measurement			
5% and less of the car seat overhangs	<1%	n/a	1%
5.01 – 15% of car seat overhangs	4%	1%	3%
15.01 – 25% of car seat overhangs	5%	n/a	<1%
Greater than 25% of the car seat overhangs	1%	n/a	<1%
Unknown percentage of how much car seat hangs off the vehicle seat	5%	<1%	6%
Missing/car seat does not hang over vehicle seat	85%	99%	91%
Rear-Facing Car Seat Interference With Front Seat			
Back of car seat touching vehicle front seat	21%	30%	n/a
Back of car seat not touching vehicle front seat	54%	47%	
Missing/unknown whether back of car seat is touching vehicle front seat	25%	23%	
Rear-Facing Car Seat Angle Adjustment Method			
Is upright – not reclined	3%	9%	n/a
Recline is up to 30 degrees	16%	27%	
Recline is between 30 -45 degrees	49%	46%	
Recline is approximately 45 degrees	9%	10%	
Recline is more than 45 degrees	3%	1%	
Missing/unknown recline	20%	6%	
Forward-Facing Car Seat Against Seat Back			
Car seat against vehicle seat back	n/a	n/a	90%
Car seat not against seat back due to seat back contour			4%
Car seat not against seat back due to head restraint interference			1%
Car seat not against seat back due its direction is rear-facing			<1%

Car seat not against seat back due to other reasons	n/a	n/a	1%
Car seat not against seat back due to seat back contour and other reasons			<1%
Car seat not against seat back due to seat back contour and head restraint interference			1%
Car seat not against seat back due to head restraint interference and other reasons			<1%
Missing/unknown if car seat against vehicle seat back			3%

C3. Installation Methods of Car Seat to Vehicle

Table C-10 provides how the car seat lower anchor connectors were used when installing the car seat to the vehicle. The table includes all lower anchor connector installations of rear-facing and forward-facing car seats. Data show that most of the car seats installed with the car seat lower anchor connectors used the vehicle's lower anchors designated for the used seating position (89 percent and 90 percent for rear-facing and forward-facing car seats, respectively), and that 6 percent of both rear-facing and forward-facing car seats used a lower anchor designated for another seating position. Data showed that 2-3 percent of rear-facing and forward-facing car seats were installed using a lower anchor with multiple car seats or boosters attached to it.

Table C-10: Lower Anchor Connectors Installations by Seat Type

	Rear-Facing Car Seat (n=256)	Forward-Facing Car Seat (n=934)
Lower Anchor Connectors Attached		
Both connectors attached to anchor for seating position	89%	90%
Both connectors attached to other anchor for another seating position	6%	6%
One connector attached to anchor for seating position and one attached to other anchor for another seating position	n/a	<1%
Both connectors attached to something other than anchor	1%	1%
One of the connectors not attached to anything	n/a	1%
One of the connectors attached to something other than anchor	<1%	<1%
Unknown what connectors are attached to	4%	2%
Lower Anchor Connector Direction		
Lower anchor connectors are both top side up	70%	70%
Both are upside-down	8%	12%
Both are edge side up	9%	4%
Mixed direction for lower anchor connectors	2%	5%
Unknown direction of lower anchor connector	12%	10%
Number of Lower Anchor Connectors per Anchor		
Multiple car seats or booster attached to lower anchors	2%	3%
Only the inspected car seat is attached to the lower anchors	90%	91%
Unknown if multiple car seats/boosters attached to lower anchors	8%	6%

Table C-11 provides how the seat belt was used when installing the car seat to the vehicle. The table includes all seat belt installations of rear-facing and forward-facing car seats. Data showed

that a very small percentage of car seats installed with a seat belt used the locking clip (3-4%). Only 29 percent and 33 percent of seat belt installed rear-facing and forward-facing car seats, respectively, had a locked retractor (ALR Mode) while 54 percent and 55 percent had an unlocked retractor (ELR Mode). Only a small portion of car seats with lockoffs were inspected (165 car seats with lockoff available) and of those 64 percent were in use.

Table C-11: Seat Belt Installations by Seat Type		
	Rear-Facing Car Seat (n=209)	**Forward-Facing Car Seat (n=1,109)**
Seat Belt Buckled		
Is buckled	91%	91%
Is not buckled	4%	5%
Unknown if buckled	5%	5%
Locking Clip		
No locking clip present	91%	93%
Used on lap/shoulder, within 1 inch	2%	2%
Used on lap/shoulder, greater than 1 inch	1%	1%
Used only on lap	<1%	<1%
Used only on shoulder	n/a	<1%
Other use of locking clip	<1%	<1%
Unknown use of locking clip	5%	4%
Seat Belt Retractor		
Automatic locking retractor (ALR) mode	29%	33%
Emergency locking retractor (ELR) mode	54%	55%
No seat belt retractor	9%	5%
Unknown seat belt retractor	8%	8%
Lockoff Availability and Use		
No lockoff available	58%	81%
Lockoff in use	11%	7%
Lockoff not in use/unknown use	14%	2%
Unknown lockoff availability	18%	10%
Seat Belt Retractor and Car Seat Lockoff		
ALR mode and lockoff in use	2%	1%
ALR mode and lockoff not in use	2%	1%
ALR mode and unknown lockoff use	n/a	<1%
ELR mode and lockoff in use	7%	4%
ELR mode and lockoff not in use	10%	1%
ELR mode and unknown lockoff use	<1%	<1%

Unknown retractor and lockoff in use	2%	<1%
Unknown retractor and lockoff not in use	2%	n/a
No retractor and lockoff in use	<1%	n/a
No retractor and lockoff not in use	1%	<1%
No lockoff available	58%	67%
Unknown lockoff availability	18%	8%

C4. Installation by Lower Anchor Connectors-Only or Seat Belt-Only

Table C-12 examines the installation of forward-facing car seats by way of only lower anchor connectors or only the seat belt. Data indicates that 53 percent of car seats installed only by the lower anchor connectors and 25 percent of car seats installed by the seat belt showed no lateral movement. However, Table C-11 showed that seat belt installations have a high percentage of unlocked (ELR mode) retractors (54 or 55%). When looking at seat belt-only installation of forward-facing car seats with a locked (ALR mode) retractor, data shows that 43 percent of them show no lateral movement, while for seat belt-only installation with an unlocked (ELR mode) retractor, only 15 percent of them show no lateral movement.[20] Detailed data on seat belt installations of forward-facing car seats with locked and unlocked retractors can be found in Table C-9.

Table C-12: Forward-Facing Car Seat to Vehicle Installation Methods

	Lower Anchor Connectors-Only (n=262)	**Seat Belt-Only (n=765)**
Lateral Movement		
Does not move laterally	53%	25%
Moves 1 inch laterally	14%	15%
Moves 2 inches laterally	16%	24%
Moves 3 inches laterally	10%	24%
Missing/unknown for lateral movement	8%	13%
Routing		
Forward-facing slots	67%	63%
Rear-facing slots	32%	31%
Other unconventional routing	1%	3%
Unknown routing	<1%	3%
Belt/Strap Twisting		
Is twisted	30%	35%
Is not twisted	61%	58%
Unknown if twisted	8%	7%

[20] Unlocked (ELR mode) retractor seat belt installations are not expected to have any lateral movement; however, the inspection of installation tightness on car seats was performed, in many cases, with a child sitting on the car seat. The weight of the child could affect the amount of movement the inspector was able to obtain.

Table C-13 provides detailed data on the lateral movement of seat belt installations of forward-facing car seats with locked and unlocked retractors.

Table C-13: Seat Belt Installations of Forward-Facing Car Seat to Vehicle With Locked and Unlocked Retractors				
	Seat Belt-Only (n=765)	**Seat Belt-Only and ALR Mode (n=239)**	**Seat Belt-Only and ELR Mode (n=416)**	**Seat Belt-Only and Lockoff in Use (n=40)**
Lateral Movement				
Does not move laterally	25%	43%	15%	42%
Moves 1 inch laterally	15%	19%	13%	29%
Moves 2 inches laterally	24%	13%	31%	22%
Moves 3 inches laterally	24%	12%	28%	5%
Missing/unknown for lateral movement	13%	12%	13%	1%

Similar to Table C-12, Table C-14 examines the installation methods of rear-facing car seats by using only lower anchor connectors or by using only the seat belt. Data indicate that 59 percent of rear-facing car seats installed with lower anchor connectors and 24 percent of rear-facing car seats installed using only the seat belt showed no lateral movement. Of seat belt-only rear-facing car seat installations with the seat belt retractor in ALR mode, 46 percent showed no lateral movement. Detailed data on seat belt installations of rear-facing car seats with locked and unlocked retractors can be found in Table C-15.

The routing method information collected for rear-facing car seats provided paradoxical results. Data indicated that 42 percent of the car seats installed only with lower anchor connectors, and 19 percent of the car seats installed with only a seat belt, were routed through forward-facing slot/channels. Rear-facing infant car seats only have one available route for slots; therefore these results will be grouped with unconventional routing. Sixty-eight percent of car seats installed with only a seat belt and 60 percent of car seats installed only with lower anchor connectors were routed through rear-facing slot/channels.

Table C-14: Rear-Facing Car Seat to Vehicle Installation Methods With Locked and Unlocked Retractors		
	Lower Anchor Connectors-Only (n=211)	**Seat Belt-Only (n=171)**
Lateral Movement		
Does not move laterally	59%	24%
Moves 1 inch laterally	21%	24%
Moves 2 inches laterally	14%	23%
Moves 3 inches laterally	2%	20%
Missing/unknown for lateral movement	5%	9%
Routing		
Rear-facing convertible using forward-facing slots	8%	8%
Rear-facing slots	60%	68%
Other unconventional routing	30%	22%
Unknown routing	2%	2%
Belt/Strap Twisting		
Is twisted	16%	16%
Is not twisted	82%	76%
Unknown if twisted	2%	8%

Table C-15 provides the same data as table C-13 but specific to rear-facing car seats. Finally, Tables C-16 and C-17 breakout Table C-15 by rear-facing infant car seats and rear-facing convertible car seats.

Table C-15: Seat Belt Installations of Rear-Facing Car Seat to Vehicle With Locked and Unlocked Retractors				
	Seat Belt-Only (n=171)	**Seat Belt-Only and ALR Mode (n=58)**	**Seat Belt-Only and ELR Mode (n=77)**	**Seat Belt-Only and Lockoff in Use (n=26)**
Lateral Movement				
Does not move laterally	24%	46%	13%	62%
Moves 1 inch laterally	24%	29%	24%	29%
Moves 2 inches laterally	23%	16%	23%	0%
Moves 3 inches laterally	20%	7%	27%	9%
Missing/unknown for lateral movement	9%	3%	14%	<1%

Table C-16: Seat Belt Installations of Rear-Facing Infant Car Seat to Vehicle With Locked and Unlocked Retractors				
	Seat Belt-Only (n=129)	**Seat Belt-Only and ALR Mode (n=39)**	**Seat Belt-Only and ELR Mode (n=61)**	**Seat Belt-Only and Lockoff in Use (n=20)**
Lateral Movement				
Does not move laterally	23%	39%	14%	70%
Moves 1 inch laterally	25%	33%	25%	18%
Moves 2 inches laterally	19%	17%	19%	0%
Moves 3 inches laterally	21%	8%	26%	12%
Missing/unknown for lateral movement	11%	3%	16%	<1%

Table C-17: Seat Belt Installations of Rear-Facing Convertible to Vehicle With Locked and Unlocked Retractors				
	Seat Belt-Only (n=42)	**Seat Belt-Only and ALR Mode (n=19)**	**Seat Belt-Only and ELR Mode (n=16)**	**Seat Belt-Only and Lockoff in Use (n=6)**
Lateral Movement				
Does not move laterally	29%	79%	10%	35%
Moves 1 inch laterally	16%	10%	21%	65%
Moves 2 inches laterally	37%	11%	38%	0%
Moves 3 inches laterally	15%	0%	29%	0%
Missing/unknown for lateral movement	2%	0%	3%	0%

C5. Installation by Lower Anchor Connectors and Tether Strap or Seat Belt and Tether

Table C-18 examines the installation methods forward-facing car seats by lower anchor connectors and tether strap or by seat belt and tether strap. Data are not provided for rear-facing car seats, since they do not normally use the tether strap for installation. Two percent of rear-facing car seats were observed installed with the tether strap (2% installed using lower anchor and tether strap, and less than 1% installed using seat belt and tether strap).

Seventy-nine percent of lower anchor connectors and tether strap installed forward-facing car seats and 66 percent of seat belt and tether strap installed forward-facing car seats showed no slack. Tether routing above the seat without a head rest or above an integral head rest and under an adjustable head rest were the most common tether strap routings in lower anchor connectors (79%) and seat belt installations (70%). About 10 percent of tether straps were installed with a twisted strap. Most tether straps were attached to the vehicle tether anchor designated to the used

seating position. Detailed data on seat belt and tether installations of forward-facing car seats with locked and unlocked retractors can be found in Table C-19.

Table C-18: Forward-Facing Car Seat to Vehicle Installation Methods Using Tether Strap		
	Lower Anchor Connectors and Tether Strap (n=529)	**Seat Belt and Tether Strap (n=201)**
Lateral Movement		
Does not move laterally	62%	34%
Moves 1 inch laterally	15%	18%
Moves 2 inches laterally	9%	22%
Moves 3 inches laterally	8%	19%
Missing/unknown for lateral movement	7%	7%
Routing		
Forward-facing slots/channels	77%	70%
Rear-facing slots/channels	21%	25%
Other unconventional routing	1%	1%
Unknown routing	1%	4%
Belt/Strap Twisting		
Is twisted	13%	22%
Is not twisted	83%	72%
Unknown if twisted	4%	5%
Tether Strap Tightness		
No slack in tether	79%	66%
1 inch of slack	9%	18%
2 inches of slack	6%	10%
Greater than 2 inches of slack	2%	3%
Unknown amount of slack	3%	4%
Tether Strap Attachment		
Tether anchor for this seating position	93%	83%
Tether anchor for another seating position	2%	2%
Cannot tell what tether is attached to	2%	4%
Other method of attachment	1%	8%
Unknown method of attachment	3%	3%
Tether Strap Routing		
Over integral/no head restraint	37%	47%
Over raised adjustable head restraint	3%	4%
Over down adjustable head restraint	3%	2%
Under adjustable head restraint	42%	23%

Around headrest	7%	17%
Other method of routing	3%	1%
Unknown method of routing	5%	6%
Tether Strap Twisted		
Is twisted	9%	12%
Is not twisted	71%	68%
Missing/Unknown if twisted	20%	20%

Table C-19 provides detailed data on the lateral movement of seat belt and tether installations of forward-facing car seats with locked and unlocked retractors.

Table C-19: Forward--facing Car Seat to Vehicle With Locked and Unlocked Retractors

	Lower Anchor Connectors and Tether Strap (n=529)	Seat Belt and Tether Strap (n=201)	Seat Belt and Tether Strap and ALR Mode (n=79)	Seat Belt and Tether Strap and ELR Mode (n=96)	Seat Belt and Tether Strap and Lockoff in Use (n=19)
Lateral Movement					
Does not move laterally	62%	34%	57%	13%	83%
Moves 1 inch laterally	15%	18%	18%	13%	6%
Moves 2 inches laterally	9%	22%	6%	38%	7%
Moves 3 inches laterally	8%	19%	7%	31%	0%
Missing/unknown for lateral movement	7%	7%	12%	5%	5%

C6. Restraining of Child in Vehicle

Table C-20 provides the shoulder belt fit for children in highback and backless booster seats. This table provides a more in-depth look of the data provided in Table 4 on shoulder belt positions.

Table C-20: Shoulder Belt Position of Restrained Child in Booster Seat		
	Highback Booster (n=708)	**Backless Booster (n=672)**
Shoulder belt over body – centered on shoulder	63%	52%
Shoulder belt over body – touching shoulder	11%	11%
Shoulder belt over body – below shoulder/around arm	8%	1%
Shoulder belt over body – above shoulder at neck/face	6%	18%
Shoulder belt behind arm or back	4%	5%
Not applicable/no shoulder belt	1%	3%
Missing/Unknown shoulder belt position	8%	10%

Table C-21 provides additional data collected that was not provided in Table 4 with regard to how children were restrained into the vehicle using a booster sear or just a seat belt.

Table C-21: Restraining of Child in Booster or Vehicle Seat		
	Booster Seat (n=1,380)	**Seat Belt Only (n=242)**
Seat Belt Routed in Booster Seats		
Seat belt is routed	78%	n/a
Seat belt is not routed	16%	n/a
Missing/unknown for routing of seat belt	6%	n/a
Child's Head Supported		
Booster supports head	50%	n/a
Vehicle seat supports head	44%	90%
Child's head is above vehicle seat back	3%	<1%
Missing/unknown for child's head supported	3%	10%
Child Against Seat Back		
Child's back against booster	59%	n/a
Child's back against vehicle seat back	35%	76%
Child is leaning forward/slouching	2%	10%
Missing/unknown for Child's back against	4%	14%

Similarly, Table C-22 provides additional data collected that was not provided in Table 5, examining the restraining of a child in rear-facing and forward-facing car seats. Most harnesses used the same right and left harness slot height in both car seat types (91 percent of rear-facing

and 84 percent of forward-facing car seats). The harness slot height was at or up to 2 inches below the child's shoulder level in 73 percent of rear-facing car seats and it was at or 2 inches above the shoulder level in 56 percent of forward-facing car seats.

Table C-22: Restraining of Child in Car Seat		
	Rear-Facing (n=442)	**Forward-Facing (n=1,992)**
Harness Strap Buckling		
Harness strap is buckled	95%	90%
Harness strap is not buckled	1%	1%
Missing/unknown harness strap buckled	<1%	2%
Harness not used/Missing/unknown harness use	4%	6%
Harness Straps Position		
Harness straps both over shoulders/body	94%	82%
One or more harness straps behind arm/back/leg	1%	5%
Missing/unknown position of harness straps	2%	7%
Harness not used/Missing/unknown harness use	4%	6%
Harness Slot Use		
Sliding adjustment harness slots – no slots	21%	31%
Uppermost harness slots used	37%	38%
Middle harness slots used	21%	20%
Lowest harness slots used	14%	4%
Different levels of harness slots used	<1%	<1%
Missing/unknown harness slots used	7%	7%
Harness Slot Position in Relation to Shoulders		
Harness slots at both shoulders	44%	41%
Harness slots above both shoulders	16%	20%
Harness slots below both shoulders	31%	23%
Different harness slot position in relation to shoulders	2%	2%
Missing/unknown harness slot position in relation to shoulders	6%	14%
Harness Slot Position in Relation to Shoulders Measurement		
Unknown inches above shoulders	1%	3%
Less than and equal to 1 inch above shoulder	11%	11%
1.01 – 2.00 inches above shoulder	4%	4%
2.01 – 3 .00 inches above shoulder	<1%	2%
3.01 – 4.00 inches above shoulder	<1%	<1%
Greater than 4.00 inches above shoulder	<1%	<1%
Unknown inches below shoulders	1%	3%
Less than and equal to 1 inch below shoulder	23%	12%
1.01 – 2.00 inches below shoulder	6%	6%
2.01 – 3 .00 inches below shoulder	1%	2%
3.01 – 4.00 inches below shoulder	<1%	<1%
Greater than 4.00 inches below shoulder	n/a	1%

Different harness slot position measurements below shoulder	n/a	<1%
Harness slots at both shoulders	44%	41%
Different harness slot position in relation to shoulders	2%	2%
Missing/unknown harness slot position in relation to shoulders	6%	14%
Height Measurement for Rear-Facing		
Missing/unknown where's child's head in relation to top of car seat	5%	n/a
Child's head at the top of the car seat	4%	
Unknown inches above top of car seat	n/a	
1 inch above top of car seat	<1%	
Greater than 2 inches above top of car seat	n/a	
Unknown inches below top of car seat	2%	
1 inch below top of car seat	10%	
2 inches below top of car seat	19%	
3 inches below top of car seat	21%	
4 inches below top of car seat	17%	
5 inches below top of car seat	5%	
6 inches below top of car seat	7%	
Greater than 6 inches below top of car seat	10%	
Child Height Landmark for Forward-Facing		
Child's ears above the car seat shell	n/a	2%
Child's ear not above the car seat shell		78%
Missing/unknown whether child's ear above shell		19%

Appendix D: List of Defined Misuses

Table D-1: List of Defined Misuses
Car Seat to Vehicle Installation
Car seat's direction is incorrect
Moves 3 inches laterally
Other method of attachment of car seat to vehicle
Car seat not attached to vehicle
Car seat not against vehicle back
Child less than 1 years old and car seat is upright
Child less than 1 years old and car seat angle is up to 30 degrees
Recline of more than 45 degrees
Restraining a Child in Car Seat
Child seated in front row, with an active air bag
Car seat is cracked/broken shell
Car seat has broken/frayed harness
Car seat uses aftermarket product, belt tightener
Location of car seat not on vehicle seat
Harness not in use
Given harness in use, harness strap not buckled
Given harness in use, one or more harness straps behind arm/back/leg
Given harness in use, harness slack is greater than 2 inches
Given direction is rear-facing, both harness slot position above the child's shoulder by more than 2 inches
Given direction is forward-facing, both harness slot position below the child's shoulder by more than 2 inches
Child's head is above the top of car seat
Restraining a Child in Booster Seat
Child seated in front row, with an active air bag
Location of booster seat not on vehicle seat
Booster seat is cracked/broken shell
Booster seat has broken/frayed harness
Booster seat uses aftermarket product, belt tightener
Seat belt is not buckled
Child's head above vehicle seat back
Shoulder belt behind arm or back
Lap belt across abdomen/ribcage
Lap belt not used

Appendix E: Observed Misuse

This section provides further information on the car seats/booster seats that were clearly identified as misuse before the multiple simple random imputation method was applied.

Misuses are not mutually exclusive, and in some cases, more than one misuse was observed regarding a car seat or booster seat. Still, in cases with any misuse, more than 50 percent of each car seat type had only one observed misuse, and for booster seats, over 80 percent had only one observed misuse. Table E-1 provides the distributions of number of misuses per case that were clearly identified as misuse before the multiple simple random imputation method was applied.

Table E-1: Number of Misuses per Identified Cases With Observed Misuse (n=1,866)

Misuse	Rear-Facing Infant (n=151)	Rear-Facing Convertible (n=77)	Forward-Facing (n=1,379)	Highback Booster (n=111)	Backless Booster (n=148)
1	56%	55%	52%	84%	81%
2	27%	35%	28%	14%	18%
3	15%	5%	15%	2%	1%
4	2%	5%	4%	n/a	n/a
5	<1%	n/a	1%	n/a	n/a
6	n/a	n/a	<1%	n/a	n/a

Table E-2 takes the data provided by Table 7 and extends it to the percentage of exhibited misuse by driver's confidence on correct installation of car seat/booster seat. The table indicates that as the level of confidence rises, the misuse rate declines. Nevertheless, more than 50 percent of each response except the highest confidence, exhibited a misuse in the car seat/booster seat.

Table E-2: Observed Misuse by Drivers' Confidence on Correct Installation of Car Seat/Booster

Confidence Level	Misuse Percentage
Not confident (n=76)	62%
Slightly confident (n=85)	71%
Somewhat confident (n=463)	64%
Confident (n=1,053)	53%
Very confident (n=1,415)	38%
Missing/ Refused/ Unknown (n=291)	55%

Appendix F: Multiple Imputations

The simple random imputation was conducted for each collected data point, independently, that calculated misuse. Five independent imputation trials were run with each imputation given a random seed. Table F-1 provides the analysis of overall misuse for each of the five trials of imputations.

Table F-1: Overall Misuse Percentages of Car Seats and Booster Seats by Imputation Trials

	Imputation 1	Imputation 2	Imputation 3	Imputation 4	Imputation 5
	Misuse	Misuse	Misuse	Misuse	Misuse
Total	**46%**	**45%**	**46%**	**46%**	**46%**
Rear-facing infant car seat	49%	47%	56%	47%	47%
Rear-facing convertible	42%	47%	47%	43%	42%
Forward-facing car seat	62%	60%	61%	63%	62%
Highback booster	16%	16%	16%	17%	16%
Backless booster	24%	25%	23%	23%	24%

Each imputation provides a set of point and variance estimates for overall misuse. Let $\hat{Q}_i$ and $\hat{U}_i$ be the point and variance estimates from the *i*th imputed data set, *i*=1, 2, …, *m*. Table F-2 provides the point and variance estimates from the five imputed data sets. [21]

Table F-2: Point and Variance Estimates of Overall Misuse by Imputation Trials

Overall Misuse	Imputation 1	Imputation 2	Imputation 3	Imputation 4	Imputation 5
Point Estimate, $\hat{Q}_i$	46.1641	44.8426	46.0555	45.9964	45.7412
Variance Estimate, $\hat{U}_i$	10.0210	11.3522	13.6937	8.9868	9.7944

Then the point estimate for overall misuse, Q, from multiple imputations is the average of the *m* complete-data estimates:

$$\bar{Q} = \frac{1}{m}\sum_{i=1}^{m}\hat{Q}_i = 45.7600$$

Let $\bar{U}$ be the within-imputation variance, which is the average of the *m* complete-data estimates:

[21] Rubin, D. B. (1987). *Multiple imputation for nonresponse in surveys*. New York: J. Wiley & Sons.

$$\bar{U} = \frac{1}{m}\sum_{i=1}^{m} \hat{U}_i \ = 10.7696$$

And B be the between-imputation variance:

$$B = \frac{1}{m-1}\sum_{i}^{m}\left(\hat{Q}_i - \bar{Q}\right)^2 = 0.2871$$

Then the variance estimate associated with $\bar{Q}$is the total variance:

$$T = \bar{U} + \left(1 + \frac{1}{m}\right)B = 11.1142$$

The degrees of freedom are given by:

$$v = (m-1)\left[1 + \frac{\bar{U}}{(1+m^{-1})B}\right]^2 = 4162$$

Thus a 95 percent interval estimate for overall misuse is:

$$\bar{Q} \pm t_{v,1-\alpha/2}\sqrt{T} = (39.2257, 52.2942)$$

The following diagnostic measures indicate how strongly the estimated overall misuse is influenced by missing data. The relative increase in variance due to nonresponse is:

$$r = \frac{(1+m^{-1})B}{\bar{U}} = 0.0320$$

The estimated rate of missing information is:

$$\hat{\lambda} = \frac{r + 2/(v+3)}{r+1} = 0.0315$$

DOT HS 812 142
May 2015

U.S. Department
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11476-050615-v2