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Child Restraint System Data Collection in NHTSA's Crash Investigation Programs

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Abstract

This document describes the evolution of data collection of child restraints systems (CRS) in NHTSA's primary crash investigation programs since 1975. A discussion on observational and representative special studies involving child restraints is also discussed as are the collaborative efforts of NHTSA with our partners in law enforcement, child safety advocacy groups, the medical community, research organizations and other stakeholders to improve the overall recording of CRS information and to improve data uniformity.

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Definitions

ANSI – American National Standards Institute

CDS – Crashworthiness Data System

CHOP – Children's Hospital of Philadelphia

CRS – Child Restraint System (i.e., child safety seat or booster seat)

CIREN – Crash Injury Research & Engineering Network

CISS – Crash Investigation Sampling System – a replacement of CDS

CPST – Child Passenger Safety Technician

FARS – Fatality Analysis Reporting System

FHWA – Federal Highway Authority

FMCSA – Federal Motor Carrier Safety Administration

GES – General Estimates System

GHSA – Governors Highway Safety Administration

LATCH – Lower Anchors and Tethers for Children

MMUCC – Model Minimum Uniform Crash Criteria

NASS – National Automotive Sampling System

NCRUSS – National Child Restraint Usage Special Study

NOPUS – National Occupant Protection Use Survey

SCI – Special Crash Investigations

TABLE OF CONTENTS

1. Introduction

NHTSA understands the importance of collecting child restraint system (CRS) data since motor vehicle crashes are the leading cause of death to children 14 years old and younger. Of the 35,092 motor vehicle traffic fatalities in 2015 in the United States, 1,132 (3.3%) were children (National Center for Statistics and Analysis, 2018). In addition to 1,132 fatalities, it is estimated that more than 178,000 children are injured in motor vehicle traffic crashes annually. Although the number of fatalities and injuries has decreased markedly since 1996, down 37 percent and 14 percent, respectively, NHTSA is very interested in accurately quantifying and understanding the prevalence of CRS use by the driving public and in motor vehicle crashes.

NHTSA, through the National Center for Statistics and Analysis, collects CRS data in its crash investigation-based data systems and has done so since the inception of the National Automotive Sampling System program in 1979. The presence of an occupied CRS in a vehicle in a crash, the type and usage of an internal harness, and the CRS orientation have been collected since 1988. In addition to the NASS program and its successor – the Crash Investigation Sampling System – the Special Crash Investigations and the Crash Injury Research Network programs also collect CRS data. This data is supplemented by the Fatality Analysis Reporting System. FARS is a nationwide census providing NHTSA, Congress and the American public yearly data regarding fatal injuries suffered in motor vehicle traffic Crashes (NCSA, 2014). As the use of CRSs proliferated over the last three decades, the volume of data collected in these programs has increased concurrently. Each method has its own limitations and NHTSA is continually working to reduce limitations where possible.

NHTSA has also conducted special studies on CRS usage habits by the general public. The Child Restraint Use Survey/Lower Anchors and Tethers for Children Use and Misuse was an observational study conducted in 2005, the National Child Restraint Usage Special Study was a statistically representative sample conducted in 2011 and the National Occupant Protection Use Survey is a probability-based survey on seat belt and CRS use and is conducted annually. All of these studies involve on-site monitoring of CRS use in real-world environments and the details of these efforts are discussed later in this report.

NHTSA consults regularly with other stakeholders – law enforcement, child safety advocates, the medical community, research organizations and many other organizations – on CRS-related issues to improve the overall recordation of CRS information and to improve data uniformity. NHTSA has worked closely with medical and industry partners such as the Children's Hospital of Philadelphia to create unique studies that examine particular questions of interest on CRS usage practices throughout the country. NHTSA also takes an active role in the Model Minimum Uniformity Crash Criteria program along with local, State and national stakeholders and provides the curriculum to train the more than 40,000 actively certified child passenger safety technicians currently advising parents across the country on proper CRS installations in vehicles.

2. Data Collection Programs

NHTSA has operated multiple investigation-based data collection programs with detailed scene, vehicle, occupant injury and CRS information: the NASS, NASS-Crashworthiness Data System, CISS, SCI, and CIREN. This data has been supplemented by information on fatalities collected nationwide in FARS. Data from each of the programs has been critical in NHTSA's evaluation of vehicle crashworthiness countermeasures such as air bags, seat belts, child restraints and identifying problem areas where improvements can be made. The focus of these data collection programs has differed somewhat, but they were intended to complement one another.

NASS (1979-1987) was NHTSA's initial nationally representative crash data collection system and served as the forerunner to NASS-CDS. NHTSA reevaluated its data collection programs in 1988 and elected to divide NASS into two components: NASS-CDS and NASS-General Estimates System, the latter of which being a police-report based nationally representative sample designed to collect basic statistical information to monitor traffic safety trends.

NASS-CDS (1988-2015) was a nationally representative sample of light vehicles towed from crashes with an emphasis on the crashworthiness of the vehicle. NASS conducted detailed investigations of the crash scene, vehicle damage and injury backed up by in-depth interviews with crash victims. The case selection algorithm was designed to give fatal and severe injury crashes a higher probability of selection. Data was collected at 24 sites across the country with an average of 4,500 cases per year between 1988 and 2015. Since 1988 the NASS-CDS program has investigated 5,483 cases that had an occupied CRS and 6,747 child restraints overall. Note

that many of the CRSs were removed from the vehicle prior to the inspection; therefore, many of the CRS variables could not be determined. For a more detailed analysis the CRS data collected since 2004, the NASS-CDS case viewers are available at https://crashviewer.nhtsa.dot.gov/ and the statistical data sets are located at ftp://ftp.nhtsa.dot.gov/NASS/.

CISS (2015-present) succeeded NASS-CDS, which ceased operating after 2015 in response to a Congressially issued directive to NHTSA to modernize its nationally representative crash databases and examine the data collected in those programs. NHTSA initiated the Data Modernization Project to affirm its position as the leader in motor vehicle crash data collection and analysis, by collecting quality data to keep pace with emerging technology and evolving policy needs. To ensure the needs of the highway safety community were met, NHTSA sought input from users of the data including government, academia and industry. NHTSA's new nationally representative CISS collects scene and vehicle measurements using modern concepts, techniques and equipment.

SCI (1972-present) is a collection of approximately 125 to 150 targeted investigations each year that are used by NHTSA and the automotive safety community to understand the real-world performance of existing and emerging advanced safety systems as well as other unique safety problems occurring on the Nation's roadways. SCI cases are intended to be an anecdotal data set useful for examining special crash circumstances or outcomes from an engineering perspective. Cases of interest are derived from an extensive and diverse network of sources, including NHTSA's Vehicle Safety Hotline, the Department of Transportation's National Response Center, NHTSA's Regional Offices, the Office of Defects Investigation, automotive manufacturers, other government agencies, law enforcement agencies, insurance companies, vehicle owners, engineers and medical personnel. One focus of SCI pertains to the collection of child restraint data if the crash contains one or more of the following conditions:

- Rollover crash with an occupied CRS
- Newer vehicle with CRS present in crash
- Occupied CRS with a near-side inflatable curtain air bag deployment
- Occupied CRS in a near-side impact

- High velocity crash with minor or no injuries to child
- Low velocity crash with serious or fatal injuries to child

SCI has investigated 344 CRS-related crashes since 1990. The SCI case data and technical reports can be accessed at www.nhtsa.gov/SCI.

CIREN (1997-present) is a hospital-based study operating at six medical centers across the country collecting approximately 300 serious injury cases per year. The CIREN process combines comprehensive data elements with professional multidisciplinary analysis of medical and engineering evidence to determine injury causation in every crash investigation conducted. CIREN does not specifically seek cases with child occupants, but if selected cases have a child present in a CRS, the data is documented within the CISS parameters. CIREN case viewers and statistical data sets are accessible at www.nhtsa.gov/research-data/crash-injury-research.

FARS (1975-present) FARS contains data derived from a census of fatal traffic crashes within the 50 States, the District of Columbia and Puerto Rico. To be included in FARS, a crash must involve a motor vehicle traveling on a trafficway customarily open to the public and must result in the death of at least one person (occupant of a vehicle or a non-motorist) within 30 days of the crash. NHTSA has a cooperative agreement with an agency in each State government to provide specific information in a standard format on fatal crashes occurring in the State.

FARS was conceived, designed and developed by the NCSA in 1975 to provide an overall measure of highway safety, to help identify traffic safety problems, to suggest solutions and to help provide an objective basis to evaluate the effectiveness of motor vehicle safety standards and highway safety programs. FARS data can be accessed through www.nhtsa.gov/research-data/fatality-analysis-reporting-system-fars

3. Past NHTSA Child Restraint Data Collection

NHTSA's investigation-based data collection programs have collected CRS data since the inception of NASS-CDS, but the number of variables has increased over time in response to needs within the agency and by third parties. There are three transition years in terms of additions to CRS data collected or significant changes to note 1985, 1988 and 2002.

NASS collected a single variable in 1979, which was whether a CRS was present and used in vehicle crashes. This variable merely noted the presence of an occupied CRS in a crash. This single variable was collected until 1985 when additional variables were introduced that included the make and model of the CRS, the type (infant, convertible, booster seat) the orientation (forward-facing, rear-facing), and whether a harness, shield or tether was used to secure the child into the CRS. The design of the CRS related to how it was used was added in 1988. This provided further detail on whether the parent or caregiver used the CRS as it was designed or if it was used unconventionally.

Prior to 1999 it was viewed both at NHTSA and from partners that the existing variables collected in NASS-CDS lacked the detail/specificity necessary to meaningfully assist the agency and others in identifying the proper use, installation and performance of CRSs in crashes. The lack of critical CRS data hindered the efforts of the agency and its partners to analyze properly child-involved crash outcomes, particularly child-related injuries and child restraint performance in real-world crashes.

NCSA therefore collaborated with other offices in NHTSA in 1999 and 2000 to analyze data user needs and determine the appropriate range of variables to address the needs of all parties. Through this collaboration, the NASS data collection procedures related to CRS variables collected were enhanced. The variables date of manufacture, model number, placement, child position, and locking clip use were added to further augment CRS documentation. The variables related to harness and shield usage were more clearly defined to account for different design configurations offered by manufacturers (e.g., 5-point harness, 3-point harness, t-shield, tray shield) and the presence of a retainer clip was added. Additional variables about the presence and use of LATCH attachments were included in support of Federal Motor Vehicle Safety Standards 213 and 225. FMVSS 213 and 225 required that attachments be installed into vehicles and on CRSs by no later than September 2002 (49 C.F.R. 571.213, Child restraint Systems, 1999; 49 C.F.R. 571.225, Child Restraint Anchorage Systems, 1999). The variable belt routing was added to better understand how parents and caregivers routed the belt system through the slots/channels of the CRS to secure it to their vehicle's seat when using only the lap and shoulder belt system. Additional variables introduced in 2002 included how used, to determine if the CRS was used according to the manufacturer's instructions, as well as four vehicle-level variables that defined

the vehicle's belt retractor type, latch plate type and whether lower anchors and a tether were available in the vehicle in compliance of FMVSS 213 and 225.

Other aspects of the coded case variables such as occupant age, height and weight—to compare to CRS usage recommendations—and how the seat belt system was used in conjunction with the CRS augmented the CRS variables collected. Most NASS-CDS variables were collected during the inspection of the vehicle and CRS; however, demographic and specific CRS and belt usage variables were collected during in-depth interviews conducted with crash victims.

The detailed evolution of CRS variables can be found in **Table 1** below and are further explained in the NASS Coding and Editing and Analytical Manuals for the NASS-CDS program from 1977 to 2015 that are available at https://CRSashstats.nhtsa.dot.gov/#/DocumentTypeList/23.

Table 1 – Information on Child Restraints Systems Collected in NHTSA's Data Systems

1979	1985	1988	2002
Child restraint used in vehicle	Child restraint used in vehicle	Child restraint used in vehicle	Child restraint used in vehicle
	Make/model	Make/model	Make/model
	Type	Type	Type
	Orientation	Orientation	Orientation
	Harness/shield/tether available	Harness/shield/tether available	Harness/shield/tether available (added detail on type of harness/shield/tether
		Design feature available (Harness/shield/tether)	Design feature available (Harness/shield/tether)
		How feature used (Harness/shield/tether)	How feature used (Harness/shield/tether)
			Date of manufacture
			Model number
			Placement
			Child position
			Locking clip presence/use
			Retainer clip presence/use
			Upper LATCH tether on CRS presence/use
			Lower LATCH anchors on CRS presence/use
			Belt routing
			How CRS used
			Belt retractor type
			Latch plate type
			Upper tether in vehicle presence/use
			Lower anchors in vehicle presence/use

4. Current NHTSA Child Restraint Data Collection

The CISS added the variable manufacturer in 2017 to account for the recent consolidation of many of CRS manufacturers that were formerly single entities. CISS also refined the definition of belt locking from only a locking clip to account for internal belt locking technology that is found in many newer child restraints on the market. CISS currently collects the following CRS variables:

Child Seat Variables

- Seat Location
- Placement
- Child Position
- Manufacturer
- Make
- Model
- Model Number
- Date of Manufacture
- Type
- How Used (forward-facing, rear-facing, booster, infant seat)
- Source of Data
- Design Feature Available
    - Harness/Shield
    - Retainer Clip
    - Upper Tether
    - Lower Anchors
- How Feature Used
    - Harness/Shield
    - Retainer Clip
    - Upper Tether
    - Lower Anchors
- Belt Routing Use
- Locking Clip/Internal Locking Use

Related Vehicle Variables

- Belt Retractor Type
- Latch Plate Type
- Lower Anchors Available
- Upper Tether Available

Documentation of the CRS in a typical CISS case involves a thorough in-person inspection of the damaged vehicle and child restraint. Like NASS-CDS, this information is augmented by an in-person or phone interview with the driver or another adult occupant of the vehicle to learn the specifics on how the child was positioned in the CRS, the precise CRS components that were used, and the height, weight and age of the child.

5. NHTSA Special Studies

NHTSA has launched multiple special studies in the past to better understand how CRSs are being used in real-world scenarios. The Child Restraint Use Survey—LATCH Use and Misuse was conducted in 2005 in 31 counties across the seven States of Arizona, Florida, Michigan, Missouri, North Carolina, Pennsylvania and Washington. This was an observational study conducted at shopping centers, child care facilities and other locations examining LATCH use for children in CRSs.

NCRSUSS was a statistically representative study conducted using the 24 existing randomly selected NASS-CDS data collection sites. This study examined how child restraints and booster seats were used in vehicles, drivers' attitudes and beliefs about child and booster seats, their confidence with installing them, and lower anchor connectors and tether strap installations.

NOPUS is the only nationwide probability-based survey of seat belt use (for occupants 8 and older in both front and rear seats), motorcycle helmet use, CRS (for children under 8 years old) and driver electronic device use in the United States.

A brief synopsis of each of these studies is outlined below:

5.1 Child Restraint Use Survey – LATCH Use and Misuse

NHTSA conducted this survey from April to October 2005 to collect information about the types of restraint systems that were being used to keep children safe while riding in passenger vehicles. In particular, NHTSA was interested in whether drivers with LATCH-equipped vehicles were using this system to secure their CRSs to the vehicle, and if so, were these seats properly installed. The make, model and type of CRS installed in each seating position was recorded for each of the vehicles and demographic characteristics and the type of restraint system were collected for each occupant. In addition, information was gathered about the drivers' knowledge of booster seats and LATCH, along with their opinions on how easy it was to use LATCH (Decina, Lococo & Doyle, 2013).

A key finding of the survey was that 55 percent of child restraints, located in a seating position equipped with upper anchors, were attached to vehicles using an upper tethers. Other findings include the following:

(1) In 13 percent of the observations, the child restraint was placed in seat positions in the vehicle not equipped with lower anchors - the seat belt was used to secure the child restraint to the vehicle.

(2) Among the 87 percent who do place the child restraint at a position equipped with lower anchors, 60 percent used the lower anchor attachments to secure the child restraint to the vehicle.

(3) Eighty-one percent of upper tether users and 74 percent of lower anchor attachment users said upper tether and/or lower attachments were easy to use.

(4) Seventy-five percent preferred lower anchor attachments over seat belts of those with experience using both lower anchor attachments and seat belts.

(5) Sixty-one percent of upper tether nonusers and 55 percent of lower anchor attachment nonusers cited their lack of knowledge – not knowing what they were, that they were available in the vehicle, the importance of using them, or how to properly use them – as the reason for not using them.

A detailed report discussing the goals, objectives, methodology and key findings of this study can be found at https://CRSashstats.nhtsa.dot.gov/Api/Public/ViewPublication/810679.

5.2 National Child Restraint Usage Special Study

NHTSA conducted the NCRUSS in 2011 by documenting the use of CRSs 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 CRSs and booster seats as well as their confidence in installing them. The NCRUSS was a nationally representative survey. Results showed that 94 percent of children were restrained in child restraints, 4 percent were restrained in seat belts and 2 percent were unrestrained. By child restraint or booster seat type, 50 percent of children were restrained in forward-facing child restraints, 31-percent were restrained in booster seats, 9 percent were restrained in rear-facing infant child restraints and 4 percent were restrained in rear-facing convertible child restraints (Greenwell, 2015).

The NCRUSS also provided data on LATCH installations. Results showed that rear-facing child restraints (both infant and convertible child restraints) 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 child restraints equipped with lower anchor connectors and tether straps 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%).

A detailed report discussing the goals, objectives, methodology and key findings of this study can be found at https://CRSashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812142.

5.3 National Occupant Protection Use Survey

The 2016 NOPUS data collection, which was the latest published NOPUS survey prior to this report, was conducted from 7 a.m. to 6 p.m. during June 6 to June 25, 2016. Its data was based on the results of 66,993 occupants observed in 48,177 vehicles at 1,600 data collection sites. Of these observed occupants, 2,849 were children under 8. The NOPUS methodology includes two sub-surveys: the Moving Traffic (MT) Survey and the Controlled Intersection (CI) study.

In the MT survey, front-seat occupant shoulder belt use data and motorcyclist helmet use data are collected either at the roadside or, in the case of expressways, by data collectors in vehicles.

NOPUS derives its major estimates of front-seat belt use and motorcycle helmet use from the MT survey.

In contrast, the CI study data is collected at intersections controlled by stop signs or stoplights, where vehicle occupants are observed from the roadside. Only stopped vehicles are observed due to time constraints restricting the amount of time available to collect the variety of information required by the survey. NOPUS derives its estimates of rear-seat belt use, CRS use, driver electronic device use, and demographic characteristics of the vehicle occupants from the CI study (Li & Pickrell, 2018).

Only motorcycles and passenger vehicles (passenger cars, pickup trucks, SUVs and vans) are observed in the NOPUS. The population of interest includes all 50 States and the District of Columbia, with the sample observation sites consisting of Federal, State, and county highways, residential streets, and rural roads. Data is collected only during daylight hours when light is adequate to observe seat belt use through vehicle windows.

More details on the NOPUS sampling, data collection and estimation can be found at https://CRSashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812463.

6. Outreach With Partners

6.1 Partners for Child Passenger Safety and National Child Occupant Special Study

Over the years, NHTSA has worked cooperatively with the Children's Hospital of Philadelphia in the collection and sharing of child occupant data. In 1997, the Children's Hospital of Philadelphia, the University of Pennsylvania, and State Farm Insurance Companies joined forces to create Partners for Child Passenger Safety, a unique industry/academic research partnership with the goal of providing the Nation's only large-scale child-focused crash surveillance data system.

Beginning in 2007, CHOP worked with NHTSA to develop a system for collecting supplemental child-specific data as part of the NASS-GES and NASS-CDS. This system is known as the National Child Occupant Special Study. The overall objective of such a system is to monitor

trends in CPS, assess the performance of new safety technologies for children and serve as a national resource to assist researchers, industry and policymakers in setting the agenda for CPS in the United States.

A feasibility study was performed in 2007 and 2008 to determine the usefulness, functionality, and feasibility of the concept of a national child occupant surveillance system that relies on Federal data sources for cases. The *Future of Child Passenger Safety Surveillance*, a feasibility and justification report, was published in May 2008 (Children's Hospital of Philadelphia Research Institute, 2008). Please note that the specifications proposed in this report have been refined over the course of subsequent pilot research.

The NCOSS research group at CHOP has conducted pilot studies in collaboration with NHTSA to determine the specific methods for collecting supplemental child-occupant-specific crash data as part of the NASS surveillance system. The results showed that creating procedures to identify cases for supplemental child-specific data collection based on the NASS-GES system was feasible (Children's Hospital of Philadelphia Research Institute, n.d.).

Another pilot study was conducted in 2012 and funded by the Toyota Collaborative Safety Research Center. It tested enhanced methods of encouraging eligible subjects to participate in NCOSS. In this pilot, 495 families were identified from the NASS-GES system and contacted to complete a survey via telephone or self-administered hardcopy based on the availability of contact information on the police accident report.

6.2 Model Minimum Uniform Crash Criteria

NHTSA has a long history of working with law enforcement and other organizations to promote better CRS data collection and improve the recording of data in police and other incident reports. Since 1996 NHTSA, the Federal Highway Administration and the Federal Motor Carrier Safety Administration collaborated with the Governors Highway Safety Association to develop a voluntary data collection guideline to encourage greater coding uniformity in police reports. The collectively created MMUCC guideline identifies a minimum set of motor vehicle crash data elements and their attributes that States should consider collecting and including in their State crash data system. The foundation of the original MMUCC guideline was based on the American

National Standards Institute D.16.1 and D.20.1 and the FARS- and FMCSA-mandated data elements. The initial guideline was released in 1998 and has been subsequently updated every 5 years, the latest of which (5th edition) was released in 2017 and can be found at www.ghsa.org/sites/default/files/publications/files/MMUCC_5thEd_web.pdf.

Each edition consists of 107 to 115 elements collected uniformly by police jurisdictions across the Nation. The MMUCC collected and derived data elements pertaining to CRS include the first responder's interpretation of injury level to the child on a scale from no injury suspected to fatal injuries, seating position, air bag deployment, CRS type (forward facing, rear facing, booster seat), anatomical injury area and medical facility assigned injury severity (fatal, serious, moderate, minor, none).

6.3 Child Passenger Safety Technician

NHTSA has taken a collaborative approach with safety organizations to improve the ability of parents and caregivers in the proper use of child restraints and of the documentation of how the child restraints are being used in the real world. NHTSA established the National Passenger Safety Board in the mid-1990s to examine the state of child passenger safety nationwide. The Board is comprised of representatives of NHTSA and from national and local advocacy organizations, vehicle and CRS manufacturers and injury prevention specialists. The board recommended a national standard curriculum for the training and certification of child passenger safety technicians that has been developed and maintained by NHTSA. The curriculum is currently being updated and is due to be released in early 2019 and can be found at http://cpsboard.org/cps/wp-content/uploads/2014/01/Technician-Guide_March2014compressed.pdf.

The certifying body that administers training to technicians is a leading child passenger safety advocacy group, Safe Kids Worldwide. More than 159,000 trainees have successfully completed this program since its inception and more than 40,000 CPSTs remain certified. These technicians provide education, support and guidance in all 50 States, the District of Columbia and U.S. territories (Safe Kids Worldwide, 2017). The technicians come from a broad spectrum of the population and include police and emergency personnel, health and safety technicians, parents

and volunteers. NHTSA will continue to upgrade the standard curriculum as technology evolves and standards of CRS usage change.

7. Conclusion

NHTSA's crash investigation-based programs face challenges in obtaining a robust CRS dataset that will require attention going forward. For example, NHTSA and child seat manufacturers recommend replacing a CRS if it was involved in a moderate or severe crash. Many hospitals and other parties follow this guidance and automatically discard the CRS after a crash, restricting the ability of crash technicians to locate and inspect the CRS. This has led to an increase of unknown data elements in our databases. Going forward, NHTSA will seek to solve this problem in cooperation with its partners.

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