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

NHTSA
www.nhtsa.gov

DOT HS 811 325

May 2010

Children Injured in Motor Vehicle Traffic Crashes

DISCLAIMER

This publication is distributed by the U.S. Department of Transportation, National Highway Traffic Safety Administration, in the interest of information exchange. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Department of Transportation or the National Highway Traffic Safety Administration. The United States Government assumes no liability for its contents or use thereof. If trade names, manufacturers' names, or specific products are mentioned, it is because they are considered essential to the object of the publication and should not be construed as an endorsement. The United States Government does not endorse products or manufacturers.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 811 325		

4. Title and Subtitle	5. Report Date
Children Injured in Motor Vehicle Traffic Crashes	May 2010
	6. Performing Organization Code: NVS-421
7. Author: **Refaat Hanna**	8. Performing Organization Report No.
9. Performing Organization Name and Address: Office of Traffic Records and Analysis	10. Work Unit No.
	11. Contract of Grant No.
12. Sponsoring Agency Name and Address: Office of Traffic Records and Analysis, National Center for Statistics and Analysis, National Highway Traffic Safety Administration, U.S. Department of Transportation, 1200 New Jersey Avenue SE., Washington, DC 20590	13. Type of Report and Period Covered: NHTSA Technical Report, January 1999- December 2008
	14. Sponsoring Agency Code

15.Supplementary Notes

16. Abstract

Objectives: This study analyzes the incidence rates of incapacitating injuries as well as the commonly injured body regions among children under 8 years old involved in motor vehicle traffic crashes.

Method and Data Source: This study provides a statistical analysis of two different databases: the National Automotive Sampling System (NASS) General Estimates System (GES) for 1999 to 2008 and the National Trauma Data Bank- National Sample Project (NTDB-NSP) for 2003 to 2007.

Results: This analysis indicates that use of child safety seats is effective in reducing the incidence rates of incapacitating injuries for the three age groups and in any crash type. The analysis indicates that children involved in rollover crashes had the highest incidence rates of incapacitating injuries. In rollover crashes, the estimated incidence rate of incapacitating injuries among unrestrained children was almost three times that for restrained children. In near-side impacts, unrestrained children were eight times more likely to sustain incapacitating injuries than children restrained in child safety seats.

Head injuries were the most common injuries sustained by children in motor vehicle crashes. Children under 1 year old had higher incidence rates of head injuries than the other two age groups. Similar to head injuries, children under 1 had higher incidence rates of thoracic injuries than the other two age groups.

Cerebrum injuries (contusions or lacerations) were the most common type of head injuries among all children included in the analysis. Concussion and unconsciousness were more common among children under 1 year old than the other two age groups. Skull base fractures were more common among children 1 to 3 and 4 to 7 years old than children under 1.

Children under 1 were more likely to sustain rib fractures than the other two age groups. On the other hand, lung injuries (contusions or lacerations) were more common among older children than children under 1 year old.

17. Key Words: AIS, Children, Child Safety Seat, Head Injury, Incapacitating Injuries, Initial Point of Impact, Rollover	18. Distribution Statement: 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	27	

Form DOT F1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Objectives: This study analyzes the incidence rates of incapacitating injuries as well as the commonly injured body regions among children under 8 years old involved in motor vehicle traffic crashes.

Method and Data Source: This study provides a statistical analysis of two different databases, the National Automotive Sampling System (NASS) General Estimates System (GES) for 1999 to 2008 and the National Trauma Data Bank-National Sample Project (NTDB-NSP) for 2003 to 2007.

Results: This analysis indicates that use of child safety seats is effective in reducing the incidence rates of incapacitating injuries for the three age groups and in any crash type. The analysis indicates that children involved in rollover crashes had the highest incidence rates of incapacitating injuries. In rollover crashes, the estimated incidence rate of incapacitating injuries among unrestrained children was almost three times that for restrained children. In near-side impacts, unrestrained children were eight times more likely to sustain incapacitating injuries than children restrained in child safety seats.

Head injuries were the most common injuries sustained by children in motor vehicle crashes. Children under 1 year old had higher incidence rates of head injuries than the other two age groups. Similar to head injuries, children under 1 had higher incidence rates of thoracic injuries than the other two age groups.

Cerebrum injuries (contusions or lacerations) were the most common type of head injuries among all children included in the analysis. Concussion and unconsciousness were more common among children under 1 than the other two age groups. Skull base fractures were more common among children 1 to 3 and 4 to 7 years old than children under 1 year old.

Children under 1 year old were more likely to sustain rib fractures than the other two age groups. On the other hand, lung injuries (contusions or lacerations) were more common among older children than children under 1 year old.

1. OBJECTIVE

Objectives: Analyze the incidence rates of incapacitating injuries as well as the commonly injured body regions among children less than 8 years old involved in motor vehicle traffic crashes.

2. INTRODUCTION

Injuries suffered in a motor vehicle traffic crashes are the leading cause of death among children in the United States.[5] Studies have shown that children who are correctly using the appropriate restraint for their sizes and ages are at a significantly lower risk of sustaining serious or fatal injuries.

The injury outcome in children can be worse than similar injuries sustained by adults. For example, children who suffer traumatic brain injuries can experience lasting or late-appearing neuropsychological problems, highlighting the need for careful monitoring of children as they grow older.[4] For this reason, head injuries are of particular concern when studying children injured in motor vehicle traffic crashes.

In children, some neurological deficits after head trauma may not manifest for many years.[2] Frontal lobe functions, for example, develop relatively late in a child's growth, so that injury to the frontal lobes may not become apparent until the child reaches adolescence when higher level reasoning develops. Since the frontal lobes control social interactions and interpersonal skills, early childhood brain damage may not manifest until such frontal lobe skills are called into play later in development. Likewise, injury to reading and writing centers in the brain may not become apparent until the child reaches school age and shows signs of delayed reading and writing skills.

3. DATA AND METHODOLOGY

This study provides a statistical analysis of two different databases:

1- The National Automotive Sampling System (NASS) General Estimates System (GES) for 1999 to 2008. NASS-GES is a complex probability sample of police-reported traffic crashes that occurred in a given year.[6] The NASS-GES data can be weighted to produce national estimates. The weights result from the probabilities associated with each stage of selection, reflecting that crash's probability of selection. NASS-GES reports injuries with different severity levels. The injuries are reported based on the police reports as: no injury (O), possible injury (C), non-incapacitating injury (B), incapacitating injury (A), fatal injury (K), injured - severity unknown, died prior to crash, or unknown if injured. NASS-GES is used to identify incidence rates of incapacitating injuries in different crash scenarios and estimate effectiveness of child safety seat use. Potential misuse scenarios of the child safety seat were not identified in this analysis, which could skew some of the data findings toward higher injuries than if the child safety seats or seat belts had been properly used.

2- The American College of Surgeons (ACS) was awarded a contract from the National Center for Injury Prevention and Control (NCIPC), Centers for Disease Control and Prevention (CDC) to develop a nationally-representative sample of the trauma centers that provided data on treated

trauma patients. This report provides analysis of the National Trauma Data Bank-National Sample Program (NTDB-NSP) for 2003 to 2007. NTDB-NSP is a unique database that includes clinical and resource information for a nationally representative sample of trauma incidents.[1] NTDB-NSP is a stratified sample based in large part on existing NTDB data. Researchers can use the NTDB-NSP to produce national estimates of trauma care. For privacy reasons, the NTDB-NSP excludes data elements that could directly or indirectly identify individuals or individual trauma centers.

To establish the NTDB-NSP, a stratified sample design was used, and 100 level I and level II hospitals were included. Stratification was based on U.S. Census region (four regions), level of trauma care designation (two categories), and NTDB reporting status (two categories). Thus, there were 16 total strata: 8 NTDB strata and 8 non-NTDB strata. Of the 100 sample hospitals, 90 were allocated to the known NTDB-contributing hospitals and 10 to non-NTDB hospitals. The sample size of 100 hospitals was chosen on the basis of recent NTDB data that suggested that a sample of 100 hospitals would provide estimates having sufficient precision for most analyses at the national level.

In the NTDB-NSP, motor vehicle occupants involved in passenger vehicle crashes were identified by using the International Classification of Diseases, External Cause of Injury, Ninth Revision (ICD-9 E-Codes) between 810.1 and 819.1. Information on external causes of injury is coded and entered into the state's electronic hospital discharge data system (HDDS) or hospital emergency department data system (HEDDS).[7] Although the NTDB-NSP provides detailed medical and demographic information about these injured occupants, it lacks the information on crash characteristics such as crash direction, crash severity, and manner of collision. Information on child seating locations inside the vehicle is not available in NTDB-NSP data.

Cases not admitted to trauma centers are not included in the NTDB-NSP, including injury victims who died before they can be transported to a hospital.

The analysis of both NASS-GES and NTDB-NSP were run separately without any linkage between the two databases. The NTDB-NSP database was used due to the lack of medical information in the NASS-GES database. The AIS 2+ injuries in NTDB-NSP are likely coded as incapacitating injuries in NASS-GES.

When analyzing NTDB-NSP, only patients aged 0 through 7 years old with Abbreviated Injury Scale (AIS) severity of 2 (moderate) or higher injuries were included[3]. Among vehicle occupants who sustained AIS 2+ injuries, the injury or injuries with highest AIS for each body region were selected for analysis. For example, a child with three head injuries of AIS 2, 3 and 4 and lower extremity injuries of AIS 2 and 3, both the head injury with AIS 4 and the lower extremity injury with AIS 3 were included in the analysis.

Injury severity in this study was identified through using the Abbreviated Injury Scale (AIS). The AIS is an anatomical scoring system first introduced in 1969.[3] AIS has been revised and updated against survival to provide and accurate measure of injury severity ranking. Injuries are ranked on a scale of 1 to 6, with 1 being minor, 5 severe, and 6 an unsurvivable injury.

Examples of injury AIS coding:
Skin contusion = AIS-1; Minor contusion of liver = AIS-2; Fractured femur = AIS-3
Flail chest= AIS-4; Complex rupture spleen =AIS-5

Children in this analysis were grouped into three age groups (less than one year, 1 to 3 years and 4 to 7 years) according to the age-appropriate type of child safety seat. The analysis is limited to children involved in crashes involving passenger cars, minivans and light trucks. To account for the sample design and its associated standard errors, the Statistical Analysis System (SAS) version 9.1 ***Complex Sample*** Surveys was used to measure the confidence interval (CI) when applicable.

Both NASS-GES and NTDB-NSP estimates are based on a national probability samples.

4. RESULTS

4.1. ANALYSIS OF POLICE-REPORTED CRASHES FROM NASS-GES

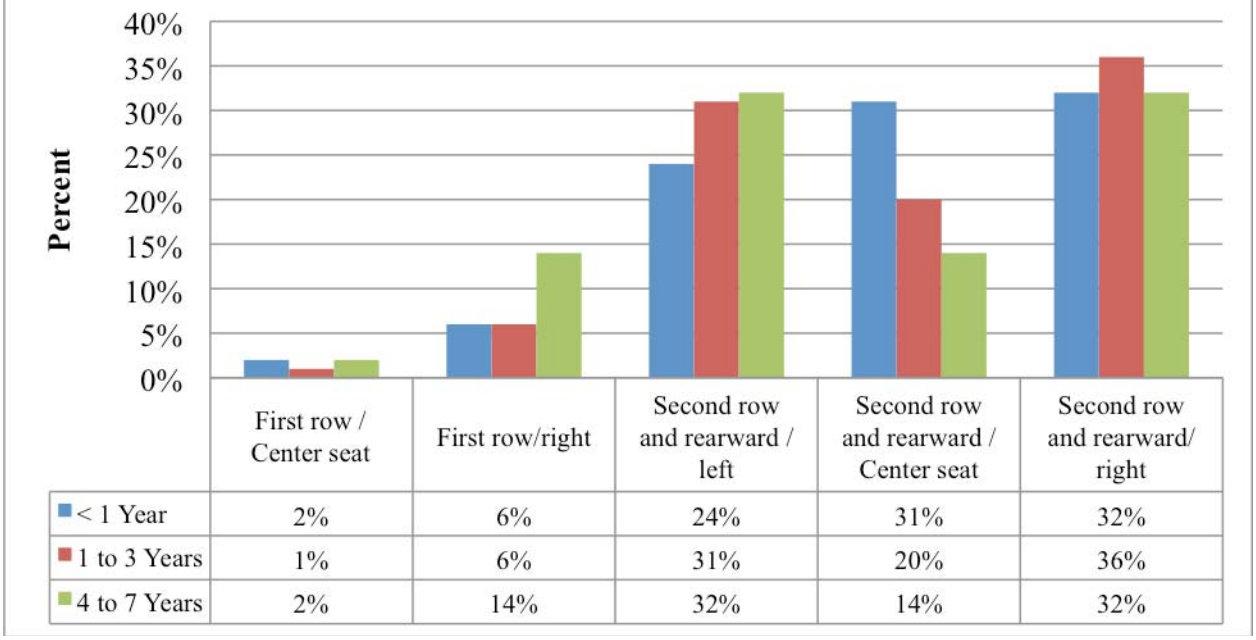
Seating Position of Children in Vehicles

Seating positions were grouped as first row and second row and rearward. Second row and rearward refers to children who were seated in the second or third rows inside the vehicle (e.g. minivans and some SUVs).

There was a noticeable variation on the seating positions inside the vehicle across the three age groups. As shown in Table 1 and Figure 1, 31 percent (95% CI 28%-33%) of the children less than 1 year old were seated on the center seat of the second row and rearward. Conversely, only 20 percent (95% CI 19%-22%) and 14 percent (95% CI 13%-15%) of children 1 to 3 and 4 to 7 years old were seated in the center seat of the second row and rearward, respectively. A higher percentage (14%) of children 4 to 7 years old were seated on the front right seat, compared to the other two age groups.

Table 1: Estimated Distribution of Seating Position in Vehicles for Child Passengers Involved in Motor Vehicle Crashes						
	< 1 Year		1 to 3 Years		4 to 7 Years	
Seating Position	**Estimated Count**	**(%)**	**Estimated Count**	**(%)**	**Estimated Count**	**(%)**
First row/center seat	13,233	**2%** *CI (1.5%-2.7%)*	37,556	**1%** *CI (1%-2%)*	61,013	**2%** *CI (2%-3%)*
First row/right	38,988	**6%** *CI (5.1%-7.3%)*	151,339	**6%** *CI (5%-7%)*	426,486	**14%** *CI (13%-15%)*
First row/unknown	2,265	**<1%** *CI (0.2%-0.6%)*	14,484	**<1%** *CI (0.4%-0.7%)*	13,856	**<1%** *CI (0.3%-0.6%)*
Second row & rearward/left	149,277	**24%** *CI (22%-25%)*	802,078	**31%** *CI (30%-32%)*	978,895	**32%** *CI (31%-34%)*
Second row & rearward/center seat	194,695	**31%** *CI (28%-33%)*	534,264	**20%** *CI (19%-22%)*	427,188	**14%** *CI (13%-15%)*
Second row and rearward/right	200,053	**32%** *CI (30%-34%)*	933,744	**36%** *CI (34%-37%)*	970,208	**32%** *CI (30%-33%)*
Second row & rearward/unknown	11,288	**2%** *CI (1.2%-2.4%)*	57,621	**2%** *CI (1%-3%)*	82,461	**3%** *CI (2%-4%)*
Unknown	21,019	**3%** *CI (2.5%-4.1%)*	83,121	**3%** *CI (2%-4%)*	94,546	**3%** *CI (2.5%-4%)*
Total	**630,819**	**100%**	**2,614,206**	**100%**	**3,054,653**	**100%**
Source: NASS-GES 1999-2008						

Figure 1: Distribution of Children Seating Position in Vehicles by Child Passengers Age
NASS-GES 1999-2008



	First row / Center seat	First row/right	Second row and rearward / left	Second row and rearward / Center seat	Second row and rearward/ right
< 1 Year	2%	6%	24%	31%	32%
1 to 3 Years	1%	6%	31%	20%	36%
4 to 7 Years	2%	14%	32%	14%	32%

Injury Severity

The vast majority of the children included in NASS-GES between 1999 and 2008 sustained no or minor injuries. As seen in Table 2, only 1 percent of the children under 1 year old, 1 percent of the children 1 to 3 years old, and 2 percent of children 4 to 7 years old sustained incapacitating injuries.

Table 2: Estimated Distribution of Injury Severity by Child Passenger Age Involved in Motor Vehicle Crashes

	< 1 Year		1 to 3 Years		4 to 7 Years	
Injury Severity	**Estimated Count**	**Estimated (%)**	**Estimated Count**	**Estimated (%)**	**Estimated Count**	**Estimated (%)**
No Injury	545,786	**87%** *CI (84%-89%)*	2,249,267	**86%** *CI (84%-88%)*	2,528,615	**83%** *CI (80%-85%)*
Possible Injury	51,204	**8%** *CI (7%-9%)*	215,772	**8%** *CI (7%-10%)*	313,632	**10%** *CI (9%-12%)*
Non-incapacitating Injury	12,177	**2%** *CI (1.6%-2.3%)*	84,993	**3%** *CI (2.8%-3.7%)*	132,210	**4%** *CI (3.8%-5%)*
Incapacitating Injury	7,572	**1%** *CI (0.1%-2.3%)*	30,500	**1%** *CI (0.1%-2.2%)*	47,521	**2%** *CI (0.4%-2.8%)*
Fatal Injury	979.957	**<1%** *CI (0.01%-0.3%)*	1,719	**<1%** *CI (0.01%-0.1%)*	2,348	**<1%** *CI (0.0%-0.1%)*
Injured, Severity Unknown	2,031	**<1%** *CI (0.1%-0.5%)*	6,026	**<1%** *CI (0.1%-0.3%)*	6,960	**<1%** *CI (0.1%-0.3%)*
Unknown if Injured	11,069	**2%** *CI (1.1%-2.4%)*	25,929	**1%** *CI (0.7%-1.3%)*	23,366	**1%** *CI (0.5%-1.2%)*
Total	**630,819**	**100%**	**2,614,206**	**100%**	**3,054,653**	**100%**

Source: NASS-GES 1999-2008

Incidence of Incapacitating Injuries in Different Crash Scenarios:

This section provides information of incidence rates of incapacitating injuries in relation to the initial point of impact (IPI), seating position inside the vehicle and use of child safety seats. To examine the incidence of incapacitating injuries in relation to the IPI and seating positions, the IPI and seating positions were grouped into nine groups as shown in Table 3. Children who were involved in rollovers and were seated in any seating position inside the vehicle were grouped as Rollover. Children who were involved in rear impacts were grouped into two groups (1) Rear Impact/First Row and (2) Rear Impact/Second Row and rearward. Children who were involved in frontal impacts were grouped into two groups (1) Children seated in the first row "Frontal Impact/First row" (2) Children seated in the second row and rearward "Frontal Impact/Second Row and Rearward." Children who were involved in side impacts were grouped into three groups (1) Near-Side Impact (2) Far-Side Impact (3) Side Impact/Center seat (Table 3).

Table 3: Seating Position and Initial Direction of the Impact (IPI)		
Initial Direction Of Impact (IPI)	**Seating Position**	**IPI/Seating Position**
Right	Right (Any Row)	**Near-Side Impact**
Left	Left (Any Row)	**Near-Side Impact**
Right	Left (Any Row)	**Far-Side Impact**
Left	Right (Any Row)	**Far-Side Impact**
Frontal	First Row	**Frontal Impact/First Row**
Frontal	Second Row +	**Frontal Impact/Second Row & Rearward**
Rear	First Row	**Rear Impact/First Row**
Rear	Second Row +	**Rear Impact/Second Row& Rearward**
Side Impact	Center seat (Any Row)	**Side Impact/Center Seat**
Rollover	Any Seating Position	**Rollover**

Injury Severity by Initial Point of Impact (IPI)

Overall, vehicle's front, rear and side were the most common IPI in all crashes involving children 0 through 7 years old. Rollovers comprised only 2 percent of the crashes involving children under 1 year old, 1 to 3 years old, and 4 to 7 year old, respectively (Table 4a). However, rollovers had the highest incidence rates of incapacitating injuries with no significant difference between the three age groups. An estimated 11 percent (95% CI 3% - 19%), 9.6 percent (95% CI 1% - 18%), and 15 percent (95% CI 6% - 24%) of children less than 1 year old, 1 to 3 years old, and 4 to 7 years old who were involved in rollover crashes sustained incapacitating injuries, respectively (Table 4b and Figure 2).

Children who were involved in frontal impacts and were seated in the front seats were twice as likely to sustain incapacitating injuries as children who were seated in the second row and rearward (Table 4b and Figure 2).

There was no significant difference in the incidence rates of incapacitating injuries for children involved in different seating positions in rear crashes.

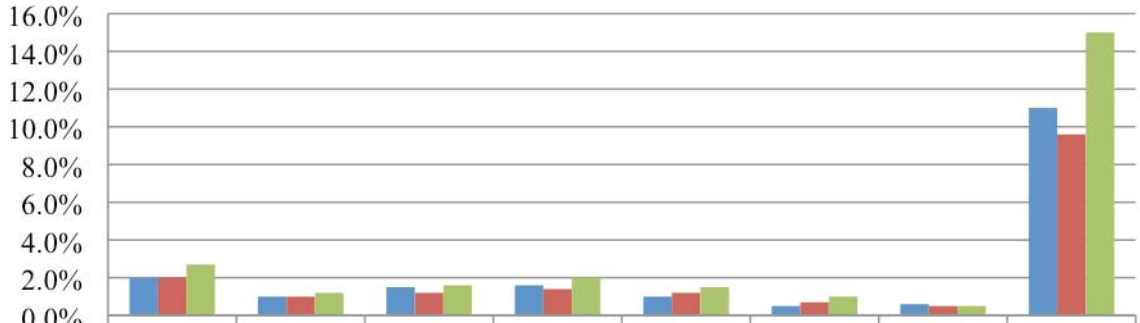
Table 4a: Estimated Distribution of IPI + Seating Position by Child Passengers Age Involved in Motor Vehicle Crashes						
Age	**< 1 Year**		**1 to 3 Years**		**4 to 7 Years**	
IPI+ Seating Position	**Estimated Count**	**Estimated (%)**	**Estimated Count**	**Estimated (%)**	**Estimated Count**	**Estimated (%)**
Frontal Impact/First Row	25,948	**4%** *CI (3.2%-5%)*	94,139	**4%** *CI (3.1%-4.1%)*	234,943	**8%** *CI (7%-9%)*
Frontal Impact/Second Row & Rearward	234,011	**37%** *CI (35%-39%)*	1,007,921	**39%** *CI (38%-40%)*	1,025,369	**34%** *CI (33%-35%)*
Near-Side Impact	61,591	**10%** *CI (9%-11%)*	280,626	**11%** *CI (10%-11.4%)*	343,830	**11%** *CI (10.6%-12%)*
Far-Side Impact	52,657	**8%** *CI (7%-10%)*	259,128	**10%** *CI (9%-11%)*	328,505	**11%** *CI (10%-11.3%)*
Side Impact/Center Seat	58,638	**9%** *CI (8%-11%)*	145,111	**6%** *CI (5%-6.2%)*	149,325	**5%** *CI (4.5%-5.3%)*
Rear Impact/First Row	9,016	**1%** *CI (1%-2%)*	42,773	**1.6%** *CI (1.3%-1.9%)*	104,390	**3.4%** *CI (3%-4%)*
Rear Impact/Second Row & Rearward	145,601	**23%** *CI (21%-25%)*	598,197	**23%** *CI (21%-25%)*	649,529	**21%** *CI (20%-23%)*
Rollover	12,965	**2%** *CI (1.5%-3%)*	49,932	**2%** *CI (1.5%-2.3%)*	52,974	**2%** *CI (1.4%-2.1%)*
Other/Unknown	30,392	**5%** *CI (4%-6%)*	136,380	**5%** *CI (4%-6%)*	165,788	**5%** *CI (4%-7%)*
Total	**630,819**	**100%**	**2,614,206**	**100%**	**3,054,653**	**100%**
Source: NASS-GES 1999-2008						

Table 4b: Estimated Incidence Rates of Incapacitating Injuries by IPI by Child Passengers Age Involved in Motor Vehicle Crashes

	< 1 Year		1 to 3 Years		4 to 7 Years	
IPI+ Seating Position	**Estimated Count**	**Estimated (%)**	**Estimated Count**	**Estimated (%)**	**Estimated Count**	**Estimated (%)**
Frontal Impact/First Row	530	**2%** *CI (0.3% - 3.8%)*	1,904	**2%** *CI (1%- 3%)*	6,320	**2.7%** *CI (1%-4.5%)*
Frontal Impact/Second Row & Rearward	2,176	**1%** *CI (0.1%-1.8%)*	9,694	**1%** *CI (0.0%-2%)*	12,026	**1.2%** *CI (0.1%-2.2%)*
Near-Side Impact	914	**1.5%** *CI (0.0% - 3.4%)*	3,420	**1.2%** *CI (0.1% - 2.3%)*	5,563	**1.6%** *CI (0.4% - 2.8%)*
Far-Side Impact	860	**1.6%** *CI (0.0%-3.6%)*	3,722	**1.4%** *CI (0.0%-2.9%)*	6,743	**2%** *CI (0.3%-3.8%)*
Side Impact/Center Seat	552	**1%** *CI (0.1% - 1.8%)*	1,763	**1.2%** *CI (0.0% - 2.7%)*	2,245	**1.5%** *CI (0.1% - 3%)*
Rear Impact/First Row	44	**0.5%** *CI (0.0% - 1.4%)*	278	**0.7%** *CI (0.1% - 1.3%)*	745	**1%** *CI (0.1% - 1.3%)*
Rear Impact/Second Row & Rearward	864	**0.6%** *CI (0.0% - 1.3%)*	2,933	**0.5%** *CI (0.1% - 1%)*	3,434	**0.5%** *CI (0.0% - 1%)*
Rollover	1,416	**11%** *CI (3% - 19%)*	4,791	**9.6%** *CI (1% - 18%)*	7,943	**15%** *CI (6% - 24%)*
Other/Unknown	213	**0.7%** *CI (0.1% - 1.4%)*	1,994	**1.50%** *CI (1% - 2%)*	2,502	**1.5%** *CI (1% - 2.2%)*
Total	**7,569**	**1%** *CI (0.1%-2.3%)*	**30,500**	**1%** *CI (0.1%-2.2%)*	**47,521**	**2%** *CI (0.4%-2.8%)*

Source: NASS-GES 1999-2008

Figure 2: Estimated Incidence Rates of of Incapacitating Injuries by IPI and Child Passenger Age
NASS-GES 1999-2008



	Frontal Impact/ First row	Frontal Impact/ Second row & rearward	Near Side Impact	Far Side Impact	Side Impact/ Center seat	Rear Impact/ First Row	Rear Impact/ Second row & rearward	Rollover
< 1 Year	2.0%	1.0%	1.5%	1.6%	1.0%	0.5%	0.6%	11.0%
1 to 3 Years	2.0%	1.0%	1.2%	1.4%	1.2%	0.7%	0.5%	9.6%
4 to 7 Years	2.7%	1.2%	1.6%	2.0%	1.5%	1.0%	0.5%	15.0%

Injury Severity by Restraint Use

Overall, in this analysis, the rate of child safety seat use in police-reported crashes varied from 85 percent (95% CI 83%-88%) among children less than 1 year old to only 24 percent (95% CI 21%-27%) among children 4 to 7 years old. A large proportion of the children 4 to 7 years old (48%, 95% CI 43%-52%) were using lap and shoulder belts (Table 5a).

The incidence rate of incapacitating injuries was lower among children restrained in child safety seats. As shown in Table 5b and Figure 3, incapacitating injuries were sustained by 8 percent (95% CI 2%-13%), 7 percent (95% CI 2.5%-11%), and 7 percent (95% CI 2.6%-12%) of children less than 1 year, 1 to 3 years and 4 to 7 years old who were not in child safety seats and did not use lap/shoulder belts, respectively. Conversely, only 1.1 percent (95% CI 0.0%-2.2%) , 1 percent (95% CI 0.0%-2%), and 1 percent (95% CI 0.2%-2%) of children less than 1 year, 1 to 3 years and 4 to 7 years old who used child safety seats sustained incapacitating injuries, respectively.

The breakdown percent distribution of the **other/unknown** category of restraint system use is provided in Table 5c.

Table 5a: Estimated Distribution of the Police-reported Child Safety Seat Use by Child Passengers Age Involved in Motor Vehicle Crashes

Age	< 1 Year		1 to 3 Years		4 to 7 Years	
Restraint Systems	**Estimated Count**	**(%)**	**Estimated Count**	**(%)**	**Estimated Count**	**(%)**
Child Safety Seat	537,142	**85%** *CI (83%-88%)*	1,919,191	**73%** *CI (71%-76%)*	722,731	**24%** *CI (21%-27%)*
Lap and Shoulder Belt	28,160	**4%** *CI (3.5%-5.5%)*	328,772	**13%** *CI (11%-14%)*	1,454,340	**48%** *CI (43%-52%)*
None Used	14,239	**2%** *CI (1.8%-2.7%)*	84,310	**3%** *CI (2.7%-3.7%)*	128,362	**4%** *CI (3.6%-4.8%)*
Other/Unknown*	***51,279***	***8%*** *CI (6%-10%)*	*281,928*	***11%*** *CI (9%-13%)*	***748,954***	***25%*** *CI (20%-29%)*
Total	**630,819**	**100%**	**2,614,202**	**100%**	**3,054,386**	**100%**

Source: NASS-GES 1999-2008

Table 5b: Estimated Incidence Rates of Incapacitating Injuries by Police-reported Child Safety Seat Use and Child Passengers Age Involved in Motor Vehicle Crashes

Age	< 1 Year		1 to 3 Years		4 to 7 Years	
Restraint Systems	**Estimated Count**	**(%)**	**Estimated Count**	**(%)**	**Estimated Count**	**(%)**
Child Safety Seat	5,822	**1.1%** *CI (0.0%-2.2%)*	17,026	**1%** *CI (0.0%-2%)*	7,540	**1%** *CI (0.2%-2%)*
Lap and Shoulder Belt	439	**1.5%** *CI (0.0%-3%)*	3,737	**1.1%** *CI (0.3%-2%)*	21,120	**1.5%** *CI (0.2%-2.7%)*
None Used	1081	**8%** *CI (2%-13%)*	5,768	**7%** *CI (2.5%-11%)*	9,199	**7%** *CI (2.6%-12%)*
Other/Unknown	***229***	***0.4%*** *CI (0.0%-0.5%)*	***3,968***	***1.4%*** *CI (0.6%-2.2%)*	***9,662***	***1.3%*** *CI (0.4%-2.0%)*
Total	**7,569**	**1%** ***CI (0.1%-2.3%)***	**30,500**	**1%** ***CI (0.1%-2.2%)***	**47,521**	**2%** ***CI (0.4%-2.8%)***

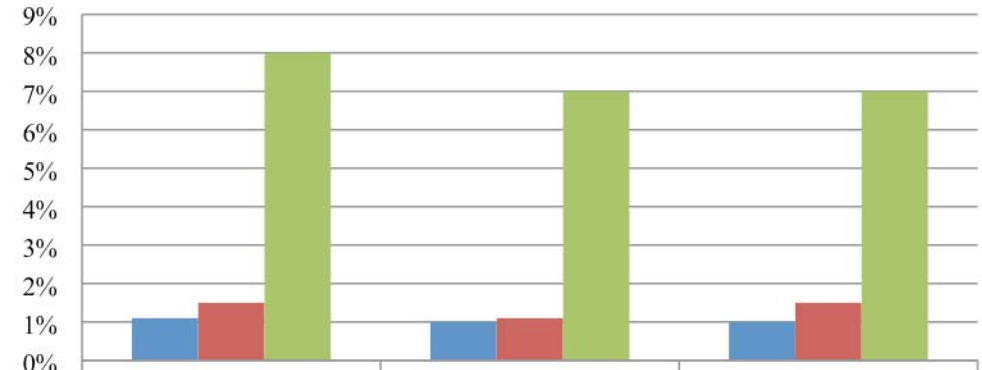
Source: NASS-GES 1999-2008

Table 5c: Details of Other/Unknown Category of Restraint System Use

RESTRAINT SYSTEM USE	< 1 Year	1 to 3 Year	4 to 7 Year
Lap Belt	0.5%	3.5%	11%
Shoulder Belt	0.1%	0.2%	0.5%
Restraint Used-Specifics Unknown or Other	3.4%	3.7%	10%
Unknown if Used	3.9%	3.2%	4%
Total	**8%**	**11%**	**25%**

Source: NASS-GES 1999-2008

Figure 3: Estimated Incidence Rates of of Incapacitating Injuries by Police-reported Child Safety Seat Use and Child Passenger Age NASS-GES 1999-2008



	< 1 Year	1 to 3 Years	4 to 7 Years
Child Safety Seat	1%	1%	1%
Lap and Shoulder Belt	2%	1%	2%
None Used	8%	7%	7%

Injury Severity by Restraint Use and Initial Point of Impact (IPI)

The information provided in this section examines the incidence rates of incapacitating injuries for the three age groups combined. The use of child safety seats reduced the incidence rates of incapacitating injuries for the three age groups and all crash types. As shown in Table 6b and Figure 4, children involved in rollover crashes had the highest incidence rates of incapacitating injuries.

Unrestrained children had significantly higher rates of incapacitating injuries regardless of their seating position inside the vehicles. As shown in Table 6b, the incidence rates of incapacitating injuries were 7 percent (95% CI 2%-12%) and 6.5 percent (95% CI 0.0%-13%) for children involved in frontal crashes and were seated in the first row and second row and rearward, respectively, compared with 1 percent (95% CI 0.1%- 1.6%) and 1 percent (95% CI 0.0%-1.7%) for children restrained children involved in frontal crashes and seated in the first row and second row and rearward, respectively.

In rollover crashes, the estimated incidence rate of incapacitating injuries among unrestrained children was 26 percent (95% CI 14%-37%) compared with 9 percent (95% CI 0.4%-18%) among children restrained in child safety seats and 10 percent (95% CI 1.1%-19%) among children who used lap and shoulder belts.

Unrestrained children had significantly higher rates of incapacitating injuries in side impacts than restrained children. Incidence rates of incapacitating injuries were 8 percent (95% CI 5%-12%), 6.5 percent (95% CI 1%-12%), and 7 percent (95% CI 2%-13%) for unrestrained children involved in near-side impacts, far-side impacts and side impacts/center seat, respectively, compared with 1 percent (95% CI 0.1%-2%), 1.3 percent (95% CI 0.0%-2.7%), and 1 percent

(95% CI 0.0%-2%) for restrained children involved in near-side impacts, far-side impacts and side impacts/center seat, respectively.

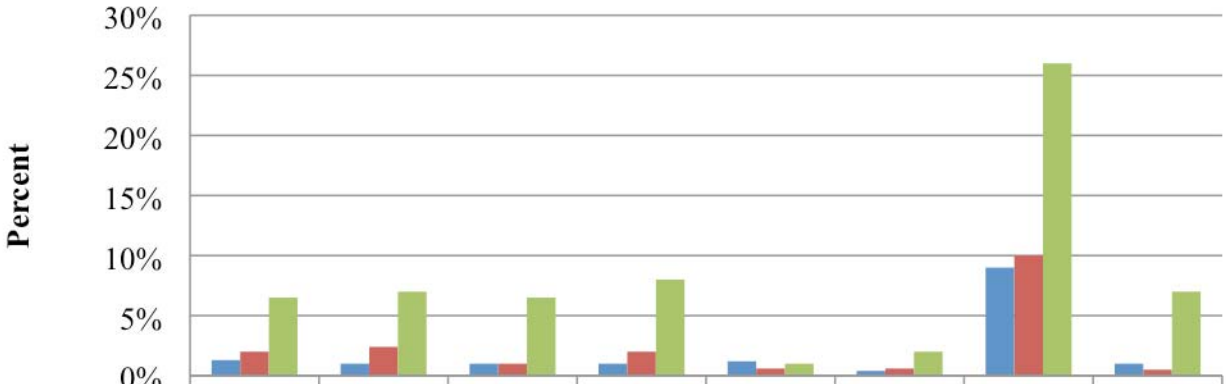
Table 6a: Estimated Distribution of IPI by Restraint Systems Use for Child Passengers Involved in Motor Vehicle Crashes

Restraint Systems	Child Safety Seat		Lap & Shoulder		None Used		Other/Unknown	
IPI+ Seating Position	**Estimated Count**	**Estimated (%)**	**Estimated Count**	**Estimated (%)**	**Estimated Count**	**Estimated (%)**	**Estimated Count**	**Estimated (%)**
Frontal Impact/ First Row	77,166	**2.5%** *CI (2.1%- 2.8%)*	180,588	**10%** *CI (9%-11%)*	27,906	**12%** *CI (10%-15%)*	69,366	**6%** *CI (5.5%-7%)*
Frontal Impact/Second Row & Rearward	1,270,065	**40%** *CI (39%- 41%)*	572,927	**32%** *CI (30%- 33%)*	69,481	**31%** *CI (27%-34%)*	354,823	**33%** *CI (31%-34%)*
Near-Side Impact	337,226	**11%** *CI (10%- 11.2%)*	239,063	**13%** *CI (12%-14%)*	19,046	**8%** *CI (7%-10%)*	90,712	**8%** *CI (7%-10%)*
Far-Side Impact	311,128	**10%** *CI (9%- 10.2%)*	229,568	**13%** *CI (12%- 14%)*	17,996	**8%** *CI (7%-9%)*	81,598	**8%** *CI (6%-9%)*
Side Impact/ Center Seat	185,158	**6%** *CI (5%- 7%)*	38,820	**2%** *CI (1.8%-2.5%)*	15,551	**7%** *CI (6%-8%)*	113,545	**10%** *CI (9%-12%)*
Rear Impact/ First Row	36,478	**1%** *CI (0.9%- 1.4%)*	84,576	**5%** *CI (4-5%.1%)*	6,497	**3%** *CI (2%-4%)*	28,366	**3%** *CI (2-3%.2%)*
Rear Impact/Second Row & Rearward	793,909	**25%** *CI (23%- 27%)*	354,682	**20%** *CI (18%-21%)*	25,957	**11%** *CI (9%-14%)*	218,779	**20%** *CI (19%-22%)*
Rollover	59,198	**2%** *CI (1.5%- 2.3%)*	26,842	**1.5%** *CI (1.2%- 1.8%)*	12,947	**6%** *CI (5%-7%)*	16,885	**1.8%** *CI (1%-2%)*
Other/Unknown	108,737	**3%** *CI (2.6%- 4%)*	84,205	**5%** *CI (3%-6%)*	31,530	**14%** *CI (11%-17%)*	108,087	**10%** *CI (8%-12%)*
Total	**3,179,064**	**100%**	**1,811,272**	**100%**	**226,910**	**100%**	**1,082,161**	**100%**

Source: NASS-GES 1999-2008

Table 6b: Estimated Incidence Rates of Incapacitating Injuries by IPI and Restraint Systems Use for Child Passengers Involved in Motor Vehicle Crashes								
Restraint Systems	**Child Safety Seat**		**Lap & Shoulder**		**None Used**		**Other/Unknown**	
IPI+ Seating Position	**Estimated Count**	**Estimated (%)**	**Estimated Count**	**Estimated (%)**	**Estimated Count**	**Estimated (%)**	**Estimated Count**	**Estimated (%)**
Frontal Impact/First Row	674	**1%** *CI (0.1%- 1.6%)*	4,328	**2.4%** *CI (1%-4%)*	2,027	**7%** *CI (2%-12%)*	1726	**2.5%** *CI (1%-4%)*
Frontal Impact/Second Row & Rearward	10,280	**1%** *CI (0.0%- 1.7%)*	5,372	**1%** *CI (0.1%- 2%)*	4,544	**6.5%** *CI (0.0% - 13%)*	3700	**1%** *CI (0.5%-1.6%)*
Near-Side Impact	3,352	**1%** *CI (0.1%- 2%)*	3,965	**2%** *CI (0.0%-3%)*	1,544	**8%** *CI (5%-12%)*	1037	**1%** *CI (0.2%-2%)*
Far-Side Impact	3,933	**1.3%** *CI (0.0-% 2.7%)*	5,045	**2%** *CI (0.2%- 4%)*	1,161	**6.5%** *CI (1%-12%)*	1185	**1.4%** *CI (0.6%-2%)*
Side Impact/Center Seat	1,913	**1%** *CI (0.0%-2%)*	215	**0.5%** *CI (0.0 %-1.5%)*	1,167	**7%** *CI (2%-13%)*	1265	**0.7%** *CI (0.0%-2.5%)*
Rear Impact/First Row	416	**1.2%** *CI (0.0%-2.4%)*	549	**0.6%** *CI (0.1% – 1.3%)*	71	**1%** *CI (0.0%-3%)*	30	**0.1%** *CI (0.0%.0.2%)*
Rear Impact/Second Row & Rearward	3,450	**0.4%** *CI (0%-1%)*	2,299	**0.6%** *CI (0.1%- 1.2%)*	445	**2%** *CI (0.0%-4%)*	1038	**0.5%** *CI (0.0%-1%)*
Rollover	5,475	**9%** *CI (0.4%- 18%)*	2,709	**10%** *CI (1.1%- 19%)*	3,353	**26%** *CI (14%-37%)*	2613	**15%** *CI (6%-25%)*
Other/Unknown	893	**1%** *CI (0.1%- 1.5%)*	814	**1%** *CI (0.3% -1.6%)*	1,735	**6%** *CI (2.4%-9%)*	1266	**1%** *CI (0.5%-2%)*
Total	**30,388**	**1%** *CI (0.0%-2%)*	**25,297**	**1.4%** *CI (0.2%-2.6%)*	**16,048**	**7%** *CI (3%-12%)*	**13,859**	**1.3%** *CI (0.5%-2%)*
Source: NASS-GES 1999-2008								

Figure 4: Estimated Incidence Rates of Incapacitating Injuries by IPI and Restraint Use
NASS-GES 1999-2008



	Far Side Impact	Frontal Impact/First row	Frontal Impact/ Second Row & rearward	Near Side Impact	Rear Impact/First Row	Rear Impact/ Second Row & rearward	Rollover	Side Impact/ Center seat
Child Safety Seat	1%	1%	1%	1%	1%	0%	9%	1%
Lap & Shoulder	2%	2%	1%	2%	1%	1%	10%	1%
None Used	7%	7%	7%	8%	1%	2%	26%	7%

4.2. ANALYSIS OF NTDB-NSP DATA

An estimated 1,731 children under 1 year old, 4,062 children between 1 to 3 years old, and 6,339 children between 4 to 7 years old were identified in NTDB-NSP dataset between 2003 and 2007. An estimated 1,188 (69%), 2,319 (57%), and 4,169 (66%) of the children under 1 year old, 1 to 3 years old, and 4 to 7 years old had Maximum Abbreviated Injury Scale (MAIS) 2+, respectively (Table 7).

Table 7: Estimated Incidence Rates of MAIS by Child Passengers Age Involved in Motor Vehicle Crashes

MAIS	< 1 Year			1 to 3 Years			4 to 7 Years		
	Count		Estimated (%)	Count		Estimated (%)	Count		Estimated (%)
	Estimated	Unweighted		Estimated	Unweighted		Estimated	Unweighted	
MAIS-1	487	103	**28%** *CI (23%-33%)*	1,664	397	**41%** *CI (36%-46%)*	2,027	515	**32%** *CI (27%-37%)*
MAIS-2	383	69	**22%** *CI (18%-26%)*	959	289	**24%** *CI (20%-27%)*	2,024	505	**32%** *CI (29%-35%)*
MAIS-3	454	93	**26%** *CI (22%-30%)*	865	236	**21%** *CI (19%-24%)*	1,209	374	**19%** *CI (16%-22%)*
MAIS-4	215	69	**12%** *CI (9%-16%)*	375	104	**9%** *CI (7%-11%)*	704	196	**11%** *CI (9%-13%)*
MAIS-5	126	27	**7%** *CI (2%-13%)*	116	45	**3%** *CI (2%-4%)*	225	76	**4%** *CI (2%-5%)*
MAIS-6	10	3	**1%** *CI (0.0%-1.4%)*	4	2	**0%** --	7	5	**0%** --
Unknown	56	18	**3%** *CI (1.2%-5.3%)*	79	42	**2%** *CI (0.4%-3%)*	143	52	**2%** *CI (1%-4%)*
Total	**1,731**	**382**	**100%**	**4,062**	**1,115**	**100%**	**6,339**	**1,723**	**100%**
MAIS 2+	**1,188**		**68%**	**2,319**		**57%**	**4,169**		**66%**

Source: NTDB-NSP 2003-2007
The estimates may not sum to the totals due to rounding

Injuries by Body Region

In this section the percentages are calculated as the total number of children who sustained certain type of AIS 2+ injury divided by the total number of children who had MAIS of 2+ within each age group. For example, a total of 1,188 children under 1 year old sustained MAIS 2+ injuries and of those, 827 sustained AIS 2+ head injuries. The incidence rate of head injuries among this age group = 827/1,188 X 100 or 70 percent.

As shown in Table 8 and Figure 4, the head was the most common body region injured in motor vehicle crashes for the three age groups included in the analysis. However, children under 1 year old had a higher percent of AIS 2+ head injuries at 70 percent as compared to 51 percent and 39 percent among children 1 to 3 years and 4 to 7 years old, respectively. Thoracic injuries were noticeably higher among children under 1 year old at 31 percent when compared to 14 percent and 12 percent among children 1 to 3 years and 4 to 7 years old, respectively.

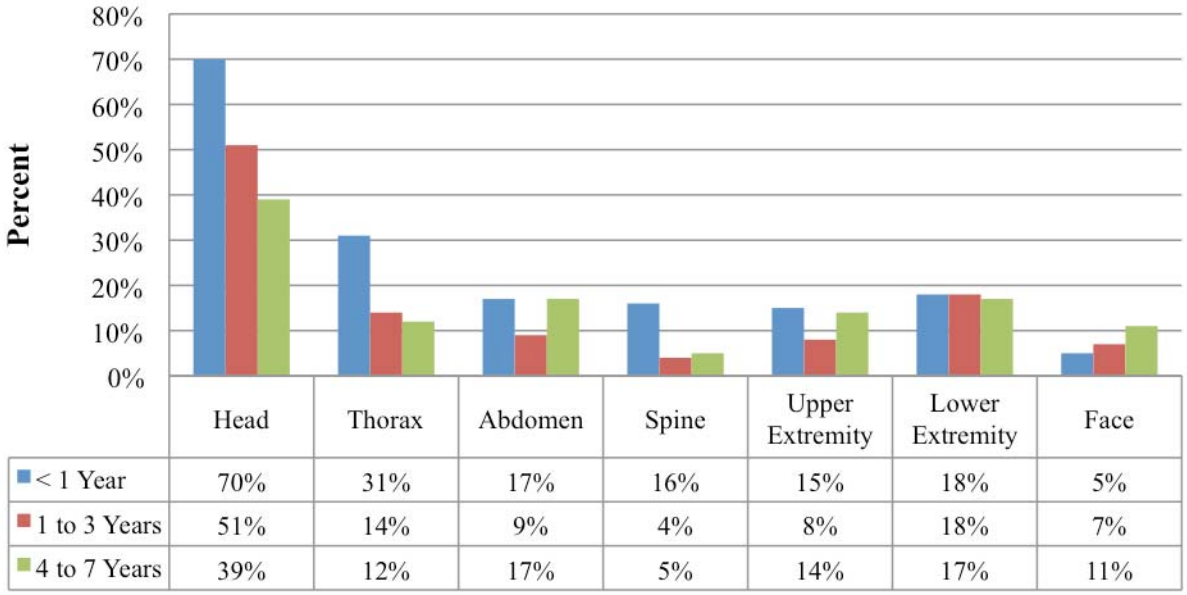
Similar to thoracic injuries, spine injuries were noticeably higher among children under 1 year old at 16 percent when compared to 4 percent and 5 percent among children 1 to 3 years and 4 to 7 years old, respectively.

Table 8: Estimated Incidence Rates of AIS 2 + Injuries by Body Region and Child Passengers Age Involved in Motor Vehicle Crashes

	< 1 Year			1 to 3 Years			4 to 7 Years		
	Count			Count			Count		
Body Region	**Estimated**	**Unweighted**	**Estimated (%)**	**Estimated**	**Unweighted**	**Estimated (%)**	**Estimated**	**Unweighted**	**Estimated (%)**
Head	827	163	**70%**	1,189	321	**51%**	1,640	449	**39%**
Thorax	369	63	**31%**	334	94	**14%**	481	156	**12%**
Lower Extremity	218	34	**18%**	412	111	**18%**	707	192	**17%**
Abdomen	205	36	**17%**	217	55	**9%**	694	202	**17%**
Spine	192	37	**16%**	84	26	**4%**	226	57	**5%**
Upper Extremity	182	35	**15%**	196	52	**8%**	600	147	**14%**
Face	57	12	**5%**	168	47	**7%**	445	102	**11%**

Source: NTDB-NSP 2003-2007
Note: Percents do not add to 100% as one occupant might sustain more than one injury

Figure 5: Estimated Incidence Rates of AIS 2 + Injuries by Body Region and Child Passengers Age NTDB-NSP 2003-2007



Injury Diagnosis

This section provides the frequency distribution of injury diagnosis for different body regions. Some injuries were grouped into one category due to their relevancy, such as small and large bowel injuries, lung contusion and laceration, cerebrum contusion and laceration, etc.

1- Head Injuries

Cerebrum injuries (contusions or lacerations) were the most common type of head injuries among all children included in the analysis. Concussions/unconsciousness were more common among children under 1 year old, when compared to the other 2 groups. Skull base fractures were more common among children 1 to 3 and 4 to 7 years old when compared to children under 1 year old (Table 9).

Table 9: Estimated Distribution of AIS 2+ Head Injuries by Child Passengers Age Involved in Motor Vehicle Crashes

	< 1 Year			1 to 3 Years			4 to 7 Years		
	Count			Count			Count		
	Estimated	Unweighted	Estimated (%)	Estimated	Unweighted	Estimated (%)	Estimated	Unweighted	Estimated (%)
Cerebrum Injury	300	62	**26%** *CI (19%-32%)*	561	148	**33%** *CI (25%-40%)*	848	227	**34%** *CI (28%-40%)*
Skull Vault Fracture	234	42	**20%** *CI (11%-29%)*	361	87	**21%** *CI (18%-25%)*	489	102	**20%** *CI (17%-23%)*
Unconsciousness/ Concussion	215	46	**18%** *CI (6%-30%)*	156	58	**9%** *CI (4%-14%)*	272	90	**11%** *CI (6%-16%)*
Subarachnoid Hemorrhage	159	34	**14%** *CI (10%-17%)*	143	43	**8%** *CI (6%-11%)*	218	52	**9%** *CI (6%-12%)*
Subdural Hematoma	120	31	**10%** *CI (6%-14%)*	144	42	**8%** *CI (5%-12%)*	184	46	**7%** *CI (5%-10%)*
Skull Base Fracture	69	15	**6%** *CI (3%-9%)*	222	49	**13%** *CI (9%-17%)*	303	82	**12%** *CI (10%-14%)*
Other	74	19	**6%** *CI (2%-9%)*	128	34	**7%** *CI (3%-11%)*	169	49	**6%** *CI (5%-9%)*
	Source: NTDB-NSP 2003-2007								

2- Thoracic Injuries

Rib fractures were more common among children under 1 year old (37%, 95% CI 22%-52%) when compared to the other two age groups. On the other hand, lung injuries (contusions or lacerations) were more common among children 1 to 3 and 4 to 7 years old when compared to children under 1 year old (Table 10).

Table 10: Estimated Distribution of AIS 2+ Thoracic Injuries by Child Passengers Age Involved in Motor Vehicle Crashes									
	< 1 Year			1 to 3 Years			4 to 7 Years		
	Count			Count			Count		
Injury Type	Estimated	Unweighted	Estimated (%)	Estimated	Unweighted	Estimated (%)	Estimated	Unweighted	Estimated (%)
Rib Fracture	214	32	**37%** *CI (22%-52%)*	36	11	**8%** *CI (5%-12%)*	86	23	**14%** *CI (10%-18%)*
Lung Injury	194	32	**33%** *CI (25%-42%)*	276	82	**65%** *CI (55%-74%)*	415	137	**67%** *CI (61%-72%)*
Thoracic Cavity Injury	121	20	**21%** *CI (10%-32%)*	86	19	**20%** *CI (13%-28%)*	93	31	**15%** *CI (10%-20%)*
Other	50	7	**8%** *CI (3%-14%)*	27	3	**6%** *CI (1%-12%)*	28	8	**4%** *CI (1%-8%)*
Source: NTDB-NSP 2003-2007									

3- Abdominal Injuries

Small-bowel injuries and large-bowel injuries were more common among children 4 to 7 years old, accounting for 30 percent (95% CI 23%-37%) of all abdominal injuries compared to only 14 percent among children under 1 year old (CL 5%-23%) and 19 percent (CI 12%-26%) among children 1 to 3 years old (Table 11).

Table 11: Estimated Distribution of AIS 2+ Abdominal Injuries by Child Passengers Age Involved in Motor Vehicle Crashes									
	< 1 Year			1 to 3 Years			4 to 7 Years		
	Count			Count			Count		
Injury Type	Estimated	Unweighted	Estimated (%)	Estimated	Unweighted	Estimated (%)	Estimated	Unweighted	Estimated (%)
Liver Injury	87	14	**32%** *CI (23%-42%)*	104	27	**30%** *CI (22%-38%)*	263	71	**25%** *CI (21%-30%)*
Spleen Injury	67	15	**25%** *CI (8%-42%)*	124	30	**36%** *CI (27%-44%)*	268	73	**26%** *CI (20%-32%)*
Small/Large Bowel Injury	38	8	**14%** *CI (5%-23%)*	66	12	**19%** *CI (12%-26%)*	311	86	**30%** *CI (23%-37%)*
Kidney Injury	41	6	**15%** *CI (5%-25%)*	30	8	**9%** *CI (6%-11%)*	122	31	**12%** *CI (8%-15%)*
Other	38	7	**14%** *CI (5%-23%)*	22	6	**6%** *CI (1%-12%)*	70	23	**7%** *CI (4%-9%)*
Source: NTDB-NSP 2003-2007									

4- Upper Extremity Injuries

Humerus fractures accounted for 43 percent (95% CI 33%-53%) of upper extremity injuries for children 1 to 3 years old. Fracture radius and ulna combined (forearm) accounted for 26 percent, 24 percent and 35 percent for children under 1 year, 1 to 3 and 4 to 7 years old, respectively (Table 12).

Table 12: Estimated Distribution of AIS 2+ Upper extremity Injuries by Child Passengers Age Involved in Motor Vehicle Crashes									
	< 1 Year			1 to 3 Years			4 to 7 Years		
	Count		Estimated (%)	Count		Estimated (%)	Count		Estimated (%)
Injury Type	Estimated	Unweighted		Estimated	Unweighted		Estimated	Unweighted	
Clavicle Fracture	59	12	**25%** *CI (12%-38%)*	52	18	**21%** *CI (12%-30%)*	191	48	**26%** *CI (20%-32%)*
Humerus Fracture	48	10	**20%** *CI (12%-29%)*	107	22	**43%** *CI (33%-53%)*	209	49	**29%** *CI (24%-34%)*
Radius Fracture	36	7	**15%** *CI (0.0%-31%)*	31	9	**12%** *CI (5%-19%)*	176	44	**24%** *CI (18%-30%)*
Ulna Fracture	25	5	**11%** *CI (0.2%-31%)*	30	5	**12%** *CI (7%-17%)*	82	21	**11%** *CI (8%-15%)*
Other	69	13	**6%** *CI (0.0%-31%)*	30	5	**12%** *CI (4%-20%)*	72	22	**10%** *CI (6%-14%)*
Source: NTDB-NSP 2003-2007									

5- Lower Extremity Injuries

Pelvic fractures were higher among children under 1 year old when compared to the other two age groups. Below knee injuries were higher among children 1 to 3 (37%, 95% CI 26%-48%) and 4 to 7 years old (35%, 95% CI 27%-42%) compared with only 17 percent (95% CI 10%-23%) among children under 1 year old (Table 13).

Table 13: Estimated Distribution of AIS 2+ Lower Extremity Injuries by Child Passengers Age Involved in Motor Vehicle Crashes									
	< 1 Year			1 to 3 Years			4 to 7 Years		
	Count		Estimated (%)	Count		Estimated (%)	Count		Estimated (%)
Injury Type	Estimated	Unweighted		Estimated	Unweighted		Estimated	Unweighted	
Pelvis Fracture	111	19	**34%** *CI (24%-44%)*	54	20	**11%** *CI (6%-16%)*	218	61	**23%** *CI (17%-30%)*
Femur Fracture	91	12	**28%** *CI (12%-45%)*	246	61	**49%** *CI (39%-60%)*	354	98	**38%** *CI 3(4%-41%)*
Tibia/Fibula Fracture	55	9	**17%** *CI (10%-23%)*	184	51	**37%** *CI (26%-48%)*	327	80	**35%** *CI (27%-42%)*
Other	68	10	**22%** *CI (18%-24%)*	15	7	**3%** *CI (0.4%-6%)*	43	10	**5%** *CI (2%-7%)*
Source: NTDB-NSP 2003-2007									

CONCLUSION

This analysis demonstrates that the use of child safety seats are effective in reducing the incidence rates of incapacitating injuries for the three age groups and in any motor vehicle traffic crash type. All children involved in rollover crashes had the highest incidence rates of incapacitating injuries. In rollover crashes, the estimated incidence rate of incapacitating injuries among unrestrained children was almost three times that for restrained children. In near-side impacts, unrestrained children were eight times more likely to sustain incapacitating injuries when compared with children restrained in child safety seats.

The head injuries were the most common injuries sustained by children in motor vehicle crashes. Children under 1 year old had higher incidence rates of head injuries when compared to the other two age groups. Similar to head injuries, children under 1 year old had higher incidence rates of thoracic injuries when compared to the other two age groups.

Cerebrum injuries (contusions or lacerations) were the most common type of head injuries among all children included in the analysis. Concussion/unconsciousness were more common among children under 1 year old, when compared to the other two groups. Skull base fractures were more common among children 1 to 3 and 4 to 7 years old than children under 1 year old.

Children under 1 year old were more likely to sustain rib fractures than the other two age groups. On the other hand, lung injuries (contusions or lacerations) were more common among older children than children under 1 year old.

Small-bowel injuries and large-bowel injuries were more common among older children. Pelvic fractures were higher among children under 1 year old when compared to the other two age groups. Below-knee injuries were higher among older children.

The injury outcome in children can be worse than similar injuries sustained by adults.[4] There is a special need to prevent head injuries among children due to their long-term complications. For example, children who suffer traumatic brain injuries can experience lasting or late-appearing neuropsychological problems, highlighting the need for careful monitoring as they get older.

In children, some neurological deficits after head trauma may not manifest for many years.[2] Frontal lobe functions, for example, develop relatively late in a child's growth, so that injury to the frontal lobes may not become apparent until the child reaches adolescence as higher level reasoning develops. Since the frontal lobes control our social interactions and interpersonal skills, early childhood brain damage may not manifest until such frontal lobe skills are called into play later in development. Likewise, injuries to reading and writing centers in the brain may not become apparent until the child reaches school age and shows signs of delayed reading and writing skills.

The information presented in this report aims to provide researchers, parents and policy makers with statistics on children injured in motor vehicle traffic crashes, and it stresses the importance of the using child safety seats.

REFERENCES

1. Fantus, R. J., & Clark, D. E. (2007). Annual Report 2007: More than 2.7 in 2007. NDTB data points. Bulletin of the American College of Surgeons, Vol. 93, No. 1.. Chicago, IL: ACS. http://www.facs.org/trauma/ntdb/fantus/0108.pdf

2. Barlow, K. M., Thompson, E., Johnson, D. & Minns, R.A. (2005) Late Neurologic and Cognitive Sequelae of Inflicted Traumatic Brain Injury in Infancy. *Pediatrics*, Vol. 116 No. 2 pp. e174-e185.

3. MacKenzie, E. J., Shapiro, S., & Eastham, J. N. (1985, June). the Abbreviated Injury Scale and Injury Severity Score: Levels of Inter- and Intrarater Reliability; *Medical Care*, Vol. 23, No. 6, pp. 823-835 www.jstor.org/stable/3764752

4. Fay, T. B., Yeats, K. O., Wade, S. l., Drotar, D., Stancin, T., & Taylor, H. G. (2009). Predicting Longitudinal Patterns of Functional Deficits in Children with Traumatic Brain Injury. *Neuropsychology*, Vol. 23, No. 3, 271–282.

5. The National Center for Injury Prevention and Control. (2008) Centers for Disease Control and Prevention. Injuries Among Children and Adolescents http://cdc.gov/ncipc/factsheets/children.htm

6. NCSA. (2005). National Automotive Sampling System (NASS) General Estimates System (GES) Analytical User's Manual. Washington, DC: National Highway Traffic Safety Administration.

7. Centers for Disease Control and Prevention. (2008, March 28). Strategies to Improve External Cause of Injury Coding in State-Based Hospital Discharge and Emergency Department Data Systems; Recommendations of the CDC Workgroup for Improvement of External Cause-of-Injury Coding. *Morbidity and Mortality Weekly Report*, Vol. 57/No. RR-1. Atlanta, GA: Centers for Disease Control and Prevention.

DOT HS 811 325
May 2010

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