Childhood Crash Injury Patterns Associated with Restraint Misuse

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CIREN- Crash Injury Research and Engineering Network
Death rates among children in motor vehicle crashes through the last decade

NHTSA - Traffic Safety Facts
Pediatric Motor Vehicle Deaths

- Motor vehicle crashes are one of the leading causes of death for 3-13 year olds.
- Premature graduation to seatbelts, none used, or child restraint misuse.
- No decrease in 4-8 yr child occupant death rates between 1994-99.
- Starting in Year 2000 fatality data reported for ages 0-15 dropped to lowest level. (0-4 down 3.9% and 5-15 down 4.6%)
2004 NHTSA Traffic Safety Facts – Total Traffic Fatalities

Total Traffic Fatalities Among Children 14 and Younger by Age Group, 1994-2004

Number of Fatalities

8-14 Years Old

4-7 Years Old

1-3 Years Old

<1 Year Old

NHTSA’s National Center for Statistics and Analysis

Children, Age 0-3, Killed, by Year and Role

[Bar chart showing the number of children killed in vehicle accidents from 1988 to 2005, differentiated by occupants and non-occupants.]
NHTSA’s National Center for Statistics and Analysis

Children, Age 4-7, Killed, by Year and Role

Non-occupant declined, but occupant shows no change last 3-4 yrs
### 2004 Traffic Safety Facts, NHTSA

#### Children Under 5 Years Old Fatally Injured in Passenger Vehicle Crashes by Age Group and Type of Restraint, 2004

<table>
<thead>
<tr>
<th>Type of Restraint</th>
<th>Infants (Under Age 1)</th>
<th>Toddlers (Age 1-4)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>None Used</td>
<td>36</td>
<td>142</td>
<td>178</td>
</tr>
<tr>
<td>Child Safety Seat</td>
<td>80</td>
<td>191</td>
<td>271</td>
</tr>
<tr>
<td>Adult Safety Belt</td>
<td>4</td>
<td>42</td>
<td>46</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120</strong></td>
<td><strong>375</strong></td>
<td><strong>495</strong></td>
</tr>
</tbody>
</table>

#### Restraint Use by Passenger Vehicle Occupants Involved in Fatal Crashes by Age Group, 2004

<table>
<thead>
<tr>
<th>Percentage Unrestrained</th>
<th>&lt;1</th>
<th>1-3</th>
<th>4-7</th>
<th>8-14</th>
<th>All Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>18</td>
<td>28</td>
<td>36</td>
<td>38</td>
<td>37</td>
<td></td>
</tr>
</tbody>
</table>
Children in Side Impacts

Roll of Booster Seat Positioning
Head Injuries

Remember that children are exposed to more surface area for head contact in crashes.
Children that are seated in vehicles expose themselves to more surface area for head contacts. Adults head contacts will occur to the greenhouse structure (roof and roof pillars).
Larger Vehicle and Side Impacts

Large vehicle types vs. compact/economical
Impact to upper door
Upper door panel intrusion

Compact Wagon vs. SUV

Upper door panel intrusion may occur into near-side impact position
Side impacts with larger vehicles with lateral door support beams

Adult pattern
Impact to thoracic region
This becomes head contacts for children
CIREN Case Review

1990’s Compact Sedan
Moderate force
Struck by large pickup
Case review

8 yr.
Back right seat - fully restrained
Sleeping with head against the door panel
No Booster Seat used
Interior Contacts and Door Panel Intrusion

40 cm of intrusion at door panel, window sill

Critical Head Injury
Side impact w/ child in booster seat

7yr old, second row right
Lap/shoulder with booster seat

Minor Head Injury

Head positioned above door interior
Inflatable Curtain

- Booster seat will allow children to possibly benefit from a side impact air bag
FRONTAL IMPACTS

Child Seat Misuse
Rear-facing Infants
Child Seat Tech 101

1. Harness SNUG
2. Retainer clip at armpit level
3. Child seat secured firmly w/ seat belt
1990’s Compact Sedan
Delta V = 12 mph/19kmph
PDOF = -30 or 11 o’clock
Case Review

Infant
Harness not used, and child seat not belted
Interior contacts

Unrestrained child seat flew forward into center instrument panel resulting in a serious head injury
1990’s Compact Sedan

Delta

V=33mph/53kmph
Child less than one year old
Infant rear facing, 5 pt. belt

Flipped forward (backwards for child seat) and then found flipped to the right and on to its side
INJURIES

Severe Head

Severe lower leg injury
Addressing Car Seat Issues

• Incompatibility and incorrect usage
  – LATCH anchorage system

• 100% of vehicles manufactured on or after Sept. 2002 must have lower anchorage

• Sept. 2000 - 100% tether anchorage required
Tether and LATCH System

Flexible 2-Point Lower Attachment With Top Tether

Bars Installed in Vehicle Seat
Frontal Impacts

Forward-Facing Child Seats

Lower Extremity Fractures
Crash Test – Feet protrude forward

A loosely installed child seat and harness straps will increase the lower extremity extension forward
Case Review

1990’s Compact Sedan
Severe frontal impact

Child less than one year old
2nd Seat Left
Early 1990’s Fisher Price model
Forward Facing
Case Review – Misuse FWD

Early 90’s Fisher Price
Adjusted to upright setting
Lap/shoulder restrained without locking clip
Child buckled in straps – should be rear-facing
Case Review – Misuse FWD

Scuff mark on driver’s seat back

Belt webbing mark – no locking clip used
Injuries

Minor Head and Neck Injury

Lower leg fracture
Research on Lower Extremity Injuries in FWD facing car seats (1-4 year olds)

“Crash Analysis of Lower Extremity Injuries in Children Restrained in Forward-Facing Car Seats During Front and Rear Impacts”
T. Bennett MD, Robert Kaufman BS, Melissa Schiff MD MPH, Charles Mock MD PhD, Linda Quan MD

IN PRESS – Journal of Trauma (submitted 12-2004)
Children (1-4 yr.) Lower Extremity Fractures

Research Summary

• CIREN – Evaluated Detailed Case Reviews
• 11 cases meeting criteria (1-4yr., frontal impacts)
  – Sources of lower extremity fractures
    • Three fourths involved contact with interior surface ahead of child
      with over half assigned to the seat back
    – 3 children only using lap or lap/shoulder belt
    – Average Delta V = 29 mph, 46 k/mph
Children (1-4 yr.) Lower Extremity Fractures Research Summary

• National Automotive Sampling System Review
  – 15 children (1-4yrs.) In-line impacts
    • Seatback support sourced to two thirds
    • Lower extremity fractures – 8 femur, 5 tibia/fibula, 2 ankle
    • 14 of 15 involved had a fatality or hospitalized occupant due to injuries.
    • Mean Delta V -40kmph/25mph
Frontal Impacts

Misuse of Forward-Facing Child Seats
Case Review Child Seat Misuse

1990’s Compact Sedan
Case occupant - 2\textsuperscript{nd} row left
2-year old - FWD facing child seat
Exterior Crush

Crush extends down left side with lateral intrusion occurring to left near-side seated positions
Child Safety Seat

- Forward-facing Evenflo car seat with a 5-point harness secured with a retainer clip
- No locking clip used
Contacts and Lateral Intrusion
Pre-impact Location of Child Seat
Forward movement of child seat matched to contact marks on door
Injury Summary

Face/Head – Moderate Injuries
Frontal Impacts

4-8 year olds

Booster positioning
Lap only restraint/Shoulder belt behind back in frontal impacts

Body buckles forward and head/face contact interior surface in front of seating position
Subject Vehicle

1990’s Compact Sedan
Moderate frontal impact

Subject
8 yr. old.

Back left seat
L/S - w/ shoulder belt behind the back
- Head contact
- Shoulder behind back
Injuries

AIS

2 Moderate injury to the face

2 Multiple moderate injuries to the abdomen
Belt Positioning Booster Seats

- Recommended for children 4-8 years old; 40-80 pounds
- Moves belt down off abdomen and neck
- Decrease the risk of head contacts and injury
CIREN Case Review

Subaru
4 yr. child, 2nd Left
Low back booster with lap and shoulder belt
Case Review

4 yr. Old
Booster Seat w/
Lap/Shoulder belt

Cosco Booster
Injuries

4 yr. old
Booster Seat w/ Lap/Shoulder belt

Minor head injury
Minor neck strain
Minor chest injury
Child seats reduce risk of injury

- When used correctly, child safety seats are
  - 71 percent effective in reducing fatalities;
  - 67 percent effective in reducing the need for hospitalization; and
  - 50 percent effective in preventing minor injuries.

Source- NHTSA
Triage for Children in Crashes
Assessing Misuse and Mechanism

• Any external marks to the child face/head
• Near-side impacts
  – Assess height of impact and door intrusion location into head or body
• Frontal impacts
  – Was another occupant in the crash critically injured /or dead
  – And/or significant frontal crush or A-pillar movement
  – Child in appropriate child seat, use of restraints correctly
• Rear or forward facing child seats
  – Is the child seat still firmly secured to the seatbelt
  – Is the harness snug and retainer clip used and positioned mid-chest
  – Examine lower extremities