

Childhood Crash Injury Patterns Associated with Restraint Misuse: Implications for Field Triage



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CIREN- Crash Injury Research and Engineering Network



www.nhtsa.gov/CIREN or find link at HIPRC.org

Seattle
CIREN
Center



Real world laboratory of motor vehicle crashes created by NHTSA in 1996.

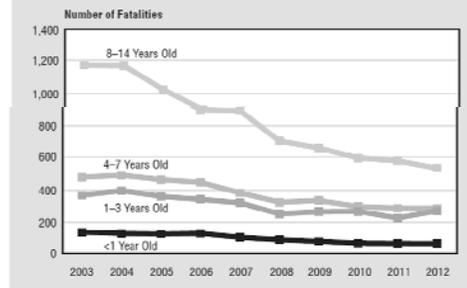
Harborview Injury Prevention and Research Center is one of 6 trauma centers contributing to the CIREN network for NHTSA.

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 are all factors that increase injury severity for children.

NHTSA's National Center for Statistics and Analysis
Traffic Safety Facts 2012

Traffic Fatalities Among Children 14 and Younger, by Age Group, 2003–2012



2012 Traffic Safety Facts, NHTSA

Percent of Passenger Vehicle Occupants Involved in Fatal Crashes, by Restraint Use and Age Group, 2012

Restraint Use (%)	Age Group (Years)							Total
	<1	1-3	4-7	8-14	<15	15-20	>20	
Restraint Used	91	88	82	78	82	63	70	70
Restraint Not Used	9	12	18	22	18	37	30	30

Note: Excluding unknown age and unknown restraint use.

2012 Traffic Safety Facts, NHTSA

Children 4 and Younger Killed in Passenger Vehicles, by Type of Restraint and Age Group, 2012

Type of Restraint	Age Group (Years)		Total
	<1	1-4	
None Used	15	73	88
Adult Seat Belt	2	19	21
Child Seat	34	137	171
Restraint Used—Unknown	0	3	3
Unknown	2	13	15
Total	53	245	298

Children in Side Impacts

Roll of Booster Seat Positioning

Head Injuries

Remember that children are exposed to more surface area for head contact in side impact crashes when not using a booster seat.

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. Passenger vehicles
Impact to upper door may occur

Example of upper door panel intrusion

Compact Wagon vs. side impact with light truck vehicle
Upper door panel intrusion may occur

This becomes head contacts for children

Side View

End View

CIREN Case review



Compact Sedan
 Moderate force
 Struck by large pickup
 8 yr. old
 Back right seat
 – lap/shoulder restrained
 Sleeping with head against
 the door panel
 No Booster Seat used

Interior Contacts and Door Panel Intrusion



Critical Head Injury



40 cm of upper door panel intrusion at location of child's head

Side impact w/ child in booster seat



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



No Head Injury



Head positioned above door interior

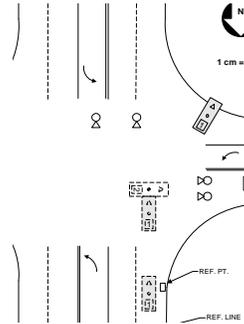
Inflatable Curtain

- Booster seat will allow children to possibly benefit from side impact air bags



Child Seat Misuse Rear-facing Infants

Case Review



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

Significant Frontal Impact

Child less than one year old
 Infant rear facing 5 pt. belt

Loose lap belt allowed child seat to extend additionally forward then it flattened down onto the center console. The child seat then rebounded and flipped over to the right and came to final rest on its side.

INJURIES

Severe Head

Severe bilateral lower leg injuries

Retainer (chest) clip was positioned incorrectly and allowed the upper body to come out of the shoulder straps putting all the loading force on the lower legs.

Frontal Impacts

Forward-Facing Child Seats

Lower Extremity Fractures

Crash Test – Feet protrude forward



A loosely installed forward facing child seat and harness straps will increase the lower extremity extension forward allowing a greater chance of contact with the seatbacks.

Case Review



Compact Sedan
Severe frontal impact



Child less than one year old
2nd Seat Left
Forward Facing Child Seat

Case Review – Misuse FWD



Lap/shoulder restrained without locking clip
Child should have been rear-facing for age



Adjusted to upright setting



Case Review – Misuse FWD

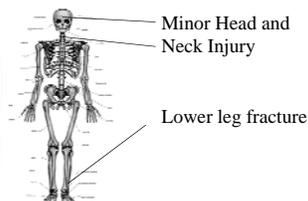


Scuff mark from lower leg on driver's seat back



Belt webbing loading mark – no locking clip used, allowed more child seat movement forward

Injuries



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

Bennet T., Kaufman, Schiff M., Mock C., Quan L. "Crash analysis of lower extremity injuries in children in forward-facing car seat during front and rear impacts." *Journal of Trauma*. 2006;61-592-597



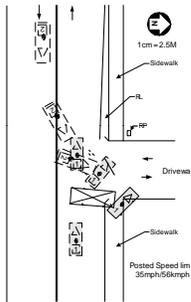
Children (1-4 yr.) Lower Extremity Fractures Research Summary

- CIREN – Evaluated Detailed Case Reviews
- Selected 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 were only using lap or lap/shoulder belt
 - Average Delta V = 29 mph, 46 k/mph

Frontal Impacts

Misuse of Forward-Facing Child Seats

Case Review Child Seat Misuse



Compact Sedan

Case occupant - 2nd row left
2-year old - FWD facing child seat

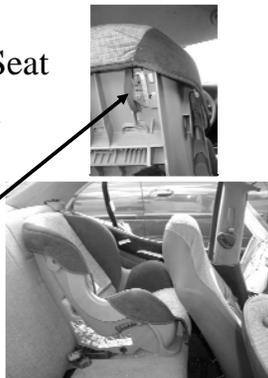
Exterior Crush



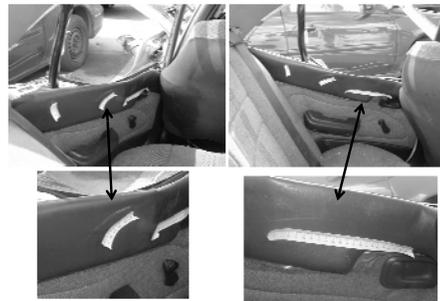
Crush extended down left side with some lateral door panel intrusion occurring to the left near-side seat positions

Child Safety Seat

- Forward-facing child car seat with a 5-point harness not secured with a retainer clip
- No locking clip used to secured child seat in vehicle



Contacts and Lateral Intrusion



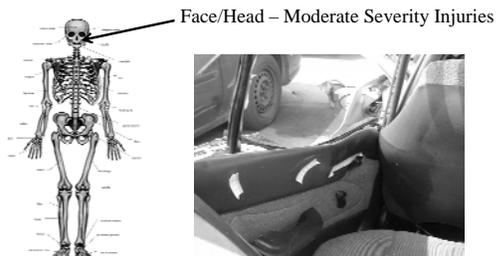
Pre-impact Location of Child Seat



Forward movement of child seat matched to contact marks on door



Injury Summary



Frontal Impacts

4-8 year olds
Booster seat positioning

Lap only restraint and shoulder belt behind back in frontal impacts

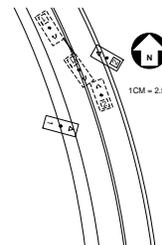


Body buckles forward and head/face contacts interior surface in front of seating position with significant loads also occurring to abdomen.

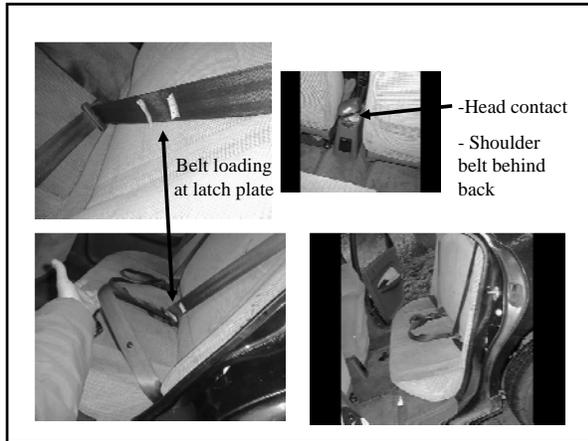
Subject Vehicle



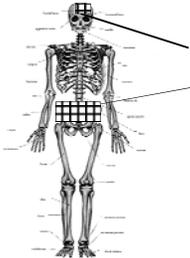
Compact Sedan
Moderate frontal impact



Subject
8 yr.old.
Back left seat
L/S - w/ shoulder belt
behind the 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
- Better positioning angle over bony pelvis
- Decrease the risk of head contacts and injury



Success Case Review



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

Case Review



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

Injuries




- Minor head injury
- Minor neck strain
- Minor chest injury

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

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

Child Seat Tech 101 for First Responders



1. Harness SNUG

2. Retainer (Chest) clip at armpit level



3. Child seat found secured firmly w/ seat belt

Bulger EM, Kaufman R, Mock C: Childhood crash injury patterns associated with restraint misuse: Implications for field triage. *Prehospital Disast Med* 2008;23(1):9–15.

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