

EPOCH – COVER – CASPER workshop

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Mechanism of Injury in Older Children



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Introduction

1 Overview of Collision studies

Injury Distribution – Restraint type

Injury Patterns – Front Impact

Injury Patterns – Side Impact

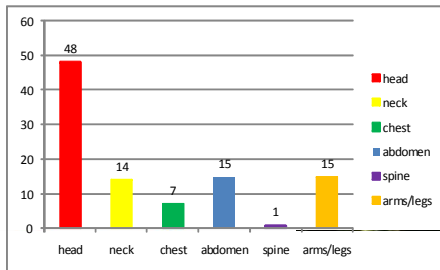
2 Mechanisms of Injury in Older Children

Children in Front Impact

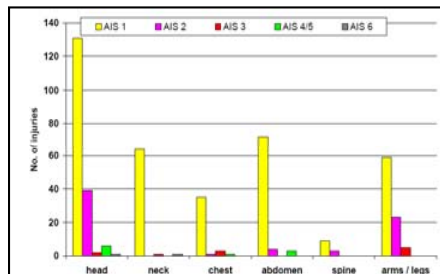
Children in Side Impact

Injury patterns for children of all ages (Johannsen 2004)

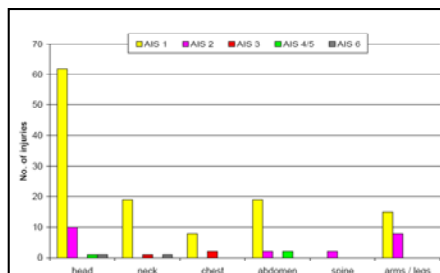
Single digit of the AIS 2005 6-digit UNI injury description indicates: AIS 1: Minor, AIS 2: Moderate, AIS 3: Serious, AIS 4: Severe, AIS 5: Critical, AIS 6: Maximum, AIS 9: Unknown



- A 90's accident study (Johannsen, 2004) showed that for children using a CRS properly, head injury are the most prevalent, followed by abdominal injuries and injuries to the extremities.
- The study does not specifically examine the effect of children travelling in booster systems or identify how many older children were involved.



- For 415 children of all ages and restraint types, the head region received the majority of injuries, followed by the abdomen, neck, limbs and chest.
- The most severe injuries were to the head, followed by the limbs.

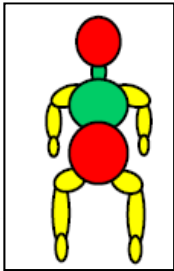


- For 200 children using CRS the head region received the majority of injuries, followed by the abdomen and neck.
- Broadly similar to the previous figure

Front impact

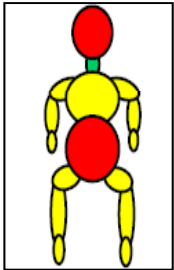
Injury patterns for children involved in front impacts

From Child Safety report and the Q dummies report (EEVC, 2008):



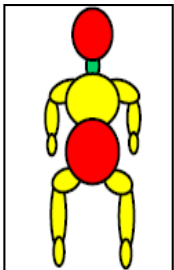
- **Booster seat and adult seat belt (group II/III):**

- Children most likely of an age between 3 and 6 years; head is the most sensitive body region, in terms of the frequency of severe injuries.
- The importance of abdominal injuries increases because the penetration of the lap section of the seat belt into the abdomen can cause injuries to the liver, spleen, and kidneys. Therefore, the abdominal area is a high priority.
- Chest injuries are not frequently reported for children seated on booster, but as the chest cavity protects vital organs, it remains an important body segment.
- The pelvis rarely suffers severe injuries in frontal impact and therefore is not a priority body region (as well as limbs even if fractures do occur).



- **Booster cushion and adult seat belt (group II/III):**

- The main body regions injured with booster cushion type CRSs are the same as for booster seats .
- In comparison with booster seats, an increase of the number of chest injuries is found, due to the fact that children using these CRSs are generally older.

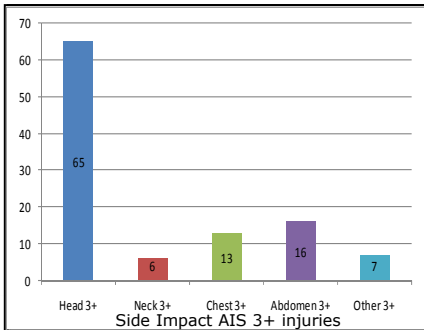


- **Adult seat belt:**

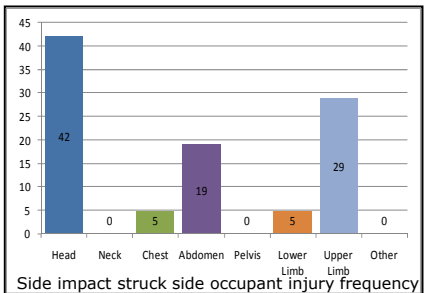
- The main body regions injured when only using the adult seat belt are similar to the ones when using booster cushions. However, the injuries are generally more severe especially in the abdominal area.

Side Impact

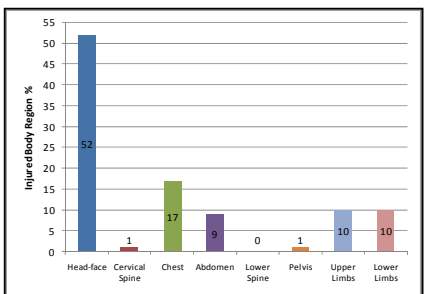
Injury patterns for children in side impact according to body region and CRS



- In the Child Safety Report (EEVC, 2006), head injuries accounted for 65% of all the severe injuries recorded in all restraint types.
- For systems without side wing protection, severe injuries occur in the chest and abdomen.
- Though the number of AIS3+ neck injuries observed was low, the child was fatally injured.



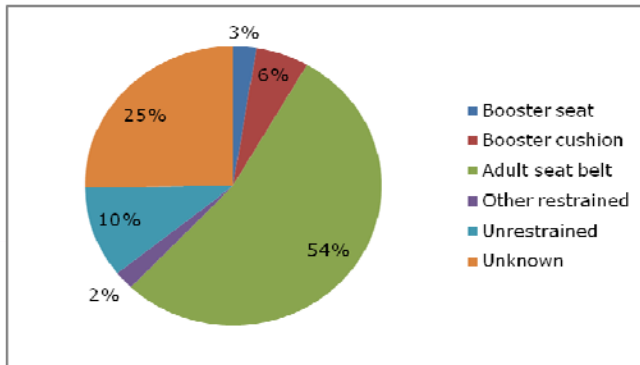
- An analysis of the French database CSFC shows that the side impact collisions represent 16% of the total accidents.
- 206 children were involved and 37% of them were uninjured, 43% sustained minor injuries, and 20% were severely injured.



- Lesire (CREST, CHILD) identified that 35 children seriously injured were using booster type restraints (likely not all older children).
- Head injuries represented over 50% of the injuries, the chest 17% and the abdomen 9%.

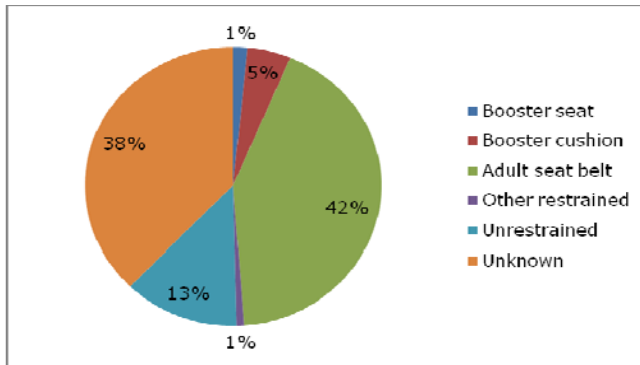
Involvement of older children in collisions

Cooperative Crash Injury Study (CCIS) database: accidents from 1998 to 2008 involving children 6 – 12 years of age.



Front impact

- 277 children involved in a front impact collision for all restraint types and injury levels.



Side impact

- 127 children involved in a side impact for all restraint types and injury levels.

The majority of children aged five to eleven were restrained by adult belt only and there was a greater proportion of children unrestrained than using child restraint systems.

Injury distribution with - restraint type for children aged 6 to 12 years

- Too few cases involving children in booster systems to compare performance to adult seat belt.
 - However - no AIS>2 injuries to children in booster seats.

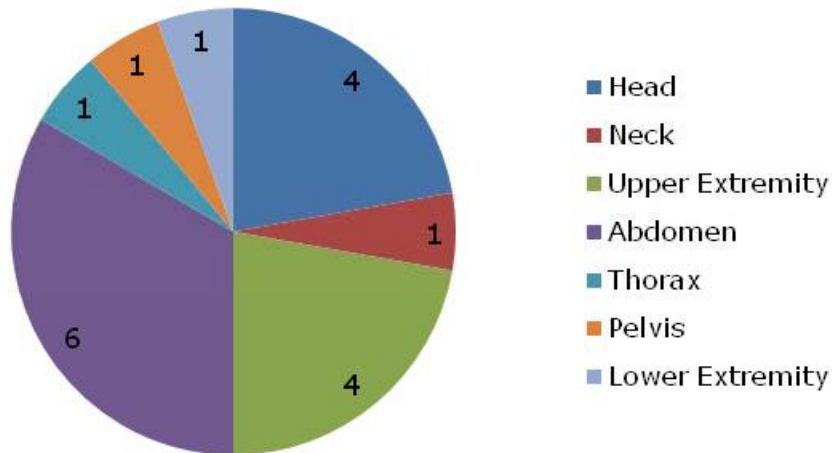
Restraint type	Total	MAIS0		MAIS1		MAIS2		MAIS≥3		Unknown	
		n	%	n	%	n	%	n	%	n	%
Booster seat	7	1	14.3	5	71.4	0	0	0	0	1	14.3
Booster cushion	16	1	6.3	8	50	1	6.3	1	6.3	5	31.3
Adult seat belt	149	20	13.4	107	71.8	8	5.4	5	2.7	9	6
Other restrained	6	1	16.7	2	33.3	0	0	1	16.7	2	33.3
Unrestrained	29	6	20.7	15	51.7	4	13.8	3	10.3	1	3.4
Unknown	70	17	24.3	36	51.4	4	5.7	3	4.3	10	14.3
Total	277	46	16.6	173	62.5	17	6.1	13	4.7	28	10.1

Injury Patterns in Front impact

- Fifteen restrained children (aged 6 to 12 years) received AIS \geq 2 injuries
 - Average age of restrained children – 9.3
 - Average velocity change (Δv) was 48 km/h
 - 6 children - were in front passenger seat
 - 9 children - were in rear outboard seats
 - 12 children - using just adult belt
 - 3 children - using booster cushions + adult belt

Injury Patterns in Front impact

Distribution of AIS ≥ 2 injuries – restrained children



- Most injuries
 - Abdomen
 - Head
 - Upper extremity
- 3 children on booster cushions
 - No abdomen injuries (low numbers)
- Supported by literature

Older Children in Front Impact

Factors affecting.....

.....injury

- Δv of case vehicle - greater injury severity
 - Δv unknown for most of cases $AIS \geq 3$
- Intrusion into seating position - greater injury severity
 - facia and footwell
- Misuse - greater injury severity
 - no information available in sample

.....performance of CRSs

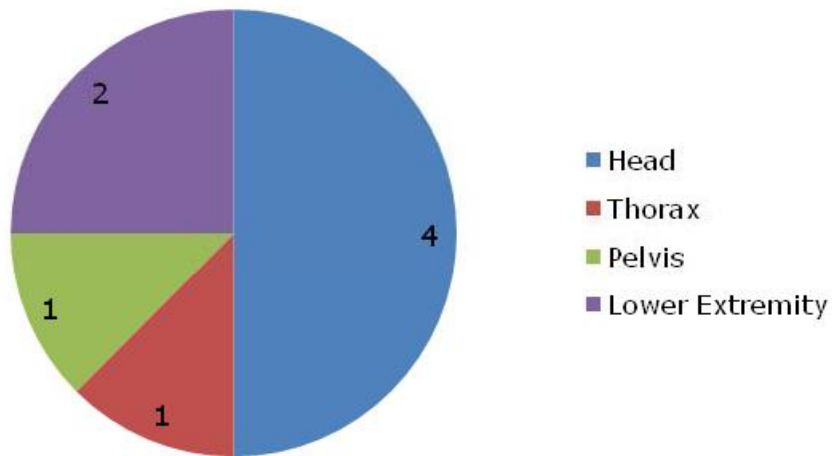
- 23/277 children – used a CRS
 - 7 - booster seat
 - 16 - booster cushion
- Booster seats - 0 $AIS \geq 2$ injuries
- Booster cushions - 3 $AIS \geq 2$ injuries
- Too few cases of CRS use for:
 - clear associations
 - related to performance
 - contributory factors
 - related to performance

Injury Patterns in Side impact

- Five restrained children (aged 6 to 12 years) received AIS \geq 2 injuries
 - Average age of restrained children – 7.8
 - Average velocity change (Δv) was 26 km/h
 - 1 child – was in front passenger seat
 - 4 children - were in rear outboard seats
 - 5 Children - using just adult belt
 - 0 children - using booster systems + adult belt

Injury Patterns in Side impact

Distribution of AIS ≥ 2 injuries (n=8) – restrained children



- 4 injuries
 - Head
- 2 injuries
 - Lower extremity
- Supported by literature

Older Children in Side Impact

Factors affecting.....

.....injury

- Too few cases with AIS \geq 2 injuries to identify
 - likelihood or severity of injury
- In general – of importance
 - proximity of child to side structure
 - level of intrusion
- 4/5 cases with AIS \geq 2 injuries
 - child was on the struck side
- 2/5 cases with AIS \geq 2 injuries
 - in car unlikely - approved to UN-ECE Regulation 95

.....performance of CRSs

- No children with AIS \geq 2 injuries used booster systems
 - impossible to comment on the performance of CRSs sin side impact

Mechanisms of injury in older children

Children in front impact

- Head Injury
 - Contact – vehicle interior
 - Fracture OR local brain injury
- Vehicle intrusion
- Poor restraint - head excursion

- Abdomen injury
 - Adult seat belt loading
- Submarining
- Poor belt positioning

- Injury to extremities
 - Contact – vehicle interior
 - Fracture
- Loose CRS
- Vehicle seat back

Mechanisms of injury in older children

Children in side impact

- Head Injury
 - Contact – vehicle interior
 - Fracture OR local brain injury
- With and without vehicle intrusion

- Lower extremities
 - Contact – vehicle interior
 - Fracture
- Intrusion of vehicle structure

For more information
Email: EPOCH@trl.co.uk
www.epochfp7.org



Enabling Protection for Older Children

