INJURIES FROM Child RESTRAINT MISUSE

Kristopher Lyon, MD, EMT, FACEP, FAEMS
Scope of the problem (2016)

723 children 12 or younger died

Restraints saved 328 children under 5 years old
Scope of the problem (2016)

- 128,000 children 12 or younger were injured
- Car seat use reduced injuries by 71-82%
- Booster seats reduce the risk for serious injury by 45% for children 4-8 years old
ALMOST $\frac{1}{2}$ OF BLACK AND HISPANIC CHILDREN WHO DIED WERE NOT RESTRAINED (2009-2010)
1/3 OF ALL CHILDREN WHO DIED IN CRASHES IN 2011 WERE NOT BUCKLED!

Evidence shows that state laws result in more children being buckled up.

Only 2 states (Tennessee and Wyoming) have child passenger restraint laws requiring car seat or booster seat use for children age 8 and under.

Child passenger restraint laws that increase the age for car seat or booster seat use result in more children being buckled up. Among five states that increased the required car seat or booster seat age to 7 or 8 years, car seat and booster seat use tripled, and deaths and serious injuries decreased by 17%.

SOURCE: Insurance Institute for Highway Safety, 2013

Note: Only age was used to determine child passenger restraint law coverage. Some states also have specific height and/or weight requirements.
Death rate per 100,000 children aged 12 or younger 2002-2011

- 2002 — 2.2
- 2003 — 2.1
- 2004 — 2.3
- 2005 — 2.1
- 2006 — 2.0
- 2007 — 1.7
- 2008 — 1.3
- 2009 — 1.4
- 2010 — 1.2
- 2011 — 1.2

MORE THAN 800 ADDITIONAL LIVES COULD HAVE BEEN SAVED IF CAR SEATS WERE USED BY 100% OF 0-4 YEAR OLDS FROM 2002-2011.

Keep California safe. Encourage drivers and passengers to buckle up.

This fact sheet provides a snapshot of motor vehicle occupant deaths and seat belt use and an overview of proven strategies for increasing the use of seat belts, car seats, and booster seats. The information can help local public health decisionmakers and community partners see gaps and identify relevant strategies to encourage people to buckle up.

**Fast Facts**

- Motor vehicle crashes are a leading cause of death during the first three decades of Americans’ lives.
- By wearing seat belts and properly buckling children into age- and size-appropriate car seats and booster seats, people can reduce the risk of serious injury and death in a crash by half.
- Although most drivers in the United States follow these safety measures on every trip, there are still millions who don’t.
- These data show what’s happening in your state.

**MOTOR VEHICLE OCCUPANT DEATHS**

Number of Deaths, 2003−2012

23,125 motor vehicle occupants were killed in California

Rate of Deaths by Age (per 100,000 population), 2012

<table>
<thead>
<tr>
<th>Age Group</th>
<th>National</th>
<th>California</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>10.8</td>
<td>6.9</td>
</tr>
<tr>
<td>21-34</td>
<td>6.8</td>
<td>4.0</td>
</tr>
<tr>
<td>35-54</td>
<td>8.1</td>
<td>4.5</td>
</tr>
<tr>
<td>55+</td>
<td>7.0</td>
<td>4.2</td>
</tr>
<tr>
<td>All ages</td>
<td>8.6</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Rate of Deaths by Gender (per 100,000 population), 2012

<table>
<thead>
<tr>
<th>Gender</th>
<th>National</th>
<th>California</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>9.4</td>
<td>5.6</td>
</tr>
<tr>
<td>Female</td>
<td>4.7</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Source: Fatality Analysis Reporting System (FARS).

**RERAINT USE**

Percentage of Drivers and Front Seat Passengers Wearing Seat Belts

<table>
<thead>
<tr>
<th></th>
<th>National</th>
<th>California</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td>86%</td>
<td>96%</td>
</tr>
<tr>
<td>Front seat passengers</td>
<td>86%</td>
<td>96%</td>
</tr>
</tbody>
</table>


Working together, we can help keep people safe on the road—every day.
Crandall, J.R. 2013, Pediatric Injury Biomechanics
Research on the effectiveness of RFCRS has found them to reduce fatal injury by 71% for infants <1 year of age in passenger cars and by 58% in light trucks (Hertz 1996).

In Sweden, children remain rear facing up to the age of 4 years and transition directly from the RFCRS to a booster seat.

Crandall, J.R. 2013, Pediatric Injury Biomechanics
Children age 0-23 month across all types of crash are 76% more likely to be seriously injured if restrained in forward facing child restraint system when compared to children in rear facing child restraints.

Crandall, J.R. 2013, Pediatric Injury Biomechanics
12% of fatalities due to gross misuse of the child restraint.

Crandall, J.R. 2013, Pediatric Injury Biomechanics
Restraint Misuse

Decina and Lococo 2005
72.6% of 5000 children observed had some form of misuse

Greenwell 2015 46% misuse
Contact Head Injuries

- Excursion of the head
- Intrusion
- Looseness of restraint harness.
- Looseness of restraint attachment.
Contact Injuries

- Skull Fracture
Contact Injuries

- Epidural Hematoma
Contact Injuries

- Frontal Lobe Contusion
Non Contact Head Injuries

- Loose attachment to vehicle limits effectiveness of vehicle energy management systems.
- Loose harness allows movement between torso and back of seat.
- Produce brain injuries without external trauma.
Extremity Injuries

- Increased movement of FFCRS allows lower extremities to contact front seatback.
Cervical Spine

- Rare in restrained children.
- Higher mortality due to upper cervical spine
- Under 8-9 years may injuries of upper C Spine and SCIWORA
DURBIN ET AL 2003 59% LOWER ODDS OF INJURY IN 4-7 YEAR OLDS VERSUS SEATBELTS
Seat-Belt Syndrome

- Distinct pattern of injury associated with lap belts.
  - *Hip and abdominal contusions aka seatbelt sign*
  - *Pelvic fractures*
  - *Lumbar spine injuries*
    - Subluxations
    - Compression fractures of L2-L4
  - *Intra-abdominal injuries of solid organs and hollow viscera*
    - GI perforation
    - Small bowel mesenteric tears and perforation
SEAT BELT SYNDROME
Seat Belt Syndrome

Risk Factors:

- Age 4-8
- Poor fit of belt
- Child movement forward prior to crash
- Shoulder belt placed behind back

Children with appropriate CRS 1/3 as likely as suboptimally restrained to sustain abdominal injury
Seat Belt Syndrome

- Lumbar Fractures: Due to excessive flexion
  - Chance fractures
  - Compression fractures
Airbags

- Children 12 and younger should not be placed in the front seat especially with active airbag.
  - Atlanto-occipital fracture
  - Brainstem injuries
  - Diffuse axonal injury
SEATING POSITION

Center rear seat considered safest for children in child restraints (Lund 2005)
<table>
<thead>
<tr>
<th></th>
<th>RFCRS, 0–11-month-olds</th>
<th>FFCRS, 12–47-month-olds</th>
<th>Belt-positioning booster seats, 4–7-year-olds</th>
<th>Seat belt (lap and lap–shoulder), 4–7-year-olds</th>
<th>Seat belt (lap and lap–shoulder), 8–15-year-olds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall AIS2+ injury risk (per 1,000 children in crashes)</td>
<td>2.3</td>
<td>3.0</td>
<td>4.9</td>
<td>16.6</td>
<td>13.6</td>
</tr>
<tr>
<td>Head (%)</td>
<td>83.3</td>
<td>56.9</td>
<td>61.1</td>
<td>67.3</td>
<td>62.5</td>
</tr>
<tr>
<td>Face (%)</td>
<td>0.0</td>
<td>8.3</td>
<td>7.0</td>
<td>5.8</td>
<td>6.5</td>
</tr>
<tr>
<td>Chest (%)</td>
<td>2.4</td>
<td>2.8</td>
<td>5.7</td>
<td>1.3</td>
<td>5.9</td>
</tr>
<tr>
<td>Abdomen (%)</td>
<td>2.4</td>
<td>3.3</td>
<td>8.9</td>
<td>17.8</td>
<td>7.1</td>
</tr>
<tr>
<td>Neck/spine (%)</td>
<td>0.0</td>
<td>1.7</td>
<td>1.3</td>
<td>0.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Upper extremity (%)</td>
<td>7.1</td>
<td>8.3</td>
<td>7.0</td>
<td>4.5</td>
<td>11.0</td>
</tr>
<tr>
<td>Lower extremity (%)</td>
<td>4.8</td>
<td>18.8</td>
<td>8.9</td>
<td>2.5</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Data from PCPS from 12/1/98-11/30/07. Limited to model year 1998 and newer vehicles. Differences between restraint types should not be interpreted as statistically significant differences.
### Table 2.3 Summary of restraint effectiveness data

<table>
<thead>
<tr>
<th>Restraint</th>
<th>Effectiveness for reducing fatalities</th>
<th>Comparison group</th>
<th>Effectiveness at reducing serious injuries</th>
<th>Comparison group</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFCRS</td>
<td>71% reduction (Hertz 1996)</td>
<td>Unrestrained occupants up to 1 year of age</td>
<td>44% reduction (Henary et al. 2007)</td>
<td>Children aged 0–23 months in FFCRS</td>
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<tr>
<td></td>
<td>44% reduction (Henary et al. 2007)</td>
<td></td>
<td>90% reduction (Jakobsson et al. 2005)</td>
<td>Unrestrained occupants up to 4 years of age</td>
</tr>
<tr>
<td>FFCRS</td>
<td>71% reduction for correctly used seats (Kahane 1986)</td>
<td>Unrestrained occupants 0–4 years of age</td>
<td>72% reduction (Winston et al. 2000)</td>
<td>Seat belt restrained 2–5-year-olds</td>
</tr>
<tr>
<td></td>
<td>54% reduction (Hertz 1996)</td>
<td>Unrestrained occupants 1–4 years of age</td>
<td>71% reduction (Arbogast et al. 2004b)</td>
<td>Seat belt restrained 1–4-year-olds</td>
</tr>
<tr>
<td></td>
<td>28% reduction (Elliott et al. 2006)</td>
<td>Seat belt restrained 2–6-year-olds</td>
<td>82% reduction (Zaloshnja et al. 2007)</td>
<td>Seat belt restrained 2–3-year-olds</td>
</tr>
<tr>
<td></td>
<td>67% reduction (Rice and Anderson 2009)</td>
<td>Unrestrained children aged 3 and under</td>
<td>59% reduction (Durbin et al. 2003a)</td>
<td>Seat belt restrained 4–7-year-olds</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>45% reduction (Arbogast et al. 2009a)</td>
<td>Seat belt restrained 4–8-year-olds</td>
</tr>
<tr>
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<td>45% reduction in MAIS ≥ 2 injuries (NHTSA 2010)</td>
<td>Seat belt restrained 4–8-year-olds</td>
</tr>
<tr>
<td>BPB</td>
<td>67% reduction for children aged 4–5 years (Rice and Anderson 2009)</td>
<td>Unrestrained 4-5-year-olds</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>55% reduction for children aged 6–8 years (Rice and Anderson 2009)</td>
<td>Unrestrained 6–8-year-olds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seat belts</td>
<td>29% reduction in frontal impact crashes (Morgan 1999)</td>
<td>Unrestrained occupants aged 5 and older</td>
<td></td>
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</tr>
</tbody>
</table>
Using the correct car seat or booster seat can be a lifesaver: make sure your child is always buckled in an age- and size-appropriate car seat or booster seat.

**REAR-FACING CAR SEAT**
Birth until age 2-4
Buckle children in a rear-facing car seat until they reach the maximum weight or height limit of their car seat. Keep children rear-facing as long as possible.

**FORWARD-FACING CAR SEAT**
After outgrowing rear-facing seat until at least age 5
When children outgrow their rear-facing car seat, they should be buckled in a forward-facing car seat until they reach the maximum weight or height limit of their car seat.

**BOOSTER SEAT**
After outgrowing forward-facing seat and until seat belts fit properly
Once children outgrow their forward-facing seat, they should be buckled in a booster seat until seat belts fit properly. Proper seat belt fit usually occurs when children are 4 feet 9 inches tall and age 9-12.

**SEAT BELT**
Once seat belts fit properly without a booster seat
Children no longer need to use a booster seat once seat belts fit them properly. Seat belts fit properly when the lap belt lays across the upper thighs (not the stomach) and the shoulder belt lays across the chest (not the neck).

Keep children ages 12 and under properly buckled in the back seat. Never place a rear-facing car seat in front of an active air bag.

*Recommended age ranges for each seat type vary to account for differences in child growth and height/weight limits of car seats and booster seats. Use the car seat or booster seat owner’s manual to check installation and the seat height and weight limits, and proper seat use.