Injury Prevention & Crash Dynamics

Objectives

- Describe challenges to crash survival.
- Explain the concept of crash forces.
- Describe five ways that car seats, booster seats, and seat belts prevent injury.

Challenges to Crash Survival

Motor vehicle crashes are a leading cause of death in the U.S. (CDC, 2013)
(Based on latest mortality data available from CDC's National Center for Health Statistics)

- ☑ Car seat, booster seat, and seat belt use decrease, as children get older. Most children are restrained during the first year of life because they appear to be more fragile and need more protection (NHTSA, 2010).
- ☑ Car seat, booster seat, and seat belt misuse rates vary from 74 to 90% (NHTSA, 2005).
- ☑ Misuse and nonuse are important issues to address with caregivers.
- ☑ Correct selection, installation, and use of a car seat can be challenging.
- ☑ Caregivers may have outdated or incorrect information about car seats, booster seats, and seat belts.
- ☑ Caregivers may not choose best practice over personal preferences or actual safety over perceived safety. For example, caregivers might prioritize wanting to see the child more easily and move the child to a forward-facing car seat over best practice recommendations.

INJURY PREVENTION is a process used to decrease injuries or death due to an injury. However, it does not work 100 percent of the time.

Many factors in a crash determine outcomes such as vehicle size, speed, and point of impact.

Because the heads of young children are disproportionately large compared to their bodies and their pelvic bones and spines are underdeveloped, correctly installed and used car seats, booster seats, and seat belts help to protect children in vehicles.

Fatalities are just the tip of the iceberg. Many more injuries occur than deaths each year. Some injuries have lifelong effects and can be costly.

Vehicle crashes can result in injuries and deaths

By understanding the correct use of car seats, booster seats, and seat belts, it is easy to see errors and misuse – and offer information and resources to caregivers to correct the errors and misuse.

Resources for Current Injury and Misuse Data

Examples of resources for current injury, misuse, and error rates in your community and across the nation are listed below. Resources for current data are also available at www.cpsboard.org.

- American Academy of Pediatrics (AAP) at http://www.aap.org
- Car seat and booster seat and vehicle manufacturer websites
- Centers for Disease Control and Prevention (CDC) at www.cdc.gov/injury/WISQARS
- Children's Hospital of Philadelphia (CHOP) at http://www.chop.edu/service/car-seat-safety-for-kids/index.html
- Governors Highway Safety Administration (GHSA) at www.ghsa.org
- Insurance Institute for Highway Safety (IIHS) at www.highwaysafety.org or http://www.iihs.org
- National Highway Traffic Safety Administration (NHTSA) at www.safercar.gov
- NHTSA's National Center for Statistics and Analysis (NCSA) at www.nhts.gov
- Safe Kids Worldwide at http://www.safekids.org
- State and local health departments

NOTE: Review educational materials (articles, websites, videos, brochures, handouts, etc.) every year to be sure you are providing accurate and current information. Go to NHTSA's http://www.trafficsafetymarketing.gov for up-to-date consumer information.

"CPS Technicians play such a critical role in explaining the engineering of crash dynamics in lay terms so parents understand the reasons behind best practice recommendations."

Kristy Arbogast, PhD
Center for Injury Research and Prevention
Children's Hospital of Philadelphia

The Concept of Crash Forces

There are many factors related to injury prevention that must be considered before, during, and after a crash to prevent or minimize injuries from occurring. Here are a few examples:

- Road conditions before the crash
- Car seat use during the crash
- Seat belt use (such as using lap belt correctly or incorrectly) during the crash
- Emergency response time after the crash

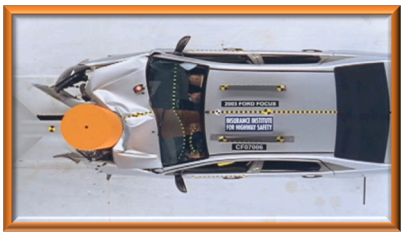
You might do everything correctly when driving safely and still get into a collision. One way to understand the value of occupant protection and how it helps you survive a collision is to look at the dynamics of a collision. Every vehicle collision includes three crashes.

- The vehicle crash
- The human crash
- The internal crash

VIDEO • 3 Stages of a Collision

Watch carefully for and take notes about the characteristics of the three stages (crashes) of a collision below.

☑ **The Vehicle Crash.** The first stage involves the vehicle. A crash causes the vehicle to buckle and bend as it hits something and comes to an abrupt stop. This occurs in approximately 1/10 of a second in a front-end collision. The crushing of the front end absorbs some crash forces and cushions the rest of the vehicle. As a result, the passenger compartment comes to a more gradual stop than the front of the vehicle.



The vehicle crash

☑ **The Human Crash.** The second stage occurs as the vehicle stops. In a crash, occupants move toward the point of impact, at the vehicle's original speed. Just after the vehicle comes to a complete stop, occupants collide with the steering wheel, windshield, seat belt, or some other part of the vehicle interior. This is the human crash. **NOTE:** All objects in the vehicle move with the same speed upon impact whether belted or not.

Another form of the human crash is the person-to-person impact:

- Unbelted occupants colliding with each other or an unbelted occupant colliding with a belted occupant can cause many serious or fatal injuries.
- Unbelted rear-seat occupants become high-speed projectiles striking people in the front seat.

The human crash

Some crashes are so violent that even properly restrained occupants are injured or killed. If the occupant compartment is crushed, car seats and seat belts may be unable to prevent injury or death.

☑ **The Internal Crash**. The third stage occurs after an occupant's body comes to a complete stop. The internal organs are still moving forward until the organs hit something. Suddenly, organs hit other organs or the skeletal system. This third crash is the internal crash, often causing serious or fatal injuries.

The internal crash

Crash Forces: Weight X Speed = Restraining Force

In any crash, even a minor one, occupants in the vehicle can be seriously injured. Most people are unaware of the force a vehicle has when moving. Consider:

- A vehicle going 40 mph would hit a tree with the same force as hitting the ground after falling off a 50-foot cliff. A person inside the vehicle would hit the windshield with the same force as hitting the ground after a fall from a 5-story building.
- It is important for caregivers to understand that the forces involved in a crash can kill or cause serious injuries to themselves and their child.
- One way to help caregivers understand such forces is to explain that the force needed to restrain an occupant approximately equals the weight of the occupant multiplied by the vehicle speed.

  Example: A 10-pound infant in a vehicle moving at 30 miles per hour could require at least 300 pounds (10 x 30 = 300) of restraining force to keep from moving forward.

It is important for caregivers to understand that holding a child in their lap or unrestrained presents great risk to the unbelted child.

Progress Check: Estimating Restraining Force

Estimate restraining force using your weight and a crash at 30 mph.

Rollovers, Rotations, and Ejection

Dangerous crash events can occur in almost any type of collision or chain of crash events. Here are the most common types of crashes and their related injuries.

- Frontal crashes are the most frequent and can result in neck, head, upper body, and lower body injuries.
- Rear-end crashes are also common and can result in back and neck injuries.
- Lateral and side impact crashes can result in torso, head, hip, and leg injuries.
- A **rollover** crash occurs when the vehicle rolls over onto its side or top (upside down) one or more times. A **vault** is similar, but the vehicle flips end over end. A rollover/vault is often responsible for occupants being thrown from vehicles.

Rollovers, Rotations, and Ejection (continued)

- In a **rotation** (or spin), unrestrained occupants are more likely to be injured as they hit the vehicle interior repeatedly and are much more likely to be thrown from the vehicle than restrained occupants.
- In an **ejection**, vehicle occupants are thrown out a window or door, skid along the pavement, and may be pinned or crushed under a vehicle. Landing gently on a soft surface is highly unlikely.
- A common myth about car seat, booster seat, and seat belt use is that occupants are better off being thrown clear of a crash. People thrown from a vehicle are four times more likely to be killed than those who remain inside (NHTSA, 2009).

Even in the very rare chance of a vehicle fire or landing in the water, a properly belted occupant is more likely to be uninjured and conscious, thus able to exit from the vehicle.

2-year-old correctly restrained

How Car Seats, Booster Seats, and Seat Belts Prevent Injury

The use of car seats, booster seats, and seat belts is one of the most important actions that can be taken to prevent injury in a vehicle crash. While car seats, booster seats, and seat belts do not prevent crashes from taking place, they play a major role in reducing the severity of injury to vehicle occupants involved in a collision. An occupant's chance of survival increases dramatically when appropriately restrained.

4-year-old correctly restrained

What are the ways in which car seats, booster seats, and seat belts can prevent injury?

- ☑ Keep people in the vehicle.
- ☑ Contact the strongest parts of the body.
- ☑ Spread forces over a wide area of the body.
- ☑ Help the body to slow or "ride down" the crash forces.
- ☑ Protect the head, brain, and spinal cord.

6-year-old correctly restrained

How Car Seats, Booster Seats, and Seat Belts Prevent Injury (continued)

Here are additional points to understand and emphasize when talking with caregivers or others.

- Car seats, booster seats, and seat belts are designed to contact the body at the strongest parts of its structure. For an older child and adult, these parts are the hips and shoulders.
- Car seats, booster seats, and seat belts are designed to spread crash forces over a wide area of the body, putting less stress on any one part.
  - Lap-and-shoulder belts and car seat harnesses spread the force across a large area of the body.
  - A rear-facing car seat spreads the crash force across the shell of the seat, protecting the child's head, neck and spinal cord.
- A quick change in speed is what causes injury.
  - During a motor vehicle crash, the vehicle crush zones help to extend the time it takes for the vehicle and its occupants to slow down.
  - Car seats, booster seats, and seat belts allow the body to slow down with the crash. This extends the time when the occupant experiences the forces during a crash.
- A shoulder belt or harness helps to keep the head and upper body away from the hard interior surface of the vehicle.

8-year-old correctly restrained

15-year-old correctly restrained

An occupant's chance of survival increases dramatically when appropriately restrained

TIPS FOR DISCUSSING INJURY PREVENTION

- **Make sure children are safe in and around vehicles – even when not on the road.**
- **Caregivers must be educated on avoiding a vehicle backover, ensuring children are not accidentally locked in vehicle trunks, and preventing children from being caught in a power window.**
- **Injury prevention requires education supervision, and attention.**

Wearing a seat belt enables a person to receive the full benefit of the air bag and other safety features in the vehicle.

Car Seats/Booster Seats, Seat Belts, and Air Bags = The Best Chance of Survival

Progress Check and Summary

Answer the following questions to prepare for conversations you will have with caregivers to educate them about injury prevention and crash dynamics.

1. What are two challenges related to children, crash survival and car seat, booster seat, and seat belt use?

2. What are the three crashes involved in every vehicle collision?

3. What is the equation for estimating restraining force?

4. How much force would a 10-pound infant in a vehicle moving at 40 mph require to keep from moving forward?

5. What are the five ways car seats, booster seats, and seat belts help prevent or reduce injuries?