Rear Seat Occupant Safety

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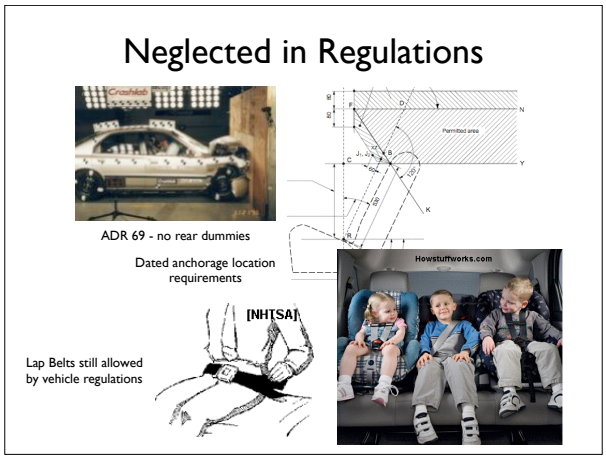
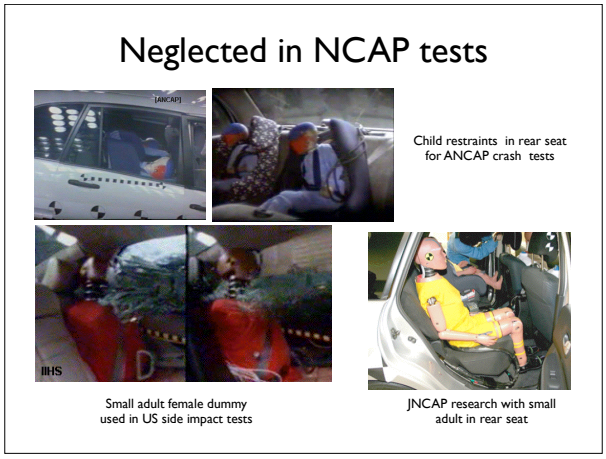
How well are adults and older children protected by rear seat restraint systems?

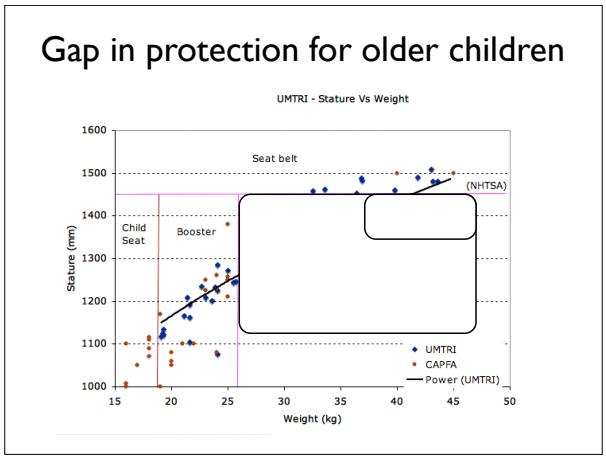
About 10% of crashed vehicles in the USA have rear seat occupants and more than half are children. I will be briefly reviewing the research into the safety of these rear seat occupants.
What do regulations require?
Do New Car Assessment Programs (NCAP) assess rear occupant protection?
Anthropometry
Accident studies
Crash research



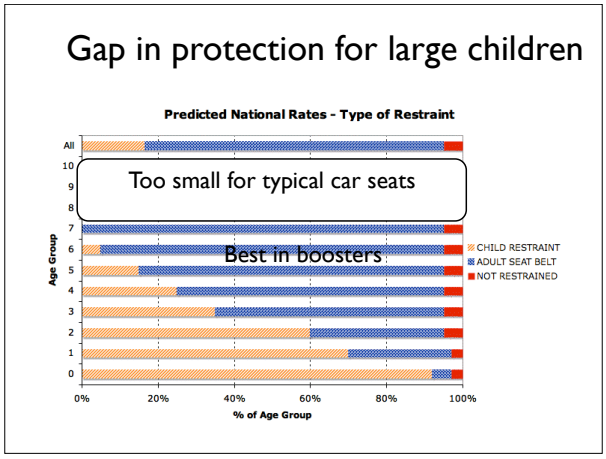
*Vehicle safety regulations do not require a dummy in the rear seat for dynamic test of the restraint system
*Rear seat belt anchorage location and seat belt strength mostly based on 1970s research
*No requirement for 3 point seat belt in centre rear seat



*Euro NCAP and ANCAP have child dummies in child restraints for crash tests – but no assessment of compatibility between vehicle and child restraint or ease of installation.
*IIHS has 5% female dummy in rear seat for side impact tests but not frontal test. The IIHS test is the only one that looks at side impact protection for adults in rear seats. Other NCAPs should look at this test.
* NHTSA and Japan NCAP looking at adult dummies in the rear seat

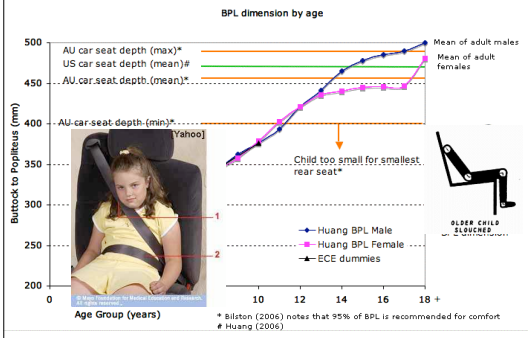


This chart shows child height vs weight. The US recommendation is that children should use a booster seat until they are 145cm tall.
Children over 26kg are too heavy for current Australian booster seats but most are too short for correct use of an adult seat belt.
As you will hear in a later talk, the Australian booster standard is being reviewed to cater for larger children but there will still be a gap in optimum protection.



Children between 7 and 10 years of age are using seat belts without boosters and so are sub-optimally restrained

Rear seat geometry



* Research shows that all car rear seats are too deep for most children and many are too deep for small adults. This chart shows the seated knee length for children and the results of surveys of typical car seats

*Too short a seat results in a slouched seating position

*Lap portion of seat belt rides up, risking abdomen injury

*MRI have also found problems with the sash belt falling off the shoulder or rubbing the neck

Solutions for Older Kids

ANCAP - how well does the seat and seat belt fit a small occupant?

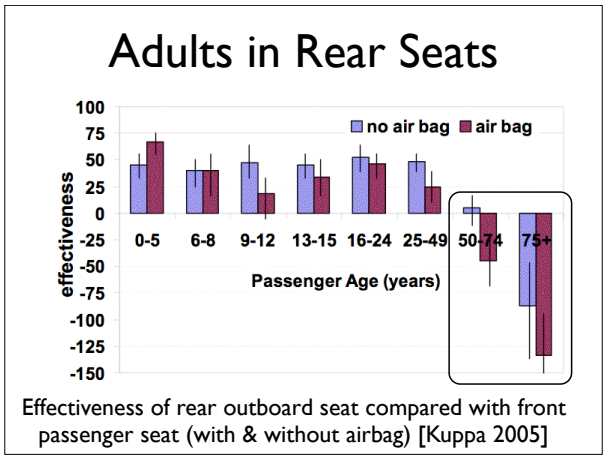
ANCAP could assess the seat and seat belts for older children or small adults, based on PoW MRI research and encourage better geometry. Discourage lap-only seat belts.

Volvo recently announced this optional rear seating system.
It can be adjusted to two heights and the cushion depth suits child.

NCAPs should give recognition to such innovative systems.

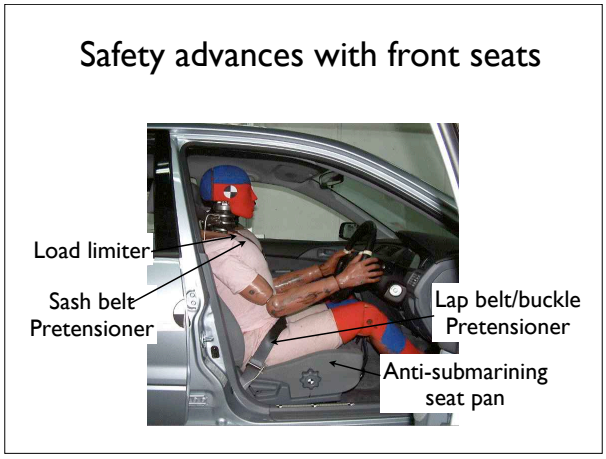
To encourage more appropriate restraint use for older children a ride-height line for car rear seats has been suggested.

Children and adults are familiar with similar systems at amusements parks and it is easier to reason with a child if there is a physical indicator.



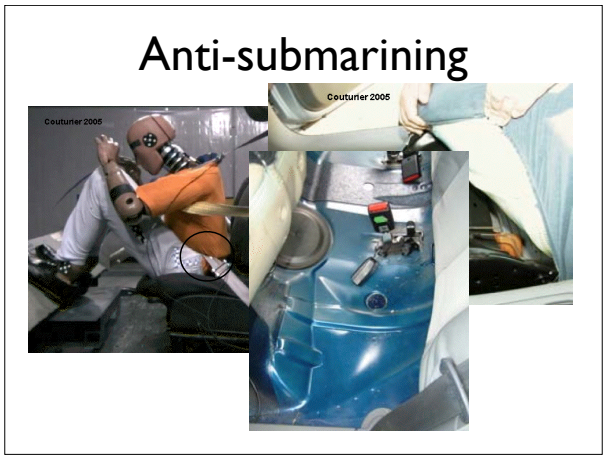
Effectiveness of rear outboard seat compared with front passenger seat (with & without airbag) [Kuppa 2005]

This chart shows that for most age groups the rear seat is about 50% safer than the front seat – this can be expected because the survival space is less likely to be compromised in the rear. However, recent accidents studies have found that people over 50 are much more likely to suffer serious chest injuries in the rear seat than the front seat. The main cause of these injuries is loading from the seat belt (but they are still much better off than having no seat belt).



There have been several major features that have reduced the risk of injury to front seat occupants over the last 15 years, aside from the obvious front airbag.

1. A pretensioners in the retractor associated with the sash portion of the seat belt tightens the seat belt and reduce the jarring loads due to slack
2. A pretensioner in the buckle assembly reduces slack in the lap portion of the seat belt and helps the seat belt engage the pelvic bones.
3. Load limiters that are usually built into the retractor, allow some controlled payout of the webbing to help limit the maximum loads applied to the chest by the seat belt
4. The structure of the seat base is designed to engage the dummy thighs and take some of the forward forces. This also reduces the risk of submarining.



It is worth looking at anti-submarining in more detail. The dummy hips have rotated, allowing the lap belt to ride over the pelvic bones and load the abdomen – a dangerous condition.
The antisubmarining pan in most front seats helps to prevent this motion. Here is a seat pan that has been loaded in a crash.
A few vehicles have this type of seat pan in the rear seat. Most don't and occupants are exposed to unnecessary risk of abdomen and spinal injury.

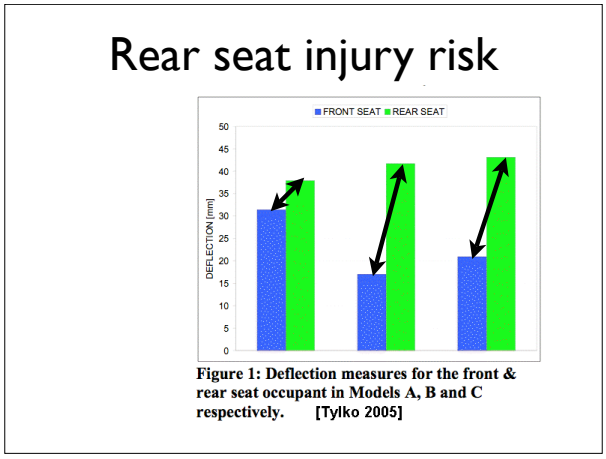


Figure 1: Deflection measures for the front & rear seat occupant in Models A, B and C respectively. [Tylko 2005]

Without pretensioners, load limiters and anti-submarining seats the seat belts loads for rear seat occupants are often noticeably higher than those for the front seat.
As a result, dummy chest deflection tends to be higher for the rear seat occupant. Older occupants are more susceptible to these high chest deflections, as evidenced by the US accident statistics. However, they also put younger occupants at unnecessary risk.

This is the 64K offset crash test, conducted in Australia, Europe, Japan and the USA. Australasian NCAP could replace one of the two rear-seat child restraints with a small adult female dummy. Injury risk, lap-belt positioning and tendency to submarine could be then assessed and a rear seat occupant rating published.
The photograph is from a research test undertaken by Japan NCAP and it is likely that they will soon include the adult dummy in the rear seat. With current rear seat restraints there is a risk that the rear seat dummy will slip out of the seat belt and strike the occupant in front. This would render the front dummy injury measurements unusable. For this reason it may be best to locate the dummy on the passenger side since the front passenger dummy is less important in this type of test.