Synthesis title:

Child Restraint Systems

Category: Vehicles

Other Relevant Topics:

- Seat Belts
- Advanced Vehicle Systems – Collision Protection
- Crash Mitigation and Collision Avoidance

Keywords:

Child car restraints, Child car seats, Child seats, Child restraints, Rear-facing baby seats, Rearward-facing baby seats, Forward-facing child seats, Booster seats, Booster cushions

About the Road Safety Observatory

The Road Safety Observatory aims to provide free and easy access to independent road safety research and information for anyone working in road safety and for members of the public. It provides summaries and reviews of research on a wide range of road safety issues, along with links to original road safety research reports.

The Road Safety Observatory was created as consultations with relevant parties uncovered a strong demand for easier access to road safety research and information in a format that can be understood by both the public and professionals. This is important for identifying the casualty reduction benefits of different interventions, covering engineering programmes on infrastructure and vehicles, educational material, enforcement and the development of new policy measures.

The Road Safety Observatory was designed and developed by an Independent Programme Board consisting of key road safety organisations, including:

- Department for Transport
- The Royal Society for the Prevention of Accidents (RoSPA)
- Road Safety GB
- Parliamentary Advisory Council for Transport Safety (PACTS)
- RoadSafe
- RAC Foundation

By bringing together many of the key road safety governmental and non-governmental organisations, the Observatory hopes to provide one coherent view of key road safety evidence.

The Observatory originally existed as a standalone website, but is now an information hub on the RoSPA website which we hope makes it easy for anyone to access comprehensive reviews of road safety topics.

All of the research reviews produced for the original Road Safety Observatory were submitted to an Evidence Review Panel (which was independent of the programme Board), which reviewed and approved all the research material before it was published to ensure that the Key Facts, Summaries and Research Findings truly reflected the messages in underlying research, including where there may have been contradictions. The Panel also ensured that the papers were free from bias and independent of Government policies or the policies of the individual organisations on the Programme Board.

The Programme Board is not liable for the content of these reviews. The reviews are intended to be free from bias and independent of Government policies and the policies of the individual organisations on the Programme Board. Therefore, they may not always represent the views of all the individual organisations that comprise the Programme Board.

Please be aware that the Road Safety Observatory is not currently being updated; the research and information you will read throughout this paper has not been updated since 2017. If you have any enquiries about the Road Safety Observatory or road safety in general, please contact **help@rospa.com** or call **0121 248 2000**.

How do I use this paper?

This paper consists of an extensive evidence review of key research and information around a key road safety topic. The paper is split into sections to make it easy to find the level of detail you require. The sections are as follows:

Key Facts	A small number of bullet points providing the key facts about the topic, extracted from the findings of the full research review.
Summary	A short discussion of the key aspects of the topic to be aware of, research findings from the review, and how any pertinent issues can be tackled.
Methodology	A description of how the review was put together, including the dates during which the research was compiled, the search terms used to find relevant research papers, and the selection criteria used.
Key Statistics	A range of the most important figures surrounding the topic.
Research Findings	A large number of summaries of key research findings, split into relevant subtopics.
References	A list of all the research reports on which the review has been based. It includes the title, author(s), date, methodology, objectives and key findings of each report, plus a hyperlink to the report itself on its external website.

The programme board would like to extend its warm thanks and appreciation to the many people who contributed to the development of the project, including the individuals and organisations who participated in the initial consultations in 2010.

KEY FACTS

In 2016, 18 children under 12 years old were killed while travelling in cars in Great Britain, 247 were seriously injured and there were 5,268 child car casualties (reported to the police) in total. (RRCGB 2015, DfT, 2017)

Adult Seat belts do not fit children correctly, and so do not offer the same level of protection as they do for adults (although they are far better than using no restraint at all). Therefore, children need to use child car restraints, not just seat belts on their own.

Using an appropriate child car restraint is highly effective in reducing the risk of death or injury for child car passengers in a crash. Children using an appropriate child restraint are significantly less likely to be killed or injured than unrestrained children, and are also less likely to be killed or injured than children using adult seat belts.

In the UK, children (with very few exceptions) in cars, vans and other goods vehicles must travel in an appropriate child restraint from birth until either they are 135cm (4'5") tall or have reached the age of 12 years (whichever comes first). Child car restraints must be approved to either UNECE Regulation R44 (Child Restraints) or UNECE Regulation 129 (Enhanced Child Restraints).

Rearward-facing Child Restraints

Babies and infants need to be carried in rearward-facing baby seats. This reduces the risk of death or injury in a crash by 90% compared with being unrestrained. It is common in the UK for infants to be moved into forward-facing child seats when they reach 13kgs in weight, around 1 year old.

However, research in Sweden indicates that children are safer in an appropriate rearward-facing seat until they are 3 or 4 years of age, although this was compared with being in a booster seat, rather than a forward-facing seat with an integral harness, which is more common in the UK for this age group.

Forward-facing Child Restraints

Research in the USA found that the risk of serious injury was 78% lower for children in forward facing child restraints than for those in seat belts. Another USA study concluded that **t**he odds of injury were 81.8% lower for toddlers in child seats than for toddlers wearing seat belts.

Booster Seats and Booster Cushions

Swedish research concluded that children aged 4 to 10 years who used a booster seat were 77% less likely to be injured in an accident compared with an unrestrained child. USA research found that the odds of injury were 59% lower for 4 to 7 year old children in booster seats than in seat belts.

Analysis of 10 years of data in the United States showed that 4 to 8 year old children in booster seats were 7.7 times less likely to suffer moderate to serious injuries in frontal and side impacts than unrestrained children, They were also 13.3 times less likely to suffer moderate to serious injuries in rear impacts and 23.6 times less likely to suffer these injuries in rollover crashes.

Risk According to Seating Position in the Car

It is safer for children to sit in the rear of the car than in the front. The centre rear seat is safest of all, but only if it has a 3-point seat belt and not just a lap-only belt.

Child Restraint Use

Observational surveys in 2008 in Great Britain found that three-quarters (74%) of 1 to 4 year old children travelling in the front of cars were using a child car restraint (a forward-facing child restraint, a booster seat or booster cushion), but most (93%) did so in the rear.

Older children (or 5 – 9 years) were much less likely to use child car restraints, with only 28% doing so in the front and 43% in the rear.

Incorrect Use of Child Car Restraints

Although child car restraints are very effective in reducing the risk of death or injury in a vehicle crash, their effectiveness is reduced if the restraint is not being used or fitted properly.

Using ISOFIX child car seats may reduce the likelihood of the seat being incorrectly fitted.

Seats which conform to the new i-size standard are designed to provide side impact protection and keep children rearward-facing until they are at least 15 months old.

SUMMARY

Travelling as a passenger in a car is one of the main ways that children under 12 years old get about.

In 2016, 18 children under 12 years old were killed while travelling in cars in Great Britain, 247 were seriously injured and there were 5,268 child car casualties (reported to the police) in total. (RRCGB 2015, DfT, 2017)

In a collision, an unrestrained vehicle occupant continues to move at the same speed the vehicle was travelling in until they hit something, such as part of the vehicle's interior. This can cause a range of injuries, including fatal ones. They may also be ejected from the car through one of the windows.

Adult Seat belts do not fit children correctly and so do not offer the same level of protection as they do for adults (although they are better than using no restraint at all). Therefore, children need to use child car restraints, not just seat belts on their own.

The safest way for children to travel in cars is in a correctly fitted child restraint that is suitable for their weight and size, and in the rear of the car.

In the UK, the law requires all children (with very few exceptions) in cars, vans and other goods vehicles to be carried in an appropriate child restraint from birth until either they are 135cm (4'5") tall or have reached the age of 12 years (whichever comes first).Child car restraints must conform to either the Regulation R44 standard or the Regulation 129 (i-size) standard.

The Effectiveness of Child Car Restraints

Using an appropriate child car restraint is highly effective in reducing the risk of death or injury for child car passengers in a crash.

Children using an appropriate child restraint are significantly less likely to be killed or injured than unrestrained children.

They are also less likely to be killed or injured than children using adult seat belts.

Child Car Restraints Compared with Seatbelts

Although a child wearing an adult seat belt is far less likely to be killed or injured than an unrestrained child, they are more likely to be killed or injured than one using an appropriate child car restraint.

Rearward-Facing Baby and Infant Seats

Babies and infants need to be carried in rearward-facing baby seats. This reduces the risk of death or injury in a crash by 90% compared with being unrestrained.

It is common practice in the UK for infants to be moved into forward-facing child seats when they reach 13kgs in weight, around 1 year old.

Research in Sweden indicates that children are safer in an appropriate rearward-facing seat until they are 3 or 4 years of age, although this was compared with being in a booster seat, rather than a forward-facing seat with an integral harness, which is more common in the UK for this age group.

Forward-facing Child Restraints

Research in the USA found that the risk of serious injury was 78% lower for children in forward facing child restraints than for those in seat belts. Another USA study concluded that **t**he odds of injury were 81.8% lower for toddlers in child seats than for toddlers wearing seat belts.

Booster Seats and Booster Cushions

Booster seats are designed for children from about four years old until they are large or old enough to use the vehicle's seat belts. They aim to raise the child so that the adult seat belt fits correctly and the child can travel in greater comfort and safety.

Swedish research concluded that children aged 4 to 10 years who used a booster seat were 77% less likely to be injured in an accident compared with an unrestrained child. USA research found that the odds of injury were 59% lower for 4 to 7 year old children in booster seats than in seat belts.

Analysis of 10 years of data in the United States showed that 4 to 8 year old children in booster seats were 7.7 times less likely to suffer moderate to serious injuries in frontal and side impacts than unrestrained children, They were also 13.3 times less likely to suffer moderate to serious injuries in rear impacts and 23.6 times less likely to suffer these injuries in rollover crashes.

Risk According to Seating Position in the Car

It is safer for children to sit in the rear of the car than in the front.

The centre rear seat is safest of all, but only if it has a 3-point seat belt and not just a lap-only belt.

Use of Child Car Restraints

In 2008 in Great Britain three-quarters (74%) of 1 to 4 year old children travelling in the front of cars were using a child car restraint (a forward-facing child restraint, a booster seat or booster cushion), but most (93%) did so in the rear.

Older children (or 5 – 9 years) were much less likely to use child car restraints, with only 28% doing so in the front and 43% in the rear.

Almost all of those who were not using a child car restraint were wearing a seat belt.

Incorrect Use of Child Car Restraints

Although child car restraints are very effective in reducing the risk of death or injury in a vehicle crash, their effectiveness is reduced if the restraint is not being used properly.

Common forms of inappropriate use include using a restraint that is not suitable for the child's size and weight (typically, moving a child up to the next size of restraint too soon), and common forms of misuse include using a restraint that is not suitable for the vehicle in which it is fitted and not fitting the restraint securely.

Two groups of children are most at risk when they are not properly restrained: infants using forward facing child restraints when they are less than one year old, and children using the seat belt when they should be using a forward facing child seat or booster seat.

Using ISOFIX child car seats may reduce the likelihood of the seat being incorrectly fitted.

Promoting Child Car Restraint Use

There is evidence that educational campaigns can improve child car restraint use, especially in combination with laws mandating their use.

As it is well established that parents often find it difficult to choose and use an appropriate child restraint, many interventions have been devised to help parents.

Disadvantaged Groups

Children in deprived areas may face greater risk as car passengers because their parents are not able to afford safety equipment, such as child car restraints.

Free or loaned child seat schemes can be effective in increasing the likelihood of children being restrained.

Some evidence suggests that restraint use is higher among higher social groups, but that lower social groups can be effectively targeted.

Room for Improvement

Seats which conform to the new i-size standard are designed to provide better side impact protection and to keep children rearward-facing until they are at least 15 months old.

The likelihood of child restraints being fitted incorrectly can be reduced by improving the design of the restraints so they are easier to fit (eg, ISOFIX or i-size) and by providing education to parents on how to choose and use child car restraints.

METHODOLOGY

A description of the methodological approach to all of the research reviews in the Road Safety Observatory is available at http://www.roadsafetyobservatory.com/Introduction/Methods.

This review was originally compiled during January to April 2012, and revised in July 2013. It was updated in November 2015. In December 2017, statistics from Reported Road Casualties Great Britain were updated to Reported Road Casualties Great Britain 2016.

The steps taken to produce this review are outlined below:

Identification of relevant research

Searches were carried out on pre-defined research (and data) repositories, as described in http://www.roadsafetyobservatory.com/Introduction/Methods. Various project websites, such as those of the EC CHILD, CREST and CASPER projects, and the NHTSA ESV archives were also used.

Search terms used to identify relevant papers included but were not limited to:

"child car restraints", "child car seats", "child seats", "child restraints", rear-facing baby seats", "rearward-facing baby seats", "forward-facing child seats", "booster seats", "booster cushions"

The definitions of child car restraints in this review are shown in the table below. However, different terms are used in many of the research papers. For example, in Sweden, rearward-facing child seats include seats for children up 3 or 4 years old, whereas in the UK, it normally refers to seats for babies up to about 1 year old. In countries, such as the USA, the term child car seat is commonly used, and in some of the papers it is not specified whether these refer to forward-facing child seats or booster seats, or both, although as the age range of children is specified, it is possible to infer which type of seat is being described.

A total of 157 potentially relevant research papers were identified. Following the initial review, 56 pieces of research were taken forward to form the basis for this synthesis, 10 of which were published in the UK.

Initial review of research

This primarily involved sorting the research items based on key criteria, to ensure the most relevant and effective items went forward for inclusion in this review. Key criteria included:

- Relevance: whether the research makes a valuable contribution to this synthesis, for example robust findings from a hospital-based study.
- Provenance: whether the research is relevant to drivers, road safety policies or road safety professionals in the UK. If the research did not originate in the UK, the author and expert reviewer have applied a sense check to ensure that findings are potentially relevant and transferable to the UK.

- Age: Priority is given to the most up-to-date titles in the event of over-lap or contradiction, although older research papers are included because much of the research took place as child restraints were being developed and used.
- Effectiveness: whether the research credibly proves (or disproves) the effectiveness of a particular road safety initiative or intervention.

A similar search was conducted in October 2015, but limited to new research studies that had been published in 2014 and 2015, following which 10 new studies were added to the review, and reported casualty data was updated to include 2014 data, the latest available at the time of the update.

Detailed review of research
Key facts, figures and findings were extracted from the identified research to highlight pertinent road safety issues and interventions.

Definitions

Type of Child Restraint	Weight or Height Range	Approx. Age Range
Rearward-facing baby seat	Group 0 0 - 10kg (22 lbs)	Birth to 6-9 months
	Group 0+ 0 - 13kg (29 lbs)	Birth to 12-15 months
	i-size Not based on weight, but child's height must be within the range specified for the seat	Up to at least 15 months
Combination seat (Rearward and Forward-facing)	Group 0+ and 1 0-18 kg (40 lbs)	Birth - 4 years
	Group 0+, 1 & 2 (55 lbs) Birth to 25 kg	Birth to 6 years
Forward-facing child seat	Group 1 9-18 kg (20 - 40 lbs)	9 months - 4 years
	Group 1, 2 and 3 9 - 36 kg (20 - 79 lbs)	1 to 11 years
High-backed Booster Seat	Group 2 15 - 25 kg (33 - 55 lbs)	4 to 6 years
High-backed Booster Seat	Group 2 and 3 15 - 36 kg (33 - 79 lbs)	4 to 11 years
Booster Cushion	Group 2 and 3 15 - 36 kg (33 - 79 lbs)	4 - 11 years
Booster Cushion	Group 3 22 - 36 kg (48 - 79 lbs)	6 - 11 years

The weight ranges are derived from from UN Regulation 44 (Child restraint systems), which specify minimum and maximum weight ranges for child restraint systems. i-size seats conform to UN Regulation 129, and are based on a child's height rather than weight.

Group 0 rearward baby seats, Group 0+, 1, 2 combination seats and Group 2 forward-facing seats are less common than the other types.
Many child seats cover more than one group and are adjusted as the child grows. They may be called combination seats, extended seats or multi-group seats. For example:

- Group 0+ and 1 seats start off rearward-facing until the baby is at least 9 kg and are then turned forward-facing - some stay rearward facing until the child has reached 18 kg.
- Group 0+, 1 and 2 seats (which are not very common) start rearward-facing up to 18kg and are then turned forward-facing (they can be turned forward facing from 9 kg).
- Group 1, 2 and 3 seats are forward-facing. The child uses the seat's integral harness, or an impact cushion, until they are 15 kg and then uses the car's seat belt, which secures the child and the seat.
- Group 2 and 3 seats are high-backed booster seats, although they can also be booster cushions without a back. On some of the high-backed seats, the back can be removed once the child reaches 22 kg, but it is far better to keep the back on the seat

KEY STATISTICS

In 2016, 18 children under 12 years old were killed while travelling in cars in Great Britain, 247 were seriously injured and there were 5,268 child car casualties (reported to the police) in total. (RRCGB 2015, DfT, 2017)

Child Casualties in Cars, 2016, Great Britain[1]

	Killed	Seriously Injured	All
0 - 4 years	7	83	1,521
5 - 7 years	3	73	1,603
8 - 11 years	8	91	2,144
Total*	**18**	**247**	**5,269**

*Includes age not reported.

Over the five year period, from 2012 to 2016, 67 children under 12 years old were killed in car crashes, 1,024 were seriously injured and there were over 25,000 child car passenger casualties in total. However, it is not known how many of these children were:

- Using a correctly fitted, appropriate child restraint
- Using an incorrectly fitted or inappropriate child restraint
- Using a seat belt instead of a child restraint
- Completely unrestrained

In a collision an unrestrained vehicle occupant continues to move at the same speed the vehicle was travelling until they hit something, such as part of the vehicle's interior. They may also be ejected from the car through one of the windows. This can cause a range of injuries, including fatal ones.

Seat Belts and Children

The main system for safely restraining occupants in vehicles is, of course, seat belts. However, seat belts do not fit children properly, and do not fit babies at all. This means they are less effective in protecting children, and in some circumstances, could even cause injury.

Children are not simply smaller adults; they are proportioned differently, their bones are not fully formed and their skeletal structure does not cover and protect their internal organs in the way it does in adults. All of these things change as children grow older, meaning that the type of restraint system they use also needs to change, until they reach the point where the seat belts can provide the same protection as for adults. (Burdi and Huelke, 1969, WHO, 2009)

In the UK, children must use an appropriate child restraint (with very few exceptions) until they are 12 years old or 135 cm in height, whichever comes first. At this point must use the vehicle's seat belts.[2] Road safety organisations advise that it is better to wait until the child is at least 150 cm tall before using the seat belts without a booster seat or booster cushion.

[1] "Reported Road Casualties Great Britain 2016", Table RAS30028, Department for Transport, 2017
[2] See https://www.gov.uk/child-car-seats-the-rules for details of the law about child car restraints in Great Britain.

RESEARCH FINDINGS

Child Restraints Compared with No Restraint

A Swedish study of 3,670 children aged 0 to 15 years, involved in car crashes between 1987 and 2004, found that rearward facing child restraints (including rear-facing infant seats and rearward-facing child seats for children up to 3 - 4 years old) reduced the likelihood of injury by 90% compared with being unrestrained. Booster seats that help to position the seat belt correctly reduced the risk of injury by 77% for 4 to 10 year old children. (Jakobssen, 2005) Some of the child car restraints, such as rearward-facing child seats for older children and integrated booster cushions built into cars, in this study are different from the types used in the UK.

An analysis of fatal car accidents in the USA between 1982 and 1987 estimated that child safety seats (in the USA this term often refers to child restraint systems that have an integral harness, but not booster seats) reduced the risk of death among infants by 69% and for toddlers by 47%. Overall, children in child safety seats were 50% less likely than unrestrained children to be killed in these fatal crashes. The report estimated that using the car's adult seat belts reduced the risk of death for toddlers by 36%. It estimated that 838 children's lives were saved in the USA by child restraints and seat belts over that period, with the number saved increasing as the use of restraints increased.

The report estimated that child car restraints could have saved an additional 2,349 children if all children had been using child restraints over that period, and even more lives if child restraints were always used correctly. The report does not distinguish between different types of child restraint (eg, rearward-facing baby seat, forward-facing child seat, booster seat, booster cushion), but as the report covers infants and toddlers, it is likely that very few, if any, booster seats were included. (NHTSA, 1988)

The NHTSA report was updated in 1996 using fatal accident data for 1988 to 1994. Compared with being unrestrained, using a child car restraint reduced the risk of being killed in a crash by 71% for under one year olds, and by 54% for 1 to 4 year old children in cars. In light trucks or vans, child car restraints reduced the fatality risk by 58% for under one year old children and by 59% for 1 to 4 year old children. (NHTSA, 1996)

A 2011 NHTSA report estimated that child safety seats had saved the lives of 9,874 children under 5 years old between 1975 and 2011. In 2011, 245 children aged under 5 years were saved by child safety seats, and a further 51 could have been saved if all children had been using a child safety seat that year. (NHTSA, 2013)

An analysis of 635 child passengers aged 12 years or younger who were treated in hospital for injuries sustained in vehicle crashes found that unrestrained children were three times more likely to be hospitalised than restrained children (21% vs. 7%). (Lee, 2004)

A study of 17,980 children under 16 years old involved in crashes in 15 states between December 1998 and November 2002 found that the risk unrestrained children faced was more than 3 times the risk for restrained children. (Durbin, 2005)

A case-control study of 129 child car passengers aged 0–11 years injured in motor vehicle accidents in 1996 in Athens suggested that unrestrained 0 to 4 year old children were 3.3 times more likely to be injured than restrained children. It estimated that in Greece about two thirds of all childhood injuries from car crashes could have been avoided by the regular use of proper child restraints. (Petridou, 1998)

An analysis of injury rates for car passengers under 15 years old in the USA in 1990 and 1991 found that 19% of children under 1 year old who were in an appropriate restraint were injured, compared with 40% of those who were not restrained. Unrestrained children were 1.5 to 2.5 times more likely to be injured than restrained children. (Johnston, 1994)

An analysis of data of crashes involving child car passengers under one year old from 2007 to 2011 in the USA found that properly restrained infants were 12.7 times less likely to present to a trauma centre after a motor vehicle crash. However, the likelihood of the child passenger receiving traumatic brain injuries in higher speed crashes was similar among properly restrained and improperly or unrestrained infants. (C Stewart et al, 2014)

Child Car Restraints Compared with Seatbelts

A USA study of 2 to 3 year old rear seat child passengers in crashes that resulted in at least one vehicle being towed away between 1998 and 2004 concluded that **t**he odds of injury were 81.8% lower for toddlers in child seats than for toddlers wearing seat belts. (Zaloshnja, 2007)

Another American study comparing the use of child restraints with seat belts by 2 to 6 year old children involved in vehicle crashes between 1998 and 2003 found that compared with seat belts, child restraints (when not seriously misused) were associated with a 28% greater reduction in the risk for death in children of that age group. When including cases of serious misuse, the effectiveness was slightly lower, at 21%. (Elliot, 2006)

A study of crashes in 15 states in America between December 1998 and May 2002 involving 1,207 children aged 12 and 47 months, seated in the rear of vehicles, found that the risk of serious injury was 78% lower, and the risk of hospitalisation was 79% lower, for children in forward facing child restraints than for those in seat belts. (Arbogast, 2004)

A study of 17,980 children under 16 years old involved in crashes in 15 states between December 1998 and November 2002 found that the risk for inappropriately restrained (defined as using a seat belt rather than a child safety seat or booster seat) children was almost double that of appropriately restrained children. (Durbin, 2005)

An analysis of fatal car accidents in the USA between 1982 and 1987 estimated that children in child safety seats were 50% less likely than unrestrained children to be killed, but those using the car's adult seat belts were only 36% less likely to be killed. (NHTSA, 1998)

When these estimates were updated in 1996, the estimates for the effectiveness of seat belts on their own had increased to 47% in cars and 48% in light trucks or vans. The effectiveness of child restraints had also increased from 69% to 71% for under one year olds and from 50% to 54% for one to four year olds. (NHTSA, 1996)

Rearward-Facing Seats

A 1996 NHTSA report estimated that child car restraints reduced the risk of being killed in a crash by 71% for under one year olds, and by 58% in light trucks or vans. (NHTSA, 1996)

An investigation in Sweden of the effectiveness of child restraints using data from insurance claims found that children in rear-facing child restraints were at the lowest risk of injury. The injury risk for children aged 0 – 4 years was almost five times greater in a forward-facing child restraint than in a rearward-facing one. While rearward-facing seats were 90% effective at reducing injuries, forward-facing seats in a rear outboard position were 60% effective. The forward-facing seats were much more effective in frontal collisions than in side impacts. (Gustafssen, 1987) It is important to note that the forward-facing seats in this study were booster seats, not forward-facing child seats with an integral harness.

The BMJ has recommended that children should travel in a rearward-facing seat until they are four years old because the relatively large head mass and the anatomy of the spine of young children can lead to excessive stretching or even transection of the spinal cord in a frontal crash when in a forward facing car seat. (Watson & Monteiro, BMJ, 2009)

The American Academy of Pediatrics recommends that all infants and toddlers travel in a rear-facing car safety seat until they are two years old, or they have reached the maximum weight or height limitations of their rear-facing seat. (Pediatrics, 2011)

Evidence from Sweden shows that rearward-facing child seats (this included both rearward-facing baby seats and rearward-facing child seats for older children) reduced the risk of injury by between 76% and 92%. (Carlsson, 1991)

An examination of injuries suffered by children aged under 2 years who were using child restraints concluded that "it is possible that a redesigned car safety seat (e.g. one that would allow children to ride rear facing in the rear until 2 or 4 years of age), would help to reduce severe head and neck injuries to child passengers" (Fuchs, 1989)

Child Restraints for Premature and Low Birth Weight Babies

Research carried out in the United States in the 1980s raised concerns that the rearward-facing baby seats available were not suitable for premature and low birth weight babies who were at risk of cardio-respiratory problems when placed in a semi-reclined position. (Bull and Stroup, 1985, and Leuschen,1986).

The American Academy of Pediatrics recommends that infants of less than 37 weeks gestation at birth be monitored in their car safety seat before being discharged from hospital. They recommend that a normal rear-facing baby seat be used, unless the baby has manifested apnea (stopping breathing), bradycardia (slow heart rate), or desaturation (low oxygen levels) when semi-reclined in a car safety seat. Infants who have manifested such conditions in a semi-upright position should travel in a supine or prone position in car bed (a child restraint system in which the baby lies flat; sometimes called a 'baby carrier') after an observation period that is free of such events. (Bull and Engle, 2009)

However, a Cochrane Review concluded that it is unclear whether undertaking such a pre-discharge assessment is beneficial or harmful to preterm infants, and that further studies are needed. The authors raised concerns that the assessments may cause undue parental anxiety. (Piley and McGuire, 2009)

Forward-Facing Child Seats

Forward-facing child seats are designed for children within the weight range 9 to 18 kg. Most types have an integral five point harness which restrains the child in the child seat, but some types have an impact pad instead of a harness (they are often called 'shield systems').

In the United States, it is estimated that forward-facing child seats reduce the risk of death for toddlers by 54%. (NHTSA, 1996) Further USA research found that 19% of 1 to 4 year old children involved in a collision and who were using a forward-facing child seat were injured compared with 22% of those in a seat belt and 43% of those who were unrestrained. (Johnston et al, 1994)

A USA study of 2 to 3 year old rear seat child passengers in crashes between 1998 and 2004 concluded that the odds of injury were 81.8% lower for toddlers in child seats than for toddlers wearing seat belts. (Zaloshnja, 2007)

Analysis of 10 years of data in the United States showed that children aged 1 to 3 years who were in forward-facing child restraints had a low risk of injury in frontal, side and rollover crashes compared with unrestrained children. The risk of suffering moderate to serious injury in a rollover crash was about 10 times higher for an unrestrained child than for one in a forward-facing child seat. (Singh et al, 2007)

Forward-facing Child Restraints with a Shield System

Child restraints with 'shields' or impact pads rather than an integral harness are becoming more popular. It is estimated that about 10% of forward-facing child restraints sold are shield systems, although, they are seldom observed in research studies. An analysis of the performance of shield and harness systems in dummy tests, found that the claims that shield systems protect the neck better than 5-point harness systems, are not supported by the test results. To the contrary, the limited accident data available suggested different neck injury patterns for shield systems that cannot be evaluated with the current crash test dummies, and possibly higher risks for the abdomen and thorax than with 5-point harness.

The report concluded that, based on the data that was analysed, the consequences of the current revival of shield systems on child protection cannot be determined with certainty. No clear benefit could be established from using shield-type restraints, and it is unclear if test procedures are sufficient to evaluate shield systems' real world protection. (Johannsen et al, 2013)

Booster Seats and Booster Cushions

Booster seats are designed for children from about four years old until they are large or old enough to use the vehicle's seat belts. They aim to raise the child so that the adult seat belt fits correctly. Those that have side impact wings also provide some protection from side impacts.

The Swedish study of car accidents involving 3,670 children, aged 0-15 years, between 1987 and 2004 found that children aged 4 to 10 years who used a booster seat, which raises their body position so that the adult seat belt (which goes around both the booster seat and the child sitting in it) fits them properly, were 77% less likely to be injured in an accident, compared with an unrestrained child. The researchers found that abdominal injuries mainly occurred in children using only a seat belt, emphasising the need for belt-positioning boosters. (Jakobssen, 2005)

A study of 3,616 crashes involving 4,243 children aged 4 to 7 years in 15 States between December 1998 and May 2002 found that 1.95% of those in seat belts were injured, compared with only 0.77% of those in booster seats. The odds of injury, adjusting for child, driver, crash, and vehicle characteristics, were 59% lower for 4 to 7 year old children in booster seats than in seat belts. (Durbin, 2000)

In children aged 4 to 7 years, booster seats were estimated to reduce the odds of sustaining clinically significant injuries during a crash by 59% when compared with using the vehicle's seatbelts. (Ehiri, 2009)

Analysis of 10 years of data in the United States showed that 4 to 8 year old children who were in booster seats were 7.7 times less likely to suffer moderate to serious injuries in frontal impacts and 7.7 times less likely to suffer these injuries in side impacts than unrestrained children, They were also 13.3 times less likely to suffer moderate to serious injuries in rear impacts and 23.6 times less likely to suffer these injuries in rollover crashes. (Singh et al, 2007)

There is evidence that the design of some booster seats needs to be improved to reduce the risk of a child 'submarining' under the lap belt. Inspections and tests in the USA found that most booster seats incorporate anti-submarining seat ramps, seat surfaces and lap belt guide hooks, which help to minimize the potential for submarining. However, two of the booster seats evaluated did not provide any significant anti-submarining design. The authors called for features such as anti-submarining seat bottom ramps, low compressibility seating surfaces, and effective lap belt guide hooks to be part of the requirements for booster seats. (Whitman et al, 2013)

An analysis of the injuries suffered by 6 – 12 year old children in moderate to severe collisions found that none of those in booster seats suffered moderate or severe injuries, unlike those who were unrestrained, using an adult seat belt or using a booster cushion. None of the children in side impact collisions who were using booster seats or booster cushions suffered moderate or severe injuries. Chest injuries were less common for children using booster seats than for those using booster cushions or just the adult seat belt, possibly because booster seats help to position the seat belt correctly and securely. However, the authors noted that the numbers involved in the study were too small to draw conclusions. (Visvikis et al, 2009)

Although booster seats and booster cushions provide good protection for children who are using them correctly, younger children face a higher risk of neck injuries in these types of child restraints than in a forward-facing seat with an integral harness. head injuries are the most common type of injury for children in these types of restraints, with chest injuries being more common in booster cushions than in booster seats (Lesire et al, 2010)

Risk According to Seating Position in the Car

A USA study of 17,980 children under 16 years of age involved in crashes between 1998 and 2002 concluded that while using appropriate child restraint provides more protection than just sitting in the rear, the optimum protection is achieved by using an appropriate child restraint in the rear of the vehicle rather than in the front. (Durbin, 2005)

An analysis of fatal car crashes in the USA between 1982 and 1987 showed that unrestrained children were more likely to sit in the front, than in the rear seats, and indicated that children sitting in the rear were 33% less likely to be killed than children sitting in the front. (NHTSA, 1988)

Based on insurance claim records and a telephone survey of parents involved in crashes with child occupants aged 0 to 3 years who were using a child restraint in the rear of a vehicle it was estimated that children sitting in the centre had a 43% lower injury risk than those seated in either of the rear outboard positions. (Kallan, 2008)

A study examining injury patterns among restrained 4 to 9 year olds by seat location and the point of impact on their vehicle identified that the most serious injuries occurred to children seated on the side of the vehicle that was impacted in lateral collisions. (Agran, 1989)

A 1993 study identified that nearside impacts create a higher risk of injury to child car occupants (Langweider et al, 1993, reported in Lesire et al, 2010). A 2004 study identified that children sitting on the side of the vehicle that was struck are at much higher risk of injury than children sitting on the opposite side of the vehicle (Arbogast et al, 2004, reported in Lesire et al, 2010). Another 2004 study concluded that children sitting on the nearside seat of the vehicle suffered more severe injuries than those sitting in the centre or off-side seats. (Howard et al, 2004, reported in Lesire et al, 2010).

In the State of Victoria, Australia, data from almost 31,000 crash records found that the relative risk of death for children under 4 years old in the front seat was twice as great as when travelling in the rear, and the risk of serious injury was 60% greater. The relative risk of death whilst travelling in the front seat was almost four times greater for children aged under 1 year old. The authors suggested changing the law to require children, especially under 5 year olds, to sit in the rear. (Lennon, 2008)

Analysis of fatal crashes in the United States between 2000 and 2003 showed that sitting in the rear middle seat is safer than any other position. Overall, the rear seats had a 29% increased odds of survival over the front seats and the rear middle seat had a 25% increased odds of survival over the other rear seat positions. After correcting for potential confounding factors, occupants of the rear middle seat had a 13% increased chance of survival when involved in a fatal crash than occupants in other rear seats. (Mayrose and Priya, 2008)

However, an analysis of properly restrained child passengers from data in another database, the National Automotive Sampling System (NASS), did not find that the centre rear seat to be any safer than either of the outboard rear seats. (Lund 2005)

Although not specifically about child car passengers, a recent Australian study found that rear seat car passengers are sustaining more severe injuries than front seat passengers, possibly because of the introduction of safety features aimed at front seat protection, such as frontal airbags. (Mitchell et al, 2015)

Child Restraints and Side Impacts

Side impacts account for about 25% of accidents involving children in cars. As noted earlier, forward-facing child restraints are much more effective in frontal collisions than in side impacts. In this research, although the number of side impacts in the database was small, head injuries accounted for 62% of all severe injuries in all types of restraint, indicating that the level of head protection is insufficient. (EEVC WG 18)

Severe chest and abdomen injuries also occurred, mainly in children using a booster seat or booster cushion, or just using the adult seat belt. These injuries were rarely seen in children using a restraint with a shell, such as rearward- and forward-facing seats. Of the children involved in side impact collisions, 20% suffered severe injuries and 43% minor injuries. (EEVC WG 18)

The analysis of almost 4,000 injured child car passengers in Swedish accident records also identified that head injuries are the most frequent moderate or severe injuries for side (as well as frontal) impacts. Although rearward-facing child seats are designed primarily for frontal impacts, the Swedish data showed that they provided good protection in side and rear-end impacts. In fact, the database contained no rearward-facing child who had severe injuries in side or rear impacts. (Jakobsson et al, 2005)

A TRL project that included research to develop a side impact test for child restraints, identified from its fatal accident database that over one third (35%) of children who were killed in car accidents even though they were using a child restraint, were killed in side impacts (including sideswipes). It concluded that a backrest with side wings could help to minimise head injuries in side impacts. (Lowne, 2000)

A new standard for child car restraints, Regulation 129 (commonly referred to as i-size) was introduced in July 2013. One of the main improvements this provided over Regulation R44 is that it requires child car seats to provide better protection from side impacts. UK law to allow Regulation 129 child car seats to be used came into force in Spring 2015, therefore parents may now choose to child car seats that conform to either Regulation 44 or to Regulation 129. (United Nations, 2013)

USE OF CHILD CAR RESTRAINTS

The table below shows the use of child restraints in Great Britain in 2008, two years after the law was changed to require virtually all children to use child restraints until they are either 135cm tall or 12 years old. It shows that three-quarters (74%) of 1 to 4 year old children travelling in the front of cars were using a child car restraint (either a forward-facing child restraint or a booster seat or booster cushion), but most (93%) did so in the rear. Older children (or 5 – 9 years) were much less likely to use child car restraints, with only 28% doing so in the front and 43% in the rear. (TRL, 2008)

Use of restraints by younger children (%), October 2008

	Front seat passengers		Rear seat passengers	
	1–4 years old	5–9 years old	1–4 years old	5–9 years old
Seat belt worn	20	71	5	51
Child seat used	53	0	75	6
Rear facing child seat used	0	0	1	0
Booster seats and cushions used: Properly	21	28	18	37
Wrongly	0	0	0	0
Unrestrained: on seats	5	1	1	6
on passenger's lap	1	0	1	0

Misuse of Child Car Restraints

Although child car restraints are very effective at protecting children in cars, their effectiveness can be reduced, or even negated altogether, if the restraint is unsuitable for the child and/or is not correctly fitted in the car. Surveys over many years have consistently found high levels of child car seat misuse and common types of misuse.

An analysis of injury rates for car passengers under 15 years old in the USA in 1990 and 1991 found that 19% of children under 1 year old who were in an appropriate restraint were injured, compared with 30% of those in an inappropriate restraint. Children who were inappropriately restrained were at greater risk than those who were appropriately restrained. (Johnston, 1994)

An observational survey in 2006 and 2007 found a high frequency of seat belt misuse among children travelling in booster seats. Of 564 children in belt-positioning booster seats, about two-thirds (65%) were misusing the seat belt in at least one way. Common misuses were the shoulder belt being placed over the booster seat armrest (35.8%), shoulder belt not at mid-shoulder position (28.5%), seat belt too loose (24.5%), and the shoulder belt either behind the child's back (9.1%) or under their arm (10.0%). (O'Neil et al, 2009)

Six case studies illustrating the injury patterns associated with various types of restraint misuse in infants (under 1 year old), toddlers (aged 1 to 4 years), young children (aged 4 to 8 years), and pre-teens (aged 8 to14 years), showed that restraint misuse leads to increased morbidity and mortality for children in motor vehicle crashes. (Bulger and Kaufman, 2008)

The use of child restraints by 635 child passengers aged 12 years or younger who were treated in hospital for injuries sustained in vehicle crashes was analysed. Over three- quarters (77%) of inappropriate restraint use was among children aged 4 to 8 years who were placed in seat belts before they were large enough for the seat belt to fit properly. (Lee, 2008)

Some parents purchase second hand child car restraints, which may not provide the best protection for their child. Hampshire County Council Trading Standards Service conducted a study on the crash performance of second hand child restraints – all 15 child seats tested, failed to meet the (then current) R44.03 standard. (Willis, 2006)

Trials of parents attempting to fit child restraints into cars by following the manufacturer's instruction booklets illustrated that there was considerable variation in the quality and user-friendliness of the instruction booklets, and that generally the trial participants found them daunting and unhelpful. (RoSPA, 2001)

To help parents, many 'Inspection Clinics' (under various names) are run across Britain to which parents are able to bring their child restraint, ideally in their car and with the child who uses it, to a convenient location (such as a supermarket car park) where the restraint is checked by an expert to assess whether it is suitable for the child, for the vehicle and whether it is fitted correctly.

The CHild Injury Led Design (CHILD) project, part funded by the EC, included literature reviews of the incorrect use of child restraints in several countries. In the UK, surveys by local councils, child product manufacturers and safety organisations consistently find high levels of child car restraint use, but low levels of correct fitting. The project also identified a lack of confidence amongst parents about their ability to fit their child restraints correctly. (Willis, 2006)

This project also found that children in inappropriate or incorrectly fitted child car restraints are more likely to suffer severe injuries, especially more head injuries, in accidents than children who are correctly restrained. However, they are still at lower risk than children who are travelling unrestrained. (Willis, 2006)

Data from the EC-funded CASPER project found that misuse of child seats was still a widespread and serious problem (based on studies in Berlin, Lyon and Naples). The main problems were not threading the vehicle seat belt correctly through the child restraint, and the general installation of the child seat in the vehicle

Comparisons between studies conducted in Lyon in 2003 and in 2011 showed the average rate of misuse was about 71% in 2003 and 65% in 2011. The main differences were with forward facing systems with an integral harness, the use of which was better in 2011 than in 2003 with a decrease of serious misuse, such as incorrect harness use. For booster seats, the most frequent misuse was the same in 2011 as in 2003, with the lower belt guides often not used and the chest part of the seatbelt under the arm.

One of the other main faults, moving a child into the next type of child restraint too early, had similar rates in 2003 and 2011.

Factors, such as the available time and the trip purpose, influenced how well parents secured their children; they want to secure their child correctly, but it needs to be easier and simpler for them to do so. Most of the misuse problems could probably be reduced by providing better help and guidance top parents. (Lesire et al, 2013a)

An additional study in Belgium of 1,500 children illustrated the same tendencies as in the other studies: many children not correctly restrained, child restraint use being much lower for children older than 6 years, and too many parents not being aware that they are not using child restraints properly. (Lesire et al, 2013a)

A roadside survey conducted in September 2011 by the Belgian Road Safety Institute (BRSI) found that at least 50% of children were not correctly restrained and 10% were not restrained at all. The most significant factors associated with child car restraint misuse were the use of a seatbelt by the driver, whether the restraint was bought in a supermarket rather than a specialised shop and the age of the child.

Most of the drivers were ignorant of their errors in using their child car restraint correctly or underestimated the risk. The three main reasons given by the drivers to explain the misuse were low attention level to safety (inattention, time pressure, and short distance), the child's resistance to being restrained, children restraining themselves and problems with the restraint.

The results suggested little or no change in the level of correct child car restraint use over the last previous years. (Roynarda et al, 2014)

TRL developed a standardised form to record details of the type of restraint, the child using it, and the way in which it is fitted. Initial analysis illustrated that 43% of parents did not know the weight or height of their child, information that is crucial when choosing a child car restraint. Although the appropriateness of the child restraints being used was generally good, there was a trend to use forward-facing child restraints as soon as possible, and sometimes too soon, with some being used by children under 9 months old.

A trend to transfer children to booster seats as soon as possible was also seen, with a large percentage of 3 year-olds using them. Most child restraints were compatible with the vehicle in which they were used, but only 53% were correctly installed, usually because the seat belt was too slack or incorrectly routed. (Pitcher, 2011)

A more recent analysis of records from child car seat checking clinics found that levels of misuse of child car seats remain high and so education and checking clinics are essential. Although most parents/guardians were able to provide the child's age, few knew their weight or height correctly, both of which are important when choosing a child car seat that is appropriate for their child. 60% of the child car seats checked had at least one form of misuse. (M Pitcher, 2015)

It has been suggested that the risk of misusing a shield-system restraint is lower because it is not necessary to fit the child in the integral harness. However, the number of cases is too small to draw any conclusion, except that shield systems are seldom observed in the three CASPER study regions and Belgium. There was only one shield system restraint in the CASPER sample, which was correctly used, and only one in the Belgium sample, which was mis-used (used without the shield). (Johannsen et al, 2013)

ISOFIX
is a system for the connection of child restraint systems to vehicles which has two vehicle rigid anchorages, two corresponding rigid attachments on the child restraint system and a means to limit the pitch rotation of the child restraint system.

It was developed to provide more a secure attachment to the vehicle and to make fitting child car restraints easier. Basically, fitting points are built into both cars and child car restraints when they are manufactured. An ISOFIX child restraint is simply 'plugged' into the corresponding fitting points in the car, removing the need to use the car's seat belts to secure the restraint. An additional top tether or bottom foot is used to prevent the restraint from titling or rotating in a frontal impact.

The TRL project that contributed to the development of ISOFIX concluded that ISOFIX with two rear rigid attachments together with an anti-rotation system, such as a top tether, would provide a good basis for a universal system with greatly reduced misuse rates and an improved dynamic performance in accidents. (Lowne, 2000)

In 2009, an AA/Populus Panel Survey of 7,791 driver sin 2008 estimated that at least 6 million cars in Great Britain (around 25% of all cars) were fitted with standardised ISOFIX fittings, but 74% of drivers were unaware of ISOFIX. (AA, 2009)

As yet, there are few published studies assessing the effectiveness of ISOFIX seats in real life. However, the EC-funded CASPER project included a study in Belgium that included enough ISOFIX seats to enable comparisons to be made with "classical" child restraints that are fitted with the vehicle seat belt. The rate of misuse with ISOFIX was 2.3 times lower than with the "classical" ones. It was almost 3 times lower for forward-facing ISOFIX restraints than for forward-facing child seats that are fitted with the vehicle seatbelt. The difference between booster seats with ISOFIX anchorages and standard booster systems was smaller, but still apparent.

However, the CASPER study also found that less than 4% of the restraints were ISOFIX restraints, despite the fact that in 2011 around half vehicles were equipped with ISOFIX anchorages. (Lesire et al, 2013a)

The EC-funded CASPER project found that the main problems are not threading the vehicle seat belt correctly through the child restraint, and the general installation of the child seat in the vehicle. Both these problems could be prevented by the use of ISOFIX, but less than 4% of the restraints were ISOFIX restraints, despite the fact that around 50% of the vehicle fleet was equipped with ISOFIX anchorages in 2011. (Lesire et al, 2013a)

A study in Belgium of 1,500 children was able to compare ISOFIX systems with "classical attachment" restraints. The rate of misuse with ISOFIX was 2.3 times lower than with the "classical" ones. It was almost 3 times lower for forward-facing ISOFIX restraints than for forward-facing child seats that are fitted with the vehicle seatbelt. The difference between booster seats with ISOFIX anchorages and standard booster systems was smaller, but still apparent. (Lesire et al, 2013a)

The 2011 roadside survey by the Belgian Road Safety Institute (BRSI) that found that at least 50% of children were not correctly restrained suggested that the ISOFIX system reduced misuse significantly, although only a small number of ISOFIX seats were observed. (Roynarda et al, 2014)

An observational study in 2005 in the USA found that although the proportion of LATCH-equipped child restraints (LATCH is a USA system similar to ISOFIX) being correctly fitted in LATCH equipped cars had increased, correct fitting was still not universal. The study did not compare LATCH-equipped child restraints with non-LATCH-equipped ones. (Decina, 2006)

A more recent USA survey of drivers' use of top tether points when fitting forward-facing LATCH child restraints found that only 56% of forward-facing child restraints were installed with the top tether, and only 39% were installed with the tether correctly. Drivers who installed child restraints without tethers most often said they did not know about the tether or how to use it. (Eichelberger et al, 2014)

i-Size (Regulation 129 Child Car Restraints

R129 was developed to introduce regulations to enable the approval of enhanced Child restraints to mitigate some of the problems associated with child restraint systems (i.e., the levels of misuse, poorer protection from side impacts, children being put in the next size restraint too soon). The proposals for a new regulation for child restraint systems were developed by an informal UNECE working group. Their recommendations were based on the work of the EC-funded EPOCh and CASPER projects, working groups such as EEVC WG12 and WG18 and research projects.

(Lesire et al, 2013b)

The regulation introduces Child Restraints designated as i-Size. The i-size system is a new UNECE regulation for child restraints, which was introduced on 9 July 2013 and will run in parallel with the existing R44.04 standard for the next few years. **"i-Size"** (Integral Universal ISOFIX Child Restraint Systems) is a category of Child Restraint System for use in all i-Size seating position designated as such in a motor Vehicle. The system is intended to be plug and play in order to simplify the current situation. I-Size seats must be marked with the I Size logo.

The current level of UNECE R129 covers child restraints which are designated as i-Size Integral child restraints. i-Size integral child seats are intended for use in the designated I-Size seating position points in the car, with the child restrained by belts that are part of the child restraint. i-Size seats will fit appropriate designated I Size positions in a vehicle i. Cars will need to provide designated i-Size seating positions to achieve the maximum 5 star Euro NCAP rating.

The main changes that i-Size introduces are:

- Child restraint systems based on the child's height rather than weight
- i-Size rearward-facing restraints will be for babies up to 15 months old
- a side impact test.

(UNECE, 2013)

Promoting Child Car Restraint Use

In 2006, a Department for Transport campaign to raise awareness of new laws about using child restraints increased awareness about the need to use child restraints and the details of the new laws. In a post-campaign survey almost two-thirds (63%) of parents said they used a child restraint when transporting a child, up from 50% before the campaign. Awareness of when children could move up to seat belts had increased, as had awareness of the new laws from 45% in July to 93%. (DfT 2006)

Amongst those aware of the legislation, a quarter said they had changed the way they transported children, most commonly by starting to put their children in child restraints. However, a significant minority, especially those transporting older children or transporting children less regularly, were still not doing so. (DfT 2006)

A review of studies published between 2000 and 2007 of the effectiveness of education and legislation interventions to increase the use of child restraints found sufficient evidence to suggest that such interventions are effective. The review found five studies involving a total of 3,070 participants. All of the interventions investigated increased the use of booster seats by the people who took part in the intervention, compared to groups that did not. Distributing free booster seats combined with education on their use, had a marked beneficial effect, as did financial incentives (such as discount coupons or gift certificates) combined with education. Education-only interventions also produced beneficial outcomes. (Ehiri, 2009)

Only one study evaluated the effectiveness of the enforcement of a booster seat law, but did not detect an effect on usage. However, the authors also concluded that there is a need for further high quality trials, especially outside the USA and Australia, where current research dominates. (Ehiri, 2009)

An evaluation of a practical education intervention in the use of child car restraints included 111 parents who were at least seven months pregnant and who were randomly assigned to one of two groups (56 intervention and 55 control). All received a free car seat and a standard education session on the use of child passenger restraints, but the intervention group also received a hands-on demonstration of how to correctly install and use the restraint in their own vehicle. Follow-up observations after birth found that only 24 (22%) of the parents correctly used the child restraint, of whom 18 (32%) were in the intervention group and 6 (11%) were in the control group. The intervention group was four times more likely than the control group to install and use the restraint correctly. (Tessier, 2010)

Child car restraint laws are one of the five key road safety laws named in the Global Decade of Action for Road Safety, only 32% of the world's population are covered by such laws. They are more common in high income countries but new laws are being enacted in middle and low income countries.

Even though child restraint laws are important, experience in high income countries shows that high levels of compliance are difficult to achieve with education and enforcement programmes, and support programmes to distribute child restraints. According to the WHO, only 17% of the 96 countries with child restraint laws have good enforcement programmes. (Keay et al, 2015)

A study of the effectiveness of four different child passenger safety leaflets on parents' knowledge, attitudes, and behavioural intentions related to best practice and proper use of child restraints found that all the education leaflets improved parents' messages knowledge, attitudes, and behavioural intentions, but the leaflet which explained the risk-reduction rationale behind the information given performed best, (K E Will et al, 2015)

An evaluation of a child car seat safety class held at a pediatric trauma center, and attended by almost 500 parents, found that it was effective at increasing parental knowledge about child passenger safety. Interactive and hands-on teaching methods may have resulted in greater retention and comprehension of the messages than more passive methods, such as showing a video in a hospital waiting room. (Muller et al, 2014)

An evaluation of a multimedia DVD designed to improve knowledge about car seat installation among parents of infants and toddlers found that it improved parents knowledge and ability (on a simulated test) to use child car seat correctly. DVD programs such as this offer a promising format for teaching, demonstrating, and facilitating desired behaviour change by using visual examples and context, and accommodate parents' busy schedules, time constraints, and family obligations. However, a significant challenge to public health advocates is dissemination of effective programs to the target populations. (Swartz et al, 2013)

Disadvantaged Groups

A review of thirty-nine studies of interventions to increase the use of child restraints, (including restraint loan schemes, educational campaigns, legislation and enforcement) found that few targeted social and economic factors. However, there was evidence that free or loaned child seat schemes increased the use of child car restraints, and some evidence suggesting that although restraint use is higher among higher socio-economic groups, lower social groups can be effectively targeted. (Towner, 2004)

A review of road safety services for disadvantaged communities cited a scheme providing a subsidy for buying child car seats as an example of good practice in that it sought to understand and address a specific need in disadvantaged communities. Providing child seats for taxis from maternity wards and child seat inspections were other examples of interventions demonstrating recognition of the needs of this target group and focusing on relevant issues for promoting behavioural change (i.e. installing good child car seats). (Lowe, 2011)

In 2005 and 2006, a small number of local councils conducted road safety interventions to supply and fit free baby seats for families from disadvantaged areas. Families in deprived areas received a voucher which was redeemable at a local retailer of child car restraints, whose staff showed the parents how fit the seat. However, the schemes were expensive to run because of the cost of the seats, and so their sustainability was questionable. (Hayes, 2008)

Between 2004 and 2006, after a local survey that found roughly 8 in 10 seats were incorrectly fitted, free inspections of child car restraints were provided by trained fire officers, alongside an educational campaign. Initially, the scheme was confined to families in deprived areas, but they proved difficult to engage and uptake was poor (despite anecdotal evidence suggesting that they drove the oldest cars and carried most children, often without restraints), so the project was opened to all people in the city who transported a child. (Hayes, 2008)

There is little evaluation to show whether such schemes are effective in reducing casualties or improving child restraint fitment and use on a large scale, perhaps reflecting the lack of well-structured evaluations rather than the schemes being ineffective. (Hayes, 2008)

Room for Improvement

The ETSC Road Safety Performance Index (PIN), a policy tool to help EU Member States improve road safety, assessed progress on improving car occupant safety in the in the EU27 countries between 2001 and 2012. It found that deaths to car occupants fell by 55% between those years, more than more than the fall of 49% in the overall death rate. However, between 2010 and 2012 the car passenger fatality rate for children (aged 0 to 14) per million child population varied between countries from less than 1 to more than 8. (Jost et al, 2014)

Child car restraint laws are one of the five key road safety laws named in the Global Decade of Action for Road Safety, only 32% of the world's population are covered by such laws. They are more common in high income countries but new laws are being enacted in middle and low income countries.

Even though child restraint laws are important, experience in high income countries shows that high levels of compliance are difficult to achieve with education and enforcement programmes, and support programmes to distribute child restraints. According to the WHO, only 17% of the 96 countries with child restraint laws have good enforcement programmes. (Keay et al, 2015)

CHILD CAR RESTRAINTS: REFERENCES

Title:	**Infants and Children in the Adult World of Automobile Safety Design: Pediatric and Anatomical Considerations for Design of Child Restraints**
Author:	A R Burdi, D F Huelke, R G Snyder and G H Lowrey
Published:	Journal of Biomechanics, Vol. 2, pp. 267-28, 1969
Link:	http://deepblue.lib.umich.edu/bitstream/2027.42/32937/1/0000320.pdf
Objectives:	To identify general principles for child restraint systems based on the basic anatomical differences between the adult and child. To produce a profile of the anatomy, anthropomctry, growth, and development of the infant and child to highlight age differences related to the design of child restraint systems.
Methodology:	Literature Review

Key Findings:

- Infants and children are not miniature adults. Their anatomy differs from adults in a number of ways. The design of occupant restraint systems needs to be based on child anatomy not the anatomy of the adult.
- The frequency of head injuries in children in automobile accidents may be due to the child's proportionately large head and higher center of gravity.
- Observations that the child's head is relatively massive and supported poorly from below have been implicated in head snapping with rapid body deceleration, which can traumatize related nerves, blood vessels, and spinal cord segments.
- The relative lack of skull protection, due to the fact that infants' skulls are not an intact bony case but a series of broadly spaced elastic bones, contributes to brain injuries in young children.
- Differences in size, structure, shape, and biomechanical properties of the infant, child, and adult pelvic skeleton must be considered in terms of lap belt design, position, and vehicle anchorage. Key differences include insufficient space in the pelvic-thigh angle for adequate positioning of the adult lap belt on the child.
- Unlike the adult, the organs of the chest are housed in an elastic and highly compressible thoracic cage, and are extremely vulnerable to non-penetrating impacts to the chest. The thoracic cage is not amenable to direct trauma or loading of webbed restraints in children.
- The most effective restraint systems for children are those which distribute impact forces over a large portion of the body.

Format: Pdf	**Cost:** Free

Title:	**Seat Belts and Child Restraints: A Road Safety Manual for Decision-makers, and Practitioners**
Author:	World Health Organisation
Published:	World Health Organisation, 2009
Link:	http://whqlibdoc.who.int/road_safety/2009/9780956140302_eng.pdf
Objectives:	To provide advice and examples that will lead to increased use of seat belts and child restraints as safety devices at a national level.
Methodology:	Literature Review, Case Studies and Good Practice Guide.

Key Findings:

- Seat belts save lives and significantly reduce injury severity for vehicle occupants.
- Around half of deaths of front seat occupants could be prevented by seat belts.
- Motor vehicle users make up a high proportion of traffic injuries and deaths in high-income countries, and the proportion is increasing in low- and middle-income countries. It is vital that seatbelt use is increased in these countries.
- Children should use restraints that are suitable for their height and weight. This reduces deaths of children by between 50% and 75%.
- Mandatory seat-belt legislation, combined with public education campaigns, is effective at increasing seat belt wearing rates and thus reducing injuries and fatalities.
- Continuous and fair enforcement of the law is essential for raising rates to a significant level. This requires strong commitment from both governments and enforcement agencies.
- A well-designed marketing and publicity campaign is essential.
- Educational programmes, combined with other activities, can help shift behavioural norms towards making seat-belt use more acceptable.
- Evaluation should be an integral component of any programme.

Format: Pdf	**Cost:** Free

Title:	**Child Passenger Safety**
Author:	American Academy of Pediatrics
Published:	Pediatrics 2011; 127;788, March 2011
Link:	http://pediatrics.aapublications.org/content/127/4/788.full.html
Objectives:	To provide evidence-based recommendations for best practice in the choice of a child restraint system to optimize safety in passenger vehicles for children from birth to adolescence.
Methodology:	Literature Review

Key Findings:

- Child passenger safety has dramatically evolved over the past decade, but motor vehicle crashes remain a leading cause of death of children 4 years and older.
- Best practice recommendations for a child restraint systems to optimize safety in passenger vehicles for children from birth through adolescence are:
  - rearfacing car safety seats for most infants up to 2 years of age.
  - forward-facing car safety seats for most children through 4 years of age.
  - belt-positioning booster seats for most children through 8 years of age.
  - lap-and-shoulder seat belts for all who have outgrown booster seats.
  - all children younger than 13 years to ride in the rear seats of vehicles.
- Every transition from one type of child restraint to another is associated with some decrease in protection; therefore, parents should be encouraged to delay these transitions for as long as possible.
- The American Academy of Pediatrics urges all paediatricians to know and promote these recommendations as part of child passenger safety anticipatory guidance at every health-supervision visit.

Format: Pdf	**Cost:** Free

Title:	**Rearward Facing Group 1 CCS** **Advise use of rear facing child car seats for children under 4 years old**
Author:	Elizabeth A Watson, and Michael J Monteiro
Published:	British Medical Journal (BMJ), 11 June 2009
Link:	http://www.bmj.com/content/338/bmj.b1994.extract
Objectives:	To explain why it is safer for young children to travel in a rear facing seat until they are 4 years old.
Methodology:	Literature Review

Key Findings:

- Many babies are switched from a rear facing car seat to a forward facing seat at 9 kg (8 months of age for a boy on the 50th centile)
- The relatively large head mass and differences in the anatomy of the cervical spine in young children can lead to excessive stretching or even transection of the spinal cord if a child is involved in a frontal (head-on) crash while in a forward facing car seat.
- Rear facing seats are safer than forward facing seats for children under 4 years old
- Parents and guardians should be advised to keep young children in rear facing seats for as long as possible
- In many countries it is a legal requirement that children under a certain height or age (1 m 35 cm or 12 years, in the United Kingdom) to use child restraints appropriate for their weight while travelling in a car. This significantly reduces morbidity and mortality.
- Many babies are switched from a rear facing to forward facing seat at 9 kg (age 8 months for a boy on the 50th centile. However, evidence is mounting, however, that it is safer for young children to travel in a rear facing seat until 4 years of age.

Format: Html	**Cost:** Priced

Title:	**Safety For The Growing Child – Experiences From Swedish Accident Data**
Author:	Lotta Jakobsson, Irene Isaksson-Hellman, Björn Lundell
Published:	International Technical Conference on the Enhanced Safety of Vehicles (ESV), 23rd Conference, Paper Number 05-0330, 2005
Link:	http://www-nrd.nhtsa.dot.gov/pdf/esv/esv19/05-0330-O.pdf
Objectives:	To evaluate child safety with respect to age, size in different impact situations and to identify optimal restraints and potential areas for improvement.
Methodology:	Analysis of car crashes from Volvo's statistical accident database between 1987 and 2004 involving 3,670 children, aged 0-15 years.

Key Findings:

- During the past 40 years, different child restraint systems have been developed to improve protection for children of different sizes and ages.
- The development of more effective child restraints, and increased use of restraints, in addition to enhanced vehicle safety, has increased child safety.
- The injury-reducing effect of the child restraint systems was high overall.
- The highest injury-reducing effect was found in rearward facing child restraints for children up to 3-4 years of age, offering an injury-reducing effect of 90% compared to an unrestrained child.
- Belt positioning boosters from 4 to 10 years of age were found to have an injury reducing effect of 77%.
- Compared to adults, children have a generally lower AIS 2+ injury rate, except for abdominal and lower-extremity injuries.
- Abdominal injuries are mainly found in children using only a seat belt, emphasising the need for belt-positioning boosters.
- A tendency of higher injury risk was found when the growing child switches from one restraint to another, i.e. when the child is at the youngest age approved for the restraint.
- Thus, the total injury-reducing effect would increase if all children were to use the child restraint system most appropriate for their size and age.
- The challenge is to spread information as well as enhance design to encourage everyone to use the appropriate child restraint system and to use it correctly.
- Head injuries are the most frequent moderate or severe for side (as well as frontal) impacts.
- The head is by far the most injured body region in side impacts, while in frontal impacts the injuries are more evenly distributed over the different body parts.
- Rearward-facing child seats are designed primarily for frontal impacts, however the outcome for side and rear-end impacts indicates a good performance in these situations.
- No rearward-facing child sustained MAIS 2+ injuries in side or rear-end impacts.

Format: Pdf	**Cost:** Free

Title:	**Lives Saved Through Child Restraints 82 to 87**
Author:	National Highway Traffic Safety Administration (NHTSA)
Published:	National Highway Traffic Safety Administration, 1988
Link:	http://www-nrd.nhtsa.dot.gov/Pubs/807371.pdf
Objectives:	To measure the level of child restraint use and their effectiveness in reducing fatality risk compared with children using seat belts and unrestrained children.
Methodology:	An analysis of fatal car accidents in the USA between 1982 and 1987 involving cars equipped in which the use of restraints or not by the driver and child passengers was reported. Fatality odds ratios were calculated using a matched pairs technique.
Key Findings: Between 1982 and 1987 • Child safety seats reduced the risk of death among infants (under 1 year old) by 69%. • Child safety seats reduced the risk of death among toddlers (1 – 4 year olds) by 47%. • Using an adult seat belt reduced the risk of death by 36% for toddlers. • Child safety seats saved an estimated 838 children's lives, and if all children had been using child safety seats over that period a further 2,349 children's lives could have been saved. • Children in child safety seats were 50% less likely than unrestrained children to be killed, whereas children using the car's adult seat belts were only 36% less likely to be killed. • Unrestrained children were more likely to sit in the front, than in the rear, seats, but children sitting in the rear were 33% less likely to be killed than children sitting in the front.	
Format: Pdf	**Cost:** Free

Title:	**Revised Estimates of Child restraint Effectiveness**
Author:	National Highway Traffic Safety Administration
Published:	National Highway Traffic Safety Administration, 1996
Link:	http://www-nrd.nhtsa.dot.gov/Pubs/96855.pdf
Objectives:	To update the results of the 1988 NHTSA report above.
Methodology:	An analysis of fatal car and light truck vans accidents in the USA between 1988 and 1994 in which the use of restraints or not by the driver and child passengers was reported. Fatality odds ratios were calculated using a matched pairs technique.

Key Findings:

In Cars:

- Between 1988 and 1994 child safety seats reduced the risk of death among infants (under 1 year old) by 71% (up from 69%).
- Between 1988 and 1994 child safety seats reduced the risk of death among toddlers by 54% (up from 50%).
- Between 1988 and 1994 using an adult seat belt reduced the risk of death by 47% for toddlers (up from 36%).

In light trucks and vans:

- Between 1988 and 1994 child safety seats reduced the risk of death among infants (under 1 year old) by 58%.
- Between 1988 and 1994 child safety seats reduced the risk of death among toddlers by 54% (up from 59%).
- Between 1988 and 1994 toddlers using adult seat belts reduced the risk of death by 47%.

Overall:

- Children are 26% less likely to be fatally injured if sitting the rear of a vehicle.
- The maximum potential for reducing the risk of death for child passengers is achieved by children using an appropriate child restraint in the rear of the vehicle.

Format: Pdf	**Cost:**

Title:	**Traffic Safety Facts: Children: 2011 Data**
Author:	National Highway Traffic Safety Administration
Published:	National Highway Traffic Safety Administration, 2013
Link:	http://www-nrd.nhtsa.dot.gov/Pubs/811767.pdf
Objectives:	To analyse and present data about child road fatalities in the USA.
Methodology:	Analysis of child fatality data in the USA.

Key Findings:

- Motor vehicle crashes were the leading cause of death for children aged 4 years, and aged between 11 and 14 years.
- 1,140 children aged 14 years or younger were killed on USA roads in 2011, 4% of total road deaths.
- Lap and shoulder seat belts reduce the risk of death for front seat car occupants aged 5 or older by 45%, and reduce the risk of moderate to critical injury by 50%.
- Research on child safety seats has found that they reduce the risk of fatal injuries by 71% for infants (under 1 year old) and by 54% for toddlers (1 – 4 years old) in cars.
- In 2011, 663 children under 5 years old were saved by restraints, 245 of whom were using child safety seats, and 18 were using seat belts. A further 51 lives could have been saved if child safety seat use was 100%.
- Between 1975 and 2001, an estimated 9,874 lives (children under 5 years old) were saved by child safety seats.

Format: Pdf	**Cost:** Free

Title:	**Child passenger restraint use and emergency department–reported injuries: A special study using the National Electronic Injury Surveillance System–All Injury Program, 2004**
Author:	Karen C. Lee, Ruth A. Shults, Arlene I. Greenspan, Tadesse Haileyesus & Ann M. Dellinger
Published:	Journal of Safety Research**,** Volume 39, Issue 1, pp 25–31, 2008
Link:	http://www.sciencedirect.com/science/article/pii/S0022437507001429
Objectives:	To assess levels of use, mis-use and non-use of child car restraints among different groups.
Methodology:	Review of accident records for 635 injured children aged 12 years or younger who were treated at 15 hospital EDs in 2004 and interviews with parents of children attending an Emergency Department having being injured in a road accident.

Key Findings:

- In 2004, more than 180,000 child passengers aged 12 years or younger sought care in U.S. hospital emergency departments for injuries sustained in vehicle crashes
- 9% of the children were unrestrained and 36% were inappropriately restrained.
- Black and Hispanic children were about six times more likely to be unrestrained than Non–Hispanic Whites (12% and 14%, respectively, vs. 2%).
- 77% of inappropriate restraint use occurred among children aged 4–8 years, who were prematurely placed in seatbelts.
- 8% of children required hospitalization; unrestrained children were three times more likely to be hospitalized than restrained children (21% vs. 7%).
- Age–appropriate restraint use should be promoted for child passengers, particularly among Blacks, Hispanics, and children riding in trucks.

Format: Pdf	**Cost:** Free

Title:	**Car restraints and seating position for prevention of motor vehicle injuries in Greece**
Author:	E Petridou, A Skalkidou, I Lescohier, D Trichopoulos
Published:	Arch Dis Child; 78(4): 335–339, April 1998
Link:	http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1717544/
Objectives:	To assess the protective effect of child restraints and the relative safety of front and rear seating in a population where children often travel unrestrained.
Methodology:	A population control study of children aged 0–11 years injured as car passengers in a motor vehicle accident in 1996 and treated at one of the two major children's hospitals in Athens, and an observational study of a random sample of 191 children of the same age travelling in cars.

Key Findings:

- The Odds Ratio for injury was 3.3 among unrestrained children compared with restrained children (comparison essentially limited to children aged 0–4 years).
- The Odds Ratio for injury was 5.0 for children seated in the front compared with those seated in the rear (comparison essentially limited among unrestrained children).
- In Greece about two thirds of all childhood injuries from car crashes could have been avoided through the regular use of a proper child restraint.
- In the absence of a child restraint system, a rear seating position conveys substantial protection and could explain the low mortality of children as car passengers in Greece, a country which is characterised by a high overall road traffic mortality.

Format: Pdf	**Cost:** Free

Title:	**Children in Car Crashes: Analysis of Data for Injury and Use of Restraints**
Author:	Carden Johnston, Frederick P. Rivara, Robert Soderberg
Published:	Pediatrics Vol. 93 No. 6 pp. 960 –965, June 1 1994
Link:	http://pediatrics.aappublications.org/content/93/6/960
Objectives:	To determine the effect of car restraints on motor vehicle injury rates for children aged 0 to 14 years.
Methodology:	A probability sample of reported car crashes in the United States in 1990 and 1991 was analyzed for injury rates of passengers under 15 years in relation to restraint usage, age, and seating position.

Key Findings:

- Optimal restraint usage (defined as car seats for children 0 to 4 years old and lap shoulder belts for children 5 to 14 years old) was 40%.
- The use of car seats was 76% for infants (0 to 12 months old) and 41% for toddlers (1 to 4 year olds). The non use of a restraint was highest for 10 to 14 year olds (43%).
- 19% of under 1 year olds who were in an appropriate restraint were injured, compared with 30% of those in an inappropriate restraint and 40% of those who were not restrained.
- For 1 to 4 year olds, 17% of those appropriately restrained, 22% of those in a seat belt and 43% of those unrestrained were injured.
- For 5 to 9 year olds, the relative proportions were 29%, 26% and 44% and for 10 to 14 year olds, they were 28%, 29% and 49%.
- Children of all ages faced a much greater chance of being injured if they were unrestrained. Children who were inappropriately restrained were at greater risk than those who were appropriately restrained.
- Unrestrained children were 1.5 to 2.5 times more likely to be injured than restrained children.
- Use of the child car seat reduced injuries by 60% for 0 to 4 year olds, whereas the lap shoulder harness was only 38% effective for 5 to 14 year olds. Injury rates of unrestrained 0 to 4 and 5 to 14 year olds were similar.
- Greater involvement in car crashes and less use of car restraints explains the 64% higher rate of injury for 3 year olds than for infants. It is time to target the toddlers.

Format: Pdf	**Cost:** Priced

Title:	**Effectiveness of Child Safety Seats vs Safety Belts for Children Aged 2 to 3 Years**
Author:	Eduard Zaloshnja, Ted R. Miller and Delia Hendrie
Published:	Archives of Pediatrics & Adolescent Medicine *Arch Pediatr Adolesc Med.*161(1):65-68**,** 2007
Link:	http://archpedi.ama-assn.org/cgi/content/abstract/161/1/65
Objectives:	To compare the effectiveness of child safety seats and lap-shoulder belts in rear passenger vehicle seats for 2 to 3 year-old crash survivors.
Methodology:	Cohort study of a nationally representative sample of crashes in the USA involving toddlers who were sitting in the rear and using lap-shoulder belts or child seats, between 1998 and 2004.

Key Findings:

- The adjusted odds of injury were 81.8% lower for toddlers in child seats than belted toddlers.
- Child safety seats seem to be more effective rear seat restraints than lap-shoulder safety belts for children aged 2 to 3 years.
- Laws requiring that children younger than 4 years travel in child safety seats have a sound basis and should remain in force.

Format: Html	**Cost:** Priced

Title:	**Effectiveness of child safety seats vs seat belts in reducing risk for death in children in passenger vehicle crashes**
Author:	Elliott MR, Kallan MJ, Durbin DR, Winston FK
Published:	Archives of Pediatrics & Adolescent Medicine Arch Pediatr Adolesc Med;160(6):617-21, June 2006
Link:	http://www.ncbi.nlm.nih.gov/pubmed/16754824
Objectives:	To provide an estimate of benefit, if any, of child restraint systems over seat belts alone for children aged from 2 to 6 years.
Methodology:	Cohort study of a sample of children in US passenger vehicle crashes involving a fatality and a probability sample of cases without a fatality between 1998 and 2003.

Key Findings:

- Compared with seat belts, child restraints, when not seriously misused (eg, unattached restraint, child restraint system harness not used, 2 children restrained with 1 seat belt) were associated with a 28% reduction in risk of death in children aged 2 to 6 years after adjusting for seating position, vehicle type, model year, driver and passenger ages, and driver survival status.
- When including cases of serious misuse, the effectiveness estimate was slightly lower (21%).
- Based on these findings as well as previous epidemiological and biomechanical evidence for child restraint system effectiveness in reducing nonfatal injury risk, efforts should continue to promote use of child restraint systems through improved laws and with education and disbursement programs.

Format: Html	**Cost:** Priced

Title:	**The Effect Of Restraint Use And Crash Mode On Injury Severity Risk For Children**
Author:	Santokh Singh, Linda McCray and John Brewer
Published:	International Technical Conference on the Enhanced Safety of Vehicles (ESV) 20th Conference, Paper Number 07-0216, 2007
Link:	http://www-nrd.nhtsa.dot.gov/pdf/esv/esv20/07-0216-O.pdf
Objectives:	To study the effect of restraint use under different risk scenarios consisting of some possible contributors to injury risk: the restraint use, impact type, injury severity, and age of crash involved children.
Methodology:	Data analysis of children of age groups: infants, 1 to 3, 4 to 8, and 9 to 12 year olds, who were either uninjured, or sustained minor to fatal injuries in frontal, side, rear-end, or rollover crashes from the National Automotive Sampling System– Crashworthiness Data System (NASS-CDS) 1994 to 2004.

Key Findings:

In general, the restrained children were found much safer against injuries.

1 – 3 year old Children

- The relative risks of 0.303, 0.349, and 0.76 for MAIS=0 in frontal, side and rollover crashes show that there are low chances of protection against injuries for these children when they are unrestrained.
- The relative risks of 0.88, 0.79, 0.51in frontal, side, and rear-end crashes are indicative of low risk of minor injury to 1 to 3 year olds in these types of crashes.
- In rollover crashes, the relative risk of 10.33 of minor injury to an unrestrained child is about 7 times higher than the relative risk 1.42 to a restrained child.
- For moderate to serious injuries, restrained children have low relative risks of serious injury: 0.71, 0.92, and 0.88, respectively, for frontal, side, and rear-end crashes.
- The risk (10.44) to an unrestrained child in rollover crashes is about 10 times higher than the relative risk (1.48) to a restrained child.

4 to 8 year olds Children

- In side, rear, and rollover crashes, these children have greater chance of being uninjured when they are restrained.
- For minor injuries, the restrained children showed a low risk in side, rear and rollover crashes, these children have a higher risk 1.6 of sustaining minor injury in frontal crashes when they are unrestrained as compared with restrained children.
- The restrained children of this age group have much lower relative risks of moderate to serious injuries: 0.47 in frontal, 0.80 in side, 0.15 in rear impacts, and 0.24 in rollover crashes. In fact, the relative risks for the unrestrained group were, respectively, 7.7, 7.6, 13.3, and 23.6 times higher than the restrained children.

9 to 12 year old Children

- The relative risks of no injury or minor in frontal, rear and rollover crashes for the restrained group show that the restraint use provided protection against injuries to these children in these crashes. Also, the relative risk of sustaining injuries in side impacts was higher for the unrestrained children.
- The relative risks of serious to moderate injuries: 0.81 in frontal, 0.87 in side, 0.68 in rear-end, and 0.79 in rollover crashes for the restrained group show that the restraint was protective for 9 to 12 years old children against moderate to serious injuries in these types of crashes.
- The results show the overall effectiveness of restraint use in protecting the children from different crash impacts. The level of injury to a child may further depend on whether the frontal impact was full, offset, or center and side impact was near-side or far-side.
- Sample sizes in some sectors of the data were not large enough to statistically validate the findings. The reason for limited or insufficient data could either be the

rare occurrence of certain risk factor combinations or the result of insufficient attention in collecting the pertinent data. • This shows the necessity of collecting more data in such sectors of the data so that valid conclusions can be drawn about restraint systems effectiveness.	
Format: Pdf	**Cost:** Free

Title:	**An evaluation of the effectiveness of forward facing child restraint systems**
Author:	Kristy B. Arbogast, Dennis R. Durbin, Rebecca A. Cornejo, Michael J. Kallan, Flaura K. Winston
Published	Accident Analysis & Prevention, Vol 36, Issue 4, pp 585–589, July 2004
Link:	http://www.sciencedirect.com/science/article/pii/S0001457503000654
Objectives:	To determine the effectiveness of forward facing child restraint systems in preventing serious injury and hospitalization to children 12–47 months of age as compared with similar age children in seat belts.
Methodology:	A cross-sectional study of children aged 12–47 months in crashes of insured vehicles in 15 states, with data collected via insurance claims records and a telephone survey. Completed survey information was obtained on 1,207 children, representing 12,632 children in 11,619 crashes between 1 December 1998 and 31 May 2002.
Key Findings: • Serious injuries occurred to 0.47% of all 12–47-month olds studied, including 1.72% of those in seat belts and 0.39% of those in child restraint systems. • The risk of serious injury was 78% lower for children in forward-facing child restraint systems than in seat belts. • The risk of hospitalization was 79% lower for children in forward-facing child restraint systems than in seat belts. • There was no difference between the restraint types in preventing minor injuries. • As compared with seat belts, child restraint systems are very highly effective in preventing serious injuries and hospitalization. • This effectiveness estimate is substantially higher than older estimates, demonstrating the benefits of current child restraint systems designs.	
Format: Html	**Cost:** Priced

Title:	**A Prospective study of children as car passengers in road traffic accidents with respect to restraint effectiveness**
Author:	H. Gustafsson, Å. Nygren and C. Tingvall
Published	Acta Pediatrica, Vol76, Issue s339, Oct 1987
Link:	http://onlinelibrary.wiley.com/doi/10.1111/j.1651-2227.1987.tb10581.x/abstract
Objectives:	To assess the types of injuries suffered by child car passengers and the effectiveness of child car restraints in preventing such injuries.
Methodology:	Epidemiological study of injuries to children as car passengers in road traffic accidents.
Key findings: • Protective measures should be focused on the head region, as both fatal and disabling injuries occur mainly in this part of the body. • Unrestrained children at greatest risk; children in rear-facing child restraints at lowest risk. • The injury risk for children aged 0 – 4 years was almost 5 times greater in a forward-facing child restraint than in a rearward-facing one. • Rearward-facing seats were 90% effective and forward-facing seats in rear outboard position were 60% effective at reducing injuries. • Forward-facing seats distinctly more effective in frontal collisions than in side impacts. All the seats were boosters, ie no internal harness.	
Format: Html	**Cost:** Priced

Title:	**Cervical Spine Fractures Sustained by Young Children in Forward-Facing Car Seats**
Author:	Fuchs S et al
Published:	American Academy of Pediatrics Pediatrics Vol 84 No 2, pp 348-352, August 1989
Link:	http://pediatrics.aappublications.org/content/84/2/348.abstract?sid=289e6f55-df7c-4e33-9ba6-d16edbc2d09b
Objectives:	To examine injury patterns to children involved in car crashes while using (correctly or incorrectly) child safety seats.
Methodology:	Data on children injured in a car accident between October 1985 and March 1987 was collected from police and hospital records and from a survey of parents. Where possible the car safety seat in use at the time was examined.

Key Findings:

- Laws have increased the use of child safety seats and helped to reduce child deaths and injuries in cars
- However, there has also been an increase in the misuse of such seats, with as many as 74% being incorrectly used.
- In some cases this results in severe cervical spine injuries to children.
- Five cases of severely injured children are presented
    - A 16 month old girl had been unsecured in a forward-facing child seat, which was secured only by a lap belt
    - A 12 month old boy had been unsecured in a forward-facing child seat, which was not secured by a seat belt and was thrown onto the dashboard.
    - A 23 month old girl was had been restrained in a forward-facing child seat, which was secured but she was still injured
    - A 9 month old boy in a forward-facing child seat was fatally injured (as was the driver)
    - A 9 month old boy in a forward-facing seat was secured by the car's seat belt not by the child seat's harness
- Public and parent education in the proper use of child car restraints is necessary.
- A redesigned child safety seat that allowed children to travel rearward-facing until 2 or 4 years of age would help to reduce severe head and neck injuries to child passengers.

Format: Html	**Cost:** Priced

Title:	**Rearward-Facing Child Seats – The Safest Car Restraint For Children?**
Author:	G Carlsson et al
Published:	Accident Analysis & Prevention, Vol. 23, Nos. 2/3, pp 175-182, 1991
Link:	http://www.ncbi.nlm.nih.gov/pubmed/2029318
Objectives:	To evaluate the effectiveness of child restraints in reducing the risk of injury to child car passengers in Sweden.
Methodology:	Analysis of accident data from 1,500 accidents that occurred between 1976 and 1988 and in which at least one child (0 to 14 years) was present in the vehicle. Attitudinal survey amongst drivers about child safety in cars.

Key Findings:

- The use of child restraints in cars in Sweden has rapidly increased, with the major emphasis being on using rearward-facing child seats for children 0 to 4 years of age.
- There are two types of rearward-facing child restraints used in Sweden: 'infant seats' for babies from 0 to about 6 months old that can be used in the front or rear of the car and 'toddler seats' for children aged from about 6 months to about 4 years, which are used mainly in the front of cars.
- Using rearward-facing restraints reduced the risk of injury by between 76% and 92%.
- Using forward-facing child seats reduced the risk of injury by between 34% and 60%.
- Unrestrained children had the highest injury risk.
- Of the rearward-facing child seats in these accidents, 6% were incorrectly fitted.

Format: Pdf	**Cost:** Priced

Title:	**Premature infants in car seats**
Author:	Bull MJ and Stroup KB
Published:	American Academy of Pediatrics Pediatrics 1985;75:336–9,1985
Link:	http://pediatrics.aappublications.org/content/75/2/336.abstract?sid=cd32b0ef-5fa1-4d61-8325-5e64ae7276de
Objectives:	To assess the suitability of various types of infant car safety seats for premature infants
Methodology:	Babies weighing 2.0-kg (4 lb 8 oz) were placed in a representative sample of seat models. Ease and ability of the seat to fit the size of the infant and allow for proper positioning of the baby was noted.

Key Findings:

- Advancements in health care have made it possible for many premature infants weighing less than 2.2 kg (5 lb) to be discharged from the hospital.
- Medical professionals, however, have no information available from which to make recommendations about which child safety seats are most appropriate for safely transporting low-birth-weight infants.
- Current federal safety standards do not specify the minimum weight of an infant for which a seat is appropriate.
- Convertible seats with seat back to crotch strap height of 14 cm (5½ in) or less provided relatively good support for the infant.
- Seats with longer seat back to crotch strap distances allowed the infant to slouch.
- Seats with lap pads or shields were uniformly unacceptable.

Format: Pdf	**Cost:** Priced

Title:	**Risk of hypoventilation in premature infants in car seats**
Author:	M. P Leuschen, R.N. Linda S. Nelson & Robert M Nelson Jr
Published:	The Journal of Pediatrics, Volume 109, Issue 2, Pages 245-248, August 1986
Link:	http://www.ncbi.nlm.nih.gov/pubmed/3734961
Objectives:	To assess whether currently available car seats may place premature infants at risk for significant hypoxia and ventilatory compromise.
Methodology:	• Examinations of 30 newborn infants for respiratory compromise before, during, and after placement in a recommended child car restraint. Twelve of the infants were premature with a history of apnea, eight were premature without known apnea, and 10 were born at term.
Key Findings: • Both premature groups had significant decreases in oxygen saturation while in the car seat and more frequent desaturation episodes. • Premature infants with a history of apnea had more bradycardia events. • No normal term infant had any of these problems. • In addition, oxygen saturation trended downward from baseline for all premature infants during the recovery interval. • Currently available car seats may place premature infants at risk for significant hypoxia and ventilatory compromise.	
Format: Pdf	**Cost:** Priced

Title:	**Safe Transportation of Preterm and Low Birth Weight Infants at Hospital Discharge**
Author:	Marilyn J. Bull and William A. Engle
Published:	American Academy of Pediatrics Pediatrics 2009; 123; 1424, 2009
Link:	http://pediatrics.aappublications.org/content/123/5/1424.full.pdf+html
Objectives:	To ensure that preterm and low birth weight infants are transported safely.
Methodology:	Literature Review

Key Findings:

- Preterm infants are subject to an increased risk of oxygen desaturation, apnea, and/or bradycardia, especially when placed in a semi-reclined position in car safety seats.
- Therefore, monitoring in the infant's own car safety seat before discharge from the hospital should be considered for all infants less than 37 weeks' gestation at birth to determine if physiologic maturity and stable cardio-respiratory function are present.
- The amount of time the infant is seated in a car safety seat should be minimized, and car safety seats should be used only for travel.
- A conventional car safety seat that allows proper positioning of the preterm infant should be selected if a semi-upright position can be maintained safely by the infant.
- However, an approved car bed may be indicated for infants who manifest apnea, bradycardia, or low oxygen saturation when positioned semi-reclined in a car safety seat. Such should travel in a supine or prone position in car bed after an observation period that is free of such events as described above.
- If a car bed is considered, a period of cardio-respiratory monitoring while the infant is in the car bed should be performed before discharge.
- Before transitioning from a car bed, a period of observation of an infant for apnea, bradycardia, and oxygen desaturation in the infant's own semi-reclined car safety seat should be considered.
- Infants for whom home cardiac and apnea monitors are prescribed should use this monitoring equipment during travel. The equipment should be wedged on the floor or under the vehicle seat to minimize the risk of it becoming a dangerous projectile in the event of a crash or sudden stop.
- Guidance for selecting car safety seats and positioning preterm and low birth weight infants is provided.

Format: Pdf	**Cost:** Priced

Title:	**Pre-discharge "car seat challenge" for preventing morbidity and mortality in preterm infants**
Author:	Elizabeth Pilley and William McGuire
Published:	Cochrane Neonatal Group, 2009
Link:	http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD005386.pub2/pdf
Objectives:	To assess the available evidence that pre-discharge cardiorespiratory monitoring in a car safety seat prevents morbidity and mortality in preterm infants.
Methodology:	Literature review of randomised or quasi-randomised controlled trials that compared pre-discharge cardiorespiratory monitoring in a car seat versus no monitoring of preterm infants in the week prior to planned discharge from hospital.

Key Findings:

- Physiological monitoring studies indicate that some preterm infants experience episodes of oxygen desaturation, apnoea, or bradycardia when seated in standard car safety seats.
- The American Academy of Pediatrics recommends that all preterm infants should be assessed for cardiorespiratory stability in their car seat prior to discharge - the "car seat challenge".
- We did not find any randomised controlled trials that that compared pre-discharge cardiorespiratory monitoring in a car seat versus no monitoring in preterm infants in the week prior to planned discharge from hospital
- It is unclear whether undertaking a pre-discharge car seat challenge is beneficial or harmful to preterm infants.
- Further studies are needed to determine whether the car seat challenge accurately predicts the risk of clinically significant adverse events in preterm infants travelling in car seats.

Format: Pdf	**Cost:** Priced

Title:	**Analysis of the Performance of Different Architectures of Forward Facing CRS with Integral Restraint System**
Author:	H Johannsen, P Beillas and P Lesire
Published:	International Technical Conference on the Enhanced Safety of Vehicles (ESV) 23rd Conference, Paper Number 13-0226, 2013
Link:	http://www-nrd.nhtsa.dot.gov/pdf/esv/esv23/23ESV-000226.pdf
Objectives:	To analyse the performance of shield and harness systems in dummy tests, to analyse the limited accident data available and discuss the possible impact on future child safety.
Methodology:	1) Accident data, using the CASPER project accident database 2) Test results, using new tests and a reanalysis from previous tests provided by third parties 3) Results from misuse field studies.

Key Findings:

- According to ECE R44, children with a weight between 9 and 18 kg shall use a child restraint with integral restraint system, which are normally forward facing. Two types fulfilling the integral restraint system requirements can be found on the European market: 5-point-harness systems and shield systems.
- While shield systems were very popular, they had disappeared by the end of the 1990s. Today they are subject of a revival. Although a considerable number of shield systems are on sale, and it is estimated they have a market share of 10%, they are seldom observed in field data (accident data, misuse studies, and biomechanical studies).
- Shield systems are advertised to offer better neck protection in frontal impacts than 5-point-belt harness systems. In recent European consumer information campaigns they are often rated good. The only good rated group I/II/III CRS in 2012 were shield systems. The number of child restraint manufacturers offering shield systems is increasing.
- To restrain children in harness systems two independent actions are required, fixing the restraint to the vehicle and securing the child in the restraint, while in shield systems the restraint and occupant are secured by only one action. This means that the general misuse risk is lower in shield systems.
- However, not using the impact shield is a potential severe misuse. The impact shield may be perceived uncomfortable by children and may result in children resisting using the impact shield.
- Harness systems and shield systems interact in very different manners with the child, especially when skeletal load bearing structures are considered. Because is it flexible, the harness adapts to the shape of the child and potentially transfers loads to the most rigid structures: the clavicle, pelvis and rib cage. Because they are rigid and stop lower than the shoulders, shield systems are expected to interact very differently with the child. They could mainly load ribcage and abdomen. In principle it is possible to design them in way that they are also loading the pelvic bone in order to prevent abdominal loading but this does not always seem to be the case.
- 32 children involved in a frontal or lateral accident in the CASPER accident database were using such a system. However, 90% of them children were from the CREST project (1996 to 2000), and so were using older child restraints in older cars.
- 5 were not injured, 14 slightly injured, 4 sustained moderate injuries, and the remaining 9 suffered serious or worse injuries. Head injuries were the most common, followed by chest and the spinal injuries. The neck represented ‘a non-negligible’ part of severe injuries in shield systems, their outcomes being similar to the ones observed for harness systems. Injuries to limbs were less frequent than with other restraint systems. Rib fracture was a more common chest injury pattern for shield systems.

Misuse analysis • There was only one shield system, which was being used correctly, in the CASPER misuse studies. There was also only one shield restraint in the Belgium database, but it was used without shield. The number of cases is too small to draw any conclusion, except that shield systems are seldom observed in the three CASPER study regions and Belgium. • Based on the data that was analysed, the consequences of the current revival of shield systems on child protection cannot be determined with certainty. No clear benefit could be established and potential risks have been identified. It is also unclear if test procedures are sufficient for the evaluation of shield systems real world protection. Caution should therefore be exercised with these systems and studies should be performed to understand and detect as early as possible potential real world issues.
Format: Pdf **Cost:** Free

Title:	**Seat belt misuse among children transported in belt-positioning booster seats**
Author:	J O'Neil, D. M. Daniels, J. L. Talty and M J. Bull
Published:	Accident Analysis & Prevention, Volume 41, Issue 3, May 2009
Link:	http://www.sciencedirect.com/science/article/pii/S0001457509000074
Objectives:	To observe and report seat belt use among children younger than 16 years in belt-positioning booster seats.
Methodology:	A cross-sectional, observational survey of children transported in motor vehicles between 2006 and 2007 at 25 fast food restaurants and discount department stores throughout Indiana.
Key Findings: • Overall, 1,446 drivers participated, 2,287 children were observed with 564 children in belt-positioning booster seats. • At least one seat belt misuse was observed for 64.8% of the children transported. • Common misuses were the shoulder belt being placed over the booster seat armrest (35.8%); shoulder belt not at mid-shoulder position (28.5%), seat belt was too loose (24.5%), and the shoulder belt was either behind the child's back (9.1%) or under their arm (10.0%). • There is a high frequency of seat belt misuses among children transported in booster seats. Advice to parents on appropriate car seat selection, and encouragement to parents to supervise seat belt use may decrease misuse.	
Format: Pdf	**Cost:** Free

Title:	**Report on Relevant Children Injury in Road Accidents and Specification of Children Models**
Author:	P Lesire, F Cassan, J Yang, S Huang, R Willinger, M Frank, P Beillas, C Rodarius, H Johannsen and A Eisenach
Published:	CASPER Project Deliverable D.2.1.1, 2010
Link:	http://cordis.europa.eu/publication/rcn/14511_en.html
Objectives:	To identify the various child injury mechanisms in frontal and lateral collisions and to determine the associated physical parameters.
Methodology:	Analysis of accident databases and results from previous research on child safety.

Key Findings:

- Carrycots (Group 0): The number of crashes with carrycot type restraints was too low to draw conclusions.
- Rearward-facing Infant Carriers (Group 0/)+): Offer good protection in frontal impacts. But severe head injuries are most common injuries, suggesting more effective padding would reduce risk. Limb injuries also common.
- Rearward-facing systems with harness (Group 1) – more popular in Northern Europe, with some evidence they are more effective in frontal impacts than forward-facing seats. Severe head injuries less common than with forward-facing infant carriers.
- Forward-facing Systems (Group 1): Head injuries most common. Neck injuries not common, but protection important. Chest and abdominal injuries infrequent, but can be caused by high forces from the harness and its buckle, especially if child's shoulders slip out of harness.
- Forward-facing Systems with shields (Groups 1 & 2): No accident data available, but head contact with the top of the shield and risk of (total or partial) ejection possible.
- Forward-facing Seats and adult seat belt (Booster seats) (Groups 1/2/3): High risk of neck injury for young children using these type of restraint.
- Booster seats and adult seat belt (Groups 2/3): Head most often injured, but abdominal injuries also more common, especially from high forces caused by the seat belt. Limb injuries also more common.
- Booster cushions and adult seat belt (Groups 2/3): Similar injury pattern to booster seats, but more chest injuries, probably because these used by older children.
- Adult seat belts: Use of seat belts instead of a child restraint 'not negligible'. Similar injury patter to booster cushions, but more severe injuries, especially to the abdomen.
- Fewer side impacts in database mean same level of analysis not possible. But children in restraints more likely to be uninjured or only slightly injured in side impacts than children using the adult seat belt. The level of intrusion is a key determining factor.

Format: Html	**Cost:** Free

Title:	**Belt-positioning booster seats and reduction in risk of injury among children in vehicle crashes**
Author:	Durbin DR, Elliott MR, Winston FK
Published:	Journal of the American Medical Association JAMA; 289(21): 2835-40, 4 June 2003
Link:	http://jama.ama-assn.org/content/289/21/2835.full.pdf+html
Objectives:	To quantify the association of belt-positioning booster seats compared with seat belts alone and risk of injury among 4 to 7 year-old children and to assess patterns of injury among children in booster seats vs seat belts.
Methodology:	Cross-sectional study of children aged 4 to 7 years in crashes of insured vehicles in 15 states, with data collected via insurance claims and a telephone survey. A probability sample of 3,616 crashes involving 4,243 children weighted to represent 56,593 children in 48,257 crashes was collected between 1 December 1998 and 31 May 2002.

Key Findings:

- Although more than a dozen states have ratified laws that require booster seats for children older than 4 years, most states continue to have child restraint laws that only cover children up to age 4 years.
- Lack of booster seat effectiveness data may be a barrier to the passage of stronger child restraint laws.
- Injuries occurred among 1.81% of all 4 to 7 year-olds, including 1.95% of those in seat belts and 0.77% of those in belt-positioning booster seats.
- The odds of injury, adjusting for child, driver, crash, and vehicle characteristics, were 59% lower for children aged 4 to 7 years in belt-positioning boosters than in seat belts.
- Children in belt-positioning booster seats had no injuries to the abdomen, neck, spine, back, or lower extremities, while children in seat belts alone had injuries to all body regions.
- Belt-positioning booster seats were associated with added safety benefits compared with seat belts to children up to age 7 years, including reduction of injuries classically associated with improper seat belt fit in children.

Format: Pdf	**Cost:** Free

Title:	**Minimizing the Risk of Lap/Shoulder Belted Children Submarining the Lap Belt in Frontal Crashes**
Author:	G R Whitman, A V Hart, III, L Sicher, Bn Benda, L A D'Aulerio
Published:	International Technical Conference on the Enhanced Safety of Vehicles (ESV) 23rd Conference, Paper Number 13-0041, 2013
Link:	http://www-nrd.nhtsa.dot.gov/pdf/esv/esv23/23ESV-000041.pdf
Objectives:	To determine whether belt-positioning-booster seats incorporate seat bottom design features, identified by previous research, to minimize the risk of submarining.
Methodology:	The booster seats were evaluated through inspection and testing.

Key Findings:

- The majority of Belt-Positioning Booster seats (BPBs) now incorporate seating surfaces with low compressibility, anti-submarining seat ramps and lap belt guide hooks. These features combine to minimize the potential for submarining.
- However, two of the BPBs evaluated had very little or no seat ramp and, therefore, did not provide any significant restraining load to the pelvis. One of those two BPBs also had an extremely compressible seating surface.
- Previous research indicates that these deficiencies significantly increase the potential for submarining.
- Published epidemiology studies indicate that BPBs generally reduce the rate of injury to children in crashes compared to children using only the adult seat belt. However, children continue to sustain "seat belt syndrome" injuries.
- Research has determined that seat design is critical to avoid submarining the lap belt and preventing seat belt syndrome injuries.
- Children are especially vulnerable to submarining the lap belt. Yet, there are no requirements to ensure that BPBs incorporate features that have been identified as critical to avoid submarining the lap belt during frontal crashes. BPB manufacturers, automobile manufacturers, and NHTSA must work together to establish requirements that will ensure that the BPB will work properly with motor vehicle seat belts to prevent submarining and its associated injuries.

Format: Pdf	**Cost:** Free

Title:	**Literature Review, Accident Analysis and Injury Mechanisms**
Author:	C Visvikis, M Pitcher, B Girard, A Longton and M Hynd
Published:	EPOCh, Enabling Protection for Older Children, Final Project Report 218744, 2009
Link:	http://www.epochfp7.org/Publications.aspx
Objectives:	To examine how and where older children are injured when travelling in vehicles and to establish the main priorities for body areas that need to be protected by restraints systems, and to identify requirements for the child crash test dummy.
Methodology:	Analysis of the CCIS database for injuries suffered by 6 – 12 year old children in moderate to severe collisions.

Key Findings:

- None of 6 – 12 year old children in moderate to severe collisions in frontal collisions who were in booster seats suffered moderate or severe injuries, unlike those who were unrestrained, using an adult seat belt or a booster cushions.
- However, the numbers were too few to draw conclusions.
- None of the children in side impact collisions who were using booster seats or booster cushions suffered moderate or severe injuries, but again, the numbers were too few to draw conclusions.
- In front impacts, head injuries are the most common, followed by the abdomen, often due to the child 'submarining' under the lap belt because it is not positioned correctly on the child's pelvis.
- Chest injuries less common for children using booster seats than those using booster cushions or just the adult seat belt, possibly because booster seats help to position the seat belt correctly and securely.
- Upper and lower limb injuries are frequent, normally caused by impacts with rigid parts of car interior.
- In side impacts, head injuries also most common, followed by chest and abdomen injuries. Upper and lower limb injuries frequent, normally caused by impacts with rigid parts of car interior or intruding objects.

Format: Pdf	**Cost:** Free

Title:	**Interventions for promoting booster seat use in four to eight year olds travelling in motor vehicles**
Author:	Ehiri JE, Ejere HOD, Magnussen L, Emusu D, King W, Osberg SJ,
Published:	The Cochrane Collaboration, 2009
Link:	http://www.thecochranelibrary.com/userfiles/ccoch/file/Safety_on_the_road/CD004334.pdf
Objectives:	To evaluate the effectiveness of interventions to promote the use of booster seats.
Methodology:	A systematic review of studies of interventions to promote the acquisition and use of booster seats.

Key Findings:

- Public health and traffic safety agencies recommend the use of booster seats by children until the vehicle seat belt fits properly; typically when the child is at least 58 inches tall, has a sitting height of 29 inches and weighs about 80 pounds.
- In children aged 4 to 7 years, booster seats are estimated to reduce the odds of sustaining clinically significant injuries during a crash by 59%, when compared to using ordinary vehicle seatbelts.
- Despite the effectiveness, many children are not restrained in age-appropriate booster seats.
- The authors found five studies involving a total of 3,070 participants. All the interventions investigated were found to increase the use of booster seats, compared to groups receiving no intervention.
- The distribution of free booster seats combined with education on their use, had a marked beneficial effect, as did incentives (for example, booster seat discount coupons or gift certificates) combined with education.
- Education-only interventions also produced beneficial outcomes.
- One of the studies evaluated the effectiveness of the enforcement of a booster seat law, but did not detect an effect on usage.
- The current evidence suggests that several types of interventions designed to increase the use of booster seats among children aged four to eight years, are effective.
- However, there is still a need for further high quality trials, especially those conducted outside of the USA and Australia, where current research dominates.

Format: Pdf	**Cost:** Free

Title:	**Effects of seating position and appropriate restraint use on the risk of injury to children in motor vehicle crashes**
Author:	Durbin DR, Chen I, Smith R, Elliott MR, Winston FK
Published:	American Academy of Pediatrics Pediatrics 115(3):e305-9, March 2005
Link:	http://www.ncbi.nlm.nih.gov/pubmed/15741356
Objectives:	To evaluate the relationship of seating position and restraint status to the risk of injury among children in passenger vehicle crashes.
Methodology:	A cross-sectional study of children under 16 years old who were involved in crashes of insured vehicles in 15 states, with data collected via insurance claims records and a telephone survey. A probability sample of 17,980 children in 11,506 crashes, representing 229,106 children in 146,613 crashes, was collected between December 1, 1998, and November 30, 2002. Parent reports were used to define restraint status, seating position, and occurrence of clinically significant injuries.

Key Findings:

- Many states are upgrading their child restraint laws to include provisions for the use of age-appropriate restraints for 6 to 8 year olds, with some also requiring children to sit in the rear.
- Approximately 62% of children use seat belts, 35% use child restraints, and 3% use no restraint.
- Nearly 4 in 5 children sit in the rear seat, with half of children being restrained appropriately for their age in the rear, although this varies according to age.
- Overall, 1.6% of children suffered serious injuries, 13.5% had minor injuries, and 84.9% did not have any injury.
- Unrestrained children in the front are at the highest risk of injury and appropriately restrained children in the rear are at the lowest risk, for all age groups.
- Inappropriately restrained children are at nearly twice the risk of injury, compared with appropriately restrained children.
- Unrestrained children were at more than 3 times the risk.
- The effect of seating row is less than the effect of restraint status; children in the front seat are at 40% greater risk of injury, compared with children in the rear seat.
- Had all children in the study population been appropriately restrained in the rear seat, 1,014 serious injuries would have been prevented.
- Age-appropriate restraints confer relatively more safety benefit than rear seating, but the two work synergistically to provide the best protection for children in crashes.
- These results support the current focus on age-appropriate restraint in recently upgraded state child restraint laws. However, considerable added benefit would be realised with additional requirements for rear seating.

Format: Pdf	**Cost:** Priced

Title:	**Seating Patterns and Corresponding Risk of Injury Among 0 to 3 Year-Old Children in Child Safety Seats**
Author:	M J. Kallan MS, Dennis R. Durbin MD, MSCE & Kristy B. Arbogast PhD
Published:	American Academy of Pediatrics Pediatrics Vol. 121 No. 5, May 1, 2008
Link:	http://pediatrics.aappublications.org/content/121/5/e1342.abstract
Objectives:	To describe seating position patterns among appropriately restrained child occupants aged 0 to 3 years in the rear of vehicles, and to determine the association between rear seating and risk of injury.
Methodology:	Analysis of data collected, via insurance claim records and a validated telephone survey, of child occupants aged 0 to 3 years seated in a child-restraint system in the rear of a vehicle manufactured in or after 1990, involved in a crash in 16 states between 1 December 1998 and 31 December 2006.

Key Findings:

- Seating position distribution for child occupants was left outboard (31%), center (28%), and right outboard (41%).
- There was an inverse relationship between the center position and increasing child age (39% for occupants under 1 year old versus 18% for occupants 3 years old), independent of the number of additional row occupants.
- Child occupants seated in the center had an injury risk 43% lower than children seated in either of the rear outboard positions.
- The most common seating position for appropriately restrained child occupants in a child-restraint system is the right rear outboard.
- The center rear seating position is used less often by children restrained by a child-restraint system as they get older.
- Children seated in the center rear have a 43% lower risk of injury compared with children in a rear outboard position.

Format: Pdf	**Cost:** Priced

Title:	**Comparison of motor vehicle occupant injuries in restrained and unrestrained 4 to 14 year-olds**
Author:	Agran PF, Castillo DN, Winn DG
Published:	Accident Analysis Prevention, 24(4):349-55, August 1992
Link:	http://www.ncbi.nlm.nih.gov/pubmed/1605817
Objectives:	To compare the injuries suffered by restrained and unrestrained 4 to 14 year old children involved in road accidents.
Methodology:	Comparison of injuries of restrained and unrestrained 4 to 14 year-olds in nine emergency rooms and the Coroner's office in Orange County, California from 1983 to 1989.
Key Findings: • Analyses were performed separately for 4 to 9 and 10 to 14 year-olds because of differences related to the fit of the seat belt. • Significantly fewer intracranial injuries and a significantly lower mean Injury Severity Score (ISS) were seen between restrained and unrestrained 10 to 14 year-olds in the front passenger and back seats. But for 4 to 9 year-olds in the back seat only. • These same differences were noted between restrained 4 to 9 year-olds in the back compared with those in the front passenger seat. • Except for 4 to 9 year-olds in the front passenger seat, the findings are consistent with similar studies of occupants of all ages. • The results suggest that lap-shoulder belts (primary restraint in front seat) may provide less protection for 4 to 9 year-olds than for 10 to 14 year-olds and adults.	
Format: Html	**Cost:** Priced

Title:	**Some aspects of the safety of children as car passengers in road traffic accidents**
Author:	Claes Tingvall
Published:	Acta Paediatric, Volume 76, Issue Supplement s339, pages 1–35, October 1987
Link:	http://onlinelibrary.wiley.com/doi/10.1111/j.1651-2227.1987.tb10586.x/abstract
Objectives:	To investigate child safety in cars including the epidemiology of child injuries and injury assessment, restraint use effectiveness, restraint use limitations and improper use of child restraints.
Methodology:	Literature review, questionnaire survey, observational studies**,** laboratory crash tests.
Key Findings: • Child restraint use, especially the use of rearward-facing restraints, is effective in reducing injuries. • Using injuries occurring in spite of restraint use were often minor in terms of fatality risks, but injuries to the neck and head may cause long-term consequences. • The police were found to report only slightly more than half of the injured children reported to the insurance company. • Misuse of child restraints was found to decrease the effectiveness restraint use or induce injuries. • On the basis of these studies it is recommended that child restraints be incorporated into cars as an in-built system with the same basic design as restraints that are available as extra equipment. • Certain considerations should be paid, however, to those injuries occurring among restrained children that entail a risk of medical disability.	
Format: Html	**Cost:** Priced

Title:	**Motor Vehicle Childhood Injuries Caused by Noncrash Falls and Ejections**
Author:	Phyllis F. Agran, MD, MPH; Debora E. Dunkle, PhD; Diane G. Winn, RN, MPH
Published:	Journal of the American Medical Association JAMA;253:2530-2533, 1985
Link:	http://www.ncbi.nlm.nih.gov/pubmed/3981781
Objectives:	To describe the patterns of passenger travel, precipitating causes, and severity of injury in non-crash falls or ejections.
Methodology:	Analysis of data from a larger ongoing hospital-based monitoring system of a sample of children aged 0 to 14 years who were treated for injuries incurred in a motor vehicle accident.

Key Findings:

- In a sample of children aged 0 through 14 years who were treated for injuries incurred in a motor vehicle accident, a large proportion of those involved in non-crash events fell or were ejected from the vehicle.
- Over 50% of those ejected sustained serious injuries compared with 5% of those who remained in the vehicle.
- Two high-risk patterns emerged:
  (1) the young child traveling in a passenger seat falling out of the vehicle, and
  (2) the older child riding on the exterior of the vehicle and falling off during a vehicle maneuver.
- Door locks, restraint use, and prohibition of travel in non-passenger locations would prevent these serious non-crash injuries.

Format: Pdf	**Cost:** Priced

Title:	**Injuries Among 4 to 9 Year-Old Restrained Motor Vehicle Occupants by Seat Location and Crash Impact Site**
Author:	Phyllis Agran, MD, MPH; Diane Winn, RN, MPH; Debora Dunkle, PhD
Published:	American Journal of Diseases of Children Am J Dis Child;143(11):1317-1321, 1989
Link:	http://archpedi.ama-assn.org/cgi/content/abstract/143/11/1317
Objectives:	To examine patterns of injury among restrained 4 to 9 year-olds by seat location and crash impact site.
Methodology:	Analysis of data from a hospital-based monitoring system of 4 to 9 year old children injured in a motor vehicle accident.

Key Findings:

- Having outgrown their child safety seats, 4 to 9 year-old children are often placed in adult seat belts.
- 77% of the sample sustained a head or face injury.
- Upper-torso and extremity injuries were infrequent.
- Lower torso injuries occurred primarily in frontal impacts in both the back and front seats.
- Frontal impacts resulted in a greater proportion of serious injuries than rear impacts.
- The most serious injuries, however, occurred to children seated on the side of impact in lateral collisions.
- Questions must be raised regarding the appropriateness of current restraint system for young children.
- Technological improvements in vehicle design and belt systems are needed to improve protection, particularly in lateral impacts.

Format: Pdf	**Cost:** priced

Title:	**Rear seat safer: Seating position, restraint use and injuries in children in traffic crashes in Victoria, Australia**
Author:	Alexia Lennon, Vic Siskind, & Narelle Haworth
Published:	Accident Analysis & Prevention, Volume 40, Issue 2, pp 829–834, March 2008
Link:	http://www.sciencedirect.com/science/article/pii/S0001457507001741
Objectives:	To calculate relative risks of death or serious injury for children (0–3 years, 4–7 years; 8–12 years) travelling in passenger cars.
Methodology:	Analysis of data from 30,631 Victorian crash records to calculate relative risks of death or serious injury for children (0–3 years, 4–7 years; 8–12 years) travelling in passenger cars during 1993–1998 and 1999–2004.

Key Findings:

- Car crashes are a major cause of death and serious injury to children but most analyses of risk are based on USA data.
- The Australian context is different in at least three ways: (1) the proportion of passenger-side airbags, a potential risk to children in front seats, is much lower; (2) unlike in the US, Australian airbags are designed to work with restrained passengers; (3) restraint use for children 0–12 years is high (>90%).
- Over 90% were reportedly wearing a restraint, and 20% were travelling in the front seat.
- For children under 4 years travelling in the front seat, the relative risk of death was twice as great than when travelling in the rear, and the risk of serious injury was 60% greater.
- The relative risk of death whilst travelling in the front seat was almost four times greater for children aged under 1 year.
- Serious consideration should be given to mandating rear seating for children, particularly those aged 4 and under.

Format: Pdf	**Cost:** Priced

Title:	**The safest seat: Effect of seating position on occupant mortality**
Author:	James Mayrose & Aruna Priya
Published:	Journal of Safety Research Volume 39, Issue 4, Pages 433–436, 2008
Link:	http://www.sciencedirect.com/science/article/pii/S0022437508001011
Objectives:	To investigate the survival rates of occupants of passenger cars involved in a fatal crash between 2000 and 2003.
Methodology:	Univariate and a full logistic multivariate analysis of data from every fatal crash in the United States between 2000 and 2003.

Key Findings:

- The rear middle seat is safer than any other occupant position when involved in a fatal crash.
- Overall, the rear (2nd row) seating positions have a 29.1% increased odds of survival over the first row seating.
- The rear middle seat has a 25% increased odds of survival over the other rear seat positions.
- After correcting for potential confounders, occupants of the rear middle seat have a 13% increased chance of survival when involved in a fatal crash than occupants in other rear seats.
- The safest position for any occupant is the rear middle seat.

Format: Pdf	**Cost:** Priced

Title:	**The effect of seating location on the injury of properly restrained children in child safety seats**
Author:	Ulric J. Lund
Published:	Accident Analysis & Prevention**,** Volume 37, Issue 3, Pages 435–439, May 2005
Link:	http://www.sciencedirect.com/science/article/pii/S0001457504001204
Objectives:	To assess the effect of seating position on the risk of injury, and whether the center rear seat is a safer position than either of the outboard rear seats.
Methodology:	Analysis, using a multiple logistic regression model, of children seated in a child safety seat in a rear seat location using data from the National Automotive Sampling System (NASS), General Estimates System (GES)
Key Findings: • The center rear seat is not a safer seating position than either of the outboard rear seats in terms of odds of injury. • These results do not agree with those of previous studies that suggested the center rear seat is the safest position for parents to place a child safety seat.	
Format: Pdf	**Cost:** Priced

Title:	**Restraint use by car occupants, 2006-2008. Leaflet LF 2106**
Author:	TRL Ltd
Published:	TRL, December 2008
Link:	https://trl.co.uk/reports/LF2102
Objectives:	To monitor the effects of changes made in September 2006 to the regulations governing the use of restraints by child passengers.
Methodology:	Observational surveys at six monthly intervals from October 2006 to October 2008 of the use by car occupants of seat belts and other restraint systems at 32 sites chosen to represent all types of road.

Key Findings:
Although the results may not be strictly nationally representative, they give useful insights into national patterns of restraint use.

Table 5: Use of restraints by younger children (%), October 2008

	Front seat passengers		Rear seat passengers	
	1–4 years old	5–9 years old	1–4 years old	5–9 years old
Seat belt worn	20	71	5	51
Child seat used	53	0	75	6
Rear facing child seat used	0	0	1	0
Booster seats & cushions used: Properly	21	28	18	37
Wrongly	0	0	0	0
Unrestrained: on seats	5	1	1	6
on passenger's lap	1	0	1	0

Format: Pdf	**Cost:** Free

Title:	**National Database for Child Restraint Use**
Author:	Mark Pitcher, Marianne Hynd and James Onyekwere
Published:	TRL Limited
Link:	Not available online
Objectives:	To develop a standardised form to collect details of restraint use and fitting from Child Car Seat Checks run by local authorities and others, and analyse the data to identify common problems.
Methodology:	• Survey to develop a standardised form to record details of the type of restraint, the child using it, the way in which it is fitted, including incorrect fittings.

Key Findings:

- Many 'Inspection Clinics' (under various names) are run across Britain to which parents are able to bring their child restraint, ideally in their car and with the child who uses it, to a convenient location (such as a supermarket car park) where the restraint is checked by an expert to assess whether it is suitable for the child, for the vehicle and whether it is fitted correctly.
- An initial analysis of the data illustrated that 43% of parents did not know the weight or height of their child, information that is crucial when choosing a child car restraint.
- Although the appropriateness of the child restraints being used was generally good, there was a trend to use forward-facing child restraints as soon as possible, and sometimes too soon, with some being used by children under 9 months.
- A trend to transfer children to booster seats as soon as possible was also seen, with a large percentage of 3 year-olds using them.
- Most child restraints were compatible with the vehicle in which they were used, but only 53% were correctly installed, usually because the seat belt was too slack or incorrectly routed.

Format: Pdf	**Cost:** Free

Title:	**Overview Report of Research into the Incorrect Use of Child Restraints in Selected Countries**
Author:	C Willis, M Le Claire and C Visvikis (TRL) A Kirk and R Grant (VSRC)
Published:	EU Child (**Ch**ild **I**njury **L**ed **D**esign) Project, 2006
Link:	https://dspace.lboro.ac.uk/dspace-jspui/handle/2134/14369
Objectives:	To improve the knowledge of child biomechanics and injury tolerance by reconstructing real accidents with a crash test dummy.
Methodology:	Literature Review

Key Findings:

- Most countries mandate the use of child restraints but there are often gaps and exceptions, particularly as children get older.
- However, research shows that the majority of children are not restrained correctly and even with the most appropriate restraint for a child's size, the way it is used can affect its performance, possibly resulting in serious injury and death.
- In the UK the percentage of correctly fitted child restraints is low, but use is high. Parents are often not confident that their child is restrained correctly. Studies also show that instructions given with child restraints need to be clearer to increase the likelihood of correct fitting and parent confidence. Some child restraints are bought second hand and so may not provide the best protection for the child.
- In the USA as many as 80% of child restraints are misused in some way, including incorrect fitting, facing the wrong direction, the child not being properly secured in the restraint and not ensuring the child restraint is the correct type and size for the child. Interviews with parents suggest that most do not have a good understanding of the installation and use of child restraints and of those that do. There is a link between demographic factors, such as academic achievement or socioeconomic status, and misuse.
- Two groups of children are most at risk when not restrained properly: infants using forward facing child restraints when they are less than one year old, and children using the seat belt when they should be using a forward facing seat or booster seat. Child restraint misuse is associated with greater injury severity, especially more head injuries. However, the risk of sustaining injuries from misused or inappropriate child restraints is less than the risk of sustaining multiple serious injuries from travelling unrestrained.
- The major problem in Spain is lack of restraint use in general.
- In Sweden 83% of children always use a seatbelt. However, the restraint use is not always correct or appropriate. Children under 3 should travel rear facing but one study found nearly 30% travelling forward facing. Another study showed that whilst the majority of parents believe their child to be correctly restrained, only 60% fully understood the correct restraint to use for their child and how to fit it.
- In France, 73% of child restraints were misused in some way. Parents find child restraints difficult to install, second hand child restraints are used, parents take less care installing them for short trips and allow children to adopt a more comfortable position for long trips especially in the evening. The most common types of misuse were slack in the harness, slack in the seat belt and misrouting of the seat belt.

Format: Pdf	**Cost:** Free

Title:	**Childhood Crash Injury Patterns Associated with Restraint Misuse: Implications for Field Triage**
Author:	Eileen M. Bulger, MD; Robert Kaufman, BS; Charles Mock,MD, PhD1
Published:	Prehospital and Disaster Medicine, 2008;23(1)
Link:	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.176.910&rep=rep1&type=pdf
Objectives:	To describe the injury patterns associated with restraint misuse in the pediatric population, with particular focus on clues to significant injury that can be identified by the pre-hospital provider that may impact subsequent triage decisions.
Methodology:	A case series presentation that illustrates the injury patterns associated with various types of restraint misuse in infants (ages 0–1 years), toddlers (age 1–4 years), young children (ages 4–8 years), and pre-teens (ages 8–14 years). Cases were identified from the Crash Injury Research and Engineering Network (CIREN) database.
Key Findings: • Restraint misuse is a common problem leading to increased morbidity and mortality for children involved in motor vehicle crashes. • Six cases are presented that illustrate the injury patterns associated with misuse of rear-facing infant car seats, forward-facing child seats, booster seats, and shoulder belts. • Emergency medical services providers need to be aware of these issues when assessing children and determining appropriate triage to a trauma center. • Ongoing educational efforts also are vital to inform parents about the risks of inappropriate restraint use and to encourage legislators to better define appropriate restraint use for older children.	
Format: Pdf	**Cost:** Free

Title:	**A Review of Child Car Restraint Instructions**
Author:	RoSPA
Published:	RoSPA, March 2001
Link:	http://www.rospa.com/rospaweb/docs/advice-services/road-safety/practitioners/carseats-instructions-review.pdf
Objectives:	To examine the role of instructions in the fitting of child car restraints.
Methodology:	A review of manufacturer's instructions for a selection of child car restraints available in Britain, and observational surveys of volunteers fitting the restraints using the instructions.

Key Findings:

- Many people find fitting child restraints difficult. Some major retailers have trained staff who are able to help, and many manufacturers operate helplines and websites. However, problems persist.
- There is wide variety in the quality of the instructions provided with child restraints, some of which are well-written and presented with good, clear illustrations. However, others are very poor in these respects.
- Generally, the volunteers found the booklets daunting because of the amount of information, and so expected to find fitting the restraints difficult.
- Small print size and the need to cross refer between pages within the booklets caused particular problems and complaints. The volunteers felt that placing diagrams and supporting text together was the most helpful layout.
- When studying the instructions, most people focussed mainly on the diagrams. However, the quality of illustrations in the instruction booklets was very variable.
- Volunteers generally gave lower scores for the text than the diagrams. Many commented that there was too much text, and sometimes they felt much of it was irrelevant or unnecessary. A frequent comment was that it was difficult to isolate the essential information from the non-essential.
- Some instruction booklets were printed on flimsy paper and quickly became crumpled, suggesting that they would not last very long. On-product instructions were often not seen, and in some cases had begun to peel off.
- The project also identified a number of common fitting problems, especially failures to ensure the restraint was tightly secured, which are worthy of further research.

Format: Pdf	**Cost:** Free

Title:	**THINK! Road safety campaign evaluation October 2006: Post Child Restraints and Pre Mobiles**
Author:	DfT Communications Directorate
Published:	Department for Transport, 2006
Link:	http://webarchive.nationalarchives.gov.uk/+/http://think.dft.gov.uk/pdf/332982/332986/200610b.pdf
Objectives:	To measure the effectiveness of a national publicity campaign to raise awareness of new legislation governing the use of child restraints.
Methodology:	Pre and Post interview survey.

Key Findings:

- 63% of drivers used a child restraint when transporting a child, an increase from 50% at the pre-stage.
- Use of child restraints decreased as the age of the child increased.
- Amongst those who did not use child restraints, half stopped when the child was aged between 4 and 7 years, mainly due to the height or size of the child.
- Six in ten (58%) of those who carried children aged 11 or under in the previous 6 months were aware that children could legally stop using restraints when aged over 11, an increase from 20% in July. However, when asked at what height this was legal only 13% said 135cm, although this was an increase from 2% in July.
- Total awareness (spontaneous and prompted awareness combined) of the legislation had increased from 45% in July to 93% after the campaign.
- Amongst those aware of the legislation after prompting, a quarter had made changes to the way they transported children, two thirds said they did not need to make changes and one in ten had yet to make changes. The most commonly mentioned change was for children to start using child restraints.
- Of the respondents who said they had not yet made changes, most did not actually need to because they already used car seats/boosters or their child was too tall. 8% said they do not usually carry children or only carried children occasionally, but 5% said they were either unable or could not afford to purchase a seat/booster.
- Those not using child restraints are more likely to be those who transport older children, and those who transport children less regularly, therefore further publicity may be required to get the message across to these groups.

Format: Pdf	**Cost:** Free

Title:	**Effectiveness of hands-on education for correct child restraint use by parents**
Author:	Karen Tessier
Published:	Accident Analysis and Prevention 42, 1041–1047, 2010
Link:	http://www.seatsforkidscanada.com/f/Effectiveness_of_hands-on_education_for_correct_child_restraint_use_by_parents.pdf
Objectives:	To evaluate whether a hands-on educational intervention makes a significant difference in the proper use of a child passenger restraint by a parent.
Methodology:	The clinical trial design included a sample of 111 parents who were at least seven months pregnant and who were randomly assigned to one of two groups (56 intervention and 55 control)

Key Findings:

- All participants received a free car seat and a standardized education session on the safety and use of child passenger restraints.
- The experimental group received an additional component consisting of a hands-on demonstration and return demonstration of correct installation and use in their own vehicle. Follow-up observation for correctness of use was done after birth.
- A total of 24 (22%) parents correctly used the car seat; of these, 18 (32%) were in the intervention group and 6 (11%) were in the control group.
- The intervention group was four times more likely to have correct use than the control group.
- The range for the number of errors per person was 0–7, with the majority (70%) having 0–2. The rate of errors was 33% less in the intervention group. There were few serious errors in either group.
- No secondary variable (age, education, income, or help from others) had a significant effect on the outcome.
- The hands-on educational intervention made a significant difference in the proper use of a child passenger restraint.
- This study demonstrates the value of hands-on teaching for learning how to correctly install and use a child car seat.

Format: Pdf	**Cost:** Priced

Title:	**Injuries in Children Aged 0–14 Years and Inequalities**
Author:	Towner E, Dowswell T, Errington G, Burkes, M. and Towner J
Published:	Health Development Agency, 2004
Link:	http://www.nice.org.uk/niceMedia/pdf/injuries_in_children_inequalities.pdf
Objectives:	To describe and seek to understand how and why injuries disproportionately affect some children more than others.
Methodology:	Systematic review of child injury and child injury prevention studies.

Key Findings:

- There are great variations in injury mortality and morbidity, reflecting children's age, gender, socio-economic group, cultural or ethnic group, and location.
- National injury data systems provide good information on age and gender and some information on social and economic factors, but not on ethnicity or on vulnerable groups such as children in homeless families or disabled children.
- The factors associated with injury inequalities are multifaceted and inter-related; the causal pathways linking these factors to injury events remain uncertain.
- Three tiers of factors need to be considered to clarify the inter-relationships: (1) proximate tier, immediate conditions that result in exposure to hazard; (2) intermediate tier, eg childcare practices; (3) ultimate tier, the wider social, economic, political and cultural processes.
- More direct causes of injury include exposure to hazards, the ability of parents, carers and communities to protect children, and children's ability to manage hazards.
- Greater knowledge about disparities between groups and factors leading to increased risk is important in designing interventions.
- Few intervention studies explicitly address inequalities – and still fewer attempt to set out the problem in relation to that factor, take it into account when designing the intervention, and report on whether there has been any differential impact in relation to that factor.
- Many interventions target specific age groups of children, but there are few examples of results comparing the impact of an intervention on different age or gender groups.
- Interventions have increasingly been targeted at deprived individuals or groups – the main strategy adopted in interventions is the provision of safety equipment.
- Cultural differences are rarely addressed (a few interventions involved the target group in the design of the intervention), and few studies compare interventions in different ethnic groups.
- When communities have been matched in controlled interventions, broad demographic variables have been used and little attention has been paid to the context.

Format: Pdf	**Cost:** Free

Title:	**Road Safety Research Report No. 123 "Road User Safety and Disadvantage"**
Author:	Clare Lowe, Grahame Whitfield, Liz Sutton and Jeremy Hardin
Published:	Department for Transport, February 2011
Link:	http://www.dft.gov.uk/publications/rsrr-theme1-road-user-safety/
Objectives:	To provide a practical overview of road safety issues in disadvantaged areas, involving an exploration of the populations, environment, behaviour, attitudes and perceptions of risk road safety provision, the nature and extent of partnership working and the extent of community involvement in road safety delivery.
Methodology:	Analysis of casualty and deprivation data, using STATS19 and Index of Multiple Deprivation (IMD), a review of existing evidence, interviews with road safety experts and government representatives from other policy areas, a review of local data and policy and interviews with representatives of local agencies in five case study areas; research within the communities and in a relatively affluent area with a high casualty rate for comparative examination of the risks and their association with disadvantage.

Key Findings:

- There were limited number of road safety activities concerned with understanding the specific needs of disadvantaged communities, and promoting behavioural changes in response to these needs.
- However, where this did happen, they sought to address specifically identified problems, provide worthwhile support to disadvantaged communities and potentially contribute to reducing the differential risk of road accident injury.
- A leaflet on seat-belt wearing written in the specific languages where non-seat-belt wearing was prevalent is one example of such practice.
- Another example was a resource containing casualty information specific to the local area to raise awareness of the high level of child pedestrian casualties.
- The subsidy of child car seats, car seats for taxis from maternity wards and car seat inspections were also interventions that demonstrated a recognition of the needs of the target audience and a focus on promoting behaviour change.
- Road Safety Champions (a volunteer scheme), and other area-based community development activities, are further examples of interventions that aimed to understand communities and develop activities that were wanted by, and relevant to, the people in the local area.

Format: Pdf	**Cost:** Free

Title:	**Road Safety Research Report No. 97 "Widening the Reach of Road Safety – Emerging Practice in Road Safety in Disadvantaged Communities: Practitioners' Guide**
Author:	Michael Hayes, Elizabeth Towner, John Towner, Paul Pilkington and Heather Ward
Published:	Department for Transport, October 2008
Link:	http://webarchive.nationalarchives.gov.uk/+/http:/www.dft.gov.uk/pgr/roadsafety/dpp/neighbourhoodroadsafety/wideningthereach.pdf
Objectives:	To produce good practice guidance on the development and implementation of schemes to reduce road casualties in the most deprived areas through new, innovative approaches.
Methodology:	Good Practice Guide

Key Findings:

- In 2005 and 2006 Sandwell Metropolitan Borough Council and Salford City Council conducted road safety interventions to supply and fit free baby seats to families from disadvantaged areas. Similar schemes were run in Wigan and Bradford.
- Families in deprived areas received a voucher which was redeemable at a local retailer of child car restraints, whose staff showed the parents how fit the seat.
- In one area, a check within six months of receiving the seat was conducted to check that it had not been sold as soon as it was received.
- The schemes were expensive to run because of the cost of the seats, and so their sustainability was questionable.
- Between 2004 and 2006, Nottingham City Council, Nottinghamshire Fire and Rescue Service and Nottinghamshire Primary Health Care Trust ran a scheme to provide free inspections of child car restraints, by trained fire officers, alongside an educational campaign to provide advice. This followed a local survey which found that roughly 8 in 10 seats were incorrectly fitted.
- Initially, the scheme was confined to families in the deprived areas, but this target group proved difficult to engage and uptake was poor, which was disappointing as anecdotal evidence suggested that it was disadvantaged communities who drove the oldest cars and carried most children, often without restraints.
- Due to low uptake, the project was opened to all people in the city who carried a child.
- There is little evaluation to show that such schemes are effective in reducing casualties or improving child restraint use on a large-scale, which may reflect the lack of well-structured evaluations rather than any ineffectiveness in the programmes.
- Such schemes cannot use changes in casualty numbers as the measure of success because they are too low to allow meaningful before and after comparisons. But measures, such as knowledge and behaviour, take-up of the scheme, amount of publicity obtained in the local media can provide an indication of the success of the scheme.

Format: Pdf	**Cost:** Free

Title:	**Child Advanced Safety Project for European Roads (CASPER), Better Knowledge and Better Tools To Improve the Real Protection of Children In Cars**
Author:	P Lesire, H Johannsen, R Willinger, A Longton, A Kirk, P Beillas and A Fiorentino
Published:	International Technical Conference on the Enhanced Safety of Vehicles (ESV) 23rd Conference, Paper Number 13-0426, 2013a
Link:	http://www-nrd.nhtsa.dot.gov/pdf/esv/esv23/23ESV-000426.pdf
Objectives:	To synthesise the results obtained in the different parts of the EC CASPER project and considers sociological approaches, technical works, and field and accident data.
Methodology:	Review of Data from the CASPER, CREST and CHILD projects, and EEVC WG 18, ISO/TC22/SC12/WG1 and NPACS, and new data from collection of data specific to the different task topics.

Key Findings:

- Based on a detailed French study of in-car child deaths:
  - For frontal impact fatalities, the priority is to improve the quality of use of restraint systems. When the child is correctly restrained, very few fatal cases are observed in conditions similar to the frontal test of the current regulation.
  - In side impact, the current level of protection does not seem sufficient. The level of intrusion and direct impacts with intruding objects are important for children on the struck side.
  - For roll-overs the priority is to protect children from being ejected from the car and from projections inside of the car. The rate of correctly restrained children in this type of fatal accident is very low in France, which indicates that existing systems, when correctly used, could be preventing these fatalities.
  - Rear impact remains rare.
- Based on studies in 3 regions (Berlin, Lyon and Naples):
  - Misuse of child seats is still a widespread and serious problem.
  - The main problems are not threading the vehicle seat belt correctly through the child restraint, and the general installation of the child seat in the vehicle. Both problems could be prevented by the use of ISOFIX.
  - Less than 4% of restraints were fixed with ISOFIX in the vehicle, despite the fact that around 50% of the vehicle fleet was equipped with ISOFIX anchorages in 2011. Comparisons between studies conducted in Lyon in 2003 and in 2011 showed the average rate of misuse was about 71% in 2003 and 65% in 2011.
  - The main differences were with forward facing systems with an integral harness, the use of which was better in 2011 than in 2003, with a decrease of serious misuse, such as incorrect harness use.
  - For booster seats, the most frequent misuse was the same in 2011 as in 2003, with the lower belt guides often not used and the chest part of the seatbelt under the arm.
  - Factors, such as the available time and the trip purpose, influenced how well parents secured their children; they want to secure their child correctly, but it needs to be easier and simpler to fit and use child seats.

Inappropriate use

- Comparisons between studies conducted in Lyon in 2003 and in 2011 showed that the main problem continued to be moving a child into the next type of child restraint too early with similar patterns in 2003 and 2011.
- Most of the mis-use problems could probably be reduced by providing better help and guidance top parents.
- An additional study in Belgium in 2011 illustrated the same tendencies as in the other studies:

- many children not correctly restrained
- child restraint use being much lower for children older than 6 years
- too many parents not being aware that they are not using child restraints properly.

- For the first time the number of ISOFIX systems was large enough to compare with "classical attachment CRS":
  - The rate of misuse with ISOFIX systems was 2.3 times lower than with the "classical" ones.
  - It was almost 3 time slower for forward-facing ISOFIX restraints than for forward-facing child seats that are fitted with the vehicle seatbelt.
  - The difference in the rate of misuse for booster seats with ISOFIX anchorages compared with standard booster systems was smaller, but still apparent.

Format: Pdf	**Cost:** Free

Title:	**Safety Benefits of the New ECE Regulation for the Homologation of CRS - An Estimation by the EC CASPER Project Consortium**
Author:	P Lesire, R Krishnakumar, M C Chevalier, H Johannsen, G Müller, A Longton and A Kirk
Published:	International Technical Conference on the Enhanced Safety of Vehicles (ESV), 23rd Conference, Paper Number 13-0431, 2013b
Link:	http://www-nrd.nhtsa.dot.gov/pdf/esv/esv23/23ESV-000431.pdf
Objectives:	To develop a new regulation for child restraint systems that will eventually replace the current ECE Regulation 44.
Methodology:	Review of the work of the EC-funded EPOCh and CASPER projects, working groups such as EEVC WG12 and WG18 and research projects in the child safety areas.

Key Findings:

- In Germany, 1 year old children are at greatest risk, probably due to changing too early from rear facing to forward facing child restraints. In Sweden this change occurs much later, i.e. with an age of 2 to 4 years. However, the national data used for this analysis is too general to prove this theory.
- Of 206 fatally injured children aged 12 years or under, 57% were using a restraint system and 31% were not restrained. The information was unknown for the remaining 12%.
- Field studies in France found that more than two thirds of children were not correctly restrained in cars.
- Data from the CASPER project, showed that frontal impacts remain the primary accident configuration in terms of killed children, with approximately one third of the total, followed by side impacts that represent 28% and rollovers with 18%.
- Of these 206 children, 99 were using an appropriate child restraint, 66 of whom showed no evidence of misuse. This makes a maximum rate of 32% of children correctly restrained.
- Analysis of 894 child car passengers under 12 years old in the GIDAS (German In Depth Accident Study) database between 1999 and 2008 found that 417 of the 894 children were involved in a frontal impact, 249 in a side impact (145 on the far side, 104 on the near side) and 228 in a rear impact. The number of seriously injured children was low, indicating that the protection level is high in Germany, where nearly all children are restrained when travelling in cars.
- Surveys in Naples, Berlin, Hannover and Lyon found only about one third of the children were secured correctly. Comparisons with older misuse studies showed that the rate of misuse has remained constant in the last 15 years.
- There are more problems with securing the child in the restraint than with the installing the restraint in the car. However, the most common problems with installation are seat belt path, and the lack of shoulder belt guide use in Groups 2/3. These forms of misuse are critical and could lead to serious injuries if an accident occurred.
- There is a big disparity in the weight of children according to their age. For example, between 0 and 9 months of age, 40 % of children aged 0 to 9 months weigh between 9 and 13 kg and can legally travel in a forward-facing system.
- Globally about 27% of children are not using the appropriate restraint system for to their weight.
- Globally, parents tend to change the restraint systems as soon as their children have reached the lower limit of weight of the next size category. For example, 45% of the children weighing less than 9 kg are transported forward facing, which represents a high risk for them.
- 30% of children weighing between 14 and 18kg are using a booster system while it would be more appropriate for them to stay in a forward-facing seat with an integral

harness.

- A large number of parents also allow their children to use the adult seatbelt. Parents need guidance.
- Nearly half of parents think that they never make mistakes in way they use restraint systems, about a quarter feel they are doing something wrong but do not know exactly what, and a quarter know that they are making mistakes.
- Only 2% of the parents had ISOFIX and 60% did not know about ISOFIX. In focus groups, only 8% of the participants knew what ISOFIX is.
- The new regulation will improve the compatibility between child restraints and cars, use test configurations that are more realistic and cover a larger range of impacts.
- The introduction of a dynamic side impact test in the regulation will allow the coverage of most of the accident situations in which children can be still severely injured.
- The promotion of ISOFIX systems will lead to better installation of child restraint systems in cars, and parents want systems that are simpler to install.
- Information campaigns are needed in order that parents do not misunderstand the reason for and the benefits of this new regulation.

Format: Pdf	**Cost:** Free

Title:	**EEVC Working Group 18 Report: Child Safety**
Author:	European Enhanced Vehicle Safety Committee
Published:	EEVC Working Group 18, February 2006
Link:	http://eevc.net/publicdocs/EEVC_WG18_REPORT_Child_Safety-February_2006-1.pdf
Objectives:	To assess the effectiveness of child restraints in different types of impact, to assess levels and types of child restraint mis-use and to identify requirements for a child test dummy.
Methodology:	Literature review of national and European accident databases and research studies

Key Findings:

- Very few accident databases record whether child casualties were using child restraints suitable for their size and weight, nor whether they were fitted correctly.
- However, surveys consistently record high levels of misuse of chid car restraints.
- One European report found that 60% of restraints were installed satisfactorily, 21% had major misuse problems and 16% were not compatible with the car in which they were fitted.
- Frontal impacts account for about 50% of accidents involving children in cars, with side impacts representing about 25%.
- Forward-facing seats are distinctly more effective in frontal collisions than in side impacts.
- Although the number of side impacts in the database was small, head injuries accounted for 62% of all severe injuries in all types of restraint, indicating that the level of head protection was insufficient.
- Severe chest and abdomen injuries also occurred, mainly in children using a booster seat or booster cushion, or just using the adult seat belt. These injuries were rarely seen in children using a restraint with a shell (rearward- and forward-facing seats).
- 20% of the children involved in side impact collisions suffered severe injuries and 43% minor injuries.

Format: Pdf	**Cost:** Free

Title:	**The protection of children in cars - final report, TRL Report 458**
Author:	Lowne, RW,Le Claire, M,Roberts, AK
Published:	TRL Ltd, January 2000
Link:	https://trl.co.uk/reports/TRL458
Objectives:	To improve the safety of children in cars by developing a dedicated child restraint attachment system (ISOFix) and a side impact test procedure for child restraints.
Methodology:	Review of accident studies, laboratory tests.
Key Findings: • The analyses all confirm the benefits of using child restraints. • There is a need to provide improved protection in side impacts and to avoid loading from luggage by improved seat strength. • An experimental sled-based method for evaluating the performance of child restraints, under side impact conditions, was developed. The method replicates the essential interactions in a real car impact. • Tests with this experimental arrangement demonstrated that this was a practical way to evaluate the performance of child restraints under side impact conditions. • ISOFix with two rear rigid attachments together with an anti-rotation system, such as a top tether, would provide a good basis for a universal system with greatly reduced misuse rates and an improved dynamic performance in accidents.	
Format: Pdf	**Cost:** Free

Title:	**Two thirds of child car seats not fitted correctly**
Author:	AA and Britax
Published:	AA, 16 Feb 2009
Link:	http://www.theaa.com/motoring_advice/child_safety/aa-launches-range-of-aa-approved-britax-isofix-child-car-seats.html
Objectives:	To assess the level of correct and incorrect use of child car restraints.
Methodology:	Opinion Survey from 16,500 respondents.

Key Findings:

- Only a quarter of all people admitted experiencing difficulty in fitting a child car seat despite evidence that two thirds of seats are not fitted correctly.
- 66% of respondents stated that they did not know that the law requires children up to the age of 12 to use a car seat and 80% of them were not aware that UK law requires children under the height of 135cms to use a child seat.
- Grandparents had even less awareness with 74% stating that they did not know the age range over which the law requires children to use a car seat and 86% did not know the minimum height requirements.
- At least 6 million cars (around 25% of all cars) are fitted with standardised ISOFIX fittings. Despite this, 74% of drivers were not aware of ISOFIX.
- Men (31%) and those who cared for children (44%) were more likely to say they knew
- Of those who said that they didn't know what ISOFIX was:
    - 11% said it was a device to reduce toxic exhaust emissions
    - 3% said it was a universal roof rack attachment
    - 2% said it was a system to stop windscreen washers freezing up
    - 2% said it was tie-down hooks in the boot to stop luggage sliding around
- 36% said that they did not have the anchorage points required to attach an ISOFIX seat
- 29% said they did, with 8% saying that they did and that they actually used an ISOFIX restraint
- 35% didn't know if they had ISOFIX anchorage points

Format: Pdf	**Cost:** Free

Title:	**Child Restraint Use Survey: LATCH Use and Misuse**
Author:	Lawrence E. Decina, Kathy H. Lococo, and Charlene T. Doyle
Published:	National Highway Traffic Safety Administration, December 2006
Link:	www.nhtsa.gov/DOT/NHTSA/Communication%20&%20Consumer%20Information/Articles/Associated%20Files/LATCH_Report_12-2006.pdf
Objectives:	To collect information about the types of restraint systems being used. In particular, to identify whether drivers with Lower Anchors and Tethers for CHildren (LATCH)-equipped vehicles were using LATCH to secure their child safety seats to the vehicle, and if so, were the seats properly installed.
Methodology:	An observational survey of the use, misuse and consumer reaction to LATCH at 66 sites (shopping centers, child care facilities, health care centers, and recreation facilities) in seven States, and interviews with the drivers on their satisfaction with LATCH and their reasons for using or not using it.
Key Findings: • 55% of child safety seats, located in a seating position equipped with an upper anchor, were attached to the vehicle using an upper tether. • In 13% of the observations, the child safety seat was placed in a seat position in the vehicle not equipped with lower anchors - the seat belt was used to secure the child safety seat to the vehicle. • Among the 87% who placed the child safety seat at a position equipped with lower anchors, 60% use the lower attachments to secure the child safety seat to the vehicle. • 81% of upper tether users and 74% of lower attachments users said upper tether and/or lower attachments were easy to use. • 75% preferred lower attachments over seat belts of those with experience using both lower attachments and seat belts. • 61% of upper tether nonusers and 55% of lower attachments nonusers cited their lack of knowledge – not knowing what they were, that they were available in the vehicle, the importance of using them, or how to properly use them - as the reason for not using them.	
Format: Pdf	**Cost:** Free

Title:	**Proposal for a new Regulation on Child Restraints Systems**
Author:	United Nations Economic Commission for Europe (UN ECE)
Published:	UN ECE 2012
Link:	http://www.unece.org/fileadmin/DAM/trans/doc/2012/wp29/ECE-TRANS-WP29-2012-53e.pdf
Objectives:	To introduce a new regulation for the design and use of child restraint systems.
Methodology:	N/A

Key Findings:

- i-size, a new European standard for child restraints, was introduced on 9 July 2013.
- i-size will run in parallel with the existing R44.04 standard for the next few years.
- i-Size only applies to ISOFIX seats.
- i-size seats will fit every i-Size approved vehicle and cars will need to be i-Size compliant to achieve the maximum Euro NCAP rating.
- The main changes that i-size introduces are:
  - Child restraint systems will be based on the child's height rather than weight
  - i-Size rearward-facing restraints are for babies up to 15 months old
  - a side impact test.

Format: Pdf	**Cost:** Free

Title	**Infant car safety seats and risk of head injury**
Author	Camille L. Stewart, Megan A. Moscariello, Kristine W. Hansen, Steven L. Moulton
Published	Journal of Pediatric Surgery, Volume 49, Issue 1, January 2014
Link	http://www.ncbi.nlm.nih.gov/pubmed/24439608
Objectives	To assess whether car safety seats are inadequately protecting infants from traumatic brain injuries.
Methodology	Analysis of crash data from the Colorado State Department of Transportation (2007–2011) and State Department of Public Health data (2000–2011) regarding infants who presented to a trauma center after a motor vehicle crash.

Key Findings

- Colorado Department of Transportation data found 833 under one year old children were injured in motor vehicle crashes between 2007 and 2011, 94% of whom (782) were properly restrained in a child car seat.
- Properly restrained infants were 12.7 times less likely to present to a trauma center after a motor vehicle crash.
- However, the likelihood of the child passenger receiving traumatic brain injuries in higher speed crashes was similar among properly restrained and improperly or unrestrained infants.
- The average speed of the vehicles in which children were injured was 44.6 mph.
- Infants involved in moderate to high speed crashes often suffer significant head injuries despite being properly restrained.
- Child car seats are effective in protecting infants, but improvements are needed, with current impact speeds at which USA child car seats are tested being too low.

Format Pdf	**Cost:** Priced

Title	**Injury risk for matched front and rear seat car passengers by injury severity and crash type: An exploratory study**
Author	R.J. Mitchell , M.R. Bambach, Barbara Toson
Published	Accident Analysis and Prevention Vol 82, 2015
Link	http://www.ncbi.nlm.nih.gov/pubmed/26087473
Objectives	To examine the injury severity risk for rear seat compared to front seat car passengers.
Methodology	A retrospective matched-cohort analysis of vehicle crashes involving injured rear vs front seat car passengers identified in linked police-reported, hospitalisation and emergency department (ED) presentation records during 2001–2011 in New South Wales (NSW), Australia

Key Findings

- Of the 10,007 car passengers in 3,681 vehicles identified in this study who were killed or injured in car crashes, 5,419 were front seat passengers and 4,588 rear seat passengers.
- There was a higher odds of sustaining a higher injury severity as a rear- compared to a front seat car passenger, with a higher odds of rear seat passengers sustaining serious injuries compared to minimal injuries.
- Where the vehicle occupant was older, travelling in a vehicle manufactured between 1990 and 1996 or after 1997, where the airbag deployed, and where the vehicle was driven on a road with a speed limit of 70 km/h or more there was a higher odds of the rear passenger sustaining a higher injury severity then a front seated occupant.
- Rear seat car passengers are sustaining injuries of a higher severity compared to front seat passengers travelling in the same vehicle, as well as when travelling in newer vehicles and where the front seat occupant is shielded by an airbag deployed in the crash.
- The increased risk of serious injury for rear seat passengers is likely to be due to the introduction of safety features aimed at front seat protection, such as frontal airbags.
- Rear seat occupant protective mechanisms should be examined.
- Pre-hospital trauma management policies could influence whether an individual is transported to a hospital emergency department.
- Further examination of injury severity between rear and front seat passengers is warranted to examine less severe non-fatal injuries by car seating position and vehicle intrusion.

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Keywords Injury severity; Rear seat passenger; Matched-cohort study; Road trauma

Title	**National roadside survey of child restraint system use in Belgium**
Author	Mathieu Roynard, Peter Silverans, Yvan Casteels, Philippe Lesire
Published	Accident Analysis & Prevention 62, 2014
Link	http://www.sciencedirect.com/science/article/pii/S0001457513003461
Objectives	To obtain population-based estimates of the prevalence of correct and incorrect use of child car restraints and to identify predictors of misuse on the basis of observations in real traffic conditions.
Methodology	A roadside survey of child restraint system use and misuse conducted on randomly selected sites across Belgium, stratified across various types of journeys. Interviews with drivers were also conducted. The principal parameters analysed were the characteristics of the children and the car drivers, type of journey, types of CRS and types of misuse.

Key Findings:

- 1,461 children (under 135 cm tall) were observed travelling in cars.
- At least 50% of the children observed were not correctly restrained and 10% were not restrained at all.
- The most significant factors associated with child car restraint use were the use of a seatbelt by the driver, whether the CRS was bought in a was bought in a supermarket rather than specialised shop and the age of the children.
- 31% of children being driven by for unbelted drivers were not in a child car restraint, whereas only 7% of children being driven by belted drivers were unrestrained.
- 32% of correctly restrained children were being driven by drivers who were not wearing their seat belt, whereas 54% of correctly restrained children were being driven by drivers who were wearing their seat belt.
- 27% of child car restraints that had been bought in a specialized shop were misused compared to 45% of child car restraints that bought in a supermarket.
- The proportion of correctly restrained children decreasing from 75% at age 0 to 24% at age 8 and then increased back up to 63% at age 10.
- Although the sample of ISOFIX users was small (n = 76), it appears that the ISOFIX system reduced misuse significantly.
- Most of the drivers were ignorant of their own errors concerning inappropriate and/or misuse of their child car restraint or they were remiss and underestimated the risk.
- The three main reasons given by the drivers to explain or justify the misuse were low attention level to safety (inattention, time pressure, and short distance), the child's resistance to being restrained, children restraining themselves and problems with the restraint.
- These results suggest little or no change in the level of correct child car restraint use over the last previous years

Format Pdf	**Cost:** Free

Keywords: Child restraint system (CRS) CRS use CRS misuse Unrestrained Inappropriate CRS use ISOFIX Roadside survey

Title	**Adopting child restraint laws to address child passenger injuries: Experience from high income countries and new initiatives in low and middle income countries**
Author	Lisa Keay, Julie Brown, Kate Hunter, Rebecca Ivers
Published	Injury, Volume 46, Issue 6, June 2015
Link	http://www.ncbi.nlm.nih.gov/pubmed/26003092
Objectives	To describe the experience of high income countries in achieving high levels of child car restraint use.
Methodology	Editorial article

Key Findings

- Child car restraint laws are one of the five key road safety laws named in the Global Decade of Action for Road Safety.
- While comprehensive seat belts laws cover 69% of the world's population, child car seat laws cover only 32%.
- Child car restraint laws are more common in high income countries but new laws are being enacted in middle and low income countries.
- Even though child restraint laws are important, experience in high income countries shows that high levels of compliance are difficult to achieve with education and enforcement programmes, and support programmes to distribute child restraints.
- As with other forms of legislation, enforcement programmes are critical to achieving high levels of compliance.
- According to the WHO, only 17% of the 96 countries with child restraint laws have good enforcement programmes.
- Experience in high income countries also shows that education and consumer information programmes are needed to ensure that good quality child restraints are provided, and that best practice in using child car restraints is adopted.

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Keywords

Child car restraints, child car restraint legislation, compliance, WHO

Title	**Examining the relative effectiveness of different message framing strategies for child passenger safety: Recommendations for increased comprehension and compliance**
Author	Kelli England Will, Lawrence E. Decina, Erin L. Maple, and Amy M. Perkins
Published	Accident Analysis & Prevention, Volume 79, June 2015
Link	http://www.sciencedirect.com/science/article/pii/S0001457515000822
Objectives	To evaluate various methods of framing child passenger safety recommendations, and to examine the relative effectiveness on parents' knowledge, attitudes, and behavioural intentions related to best practice and proper use of child restraints.
Methodology	A randomized experiment in which 300 parents answered a pre-survey, viewed one of four versions of a child passenger safety leaflet or were in a no-education control version, and completed a post-survey. The surveys measured child passenger safety knowledge, attitudes, perceptions of efficacy and risk, and behavioural intentions. The four leaflets communicated the same child passenger safety recommendations, but each version employed a different emphasis frame (a persuasion technique that involves placing focus on specific aspects of the content in order to encourage or discourage certain interpretations of the content). The four versions were (1) recommendations organized by the natural progression of seat types; (2) recommendations which focused on avoiding premature graduation; (3) recommendations which explained the risk-reduction rationale behind the information given; or (4) recommendations which were organized by age. In a fifth no-education (control) condition, participants viewed marketing materials.

Key Findings

- Age-appropriate child restraints and putting children in the rear seats dramatically reduce injury in vehicle crashes. But parents and caregivers struggle to comply with child passenger safety recommendations, and frequently make mistakes when choosing and installing restraints.
- The risk-reduction rationale leaflet outperformed other flyers for many subscales, and significantly differed from no-education control for the most subscales, including restraint selection, rear seat knowledge, rear-facing knowledge and attitudes, total efficacy, overall attitudes, and stated intentions.
- The premature graduation flyer performed best for efficacy subscales, but did not significantly differ from the risk reduction rationale flyer for total efficacy. For changes in self-efficacy, the premature graduation flyer outperformed all other flyers.
- The natural progression flyer performed best for attitudes subscales, but did not significantly differ from the risk reduction rationale flyer.
- The age-based flyer performed significantly better than control only for changes

in overall attitudes and stated intentions. However, the age-based flyer was outperformed by the risk reduction rationale flyer for restraint selection score.
- All materials were rated favourably, with no significant differences among flyers for parent's ratings.
- This provides insight for increasing caregiver understanding and compliance with child passenger safety information.
- Recommendations include communicating the rationale behind the information given, using behaviour-based directives in headers, avoiding age-based headers, and incorporating rear-seat positioning directives throughout.
- Real behavior was not observed, only behavioural intentions, which do not always lead to actual behavior change.

Format Pdf	**Cost:** Free

Keywords
Transportation safety; Child restraint; Risk communication; Injury; Child passenger safety

Title	**Evaluation of a child passenger safety class in increasing parental knowledge**
Author	Valerie M. Muller, Rita V. Burke, Helen Arbogast, Perla C. Ruiz, Nellie M. Nunez, Katherine R. San Mateo, Francesca Cazzulino, Jeffrey S. Upperman
Published	Accident Analysis & Prevention 63, 2014
Link	http://www.sciencedirect.com/science/article/pii/S0001457513004314
Objectives	To evaluate the effectiveness of a car seat class in increasing parental knowledge about child passenger safety.
Methodology	Child car seat classes were held at a Level 1 pediatric trauma center every other Tuesday for ten months. The curriculum consisted of a child passenger safety laws discussion, a 21-min video on the use of child safety seats followed by a 15-min discussion about the video, 15 min of discussing the different types of car seats, and hands-on training on how to properly install and use child restraints. Free car seats were provided to eligible parents. A pre-test was administered at the beginning of class and a post-test at the end of the class.

Key Findings
- Child passenger restraint systems greatly reduce the risk of injury and death among child passengers, but nearly half of the children who died in 2009 as a result of motor vehicle crashes were completely unrestrained.
- Our global hypothesis is that parents and other caregivers failed to restrain children due to a lack of child passenger seat education and practice
- In this report, we postulate that a car seat class will improve the basic understanding of child passenger safety.
- Forty-four classes were held, attended by a total of 491 parents and caregivers.
- An increase in knowledge was found for all survey questions.
- Mean knowledge score for the post-test was 3.10 points higher compared to the mean knowledge score from the pre-test.

- Mean difference in knowledge scores for English-speaking participants were higher than Spanish-speaking participants.
- The results of the current study demonstrate an increase in knowledge post-intervention. Similar hospital-based education and seat distribution interventions also found an increase in knowledge post-intervention.
- Previous investigators found that an educational video can increase the use and knowledge of child passenger safety seats, however, our results demonstrated a higher difference in mean scores (2.52 point increase) between the pre- and post-tests.
- Videos in a hospital waiting room area are a passive method of using an educational video. Our video was shown in a class specific for child passenger safety education, during which parents might have paid more attention to the video.
- Our video was also followed by a discussion about the video's content, which might have resulted in greater retention and comprehension of the video's messages.
- Booster seat use and knowledge also increased significantly post-intervention in this study.
- Our results are consistent with similar studies, however, we believe that incorporating additional types of interactive and hands-on teaching methods may boost a gain in knowledge among the class participants.
- This intervention was effective at increasing parental knowledge about child passenger safety.
- The results of this study may be used to design and implement future interventions in multicultural settings

Format Pdf	**Cost:** Free

Keywords
Child passenger safety Child restraints Intervention

Title	**Keeping baby safe: A randomized trial of a parent training program for infant and toddler motor vehicle injury prevention**
Author	Lynne Swartz, Ann Glang, David C. Schwebel, E. Gwen GeigerWolfe, Jeff Gau, Susan Schroeder
Published	Accident Analysis & Prevention 60, 2013
Link	http://www.sciencedirect.com/science/article/pii/S0001457513002947
Objectives	To evaluate "Keeping Baby Safe In and Around the Car", a multimedia DVD designed to improve knowledge about car seat installation among parents of infants and toddlers.
Methodology	A randomized controlled trial with 195 parents of children aged 0 – 24 months in which effective car seat use was measured via a written knowledge quiz and car seat simulation.

Key Findings

- The treatment and control groups did not statistically differ on demographic characteristics or baseline outcome measures, suggesting randomization created initially similar groups.
- Post-test scores on both knowledge and car seat simulation measures for the intervention were significantly higher than those of the control group.
- 96.7% of Parents who responded to user satisfaction questions indicated that they agreed or strongly agreed the program was helpful to them.
- 98.9% recommended the program to other parents.
- In response to the open-ended program use/satisfaction questions, several parents in the treatment group commented on the usefulness of viewing video of correct child safety seat installation.
- Several users made recommendations for distributing the DVD to appropriate target audiences, such as expectant and new parents.
- The results were consistent across outcome measures and regardless of child age, suggest that viewing the "Keeping Baby Safe In and Around the Car" DVD resulted in significant gains in parents' car seat knowledge and their ability to discriminate the critical elements of correct car seat installation.
- DVD programs offer a promising format for learning about child seat safety. They can teach, demonstrate and facilitate desired behavior change by providing parents with visual examples and context. The format also accommodates parents' busy schedules, time constraints, and family obligations.
- When a parent owns such a program, it becomes a resource for repeated use and reinforcement of knowledge.
- A significant challenge disseminating effective programs to the target populations.
- Dissemination of engaging multimedia DVDs such as this program might reduce motor vehicle crash-related injuries to infants and toddlers.

Format Pdf	**Cost:** Free

Keywords

Unintentional injuries Car seat safety Randomized control trial Infants Parent training Observation study

Title	**RANKING EU PROGRESS ON CAR OCCUPANT SAFETY, PIN Flash Report 27**
Author	Graziella Jost, Richard Allsop and Alessio Ceci, European Transport Safety Council (ETSC)
Published	European Transport Safety Council (ETSC), April 2014
Link	http://etsc.eu/ranking-eu-progress-on-car-occupant-safety-pin-flash-27/
Objectives	To assess progress on improving car occupant safety and to make recommendations to Member States and EU institutions for measures to further reduce death and injury to car occupants.
Methodology	The ETSC Road Safety Performance Index (PIN) is a policy tool to help EU Member States improve road safety, by comparing their performance to identify and promote best practice in Europe and bring about the kind of political leadership that is needed to create a road transport system that maximises safety.

Key Findings

- Around 240,000 car occupants were killed in road collisions in the EU27 between 2001 and 2012. There were 12,345 deaths in cars in 2012 compared with 27,700 in 2001, a cut of 55%.
- Deaths of car occupants were cut by more than the overall death rate (49%) and substantially more than the rate for other road users (41%).
- Car occupants have benefitted more than other road users over the past decade because many road safety measures have targeted car occupants including improved vehicle occupant protection. But car occupant deaths still represented almost half (48%) of all road deaths in 2010-2012.
- Car occupant deaths decreased in all PIN countries since 2001. Spain and Latvia achieved the best annual average reductions between 2001 and 2012. Good progress was also made in Switzerland, the Netherlands, the UK and Sweden which are now the safest countries in terms of car occupant deaths per billion vehicle-km travelled.
- Car occupant deaths as a percentage of recorded road deaths in the PIN countries in 2012 ranged from 33% to 70%, and in most countries were between 40% and 60%.
- 4 children (aged 0 to 14) per million child population were killed in cars across the EU each year between 2010 and 2012. This rate ranged across most of the PIN countries from less than 1 to more than 8. Correct fitting and use of child restraints is important in preventing such deaths.
- Key recommendations to Member States include adopting strong legislation and apply best practice in enforcement against speeding, drink driving and the non-use of seat belts and child restraints.
- Key recommendations to EU institutions include aligning type approval crash tests with high performing Euro NCAP crash tests, and extending mandatory fitment as standard equipment of an enhanced seat belt reminder system for all vehicle seats with audible and visual warnings.

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Keywords: Child car occupants, child restraints

Title	**Use of top tethers with forward-facing child restraints: Observations and driver interviews**
Author	Angela H. Eichelberger, Lawrence E. Decina, Jessica S. Jermakian, Anne T. McCartt
Published	Journal of Safety Research, Volume 48, February 2014
Link	http://www.sciencedirect.com/science/article/pii/S0022437513001679
Objectives	To identify why parents do not use the top tether when securing their child car restraints.
Methodology	A survey conducted primarily at shopping centers, recreation facilities, child care facilities, car seat check events, and health care facilities in which drivers were asked about their knowledge and use of top tethers and experience with child restraints. Tether use was observed to verify whether tethers were being used correctly.

Key Findings

- In the USA, LATCH (Lower Anchors and Tethers for Children) is a system for attaching child restraints to vehicles.
- The LATCH system has lower attachments on child restraints that connect to anchors built into the vehicle, and a top tether that attaches the child restraint to an anchor on the rear shelf, seat back, floor, cargo area, or ceiling. The lower attachments are designed to replace the vehicle seat belt as the primary attachment to the vehicle, but the top tether should be used when installing a forward-facing restraint with either the lower attachments or the vehicle seat belt.
- 479 drivers had forward-facing child restraints equipped with tether anchors in their vehicles 56% of forward-facing child restraints were installed with the tether; 39% were installed with the tether used correctly.
- The tether was used with 71% of LATCH lower anchor installations and 33% of seat belt installations.
- Drivers who installed child restraints without tethers most often said they did not know about the tether or how to use it.
- The rate of tether use in the current study was slightly higher than in previous studies, but many parents and caregivers continue to use forward-facing child restraints without attaching the tether.
- Tether use is particularly low with seat belt installations compared with LATCH lower anchor installations. This finding suggests that many drivers do not understand that the tether should be used with either type of installation.
- Parents not using tethers most often said they did not know about tethers or did not know how to use them.
- Because the main problem is lack of awareness of the tether or how to use it, public education should focus specifically on the safety benefits of tethers and how to use them.

Format: Pdf	**Cost:** Free

Keywords
LATCH; Tether use; Child restraints; Observations; Interviews

Title	**Are Parents and Carers Fitting Child Car Seats Correctly?**
Author	Mark Pitcher, TRL
Published	TRL presentation at the Harrogate International Nursery Fair, March 2015.
Link	http://www.trl.co.uk/media/747364/are_parents_fitting_child_car_seats_correctly__31-3-15_v2.pdf
Objectives	To identify the level of child car seat misuse and the most commons forms of misuse.
Methodology	Analysis of 1,576 records of information collected during child car seat checking clinics, mostly held in 2013.

Key Findings

- Since 2010, TRL has been collecting information gathered during child car seat checking clinics conducted in over 50 locations in England and Scotland.
- Children's age, weight and height was recorded to enable an assessment of whether the child car seat being used was appropriate for the child.
- 83% of parents/guardians were able to provide the child's age.
- However, only 15% of parents/guardians knew their child's weight.
- This is a particular concerned as most child car seats conform to ECE R44, and are based on the child's weight. Parents/guardians who do not know the weight of their child, are more likely to put them in an inappropriate child seat.
- 13% of the children observed in a forward-facing group 1 child car seat were below the minimum weight of 9kg for that type of seat, and should have been in a rearward-facing seat.
- No children above 9kg were in a rearward-facing child seat, even though group 0+ seats allow children to stay rearward-facing until they are 13kg in weight.
- 4% of the children observed exceeded the maximum weight for the Group 1 child seat they were using.
- 24% of the children who were in booster seats were under the minimum weight of 15kg for that type of seat.
- Only 2% of the parents/guardians who participated in the clinics knew their child's height. This is important because the new 1-size (regulation 129) standard for child car seats is based on children's height.
- In general, only 40% of the child car seats recorded in the database were fitted correctly.
- 60% of the child car seats recorded in the database had at least one form of misuse, most commonly the:
  - child seat's internal harness too loose (20%)
  - seat belt holding the child seat too loose (17%)
  - seat belt routed through the child seat incorrectly (15%)
  - child seat's internal harness incorrectly fitted (6%)
  - child seat's internal harness twisted (3%).
- Levels of misuse of child car seats remain high and so education and checking clinics are essential.

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Keywords

Child car seats, child restraints, misuse, checking clinics

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