

# Children in cars

Research facts about  
children and car safety

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## Rear-facing seats save lives

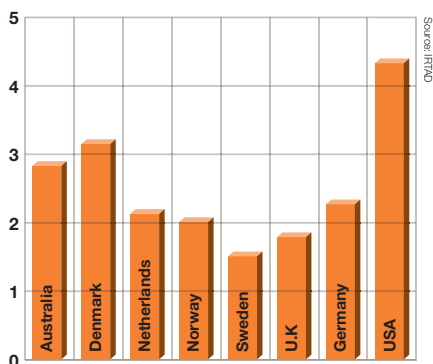
The risk of young children being killed or seriously injured is five times greater in a forward-facing child car seat than a rear-facing seat. Moreover, more recent research shows that children should sit in a rear-facing seat considerably longer than previously recommended, in fact up to the age of four or five.

Although these are known facts, parents in most countries, except for the Nordic countries, have always tended to turn their children so that they sit facing forward as early as the age of one. Children in Sweden are an exception in this respect - they continue to sit facing backwards until they are older. The Swedish recommendation is that young children should sit facing backwards at least up to the age of four. The effect of this becomes obvious when Swedish statistics are compared with those from the rest of the western world, see figure.

But the number of children that sit facing backwards has decreased during recent years in Sweden. The number of children placed in a rear-facing restraint system in the front seat has also decreased. Many vehicle manufacturers recommend that children are placed in the back seat, and the fact that more vehicles than before are equipped with passenger airbag

may have contributed to this negative change.

There is a trend that forces children to sit facing forwards, particularly in car models in which the passenger airbag cannot be disconnected. Children have to sit in the back seat, where there is often considerably less legroom for a rear-facing child than in the front seat. Many parents are therefore tempted to fit the child seat in a forward-facing position far too early. In the long term, this may lead to an increase in the proportion of injured children.



The distribution of fatalities among children per 100 000 inhabitants (1996-2000).

## Travel facing backwards for safety's sake

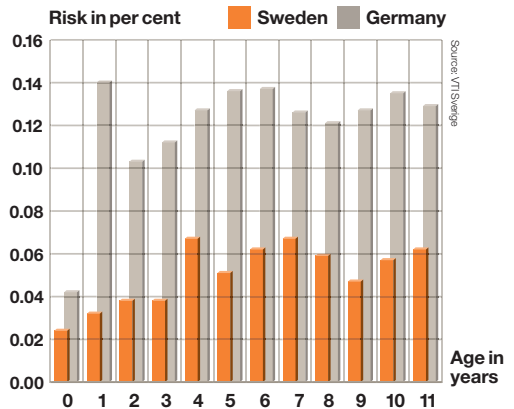
### Five times greater risk of being killed or injured in forward-facing seats than in rear-facing seats

A number of different studies based on real-life accidents show that the risk of being killed or injured in a collision increases around fivefold for children under the age of three sitting in a forward-facing seat, compared with a rear-facing seat. This is also confirmed, if Swedish accident statistics are compared with data from other countries. One example is Germany, where children usually travel in forward-facing seats from just under 12 months. The proportion of injured children increases fourfold in the age group zero to one year. In Sweden, an increase in injury rate is not seen until the age group three to four years. In other words, at the very age when Swedish parents begin letting their children travel facing forwards. However, the increase in injuries is far less substantial, since the child's neck has had time to strengthen. The differences between Sweden and Germany are illustrated by the bar chart.

### Effect of various protection systems

Rear-facing child car seat	90–95 %
Forward-facing booster cushion/seat	50–60 %
Seat belt for children under 10	20–30 %
Seat belt for adults	50–60 %

It is worth being restrained. Compared with not wearing a seat belt or other restraint, the injury-reducing effect of being restrained is considerable. The effect is greatest for children sitting in a rear-facing child car seat. At least nine out of ten children are saved from injuries as a result.

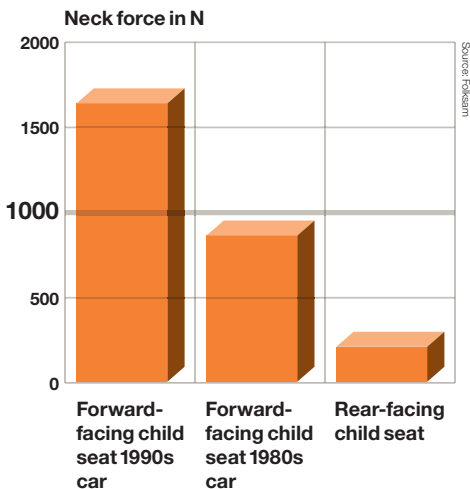


Comparison between the proportion of children injured in a car by age group in Sweden and Germany in 1999.

**New research shows that children should sit in a rear-facing seat in the front seat until the age of four or five**

Today it is important that young children sit facing backwards longer than previously. The reason may seem contradictory, but a child can only benefit from newer and safer car designs by sitting facing backwards. Cars designed in the 1990s and after, have a stiffer structure that keeps the passenger compartment intact even in a collision at a higher speed. The design increases the chance of survival, but at the same time makes higher demands

on the car's other protection systems. To reduce the load on the body, cars today are therefore fitted with airbags and seat belts with load limiters. The problem is just that these are designed for adults. For young children facing forwards, the load on the neck and head instead increases significantly in a newly designed car, compared with an older car. See the diagram below. However, new cars are not a problem for children travelling in a rear-facing child car seat. In other words, children under the age of five should sit facing backwards.



The results of head-on crash tests with a three-year-old child dummy in a forward-facing child car seat in an old (early 1980s) and a newer (late 1990s) car model.

The neck force (load) is measured in the crash test dummy. The neck force was above 1,700 N in the newer stiffer car model and 950 N in the older model. The limit value for injury is considered to be approximately 1,000 N.

The neck force in a rear-facing child car seat is also shown for comparison.

## Children are not like adults

### The child's anatomy

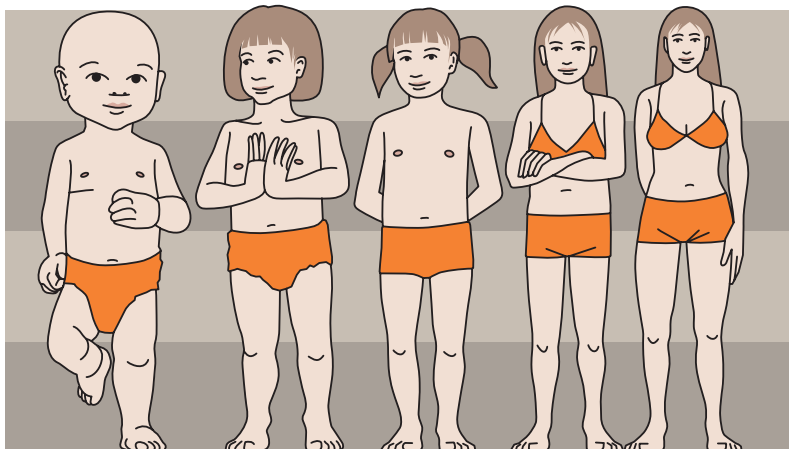
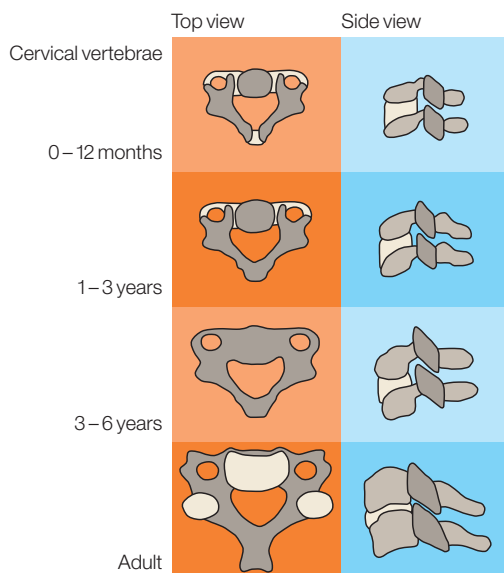
The newborn baby's cervical vertebrae consist of separate pieces of bone connected by cartilage. The skeleton is consequently soft. Gradually the cartilage turns into bone, a process that continues up to and including puberty. The neck muscles and ligaments undergo a similar development. The shape of the cervical vertebrae also changes during childhood and adolescence, from the young child's flat vertebrae to the adult's saddle-shaped vertebrae. The saddle shape means that the vertebrae can latch on to and strengthen each other, if the head is thrown forwards. Young children lack this extra protection.

### The child's proportions

The head of a child is large and heavy relative to the body. The head of a nine-month-old baby accounts for 25 per cent of the baby's weight. The equivalent figure for an adult is 6 per cent.

The head of a young child also has quite different proportions. The back of the head, and therefore the brain, is oversized compared with the face. Head injuries in a child therefore often involve brain damage. The damage can moreover be aggravated by the fact that the child's skull is not as thick and protective as that of an adult.

The child's pelvis is also undeveloped. The difference between the pelvis of an adult and that of a child is mainly that the iliac crests in the child's hip bones are not fully developed. In an accident, this is what prevents the seat-belt from riding up and damaging the internal organs of the abdomen. The pelvis is completely rounded in shape until the age of eight or ten. Adult-shaped hip bones are not fully developed until puberty. It is therefore important that both the seat with a belt and the booster cushion with a belt are designed with proper deflectors, which lead the belt away from the child's abdomen.



A child is not a miniature adult. A young child's head accounts for 25 per cent of body weight, while the equivalent figure for adults is 6 per cent.



## Everything in favour of the front seat

If the passenger airbag is disconnected there are more advantages of having the child in the front seat from the point of view of collision safety. Crash tests show a slightly lower risk of injury in the case of a frontal impact if the child is sitting in a rear-facing seat resting against the dashboard, compared with a rear-facing seat in the back seat resting against the back of the front seat. In the case of a side impact the child is better protected in the middle place in the back seat than in the front seat. However, side impact are not as common as frontal impact. So there are many advantages of having the child in the front seat :

- In the front seat the child has more legroom than in the back seat. This extra legroom means that the child can continue to ride facing backwards at least one more year in the front, compared with the back seat.
- The driver is not disturbed as much. Observations from the USA indicate an increased risk of accident when babies or children are placed in the back seat. In a comparison, the driver was distracted four times more often by a child in the back seat than by an adult passenger. And almost eight times more by a baby.
- There is better social contact between the child and the driver, which is important when travelling alone with the child.



Large family car  
front seat



Large family car  
back seat



Small family car  
front seat



Small family car  
back seat



The pictures show the difference in legroom if the child is placed in a rear-facing child seat in the front or the back seat. The boy in the picture is 4 1/2 years old and weighs 22 kg (50 lb)

### **Airbags are no good for young children**

- Never put children in a baby car seat, a rear-facing child car seat, a forward-facing seat with belt, or on a booster cushion with belt on a car seat fitted with an airbag in front of the seat.
- Children under 140 cm should not sit on a car seat with a connected airbag.

Children under 140 cm should not sit in a front seat with a connected passenger airbag. The airbag is designed for adults and can kill or seriously injure a child, even in a minor collision. The purpose of the airbag is to inflate in a few milliseconds and softly catch an adult body thrown forwards. In a rear-facing seat, the child's head is in highly dangerous proximity to an activated airbag, which inflates at a maximum of 300 km per hour. A child sitting in a forward-facing seat with belt or on a booster cushion with belt also risks injury, due to following a different trajectory than an adult.

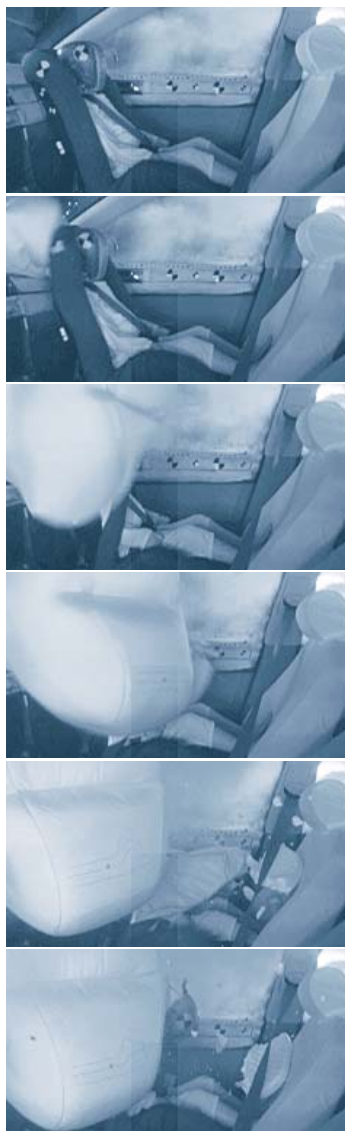
### **Get the dealer's service department to disconnect the airbag**

Always get an authorised dealer's service department to disconnect the airbag. If your car has a key switch, you can switch it off and on yourself. The key switch is reliable, but there is a risk that, due to human error, the

airbag is switched on, when it should absolutely not be. An American study of switched-off airbags shows that the airbag was switched on in half of the cases, despite a child sitting in the seat in front of it. One explanation for this high misapplication may be that the driver is warned by a light on the dashboard only when the airbag is switched off, but not when it is switched on. The car manufacturer should really take responsibility for a reliable disconnection during the period when the seat is being used by children.

### **Side airbags**

There are no real-life accidents showing that side airbags are dangerous for children in child car seats. But if the child sits with his/her head in immediate proximity to the side airbag's inflation point, tests show a risk of serious injuries. In rear-facing child car seats, the risk of the child's head coming close to the airbag's inflation point is minimal. As a precaution, you should ensure that a child sitting in a forward-facing seat or on a booster cushion does not lean against the door with his/her head. Contact your car manufacturer regarding their recommendation for your car model.



Crash tests with rear-facing child restraint and activated airbag.

## Risks of different types of collision

### Frontal impact

The most common type of collision of all is the frontal impact collision. When sitting facing forwards, the upper body is flung forwards on impact until the seat belt slows it down. At the same time, the head continues forwards at the same speed as the car was travelling before the collision. In order to stop the head's forward movement, a large load is placed on the neck. The movement sequence thereby sharply increases the risk of head and neck injuries in children. On the other hand, the movement is not so dramatic for a child in a rear-facing child car seat. The head and the body are slowed down simultaneously, when the collision forces are greatest. Since a child's neck is considerably more sensitive than that of an adult, this is also the main reason that children should travel facing backwards as long as possible.

### Side impact

Side impact are not as common as frontal impact, but when they occur the consequences are often very serious. The person sitting nearest the impacted side of the car is thrown towards the centre of the car. However, the head has no time to follow, but moves outwards relative to the rest of the body and towards the impacting car. Serious head injuries often arise at the very moment the head hits the inside of the car or the front of the colliding car.

A forward-facing child seat or booster cushion offers no extra protection over and above the car's in-built protection system. Cars with side impact protection systems and side curtain airbags have almost halved the risk of head injuries in adults. Rear-facing baby car seats and child car seats with high sides can reduce the risk of the head rolling out of the child seat.

**Rear-end collision**

A rear-end collision occurs in most cases at relatively low speeds. It is therefore rare for children to be injured. This also applies to whiplash, which is the most common injury in adults in this type of collision.

For a child sitting in a rear-facing car seat, a rear-end collision is like a frontal impact. In other words, the child car seat has a tendency to rise against the car seat back. In order to counteract this movement, child car seats often have lower anchorage straps. Some child car seats are instead fastened with a type of arm, which is locked in an unfolded position against the car seat back. On the other hand, baby car seats need no lower anchorage straps thanks to a low centre of gravity.

## European crash tests misleading

There are a number of European consumer tests of child car seats, such as EuroNCAP, ADAC and Auto Motor & Sport. All these tests primarily evaluate forward-facing child car seats, which are also intended to be suitable for young children (age 1–4). It is therefore tempting to think that good test values for forward-facing child car seats also mean good protection for younger children. The fact is that all the studies based on real-life accidents show that rear-facing seats are preferable. Moreover, the measurement criteria used in the tests are very incomplete. In most cases, only the risk of chest injuries is measured by measuring the acceleration level in the dummy's chest. Studies of real-life accidents show, however, that serious injuries to children are instead domi-

nated by head and neck injuries. The majority of European consumer tests do not measure the risk of this type of injury at all. A result based on the chest value in the child dummy gives rear-facing child car seats a totally misleading and poorer result than forward-facing seats. It is true that EuroNCAP also measures the neck force in the dummy, but the result is obscured in the total points, since the characteristics of the tested car model, in which the child car seat was tested, carry a lot of weight. Points are, for example, awarded for the facility to disconnect the passenger airbag, how well the stickers in the car warn against placing the child car seat in front of the airbag, and the space for placing more than one child car seat in the back seat.

## Our research provides you with knowledge

Folksam has carried out road safety research for many years. The reason is that we want to contribute to the quest for knowledge that can save lives on the roads. Our research is mostly based on analyses of real-life accidents, but also on the results of our own crash tests. New car models and new technical solutions mean that old knowledge must be constantly updated. What was true yesterday is not always true today.

One research area that we feel particularly strongly about is child car safety. Our experience in this area goes back a long way. Folksam was previously involved in developing child car seats, which set a new safety standard in the market. Since then we have surveyed all car accidents in which children have been seriously injured.

You are always welcome to contact us at Folksam. We have local branches throughout Sweden.

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You can find more information about road safety on [www.folksam.se](http://www.folksam.se)



