

Seat belts and child restraint seats

Summary

Seat belts reduce the risk of fatal injury by 30 to 40%, depending on the position in the passenger car. The effect of child restraint seats is slightly larger with 50%. Since the seat belt was introduced, some 9,000 fewer fatalities occurred in the Netherlands as a result of the use of seat belts. Presently, in the Netherlands, an ample 95% of the front-seat occupants of passenger cars use seat belts; circa 80% of the back-seat occupants use seat belts. Almost 90% of children are transported with sufficient protection. If *all* occupants of passenger cars were to use a seat belt, 10 fatalities per year would be prevented. In delivery vans the user percentages are considerably lower: 84% of the drivers and 75% of the front-seat occupants use seat belts. User percentages in lorries and buses are not known, but they appear to be much lower than in delivery vans.

Background and content

Passenger cars are getting increasingly safer. Primary (active) and secondary (passive) safety systems contribute to this trend. Seat belts and child restraint seats belong to the secondary safety, injury prevention systems, and they are the traditional protection devices in passenger cars. They are an essential link in the so-called 'safety chain': crumple zone–passenger cage–protection device. During the 1970s compulsory seat belt usage was implemented in practically all European countries, because research had shown that seat belts have a great impact on safety. Seat belts or child restraint seats, in combination with the airbag, protect occupants in head-on crashes. In side crashes and roll-overs seat belts and child restraint seats prevent occupants from being ejected from the car. Current developments in vehicle safety focus on integrating primary and secondary safety as best as possible to realize the highest possible total safety (integrated safety).

This fact sheet examines the usage of seat belts and child restraint seats and their effect in terms of casualty reduction. Regulations are also discussed. Moreover, the airbag is briefly examined in combination with seat belts and baby restraint seats in the front seats.

How often are seat belts and child restraint seats used in the Netherlands?

In the course of the last few decades, an increasing number of occupants have begun to use seat belts in the Netherlands (see *Table 1*). Outside built-up areas the percentage of drivers using seat belts increased from 78% in 1990 to 96% in 2008; inside built-up areas this increased from 59% to 95%. This indicates that the traditional difference between inside and outside areas has practically disappeared. The usage of seat belts by front-seat passengers has reached nearly the same level as that of drivers. The percentage of seat belt usage in the back seat increased by leaps and bounds during the last few years: from 20% in 1990 to more than 80% in 2008. In the period of 1996-1999, the police started implementing regional traffic policing plans, directed at five spearheads including seat belt usage. This has contributed to the increased usage of seat belts (see also SWOV fact sheet [Effects of police enforcement of protection devices and moped helmet use and red light running.](#))

The data in *Table 1* about seat belt usage by occupants of passenger cars is the outcome of representative national measurements carried out since 1969. They were initially carried out by SWOV. Since 2000 the Centre for Transport and Navigation (DVS) of the Ministry of Infrastructure and the Environment has carried out these measurements. These measurements do not only focus on passenger cars, but also on delivery vans. In 2008, 84% of the drivers of delivery vans used seat belts and 75% of the front-seat occupants did. Despite a considerable increase in user percentages since 2000, the level is still clearly below that of occupants of passenger cars. User percentages in lorries and buses are not known, but they appear to be far lower than in delivery vans.

Year	Drivers		Back-seat occupants	
	Outside built-up areas	Inside built-up areas	Outside built-up areas	Inside built-up areas
1990	78	59	22	18
1995	77	64	21	20
1998	80	67	43	40
2000	86	74	36	28
2002	91	83	56	49
2004	92	88	67	71
2006	94	93	73	73
2008	96	95	80	82

Table 1. *Seat belt user percentages outside and inside built-up areas in the period of 1990-2008, of drivers and back-seat occupants in passenger cars. Front-seat occupants show a development similar to that of drivers (Mulder, 1998; AVV, 2000-2006; DVS, 2007;2008).*

With the implementation of a number of new traffic rules in 2006 (see: [What are the rules in the Netherlands?](#)) safe transport of children (with a height of up to 1.35 m) in protection devices has improved considerably (see Table 2). In 2006, 28% of the observed children were transported without sufficient protection; in 2008 this was 12%. Without sufficient protection should be read as, among others, travelling in a seat without a seat belt or in an unattached carrycot, or being seated on a passenger's lap.

Year	Observed children	
	Unprotected	Protected
2002	55	45
2004	62	38
2006	28	72
2008	12	88

Table 2. *Percentages of transport of 'insufficiently protected' children in the period of 2002-2008 (AVV, 2000-2006; DVS, 2007;2008).*

How important is the effect of seat belts and child restraint seats on traffic safety?

Research has shown that seat belts reduce the risk of severe or fatal injuries considerably (see Table 3). Front seat belts are more effective than back seat belts, because the back seat already creates a more crashworthy environment than the front seats do. Furthermore, seat belts are more effective in preventing fatal injury than severe injury. The reason is that a fatality is to a large extent due to head/skull injuries and internal chest injuries. In particular these types of injuries are prevented by the seat belt during a head-on crash. The effect of seat belts is also partly dependent on the collision speed (Evans, 1996). The effect of seat belts will eventually be reduced to 0 in the case of an extremely high collision speed, but, on the other hand, the effect is very large in the case of low speed. This is the reason why it is important to use seat belts also in urban areas.

Type of injury	Seat belts in front	Seat belts in back	Child protection devices
Severe injuries	25%	20%	30%
Fatal injuries	40%	30%	50%

Table 3. *Estimated reduction of injury rate when using seat belts and child protection devices in passenger cars in the Netherlands (seat belt figures based on Evans, 1986 and 1991 child protection devices from Schoon & Van Kampen, 1992).*

More recent research has shown a slightly higher fatality rate reduction of circa 45% as a result of seat belt usage in the back seat (Mizumo et al., 2007). In addition, using seat belts in the back has a further positive effect on the front-seat occupants: research by Ichikawa et al. (2002) showed that the risk of fatal injury for front-seat occupants using seat belts is five times higher in a head-on crash when back-seat occupants with no seat belts hit the front seats. Obviously, front-seat occupants can also injure each other when at least one of them does not use a seat belt, especially in the case of side impacts.

With 50%, the effect of child protection devices is slightly higher than that of seat belts (Schoon & Van Kampen, 1992; Brown et al., 2002). These studies make no distinction between the age of the child, type of protection device or the seating position in the car.

The benefit of seat belts and child restraint seats has been proven beyond doubt in the last fifty years. Research conducted in the fifteen original EU countries (EU-15) has shown that circa 6,000 fatalities could have been prevented each year if all occupants had used seat belts (ETSC, 2006). If all occupants of passenger cars in the Netherlands had used seat belts in 2008, 10 more fatalities could have been prevented that year (see Schoon (1994) for the calculation method). Starting from 40% effectiveness, circa 9,000 fewer fatalities occurred in the Netherlands because of seat belt usage since the introduction of the seat belt. Since 1972, the year with the highest number of fatalities among car drivers, seat belt usage has resulted in a yearly average of 250 fewer fatalities among occupants of passenger cars. In 1972 the user percentage amounted to no more than 20% (only front seats); in 2008 this amounted to 95%.

What are the rules in the Netherlands?

Seat belts

The regulations for the installation and usage of seat belts first applied to passenger cars and later to all vehicles:

1 January	1971	Front-seat anchorage points and seat belts compulsory.
1 June	1975	Compulsory seat belt usage in front seats.
1 January	1980	Back-seat anchorage points for seat belts compulsory.
1 January	1990	Seat belts compulsory in back seats.
1 April	1992	Compulsory seat belt usage in back seats.
1 April	1992	Compulsory seat belt usage in all other vehicles, such as delivery vans, lorries and (non-public) buses/coaches.

Seat belts have to be installed in compliance with Article 5.2.47 of the Dutch *Traffic Regulations* (part of the 1994 Road Traffic Act). This article complies with the European Directive for seat belts and seat belt anchorage points respectively (Directives 77/541/EEG and 76/115/EEG). In the Netherlands, the compulsory usage for all occupants of passenger cars is laid down in article 59 of the *1990 Traffic Code* (RVV 1990). These regulations were tightened on 1 April 2008. Occupants must only be transported in real seats fitted with seat belts and the number of occupants must not exceed the number of seats with seat belts. An exception is made for the transport of children of up to 1.35 m in height in seats especially installed for them (in particular, extra seats in the back of station wagons that should however have seat belts installed) and for occupants using wheelchairs.

Child restraint seats

Not everyone is tall enough to be able to use seat belts safely. Seat belts have been developed for adults, not for children. Therefore, different protection devices (child restraint seats) have been developed for the safe transport of children shorter than 1.35 m. In 2006 it was decided on European level that children shorter than 1.35 m must be seated in a restraint seat or booster seat, in the front as well as in the back of the car. Only certified child restraint seats that meet the ECE requirements are allowed to be sold. They are divided into weight categories. Each weight category refers to an age group as an indication. The lightest category is the baby restraint seat; the baby is transported in this seat face backward. The reason is that the baby's body weight is divided over its various body parts differently from the way it is for adults. They have a relatively heavy and vulnerable head compared to adults, so that the head should be protected as best as possible during a crash. This works best by transporting babies face backward in a baby restraint seat, so that the body (read: head) is well caught in the restraint seat in the case of a head-on crash. The baby has outgrown its restraint seat when his/her head sticks out above the edge of the seat. A backward restraint seat is only allowed in the front seat if the airbag has been de-activated. If the airbag has been activated the outcome of a (head-

on) collision may be fatal for the child. This is the reason why cars with one or more airbags in the front-seat passenger position must legally be provided with a warning label and an airbag de-activation switch (EC Directive 77/541/EC, ECE requirements 44 and 94).

It is not allowed to have the diagonal strap of the standard three-point seat belt run behind the body of the child; seat belt adjusters¹ are also prohibited for children. For children that have outgrown their child restraint seats, booster seats have been developed as an alternative. They make sure that the three-point seat belt is strapped across the shoulder (and the thighs) correctly. It is prohibited to transport children in the luggage or loading space of a passenger car or in a trailer or caravan. Since 1 January 2004 the *Seat Distribution Regulation* has been implemented in the Netherlands under the 2002 Passenger Transport Act. This act regulates the compulsory usage for children in taxis and (non-public) buses or mini-vans.

What are the developments regarding child restraint seats?

In the US and Scandinavia child restraint seats have become available these last few years in which older children (up to about 4 years of age) are seated backward, in the same way as babies are seated in their restraint seats. This is a highly responsible way of transport if permitted by the space in the car. It is often difficult to install such child restraint seats in smaller cars, because they have to be fastened by additional straps (tethers).

Within the ECE framework (see SWOV fact sheet [Vehicle regulations](#)) new regulations are presently being implemented that do no longer refer to categories based on child weight, but on child size. The manufacturers of child restraint seats are themselves allowed to determine the size range of the restraint seats that they put on the market. New on the market are the so-called Isofix child restraint seats that need no seat belts to be fastened anymore. However, cars need to be equipped with special anchorage points. Tests have shown that these Isofix child restraint seats reduce the risk of incorrect usage, so that the protection level (effectiveness) of the child restraint seat increases. Another important benefit of Isofix child restraint seats is that the airbag(s) in front of that specific seat is/are automatically de-activated.

Nowadays, manufacturers of child restraint seats increasingly supply instruction films about the use of their restraint seats in passenger cars in addition to the mandatory instructions for use. These films are very illustrative and can contribute to preventing incorrect usage of the restraint seat in practice.

How are seat belts most effective in the case of head-on crashes?

Three-point seat belts are mainly developed to protect occupants during a head-on crash and to prevent occupants from being ejected from the car in crashes. The occupant not using a seat belt increases the risk of severe injuries in case of a crash, not only for him or herself, but also for the other occupants of the car.

It is important that a seat belt is strapped around the body well and tight. If a seat belt has too much slack, the pressure on the body increases too much during a crash. As a result, breastbone and ribs may be fractured during a crash.

The diagonal or shoulder part should not be strapped too closely to the neck, but should be strapped diagonally across the middle of the shoulder and the middle of the chest. To make sure that the shoulder part is strapped on as correctly as possible, cars are often equipped with an adjustable top anchorage point that the user should adjust as well as possible, depending on the size of the upper body and position of the seat.

The hip part should be strapped on as low as possible, below the hip and across the thighs and not across the abdomen to avoid injury to the organs. Pregnant women in particular should be careful with this. The position of the hip part depends on the position of the seat. Correct adjustments of the seat (distance to the pedals) and seating position (height and angle) help prevent the hip seat belt from being pushed up during a crash.

The tension in the shoulder seat belt is regulated by the roller mechanism in the automatic seat belt device. This tension and rolling force is in fact a compromise between required safety (tighter) and desired comfort (less tight) when driving. To prevent tension on the upper body, seat belt clips are available.. However, their use is advised against because they introduce extra slack². The general rule is that a seat belt with too much slack results in greater risks. Aside from considerably higher pressure

¹ The new regulations make an exception with respect to these seat belt adjusters: they are allowed for children and adults that are shorter than 1.50 m, but too heavy for a child restraint seat or booster seat (www.autokinderzitjes.nl).

² For pragmatic reasons SWOV finds that in the case of complaints about the seatbelt being too tight it is better to use a seat belt clip than not to wear a belt at all, or to wear it underneath the arm. This is to prevent that the seat belt tightener does not function well.

on the body in the case of a head-on crash, there is a higher risk that the seat belt does no longer run across the shoulder correctly.

Airbags provide additional protection to seat belts in the case of head-on crashes, provided the occupants are seated as far back as possible and the seat belts are strapped on tight. In the United States a minimum distance of 25 cm from the steering wheel or dashboard is standard for the airbag to work well. The airbag is mainly effective in serious crashes, when occupants could hit parts of the interior, despite the seat belts. In those cases, the airbag plus seat belt offer an estimated 10% lower risk of a fatal outcome than the seat belt alone.

What are the developments in seat belts?

Nowadays, most modern cars are fitted with seat belt tensioners (reversible or pyrotechnical pre-tensioners). A seat belt tensioner is an additional device of the three-point seat belt system that will tighten the seat belt (buckle) many centimetres more in the case of a crash to counterbalance the slack. The seat belt tensioners are activated by the same sensors that also regulate the airbags. An explosive expanding gas fills a cylinder and pushes away a piston that rolls up the seat belt in the reverse direction. In addition force limiters make sure that the seat belt also 'yields' somewhat during the crash, to reduce the force on the upper body. Presently, 'intelligent' force limiters are in the making that determine the amount of slack, dependent on the development of the crash and the available space between occupant and steering wheel or dashboard. There are first indications that these new types of force limiters could reduce the risk of thorax injuries by 45% (Van der Laan, 2009).

One of the most recent developments for safer transport of back-seat occupants are the seat belts with a cold compressed gas airbag. These so-called inflatable seat belts cover a body surface that is minimally five times larger than that of a standard seat belt, so that the forces on the body of the occupant can be counteracted more successfully. Moreover, an inflated seat belt keeps the occupant in his or her position better.

Seat belt reminders in all seating positions, thus also in the rear of the car, increase the seat belt usage percentage (see SWOV fact sheet [Seat belt reminders](#)).

Nowadays cars (and also lorries) are equipped with more and more electronic devices (sensors) that can continuously detect all kinds of movements and (crashing) situations, in the car (occupant monitoring), as well as in the environment of the car (pedestrians, cyclists). These kinds of intelligent systems are capable of sending out a signal a few seconds before a crash (pre-crash sensing) to, among others, activate a seat belt tensioner.

Conclusions

Seat belts and child restraint seats are an indispensable link in the so-called safety chain: crumple zone–passenger cage–protection device. The usage of seat belts and child restraint seats has vastly increased in the last few decades. Presently, more than 95% of the front-seat occupants of a passenger car use seat belts; circa 80% of the back-seat occupants use seat belts. Almost 90% of children are transported with sufficient protection. In delivery vans the user percentages are considerably lower: 84% of the drivers and 75% of the front-seat occupants use seat belts. User percentages in lorries and buses are not known, but they appear to be much lower than in delivery vans.

The effectiveness of the seat belt in the prevention of fatal injuries is 40%. A rough estimate indicates that in the Netherlands, since the introduction of the seat belt, about 9,000 fewer fatalities have occurred as a result of the use of seat belts. An airbag increases the effect of the seat belt. With 50%, the effect of child restraint seats is even greater than that of the seat belt. Seat belts are still being improved. Systems have been developed, among others, to reduce the forces that the seat belt exercises on the human body (the seat belt tensioner and force limiter) and to activate the seat belt even earlier in the crashing process (pre-crash sensors).

Publications and sources (SWOV reports in Dutch have an English summary)

AVV (2000-2006). [Gebruik van beveiligingsmiddelen in auto's](#). Directoraat-Generaal Rijkswaterstaat, Adviesdienst Verkeer en Vervoer AVV, Rotterdam.

- DVS (2007). [Gebruik van beveiligingsmiddelen in auto's 2007; Eindrapport](#). Directoraat-Generaal Rijkswaterstaat, Dienst Verkeer en Scheepvaart DVS, Rotterdam.
- DVS (2008). [Beveiligingsmiddelen in de auto 2008](#). Directoraat-Generaal Rijkswaterstaat, Dienst Verkeer en Scheepvaart DVS, Delft.
- Brown, J., Griffiths, M., & Paine, M. (2002). [Effectiveness of child restraints; The Australian experience](#). Research Report RR06/02 for the Australian New Car Assessment Program ANCAP.
- ETSC (2006). [Seat Belt Reminders. Implementing advanced safety technology in Europe's cars](#). European Transport Safety Council ETSC, Brussels.
- Evans, L. (1986). [The effectiveness of safety belts in preventing fatalities](#). In: Accident Analysis and Prevention, vol. 18, nr. 3, p. 229-241.
- Evans, L. (1991). [Traffic safety and the driver](#). Van Nostrand Reinhold, New York.
- Evans, L. (1996). [Safety-belt effectiveness: the influence of crash severity and selective recruitment](#). In: Accident Analysis and Prevention, vol. 28, nr. 4, p. 423-433.
- Ichikawa, M., Nakahara, S. & Wakai, S. (2002). [Mortality of front-seat occupants attributable to unbelted rear-seat passengers in car crashes](#). In: The Lancet, vol. 359, nr. 9300, p. 43-44.
- Laan, E. van der, Jager, B. de, Veldpaus, F., Steinbuch, M., Nunen, E. van & Willemsen, D. (2009). [Continuous restraint control systems: Safety improvement for various occupants](#). In: [Proceedings of the 21st International Technical Conference on Enhanced Safety of Vehicles ESV](#), 15-18 June 2009, Stuttgart, Germany. ESV paper 09-0044.
- Mizuno, K., Ikari, T., Tomita, K. & Matsui, Y. (2007). [Effectiveness of seatbelt for rear seat occupants in frontal crashes](#). In: [Proceedings of the 20th International Technical Conference on Enhanced Safety of Vehicles ESV](#), 18-21 June 2007, Lyon, France. ESV paper 07-0224.
- Mulder, J.A.G. (1998). [Gebruik van beveiligingsmiddelen in 1998](#). R-98-42. SWOV, Leidschendam.
- Schoon, C.C. (1994) [Toelichting op de rekenprogramma's 'Besparing slachtoffers bij gebruik van beveiligingsmiddelen'](#). D-94-13. SWOV, Leidschendam.
- Schoon, C.C. & Kampen, L.T.B. van (1992). [Effecten van maatregelen ter bevordering van het gebruik van autogordels en kinderzitjes in personenauto's](#). R-92-14. SWOV, Leidschendam.
- VenW (2008). [Nieuwe verkeersregels per 1 april](#). Nieuwsbericht 27 maart 2008, Ministerie van Verkeer en Waterstaat, 's-Gravenhage.