Older road users

SWOV fact sheet, August 2024

Summary

From the age of 70, road users have an increased fatality rate as a result of a road crash. The fatality rate for older car drivers (70 or older) is 2.8 times higher than for younger drivers (under 60). Looking at cyclists and pedestrians, the difference in fatality rate is much greater: for older pedestrians it is 6.6 times higher, for older cyclists 12.4 times higher. The greater physical vulnerability of older road users is one of the main causes of the high fatality rate. In addition, functional limitations may cause them to be more often involved in certain types of crashes, especially crashes when turning left at an intersection. From the crash data, no information can be extracted about those *responsible* for the crash. Therefore, we cannot say whether older road users cause crashes more often than younger road users; what we *can* say is that they become crash casualties relatively often.

Measures that may reduce the crash involvement of older road users are adjustments to infrastructure and technical systems in or on the vehicle, together with education and public communication focusing on both older and other road users. In addition, to reduce the fatality rate of older road users, measures reducing injury severity are also important.

This fact sheet, unless otherwise stated, is about healthy older road users. For more information on vehicles often used by older road users, see SWOV fact sheet *Mobility scooters, enclosed disability vehicles and microcars*.

1 How does ageing affect traffic?

The population of the Netherlands is ageing. There is even double ageing: not only are there more and more older people, the older people also reach an ever increasing advanced age (for the most recent figures, see Statistics Netherlands dashboard, accessed April 11, 2024). In addition, older people today remain more active, including in traffic, and the share of women with a driving license has increased. These trends result in a continued increase in the number and share of older road users.

During 2013-2022, 3.8% of the total number of kilometres was travelled by the over-75s, while 8% of the population was 75 or older during that period. On average, the over-75s travel fewer kilometres than younger road users. In 2013-2022, we see a slight increase in the share of kilometres travelled by older road users, especially by older cyclists (from 4.4% older cyclists in 2013 to 7.2% in 2022, see *Figure 1*); older people are becoming more active and they engage in traffic more often than before.

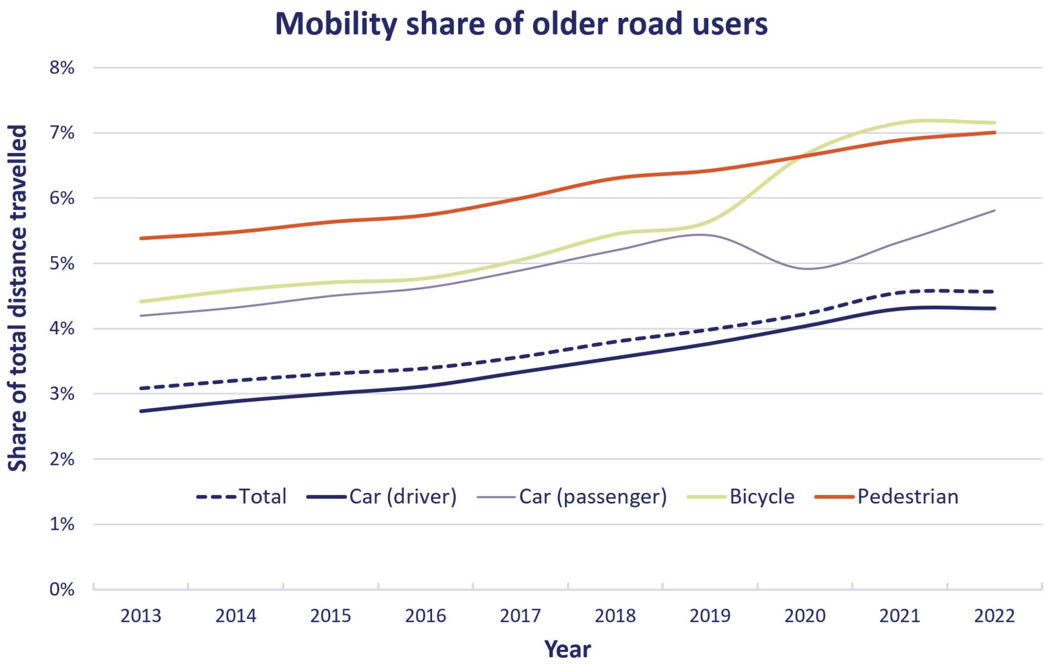

Figure 1. The share of kilometres travelled by the over-75s for all transport modes together, as car drivers and passengers, cyclists and pedestrians (source: CBS trend model [1], post-processing KiM).

In addition to the number of kilometres driven, the share of driving license owners among older generations is also increasing. Even comparing the 2023 figures to 2014, we see an increase: a total of 45% of the over-75s had a driving license in 2014, in 2023 their share was 61%. The growth in driving license ownership is greatest for women aged 75 and older (see *Figure 2*, source: CBS). In other words, the older woman of today is more likely to have a driving license than the older woman of, say, 10 years ago.

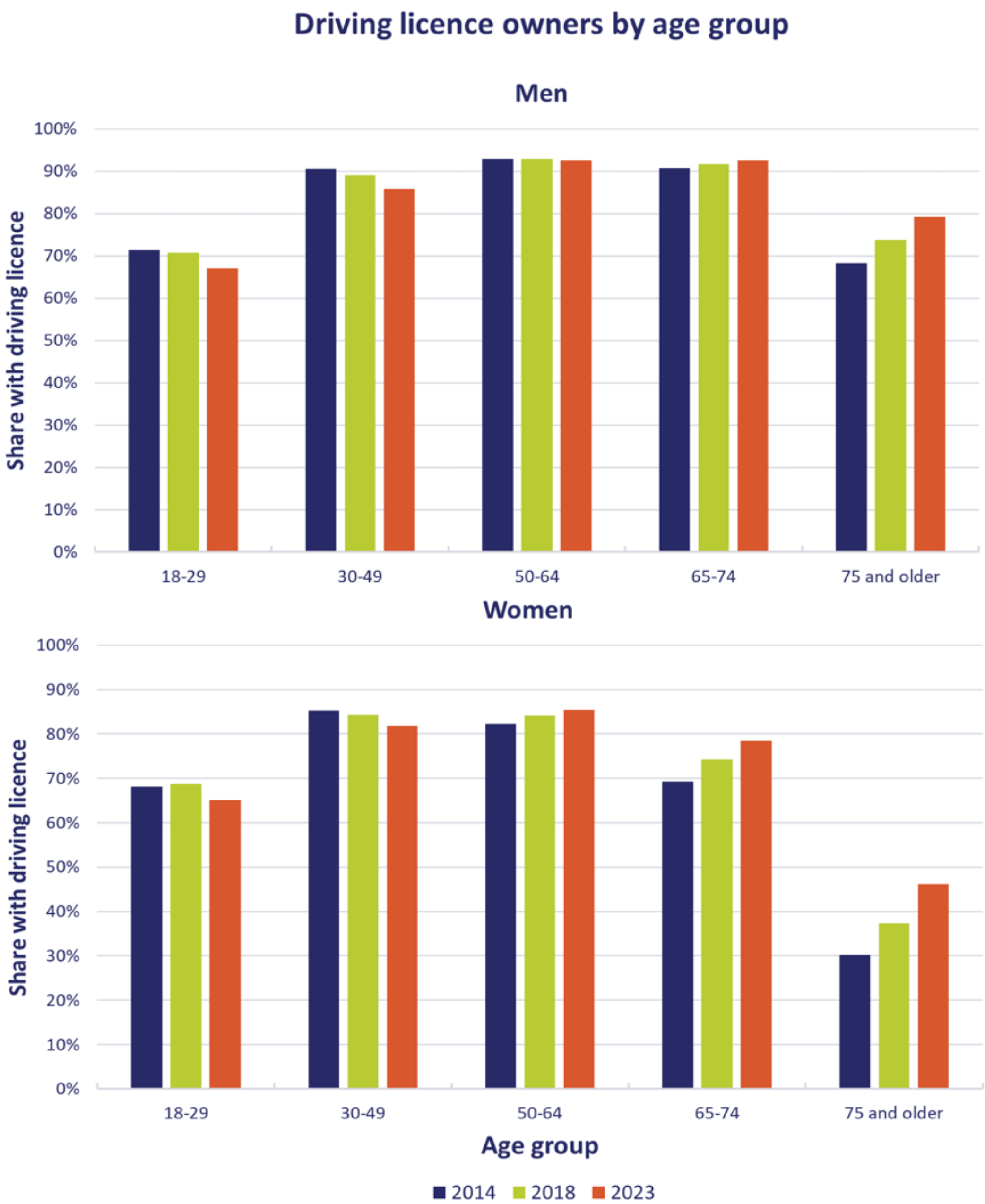

Figure 2. The share of driving license owners by age and gender, for the years 2014, 2018 and 2023 (source: Statistics Netherlands, edited by SWOV).

Relatively many older people suffer from a disorder or physical limitation that affects driving and other forms of traffic participation. As age advances, their share grows (see the question *Which disorders of older people affect road user behaviour?*). For example, 4.9% of the total population has some form of diabetes and 0.6% has some form of dementia, while among the over-65s, over 13% of the population has diabetes and 2.6% has some form of dementia (source: Statistics Netherlands).

2 Do older road users cause crashes more often than other road users?

Crash data do not allow us to extract information about road users who cause crashes. Therefore, we cannot say whether older people cause more crashes than younger road users. However, we do know that of the total number of deaths resulting from crashes involving car drivers, 14% concerned a driver that was 75 or older.

If we look at car driver involvement only, we see that an average of 51 people die as a result of a road crash involving an older driver (75 or older) (BRON, 2014-2023). This is 14% of the total number of road deaths involving car drivers (BRON, 2014-2023). Of the fatalities in crashes involving an older driver, 87% were the older drivers themselves or their passengers.

3 What is the crash rate for older road users by transport mode?

During 2013-2022, for every billion kilometers travelled, an annual average of about 61 older cyclists, 5 older drivers, and 35 older pedestrians died as a result of a road crash - an older road user implying someone aged 70 or older. The fatality rate for older drivers was 2.8 times higher than for younger drivers (under 60; see *Figure 3*). Looking at cyclists and pedestrians, the difference in fatality rate is much greater: for older pedestrians it is 6.6 times higher, for older cyclists 12.4 times higher. Whereas drivers and pedestrians aged 60-69 have a similar fatality rate as younger drivers and pedestrians, for cyclists the fatality rate increases from the age of 60 (*Figure 3*).

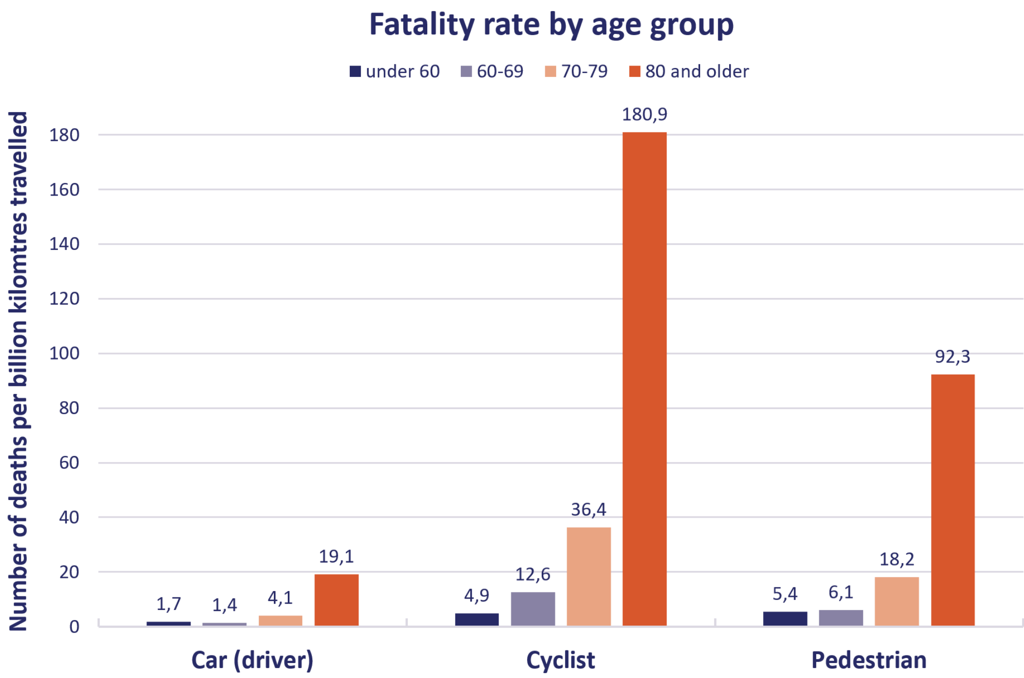

Figure 3. Fatality rate for car drivers, cyclists and pedestrians during 2013-2022, by age group (source: Statistics Netherlands road deaths and Statistics Netherlands/KiM Trend Model).

The underlying data for making a breakdown between conventional bicycles (without pedal assistance) and pedelecs are not available. The latter category is very popular among older cyclists. As yet, there is no evidence that the crash risk for older cyclists is higher when cycling on pedelecs than on conventional bicycles [2]. For older women, however, there are indications that they more often sustain serious injuries when cycling on pedelecs [3]. SWOV fact sheet *Pedelecs and speed pedelecs* discusses the question whether pedelecs are less safe than conventional bicycles.

4 In what crashes are older road users often involved?

Older road users are relatively often involved in crashes when turning left; they then fail to give way to other road users. This applies to both car drivers and cyclists. Specifically older cyclists are often involved in single-vehicle crashes and when getting on and off their bicycles.

Crash data show that 34% of fatal crashes involving an older car driver (70 or older) occurred at an intersection, compared to 15% for younger drivers (under 60) (BRON 2013-2022). An analysis of all fatal crashes in the Netherlands from 2010-2013 and 2016 involving an older car driver confirms this picture [4]. The analysis also shows that in daylight, fatal crashes involving older car drivers are more frequent than those involving younger drivers. Older car drivers are also relatively often involved in crashes at locations where traffic is regulated by signs and road signs (such as triangular priority markings – the so-called shark teeth); they go straight ahead or turn left, neglecting to yield to the right. Older car drivers are less often involved in crashes on motorways than younger drivers [4]. In the international literature, the left turns of older car drivers are also considered to be characteristic of crashes involving older drivers (see, for example, [5]). This is because turning left is a complex manoeuvre that must be performed under time pressure, and the driver has to pay attention to road users coming from different directions. In addition, older car drivers are overrepresented among wrong-way drivers (see SWOV fact sheet *Wrong-way driving*).

Older cyclists are more likely than other age groups to be involved in the following types of crashes [3]:

- crashes involving getting on and off a bicycle;
- crashes in which cyclists collide with an obstacle or go off the road;
- crashes when turning left at intersections.

Balance often plays a role in crashes that occur at low driving speeds, such as when getting on and off a bicycle [3]. A Dutch study of crashes involving cyclists aged 50 and older in which no motorised traffic was involved, showed that in a large share of single-vehicle crashes – crashes without physical contact with another road user – a second party was nevertheless indirectly involved; the older cyclist became unbalanced or veered off course due to the behaviour of another road user [6]. In about half of these single-vehicle crashes, the older cyclist collided with an obstacle, such as a pole or curb [6].

Little research has been done on the crash characteristics of crashes involving older pedestrians. A European review of the literature shows that crashes involving older pedestrians mainly occur during crossing [7]. Older pedestrians are also relatively often injured in falls, but these are not considered road crashes. A pedestrian fall or collision is only a road crash if a moving vehicle is also involved (see SWOV fact sheet *Pedestrians*).

5 What determines the (un)safety of older road users?

The road safety of older road users is largely determined by two factors: physical vulnerability and functional limitations. Both factors result in a relatively high risk of dying in a road crash. In addition, older road users often drive fewer kilometres and the conditions in which they drive are relatively dangerous: they often drive lighter cars and drive on the most dangerous roads.

Physical vulnerability

Older road users are physically frailer than younger adults [8]: for the same collision impact, they sustain more serious injuries. For example, for the same impact force, the fatality rate is approximately three times higher for a 70-year-old motor vehicle occupant than for a 20-year-old [9]. Physical vulnerability has the most serious consequences when the road user is unprotected, such as when walking and cycling. For car drivers, physical vulnerability plays a lesser role, but again it affects injury severity.

Functional limitations

With ageing, perceptual and cognitive functional limitations and disorders occur more frequently, such as reduced visual or auditory abilities, increased reaction times, and difficulties with dividing attention. However, the deterioration of these functions as it occurs with normal ageing seems to have little or no road safety consequences. Indeed, a person can often compensate for a mild single functional limitation by driving more slowly, for example [10]. Only with severe sensory, perceptual and cognitive limitations [11] [12] and in complex often unpredictable traffic situations [13] do links between functional limitations and crash involvement become apparent. In the question *Which disorders of older people affect road user behaviour?* we also elaborate on severe functional limitations that can affect fitness to drive.

The decline of motor functions can also increase crash risk for older road users. Broadly speaking, this motor function decline consists of slower movement, a decrease in muscle strength, a reduction in fine coordination, and a particularly sharp decline in the ability to adapt to sudden changes in posture. The latter aspect is particularly important for cyclists when maintaining balance at lower speeds (such as when getting on and off a bicycle) [14], but also for pedestrians [15] and public transport users when walking and standing in moving buses and trains (see SWOV fact sheet *Public transport and level crossings*).

Other causes

On average, car drivers aged 30-59 drove more than twice as many kilometres per year as drivers aged 70 or older during 2018-2022 (source: Statistics Netherlands). This average low annual number of kilometres of older drivers may partly explain their increased crash rate. Indeed, in general, drivers who drive a lot have a lower crash rate than drivers who drive much less [16]. Risk groups should therefore be determined not only by age, but also by their annual number of kilometres.

In addition, the conditions in which older people drive are relatively dangerous. Older drivers, for example, cover a proportionately large number of kilometres on less safe roads. That is, they avoid highways and therefore mainly drive on the underlying road network, where crash risk is higher [11]. Older people do not drive older cars than younger drivers, but they do drive lighter cars more often [17]. A crash study also shows that older drivers are more likely to be in the lighter car in a collision with another passenger car [4]. Together with their increased physical vulnerability, this increases the fatality rate of older drivers [4].

6 Which disorders of older people may affect their road user behaviour?

Disorders that are relatively common among older people affecting their road user behaviour involve cognitive, sensory or motor skill decline and a greater likelihood of becoming unconscious behind the wheel. The tables below briefly show which aspects of traffic participation can be affected by which disorders. The actual impact on traffic participation and driving performance depends on the severity of the disorder, use of medication and the extent to which compensation is possible.

Table 1. Sensory disorders common in older road users, to what limitations they lead and how they may affect traffic participation [11] [18].

Disorder	Limitations	Impact on traffic participation
Cataract	Sensitivity to glare, reduced contrast sensitivity and visual perception in het dark	Reduced visual perception in the dark
Macular degeneration	Reduced visual acuity	Reduced visual perception in central visual field
Glaucoma	Reduced visual field	Reduced visual perception in peripheral visual field
Hearing impairment	Reduced hearing in one or both ears	Reduced auditory perception and localisation of other traffic[1]

Table 2. Common central nervous system disorders in older road users affecting fitness to drive and the domain of impact [11] [18].

Disorder	limitations	Impact on traffic participation
Cerebral infarction	Depending on location in brain: motor impairment (such as paralysis), reduction of visual field, reduction of attention, lateral neglect and/or apraxia	Depending on impairment: e.g. inability to take in information on one side of the visual field, inability to initiate focusing of attention or a movement
Depression	Reduction in executive functions such as inhibition, decrease in mental flexibility and narrowing of attention	Reduced perception of objects in periphery, reduced processing of negative feedback while driving and suppression (inhibition) of reactions to other traffic
Dementia [19] [20]	Depending on the disease causing the dementia (such as Alzheimer's disease) and the severity of the dementia: for example, reduction in executive functions, reduction in visual recognition, apraxia, spatial disorientation and attention problems, often combined with limited disease insight	Depending on the clinical picture and severity of dementia: reduced speed of perception, abiding by traffic rules, directing attention to important elements in traffic, reacting correctly to other road users, anticipating potentially dangerous situations
Parkinson's disease (PD)	Motor impairments such as tremor at rest, rigidity in movements, disturbed reflexes, and instability. As well as impairments in executive attention and visuospatial functions. In addition, PD is often accompanied by sleep disorders	Difficulty dealing with complex and unexpected traffic situations, high risk of falling asleep at the wheel

1. On a link between hearing impairment and fitness to drive, the literature is not 100% conclusive [18].

Table 3. Other disorders common in older road users affecting their fitness to drive and the domain of impact [11] [18].

Disorder	Limitations	Impact on traffic participation
Chronic insomnia and sleep apnoea	Fatigue and cognitive decline	Reduced reaction time and greater likelihood to fall asleep at the wheel
High blood pressure	Risk of heart failure (only for very high values)	Risk of loss of consciousness and subsequent loss of control of the wheel
Cardiac arrhythmia	Risk of loss of consciousness	Risk of loss of consciousness. Stress while driving can disrupt heart rhythm, causing loss of consciousness
Coronary heart disease	Risk of angina pectoris, a heart attack or cardiac arrest	Risk of loss of consciousness. Stress while driving can trigger a heart attack, causing loss of consciousness
Low blood sugar level due to diabetes	Loss of consciousness, reduction in cognitive abilities such as attention, concentration and reaction time, increased risk of various eye disorders	Risk of loss of consciousness and reduction in cognitive abilities and perception
Osteoarthritis, rheumatism, back pain, etc.	Motor limitations depending on the disorder and body parts affected. Pain when moving	Motor limitations when operating pedals, handlebars and gears. Distraction from traffic due to pain

Older people are more likely than younger people to use medication that affects traffic participation. Examples include benzodiazepines, painkillers and antihistamines [11] [21]. In addition, older people often suffer from multiple disorders, causing them to use multiple medicines at the same time [18]. Medicines can interact and thus reduce fitness to drive. The impact of medication is also often greater for older drivers than for younger ones because medication takes longer to leave an older person's body and older people often suffer more side effects [11] [21]. Since medication is prescribed for a particular disorder, the impact of the disorder and the impact of the medication on fitness to drive are linked [11]. For more information on the impact of medication on fitness to drive, see SWOV fact sheet *Drugs and medicines*.

7 How dangerous are pedelecs for older road users?

There are no reliable data on crashes and kilometres cycled to compare the risk for older road users on pedelecs with that for older road users on ‘regular’ bicycles. For general information on the road safety of pedelecs, see SWOV fact sheet *Pedelecs and speed pedelecs*.

8 Should older road users continue to participate in traffic?

For different reasons, including mental welfare, it is very important for older people to be able to move around independently for as long as possible, at least if safety is maintained. It is therefore important to distinguish between older people with disorders that adversely affect fitness to drive and those without such disorders. Older people who can safely participate in traffic should be supported as much as possible by measures that make the traffic system suitable for them as well (see the question *What other measures may improve the safety of older road users?*).

Although the likelihood of functional limitations increases with age, by no means every older person suffers from such limitations. Moreover, functional limitations need not automatically lead to unsafe road user behaviour. An understanding of one's own limitations and thus one's ability to compensate for any limitations can prevent safety problems. There are several reasons why older road users are well able to make use of compensation options. First, they often have more freedom to choose when to travel (travelling when it is less crowded or when it is light and dry outside [22]). Second, on average older road users have a lot of driving experience and presumably more traffic insight and thus more ability to anticipate potential problem situations. A third factor could be that the need for excitement and thrills decreases with age. Consistent with this is that older road users are on average less likely to exhibit risky behaviour in traffic than younger road users [23].

Regardless of the driver's age, an illness or disorder can compromise driving safety. The Regulation on fitness to drive, requirements 2000 describes the requirements for drivers.

When older people stop driving, they often experience negative consequences. Multiple international researchers (particularly from the United States) associate driving cessation with an increased risk of depression, cognitive and physical decline, and deterioration of the social network [24], particularly for older people living in rural areas [25]. Although an early conversation about a future without a car can be stressful [26], talking to an older person in a timely manner about life without a license can ensure that driving cessation need not be a major problem [27].

There is no formal rule for determining whether a person can still cycle safely. Cycling is relatively dangerous for older road users (aged 70 or over): per distance travelled, they are 12.4 times more likely to die from a cycling crash than younger cyclists (under 60). See *What is the crash rate for older road users by transport mode?* However, in addition to providing mobility - and thus being able to maintain social contacts - cycling also provides physical exercise, which is good for the overall health of older people [28].

9 How useful is the age-related medical examination?

According to a review of the literature, age-based assessment of fitness to drive has no impact on road safety. Some studies even speak of a small negative effect on the safety and health of older people due to the choice of alternative and less safe modes of transportation and/or reduced mobility [29] [30].

In the Netherlands, drivers aged 75 and over must undergo a medical examination before they can renew their driver's license. During the examination, a doctor assesses the driver's visual acuity, motor skills, blood pressure, blood sugar levels, and cognitive or mental state. Abolishing such age-based assessments in the Netherlands is expected to have little to no impact on road safety [31]. International research also shows that age-based assessments have little effect on road safety [22][29]. Martensen [22] points, among other things, to the fact that many older people with functional limitations compensate for these shortcomings (see the question *Should older people continue to participate in traffic?*). Helman and colleagues [29] also mention that, for older people, alternative modes of transport, such as cycling or walking, are much less safe modes of transport [29].

A study of options for revising the current Dutch system of assessing medical fitness to drive concludes that abolishing the age-based assessment could make this system more efficient without significant effects on road safety [32]. A legal obligation - instead of the current moral obligation – to inform CBR about an illness or disorder affecting fitness to drive could potentially diminish any negative effects of abolishing age-based assessment.

10 How to improve the medical examination?

For the current medical examination, age is an important factor. However, it would be preferable, and in line with the risk-based approach to road safety, to consider only functional limitations and disorders that affect fitness to drive. Davidse and colleagues [32] therefore recommend abolishing the current age-based assessment. A legal obligation to report changes in medical condition and involving one's own (family) physician could make the medical examination more efficient [32].

According to Karthaus and Falkenstein [13], the most important functions for safe traffic participation as a driver lie in the visual and cognitive domains (such as divided attention). Functional limitations may be the result of normal ageing, but also a result of a condition such as Alzheimer's disease. While decline in functions and disorders that affect fitness to drive are more common in older people, the fact that a person is older should not be the focus of the medical assessment, according to these researchers. Several researchers conclude that assessing fitness to drive should be based on limitations of functions that are important for safe traffic participation: a risk-based approach [13] [29] [32]. However, there is currently no test or test battery that can validly measure all facets of a driver's medical fitness to drive in a clinical setting in a short period of time [33].

11 How effective are training programs aimed at the older road user?

International research shows that educational programs focusing on knowledge enhancement or training of skills in traffic situations (such as accompanied driving on the road), do not have a positive effect on the road safety of older car drivers. However, training programs for older drivers focusing on specific skills needed to drive safely (such as training the distribution of visual attention), may improve road safety [34]. In the Netherlands, there are also training programs for older cyclists. It is not known to what extent these contribute to road safety.

In the Netherlands, there are several courses to refresh the knowledge and skills of older car drivers, so that they make safe choices in traffic (for example, the VVN refresher course for drivers). The biggest challenge here is to also reach people who have serious doubts about their own driving skills and those who overestimate their driving skills. The latter group is quite large, as it is among younger road users [35]. Both groups are less likely to participate in these courses, on the one hand for fear of losing their driving license, and on the other hand from the belief that they do not need such a course. Online tools to assess awareness of one's own skills and driving ability may help give people a more realistic picture of their own (driving) skills [36]. Training specific skills, such as training for strength, coordination and flexibility, visual perception, visual attention distribution (Useful Field Of View), or training that covers a combination of these skills, may also increase the road safety of older drivers [34]. In addition, refresher courses are organised in the Netherlands to inform older drivers about the functional limitations associated with ageing, how to deal with them, and what resources are available to continue driving a car safely for as long as possible despite such limitations [37]. Such meetings are best accompanied by a practice drive [37].

Online refresher or practical training courses are also available for older cyclists, pedestrians and mobility scooter riders. These have been made available by VVN and the Fietsersbond, among others. 'CycleOn' is a program, initiated by the Ministry of Infrastructure and Water Management, aimed at enabling older road users to cycle safely for as long as possible. An evaluation of 'CycleOn' showed that participants and implementers were positive about the program, especially the immediately applicable practical tips were appreciated [38]. Whether the program also promotes safety is not known.

12 What infrastructure measures may improve road safety for older road users?

Infrastructural measures that are beneficial to older road users are those that break down complex tasks into smaller, more manageable subtasks, for example by enabling crossing in stages. Furthermore, it is important to make the relevant elements in traffic more visible, to limit the amount of information that must be processed simultaneously and to allow people enough time to assess the situation somewhere safe [4] [39] [40].

Tables 4, 5 and 6 show possible infrastructure measures for drivers, cyclists and pedestrians, respectively.

The measures discussed were selected for their ability to increase the safety of older road users. However, the measures will also contribute to the safety of other road users. After all, measures that, for example, give road users more time to assess a traffic situation and allow step-by-step performance of traffic tasks will ease the traffic task for all road users. In general, the decreasing complexity of the traffic task will result in fewer human errors and thus fewer crashes. The fact that infrastructural modifications benefiting older road users also have (albeit minor) positive effects on the safety of other road users is an additional argument in favour of such measures.

Infrastructure measures for older car drivers

Table 4. Possible infrastructure measures to diminish impediments experienced by older car drivers [39] [40].

Situation	Impediment	Possible solution
Approaching intersection	More time needed for decisions and task execution (e.g. lane change)	Early information on approaching situation by arrow markings and lane signs
Left turn at intersection without traffic lights	View of oncoming traffic is obstructed	Implement positive offset[2] so that facing vehicles do not obstruct each other's view
	Having to process too much information at the same time	Roundabouts, provided they are uniformly designed and lane configuration information is present
Turning left at a signalised intersection	When interacting with other road users, more time needed for decisions	Ensuring conflict-free control of traffic lights
Approaching intersection in the dark	Reduced visibility in the dark, reduced contrast sensitivity and sensitivity to glare	Improve lighting at intersections Apply background shields at traffic lights
Keeping course on road sections	Reduced contrast sensitivity	Making lines more contrasting and maintaining contrast
Reading street name signs	Reduced visual perception	Provide larger letters and greater contrast between letters and background for street signs

2. An illustration of a positive offset is shown in [39].

Infrastructure measures for older cyclists

Table 5. Possible infrastructure measures for perceived impediments of older cyclists.

Situation	Impediment	Possible solution
Interaction with motor vehicles	More time and space needed for manoeuvring	Construction of a bicycle track [3]
Turning left	Having to process too much information at the same time	Construct roundabout (allows for less complex manoeuvring when turning left), and use bike box [3].
Crossing intersection	Having to process too much information at the same time	Create safe waiting areas where cyclists have an unobstructed view of the intersection [41].
Cycling on bicycle tracks	Visual impairments, delayed information processing, deteriorated balance	No objects on bicycle tracks/lanes (such as bollards/poles), improved visual guidance of the bicycle track/lane through application of edge markings, a flat, skid-resistant, undamaged and clean surface, forgiving edges and roadsides, and proper sequencing and consistency of elements along bicycle tracks/lanes (such as no tight turn after a descent) [3].

Infrastructure measures for older pedestrians

Table 6. Possible infrastructure measures for perceived impediments of older pedestrians [39] [40].

Situation	Impediment	Possible solution
Crossing roads	Having to process too much information at the same time, slower walking speed, reduced peripheral vision, reduced flexibility neck	Add traffic lights at intersections, reduce speed of other traffic, allow crossing in stages
Crossing at pedestrian crossing	Having to process too much information at the same time, slower walking speed, reduced peripheral vision, reduced flexibility neck	Realising a pedestrian island, allowing pedestrians to pay attention to only one direction of travel when crossing, and reducing the distance to be travelled
Crossing at traffic lights	Slower walking speed and slower to start	Longer green phase for pedestrians

13 What other measures may improve road safety for older road users?

To make traffic participation safer for older road users, we must ensure that they have sufficient opportunities and time to perceive and process relevant information and that they are protected to reduce the severity of possible injuries. In addition to the infrastructure measures mentioned in the question *What infrastructure measures may improve road safety for older road users*, this can be done by using vehicle technology, ensuring sufficient protective measures and offering choices for safe forms of mobility.

Use of vehicle technology

Vehicle technology may support older drivers in various aspects of the driving task, tailored to the capabilities of the individual driver. For this purpose, technical adaptations such as power steering, automatic transmission and adjustments to the force with which the brake and/or accelerator pedal must be pressed have long existed (see www.autoaanpassers.nl). These are systems that primarily provide support for functional limitations in motor skills, such as a decrease in muscle strength. In addition, there are an increasing number of Advanced Driver Assistance Systems (ADAS) that can support older drivers. Systems to consider are listed in *Table 7*.

Table 7. Possible driver assistance systems that may support older drivers.

System	Support with	Useful for older road users?
Forward collision warning/mitigation system	Warning when approaching a vehicle	Yes, it reduces older people's reaction time when approaching a vehicle [42]
Lane Departure warning/mitigation	Warning about unintended lane changes.	Yes, can help older drivers stay in their own lanes [42]
Blind spot detection system	Warning about road users in the blind spot	Yes, is also important for older road users because it is more difficult for them to look back due to more rigid muscles in the neck and trunk [42].
Support system at intersections/left turn assist	Prediction of potential collision between two cars at an intersection	Possibly, could potentially assist older drivers in turning left, but the effect of such a system on their driving behaviour is not clear as shown, for example, in the study by Becic and colleagues [43]
Parking Assist	Assist with or automatic parking	Yes, ensures that the older driver does not overlook other objects or road users while parking [42].

Older car drivers, unlike younger drivers, are sensitive to the timing and complexity of navigation system instructions [44], have more difficulty learning new skills [45] and may rely too much on vehicle systems [42] [43].

Fully automated vehicles can be a godsend for older drivers (with functional limitations). Technology is developing rapidly, but at present the level of automation is limited to SAE Level 3,[3] where the driver must be alert to 'take over requests' from the system. Older drivers are known to react more slowly to requests to take over the wheel, with this group of drivers varying greatly in the quality of takeover. This, according to an international review of the literature, is due to the heterogeneity in this group in terms of functional limitations [46].

Examples of bicycle modifications that benefit older cyclists include anti-slip pedals, a rearview mirror on the handlebars and a more powerful headlight to see obstacles or suchlike well ahead of time [3]. There are several bicycles and systems under development that aim to reduce the risk of crashes at low speeds. Such as the so-called "SOFIETS" with low saddle height and an active handlebar support that helps to keep the bicycle stable even at lower speeds [47] or the tricycle that provides stability at standstill [3].

Means of protection

If road crashes do occur despite the above measures, the consequences can be reduced by using means of protection such as a bicycle helmet, bicycle airbag or protective devices in cars.

Airbags and seat belts are well-known protection devices for cars. These are tested against Euro NCAP standards. This is done using test dummies, which are mostly scaled to the stature of the average man in the vehicle. Although the test dummies are becoming more varied - a female test dummy is increasingly being used [48] – the dummies cannot yet simulate the frailty of an older person. The body of an older person is more vulnerable at lower speeds than the body of a younger person. Collision tests should, according to the researchers of the European project SENIORS [49], be expanded within Euro NCAP to include lower-speed (30 km/h) tests with dummies based on the characteristics of older bodies.

Examples of means of protection for cyclists are bicycle helmets and various types of airbags (the helmet airbag and the crash airbag for the cyclists themselves, and the bicycle airbag under the windshield of a car to protect cyclists in case of a collision with the car). If all over-70s in the Netherlands were to wear bicycle helmets, this would lead to an annual reduction of 45 to 50 road deaths (for more information, see SWOV fact sheet *Bicycle helmets*). Simulation studies show that bicycle airbags under the car windshield may reduce the impact on the head of cyclists who land on the windshield by approximately 75% [50].

Choice of transport mode

If driving a car is no longer justifiable from a safety point of view, older road users should be supported in switching from car mobility to other modes of transport, each target group choosing which is most suitable to them. VVN has a website (Blijf veilig onderweg) where older road users can find information on various forms of mobility (mobility scooter, microcar, pedelec, bicycle or public transport) and courses available for these transport modes. The option of public transport is very important to people who are no longer able to drive a vehicle themselves. Since older people are living independently for longer and longer, and public transport is not always nearby, it is important - especially in rural areas - that demand-dependent transport is also available.

3. An 'SAE level of automated driving' is a classification to distinguish between different levels of self-driving vehicles. At SAE level 3, the vehicle can drive autonomously under specific conditions. If at any point the specific conditions are no longer met, the driver has to take over the driving task. See SWOV fact sheet *Self-driving vehicles* Vehicles for more information on SAE levels.

Publications and sources

Below you will find the list of references that are used in this fact sheet; all sources can be consulted or retrieved. Via Publications you can find more literature on the subject of road safety.

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