ROAD SAFETY REPORT 2021

Old-Age Mobility

DEKRA

Accident Statistics
Senior citizens at high risk when using roads as pedestrians and cyclists

The Human Factor
Various measures available to compensate for performance deficits in later years of life

Technology
Driver assistance systems play an important role in improving road safety

Voluntary and Confidential

Be Mobile, Stay Mobile

DEKRA Health Check for senior citizens

Take advantage of the DEKRA Health Check specially developed for senior citizens and have your fitness to drive checked by our trained experts on a voluntary basis. We are also glad to examine and advise you in the event of limited mobility due to illness or accident. Stay mobile safely.

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On the safe side.

Life-Long Safe Mobility Must Not Be Viewed as a Utopian Dream

The figures give pause for thought: according to the latest statistics published by the European Commission, almost 30 percent of all traffic fatalities in the European Union (EU) are aged 65 or over. Senior citizens also account for almost half of all the pedestrians and cyclists killed in road accidents. This makes unprotected road users a particularly significant group among senior citizens. A key factor in this is the higher level of vulnerability that comes with older age: given a similar type of accident for each group, the risk of suffering more severe or fatal injuries is greater for senior citizens than for younger people.

And while the details of the situation differ for each EU member state, it is a universal truth that the risk of being involved in a road accident is higher for older road users – both within the EU and in other parts of the world. This means we need to act fast, particularly in light of the fact that, due to the demographic shift, the proportion of all road users who class as senior citizens will continue to rise.

There are plenty of places to start, as the many examples in this report will show. Many relate to the human factor , but there are some in the fields of infrastructure and vehicle technology, as well. With this in mind, one of the areas we are looking into is how assistance, information and comfort systems in vehicles can improve road safety for the 65+ age group. The answer is clear: such systems offer great potential. Within certain limitations, high-tech equipment in vehicles can help to compensate for age-related performance deficits and driver errors, thus providing a sense of increased safety.

In light of this, the fact that the General Safety Regulation (adopted by the European Commission in March 2019) will make a variety of safety-related driver assistance systems a legal requirement for new vehicles in Europe over a number of phases, starting in 2022, is a welcome development. However, it is important to bear in mind that it will take many years for these changes to truly penetrate the market, and many of the vehicles on our roads will still have few or no assistance systems.

Jann Fehlauer, Managing Director, DEKRA Automobil GmbH

It is also important to consider whether senior citizens even open to the idea of such systems. In order to gage the mood, DEKRA commissioned the market research and opinion polling company forsa to conduct a representative survey of around 2,000 randomly selected German motorists from all age groups. Among the many insightful results of this survey, two stand out: approximately three quarters of men and women aged 65 and over described the fact that there are assistance systems to help drivers as either "good" or "very good," and the majority of this age group also drove vehicles equipped with individual assistance systems.

Whatever action is taken to reduce the number of senior citizens who suffer severe or fatal injuries in road accidents, it is crucial to ensure that we focus primarily on complex traffic situations. It is also important that everyone involved contributes to the solution of this problem. DEKRA has already been working hard on tackling this issue for many years, in a variety of ways. We consider the DEKRA Road Safety Report – which we have been publishing annually since 2008 – to be an important contribution to making mobility on the road even safer. With this latest report, we at DEKRA are aiming once again to get people thinking and provide advice for politicians, traffic and infrastructure experts, manufacturers, scientific institutions, associations, and all road users.

Contents

Wherever the DEKRA Road Safety Report uses terms such as "road user," "pedestrian," "cyclist," etc., these terms should always be assumed to apply to all genders unless explicitly stated otherwise.

Unless explicitly stated otherwise, the terms "bicycle" and "cyclist" always include pedelecs and pedelec riders (up to 25 km/h).

The web portal: www.dekra-roadsafety.com

Since 2008, DEKRA has been publishing the annual Road Safety Report in printed form in several languages. The www.dekra-roadsafety.com web portal went live with the publication of the DEKRA Road Safety Report for 2016. Here you will find all the reports we have published since 2008, as well as additional content, such as moving pictures and interactive graphics. The portal also covers a range of other topics and DEKRA activities concerning road safety. If you have a tablet or smartphone, you can link directly from the printed version to the web portal by scanning the QR codes that can be found throughout the report. Scan the code using an ordinary QR code reader and you will be taken directly to the corresponding content.

LEGAL NOTICE
DEKRA Road Safety Report 2021 – Mobility in Old Age

Publisher:
DEKRA Automobil GmbH
Handwerkstrasse 15
70565 Stuttgart
Germany
Tel. +49 711 7861 0
Fax +49 711 7861 2240
www.dekra.com
May 2021

Responsible for the Publisher: Stephan Heigl

Concept/ Coordination/ Editing:
Wolfgang Sigloch

Editing:
Matthias Gaul

Layout:
Florence Frieser

Project Management:
Annika Zuske

Realization:
EuroTransportMedia Verlags- und Veranstaltungs-GmbH
Corporate Publishing
Handwerkstrasse 15
70565 Stuttgart
Germany
www.etm.de

Business Unit Director:
Andreas Techel

Managing Director: Oliver Trost

Picture credits: Adobe Stock – stock.adobe.com: Thomas Aumann 60, Andrey Bandurenko 6, Alessandro Biascioli 1/68, Daxiao Productions 41, jamstockfoto 39, Peter Maszlen 43, methaphum 58, tawatchai1990 1/68, v_sot 21; Antonio Avenoso 11; Marit van den Berg Photography 55; Valentin Brandes: 9; cifal Madrid 61; DEKRA 62; Cyril Entzmann/Divergence 18; FIA 4; Stephan Floss Fotografie 16; Ford 54; Fabio Frustaci/ EIDON 52; Getty Images/iStock.com: ablokhin 12, batuhan toker 34, Bobex-73 3, Anna Bryukhanova 10, dusanpetkovic 30, Silvia Jansen 64, Jay Lazarin 44, Rich Legg 15, metamorworks 48, Nastasic 8, RYosha 53, SolStock 47, Toa55 50, vm 5; Hardy Holte 42; Imago Images: Design Pics 36, JOKER 45, Jonas Walzberg 59; Instytut Transportu Samochodowego 44; Thomas Kueppers 3, 19 (2); Paulo Maria/ACP 46; Juan Carlos Ayago Merchan 33; Herby Sachs 59; Max Töpper 35; VTNZ 22.

Safe Roads Are the Key to a Livable Environment

The start of 2021 is met with the beginning of the second decade of action for road safety, calling for a recommitment from all stakeholders to reduce road traffic deaths and injuries by 50% and provide access to safe, affordable, sustainable transport systems for all by 2030. Achieving this vision requires that safety is considered a value so fundamental and non-negotiable that it becomes a hallmark of the road transport system.

Urban populations are increasing, communities are ageing, especially in the most developed countries, and people are being encouraged to walk and cycle, as concerns over congestion and air pollution move up the political agenda. New forms of mobility are also emerging increasingly leading to more user types sharing the roads. Safer streets are crucial for making spaces more livable. If streets are dangerous, all the efforts in promoting sustainable means of movement are undermined. This means that appropriate infrastructure must be available for the vulnerable road users, such as children, those with disabilities and the elderly.

2020 was an atypical year, but it has changed the way we live, work, commute and is accelerating some of the mobility trends that were already visible: if this pandemic has proved anything, it is that change is possible. Cultural and behavioural patterns that seemed so difficult, almost impossible to convert have been adjusted and dissolved; the policy response was robust.

It also gives way to a new approach to safe mobility; the opportunity to examine the core pillars we have long used and remake the foundations on which they stand.

The concept of "Old Age Mobility" sheds light on a user group which is often overlooked. Addressing the special needs of the elderly gives way to ensuring that the value of safety is felt by and is benefitting even the most marginalized. As we grow older, how do we preserve our mobility in a safe way, even when our fitness to drive, cycle or walk is decreasing?

I thank DEKRA for producing this report and highlighting the fact that the "value" of safe mobility increases, when it also reflects inclusivity.

Jean Todt
United Nations Secretary-General's Special Envoy for Road Safety
FIA President

Retaining Mobility for as Long as Possible

All around the world, people are getting older. According to forecasts, one in four people in Europe and North America could be aged 65 or over by 2050, for example. At the same time, senior citizens are becoming increasingly mobile, and many are continuing to use the roads well into their later years, in a variety of ways. However, such mobility comes with a much higher risk for this demographic than for younger age groups. In order to minimize this risk while still enabling older people to remain mobile and active members of our society, there are a number of areas where action needs to be taken.

The facts and figures in the UN's "World Population Prospects 2019" show that the global population is continuing to grow, and could rise from 7.7 billion in 2019 to as many as 9.7 billion by 2050 and 10.9 billion in 2100. More than that, however, the publication also provides irrefutable evidence that our society is aging. While only one in eleven people were over the age of 65 in 2019, the forecast estimates that this will rise to one in six by 2050 (Figure 1). The regions in which the percentage of the population aged 65+ is expected to double between 2019 and 2050 include North Africa and West Asia, Central and South Asia, East and Southeast Asia, as well as Latin America and the Caribbean. In Europe and North America, as many as one in four residents could be aged 65 or over by 2050. At a global level, the number of people aged 80 or over is expected to triple – from 143 million in 2019 to 426 million in 2050. The average life expectancy, which rose from 64.2 to 72.6 years between 1990 and 2019, is expected to reach around 77 by 2050.

65+ AGE GROUP HAS LARGEST PERCENTAGE GROWTH

GREATER RISK OF INJURY FOR SENIOR CITIZENS

The aging of the population will also lead to an increase in older road users, as stated in studies such as "ElderSafe – Risks and countermeasures for road traffic of the elderly in Europe," which was published by the European Commission in December 2015. However, this also means that the number of senior citizens who run the risk of becoming involved in or causing road accidents due to factors such as functional limitations and increased fragility will increase as well. The dynamic nature of this development was made clear in an estimate made by the European Transport Safety Council (ETSC) in 2008, which examined the impact that an increase in the percentage of older people in the population would

have on the number of traffic fatalities between the time of publication and 2050. Using figures from 2006, "Road Safety PIN Flash 9" came to the conclusion that, by 2050, one in three traffic fatalities in the European Union could be aged 65 or older. The figures from 2018 – a year in which senior citizens accounted for around 29 percent of all traffic fatalities in the EU – showed that this threshold had almost been reached already, more than 30 years earlier than predicted back in 2008.

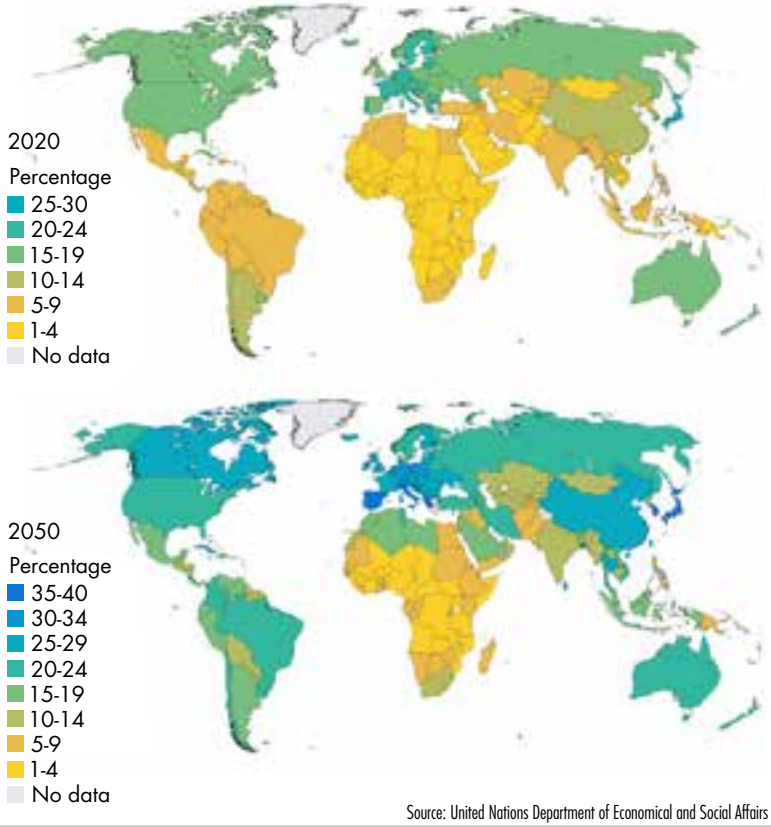
The fact is that older people are at a disproportionate risk of getting injured when compared to younger road users. This is due first and foremost to the natural aging process and the resulting deterioration in bone and neuromuscular strength. This places older people at a much greater risk of suffering severe or even fatal injuries than a young person would be if involved in exactly the same accident. An article on the safety of older road users published in the UK in 2000 illustrated this in a number of ways, including a mortality index for different age groups. The article set the value for the 20 to 50 age group at 1.0, which increased to 1.75 for 60-year-olds, 2.6 for 70-year-olds, and reached between 5 and 6 for persons aged 80 and over.

Another interesting resource on this topic are the figures collected for the EU Injury Database between 2005 and 2008 (Figure 2), which were reproduced without modification in the European Commission's report "Traffic Safety Basic Facts 2018: The Elderly." These indicate that 43 percent of all older victims of road accidents were taken to hospital – compared with just 32 percent of road accident victims overall. Whether or not a hospital stay was required also differed depending on what type of road user the patient in question was. The largest difference was in the number of injured car occupants: almost 50 percent of older people were taken to hospital after the car they were traveling in was involved in a road accident, compared to just under 25 percent of all road users in such situations. 42 percent of all the older people taken to hospital with injuries following a road accident had suffered broken bones – compared with just 27 percent of road accident victims overall.

In order to determine which parts of the body were most commonly injured among senior citizens involved in road accidents, DEKRA's accident researchers analyzed several years' worth of data from the German In-Depth Accident Study Database (GIDAS). The results showed that the percentage of pedestrians who suffered injuries to their lower extremities and the head was higher than that for car drivers. This is because pedestrians are generally hit in their lower extremities first, before their head subsequently collides with either the vehicle itself or the ground. Among car drivers, on the other hand, the most common part of the body to be injured apart from the extremities and the head was the thorax. When grading these injuries using the international Abbreviated Injury Scale

1

Percentage of Population Aged 65+

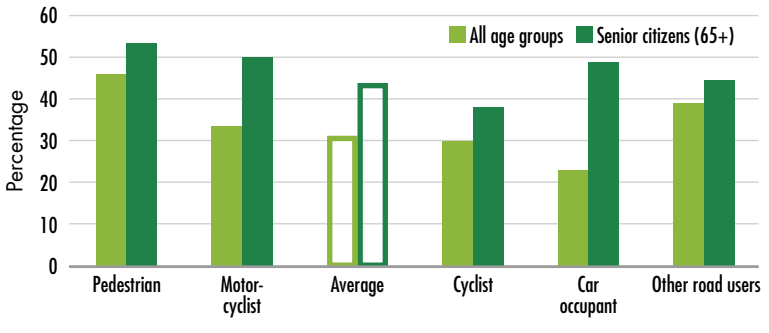


Source: United Nations Department of Economical and Social Affairs

2

Differences in Severity of Injuries

Persons taken to hospital with injuries following a traffic accident, by age group and road user type



Source: EU Injury Database

(AIS), which ranges from AIS 0 for "Not injured" to AIS 6 for "Maximum" (i.e. untreatable), it is notable that senior citizen pedestrians incur a greater percentage of severe injuries than 18 to 64-year-old pedestrians. This applies particularly to head and lower-extremity injures for AIS 3 (Serious), particularly to thorax and abdomen injuries for AIS 4 (Severe), and to neck and thorax injuries for AIS 5 (Critical). There are also a number of figures that stand out with regard to older people who are injured while driving, such as those for AIS 3 head and thorax injuries.

MEASURES MUST NOT BE PUT OFF INDEFINITELY

PROACTIVE STRATEGY REQUIRED

In order to ensure that senior citizens can use the roads safely well into their later years, the European Commission's aforementioned "ElderSafe" report lays out a comprehensive plan of action. This plan recommends that the following risk factors be turned into particular areas of focus: frailty, illnesses and functional limitations, medication intake, inner-city roads, and senior citizens as pedestrians. According to the report, a proactive strategy is required at national, regional and local levels, and must cover a wide range of measures relating to issues such as infrastructure, driver safety training and practical evaluations, and vehicle technology.

When it comes to technology, there is no doubt that driver assistance systems offer great potential for either completely preventing accidents, such as those most commonly caused by driver errors, or at the very least minimizing their consequences. And as a survey commissioned by DEKRA has shown, senior citizens in particular are very open-mined when it comes to the use of electronic assistants. More details on this can be found in the Technology chapter of this report. Of course, it is important to note that it will take a long time for vehicles with assistance systems to achieve a high level of market penetration.

To help illustrate this point, if a new assistance system were to be installed in all newly registered cars in the EU with immediate effect, it would

Age-related cognitive changes have a number of impacts, including a deterioration in the length time required to process information, which in turn leads to slower reaction times

Andreas Scheuer MdB
German Federal Minister of Transport and Digital Infrastructure

Safe Mobility: It's Everyone's Responsibility – We All Need to Do Our Part

Whether taking the car to visit one's grandchildren, using a pedelec to get out into the countryside or going shopping with the aid of a rollator, being independently mobile in older age improves one's quality of life. However, older road users are at particular risk when out and about. The risk of them suffering severe or even fatal injuries is much higher than for younger people. For example, over half of the cyclists and pedestrians who died in traffic accidents in 2020 were aged 65 or over. One factor in this is the fact that our cognitive and motor skills change as we grow older. On top of that, senior citizens are also more susceptible to injury in general.

We want older people to be able to use our roads safely and healthily for as long as possible. This is why we have made them an important target demographic for our extensive road safety work. Preventive measures keep them informed, educated, and aware of the risks they face. We are assisted in the implementation of these measures by long-standing partners such as the German Road Safety Council (DVR) and the German Road Safety Volunteer Organization (DVW).

One example of the types of programs we use is the DVW's "Stay mobile – but stay safe!" campaign. On road safety days, our aim is not just to provide advice, but also a tangible experience of the issues at hand. Am I assessing hazard situations correctly, and do I react fast enough in emergencies? How do overtiredness or the effects of medication impact my road use? Participants can test themselves in these areas using simulations and reaction exercises, thus increasing their awareness of the situation. Teaching older road users to assess their own performance levels more accurately is also the aim of the DVR's "Safe mobility" seminars. In these courses, senior citizens tackle traffic situations that are typically dangerous for older road users, and also look at new regulations and the physical and cognitive requirements for safe mobility. Experts are also on hand to provide practical tips on how to stay safe when out and about. The "Safe mobility" seminars are part of the "Safe mobility in old age" campaign, which is supported by us. This campaign aims to make motorists aged 65 and over aware of the voluntary practice programs, training options and health check-ups available to them. In order to encourage other road users to look out more for older people, we have also launched the "I feel young – I just need a little longer" campaign, which uses humorous messages to increase consideration and awareness of the elderly.

With these measures and many more besides, we hope to further reduce the number of senior citizens who are injured and killed on the roads. This will also take us one step closer towards "Vision Zero" – our aim to reduce the number of traffic fatalities to zero in the medium term. In order to achieve this, we need others to help us out and take responsibility. Our entire society needs to pull together and work as a team. That is why we have adopted a comprehensive approach in keeping with our motto: "safe mobility: we all need to do our part." This means that everyone who has an influence on road safety – from the federal level to state and individual municipalities – needs to join forces and commit to implementing new measures. With this in mind, we got everyone together to forge a "Pact for road safety." This is the strategic framework that lays down our common goals and areas requiring action. States and leading municipal associations have committed to the implementation of this strategy. The pact is also open to any other supporters who wish to join our cause.

There's still plenty to do in order to improve road safety. But together, we can make it. And DEKRA will be a reliable partner at every stage of the journey – as this road safety report shows, the company plays a valuable role in improving safety on our roads. Thank you, DEKRA!

take more than eleven years until half of the cars on the road were fitted with this system. However, since there are also many years of evaluation and legislation processes between a system becoming ready for launch on the market and its installation becoming a legal requirement, it is likely to take around 20 years before half of all car drivers have any such system in their vehicles.

This means that, if we want to improve road safety as quickly as possible, especially for senior citizens, in order to help them retain their mobility for as long as possible, measures pertaining to physical infrastructure and the vehicles themselves can only be a secondary priority. Our main focus – as demonstrated in the following chapters of this report – must be on the human factor. At the same time, however, measures that will have a long-term impact must not be put off indefinitely.

The Facts at a Glance

- **In Europe and North America, one in four residents are expected to be aged 65 or over by 2050.**
- **Current EU averages show that one in three traffic fatalities are already aged 65 or over.**
- **The natural human aging process means that senior citizens are at a much greater risk of suffering severe injuries than younger people would be if involved in the exact same accident.**
- **When grading injuries using the international Abbreviated Injury Scale (AIS), it is notable that senior citizens incur a greater percentage of severe injuries than 18 to 64-year-olds when using the roads as pedestrians or car drivers.**
- **In order to improve road safety for senior citizens, a proactive strategy that takes all types of mobility into account is required at national, regional and local levels.**
- **It is a social obligation to ensure safe, individual mobility for both senior citizens and the general population alike. In order to achieve this, we need to increase our efforts with regard to infrastructure, technology, and particularly people themselves.**

Severely Increased Risk for Pedestrians and Cyclists

Road accident statistics are affected by all manner of different factors. This means that, in order to come up with measures to increase road safety, a highly nuanced approach that accounts for these factors and how they are interconnected is required. This chapter focuses on the analysis of accident statistics for older people in different regions around the world. The aim of this is to identify age-related risks so that the subsequent chapters can be used to develop approaches toward maintaining safe mobility for older people.

The available infrastructure, population composition, financial means, attitudes towards both safety in general and road safety in particular – when it comes to road traffic, there are sometimes significant differences between different countries, and even within individual countries and regions. For example, rural road traffic is considerably different to that in urban areas. When comparing towns and cities, the factors that play a key role include the availability of local public transport, the bicycle path network, and the topography. The results will also differ depending on which modes of transport are included in the analysis. Increasing safety for cyclists requires different concepts than for car occupants. At the same time, care must be taken to ensure that any measures introduced to increase the safety of one group of road users do not impede the safety of others. Another factor to consider is the reason why these different groups use the roads in the first place. Are they commuting to and from work? Going shopping? Transporting products and goods across short/long distances? Or traveling purely for leisure reasons?

Within the context of all these factors, it is also essential to consider the age of the road users. As people advance in age, their circumstances and mobility-related needs change. Increased life experience changes people's attitudes towards risk acceptance and risky behavior, not to mention their ability to anticipate critical situations. The boundaries of what is physically and cognitively possible for them also shift. If we are to achieve

the objective of increasing road safety for everyone while also meeting the individual mobility requirements for each age group, a highly nuanced approach and precise analyses will be required. Comparing accident statistics between various age groups is a suitable means of identifying the different – or even identical – weak points in how they use the roads.

Looking at absolute figures can only offer a limited insight when focusing on the age of the road user. In most countries, there is a lack of reliable age-related data on road use, i.e. on the routes taken with different means of transport, the time spent in road traffic, and the usage frequency of urban and rural roads and freeways. However, taking an age group as a percentage of the population and considering it in relation to the frequency of accident involvement or the severity of injuries provides important indications of how relevant these statistics are within traffic events as a whole and for long-term changes.

STARK DIFFERENCES BETWEEN CONTINENTS

If we start from a global perspective and carefully examine the absolute figures, it is noticeable that, according to the Institute for Health Metrics and Evaluation (IHME) at the University of Washington in Seattle, the number of global traffic fatalities has stagnated in recent years at around 1.25 million – WHO estimates being as high as 1.35 million traffic fatalities. This stagnation is prevalent to the same degree on almost every continent. Although the number of traffic fatalities mainly decreased between 1990 and 2019, at least for road users aged 49 and under, there were significant increases in some of the demographics aged 50 and over. For example, according to the IHME, the number of 65 to 69-year-old road users killed globally in accidents increased by more than 65 percent between 1990 and 2019, from 39,000 to around 65,000. In Asia alone, the number doubled from 20,000 to more than 40,000.

Antonio Avenoso
Executive Director, European Transport Safety Council (ETSC)

Keeping Old Ppeople 'Safe' Inside is No Solution

To tackle the multiple challenges of air and noise pollution, road safety, climate change and sedentary lifestyles on public health, there has been a welcome move to promoting walking and cycling in European countries in recent years. The COVID-19 pandemic has accelerated these trends to some extent.

For Europe's ageing populations, much is at stake. Older people need to remain active in order to stay healthy, but they also face greater risks on the road – especially when walking and cycling.

ETSC's 2020 report on walking and cycling shows that, while people over 65 years of age represent 20% of the population, they account for around half of walking and cycling deaths. There are 5,180 pedestrian deaths and 2,160 cyclist deaths in the EU each year, though underreporting of deaths is a particular problem for these transport modes. Cycling crashes and pedestrian falls that do not involve another vehicle often go unreported as traffic injuries or deaths.

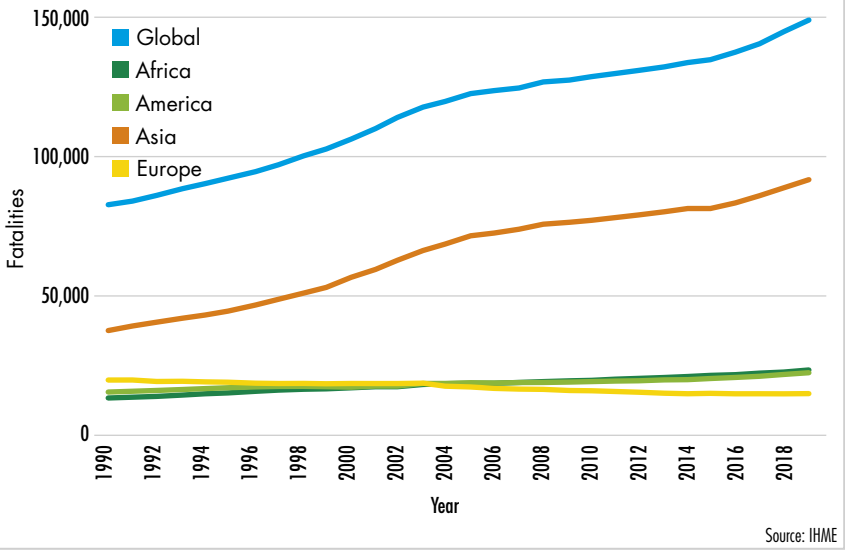
Factors that can explain the higher mortality of older people are physical, such as the increased fragility of the ageing body, decreasing ability to keep balance, use of medicinal or prescription drugs and general deterioration of reaction speed. Traffic behaviour might be impacted due to a relatively high and increasing share of pedelec use, inducing more cycling, higher speeds and more severe injuries.

Many of the measures that can make a safe road transport system for all vulnerable road users will also benefit older people. Separated cycle lanes, improved junction design, better street lighting, lower speeds: these tried and tested solutions could help make cycling and walking safer for young and old alike. But older people may also need specific interventions such as measures to help prevent falls while walking (which often go unreported as traffic injuries and deaths), longer crossing times at signalled junctions and other measures specifically targeted at these groups.

Keeping old people 'safe' inside is no solution. Europe needs to create a world where older people can remain active, and safe throughout their lives.

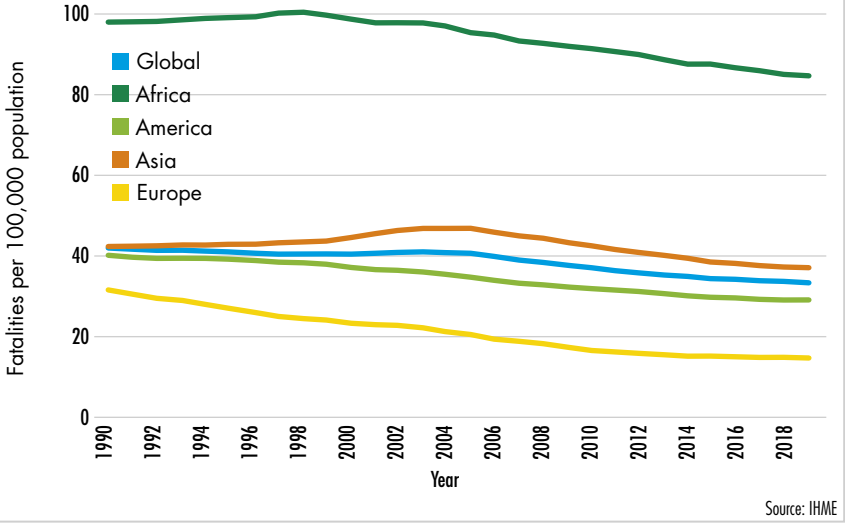
INCREASING SAFETY FOR CYCLISTS REQUIRES DIFFERENT CONCEPTS THAN FOR CAR OCCUPANTS

3 Senior Citizens Aged 70+ Killed in Road Traffic



Source: IHME

4 Senior Citizens Aged 70+ Killed in Road Traffic by Population



Source: IHME

When riding without a helmet, it is not only older road users who increase their risk of injury in an accident many times over

For people over the age of 70 (Figure 3), the global rate of increase was over 80 percent – from 82,000 to just under 150,000. Once again, Asia makes up the lion's share: in 2019, just under 92,000 people aged 70 or over there died in road traffic accidents – around two and a half times as many as in 1990. In terms of the number of fatalities for people over 70 per 100,000 population (Figure 4), Africa had over 80 fatalities in 2019, placing it far above the average figures for Asia (35), America (27) and Europe (13). Globally, this figure was 32 for the over-70s demographic. Things look considerably better for the other age groups in this context. For the 15 to 49-year-olds, around 16 people per 100,000 population died worldwide in road accidents in 2019, and 22 per 100,000 population for the 50 to 69-year-olds.

The number of fatalities in relation to the type of road user are also very revealing: globally, around 55 percent of the people over 70 who died due to road accidents in 2019 were pedestrians (approx. 82,500). Asia accounted for the majority of this number, with just under 56,000 (68 percent). The number of car occupants in this age group who died worldwide in 2019 was around 44,000, of whom just under 19,000 were in Asia alone. Most of the cyclists and motorcyclists who were killed – around 80 percent – were also in Asia.

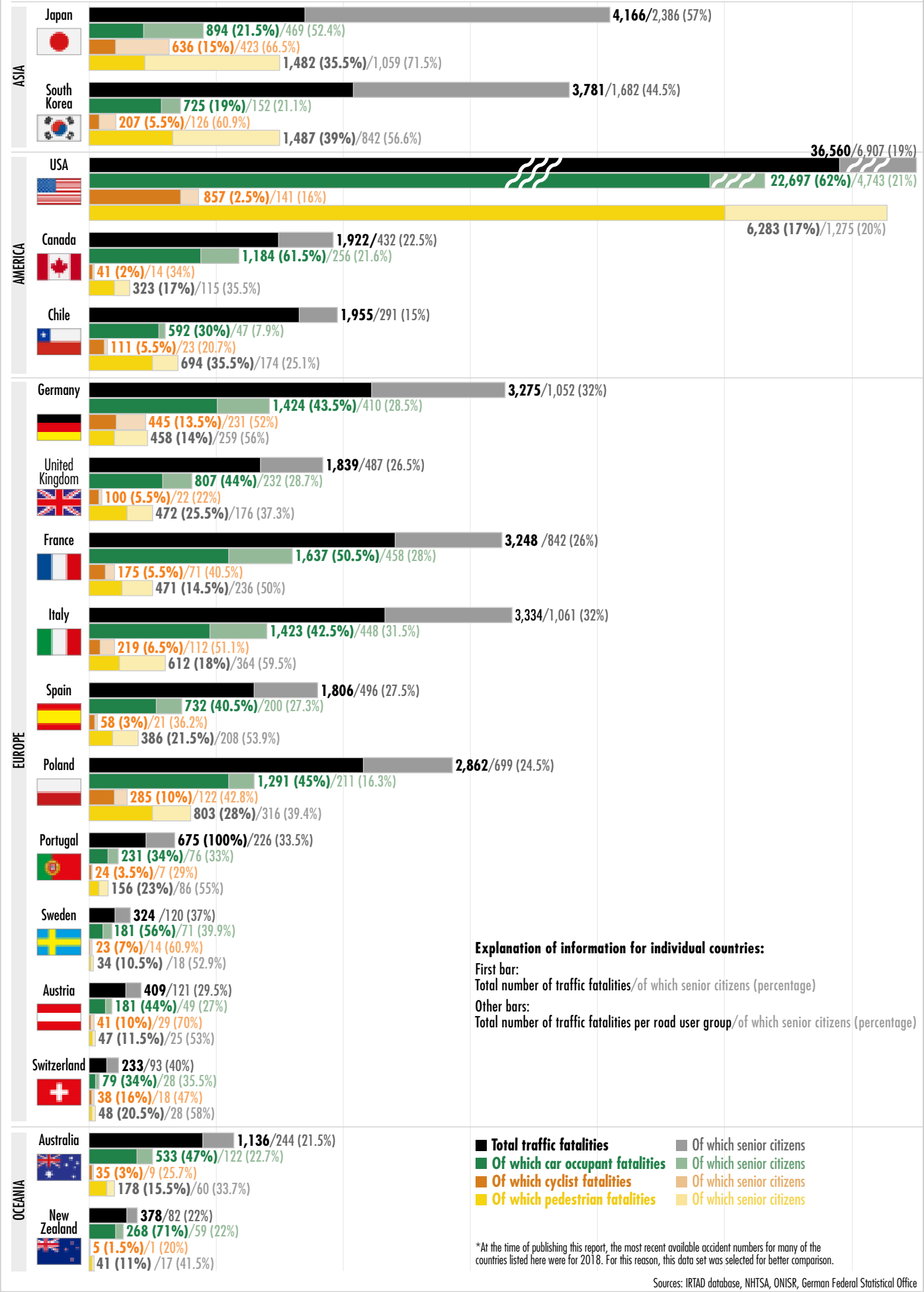
The quoted figures may not be completely reliable on such a detailed scale, as some of them are merely estimates, as stated in the IHME's "GBD Compare" online tool. Nevertheless, they show a trend that can be confirmed by examining the statistics and surveys published by other institutions: senior citizens are at high risk in road traffic – not only as car occupants, but especially as pedestrians and cyclists, as illustrated in Figure 5.

LOOKING AT SELECTED COUNTRIES OUTSIDE OF THE EU

According to the International Traffic Safety Data and Analysis Group (IRTAD), the number of 18 to 24-year-olds who died in road accidents in the countries that were analyzed dropped by 25 percent between 2010 and 2018, and the same figure dropped by 6.9 percent for 25 to 64-year-olds. The trend during this same period for senior citizens was the inverse of this: the number of over-65s who were fatally injured in accidents

5

Number of Senior Citizens (65+) Killed Across all 2018 Traffic Fatalities – International Comparison (Selection)*



*At the time of publishing this report, the most recent available accident numbers for many of the countries listed here were for 2018. For this reason, this data set was selected for better comparison.

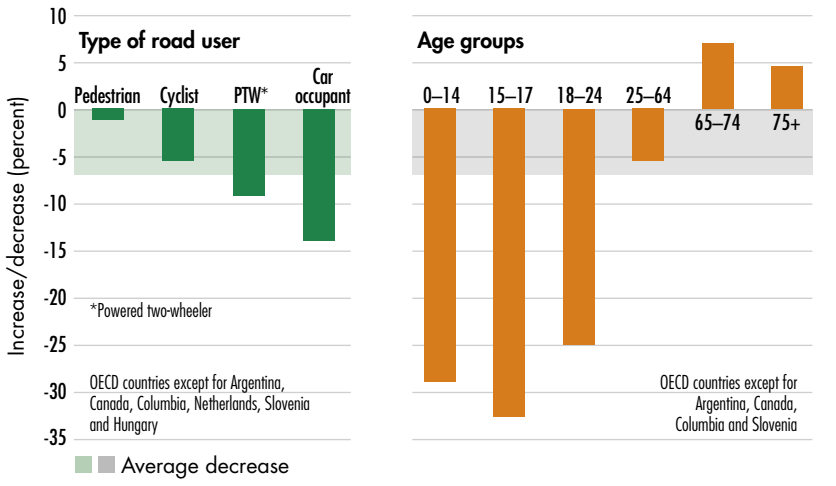
Sources: IRTAD database, NHTSA, ONISR, German Federal Statistical Office

rose by around seven percent, while there was a 4.7 percent increase among over-75s (Figure 6).

One reason for this increase is the growing number of senior citizens in the population as a whole. Furthermore, senior citizens nowadays are often much more mobile than in previous decades, and continue to be active road users well into their later years. In 13 out of 31 countries with available data analyzed by IRTAD, for example, the data showed that citizens who were 75 or over had the highest mortality rate in 2018. This rate was highest in South Korea – at 29.7 traffic fatalities per 100,000 population. The national average for traffic fatalities there was 7.3 per 100,000 population. Overall, senior citizens accounted for 44.5 percent of all traffic fatalities in South Korea in 2018. Within this group, a disproportionately high number of those who were killed were pedestrians or cyclists.

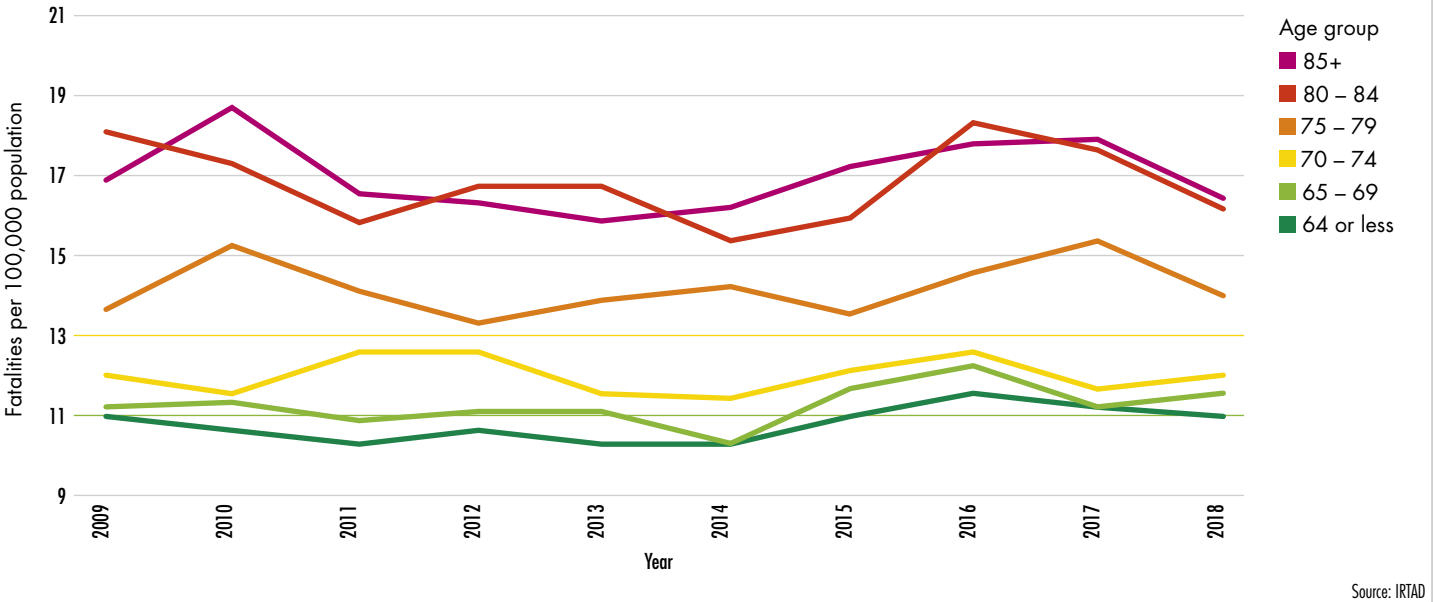
A 2016 report on South Korea published by the OECD's International Transport Forum listed a number of reasons why this particular country performed much worse in road safety when compared to other OECD nations. It appears that many pedestrians in South Korea cross the road without paying attention to traffic. When the pedestrians in question are senior citizens, they are more likely to die from the consequences of an accident than a younger person. Another problem is that crossings on wide roads take more time to cross, which increases the risk of an accident occurring after the pedestrian traffic light has turned red. Senior citizens are at a disadvantage here, as they generally walk more slowly than younger people. Combined with the supposedly reckless behavior of some road users, this places senior citizens at greater risk. This issue also applies to another Asian country: Japan. Older road users there are also by far the group at most risk of being involved in an accident. Senior citizens made up 57 percent of all road traffic fatalities in 2018. Most of the senior citizens killed in road traffic in Japan are pedestrians. According to the

6 Trend for Traffic Fatality Numbers by Type of Road User and Age Group – 2010 to 2018



Source: IRTAD

7 Traffic Fatalities per 100,000 Population by Age Group



Source: IRTAD

Crossings on wide roads take more time to cross, and increase the accident risk for older pedestrians

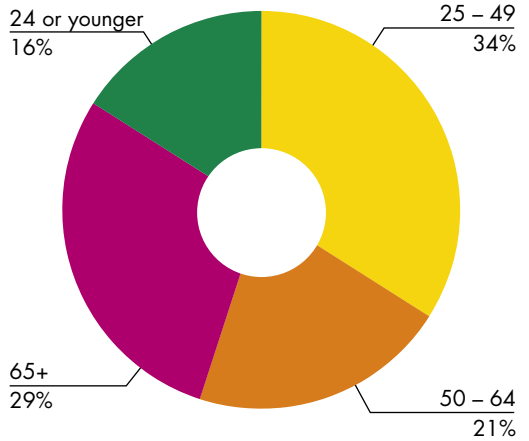
IHME, the same applies to several non-European countries, including Brazil, Chile and China.

In the USA, there are no particular anomalies in the data for senior citizens. As in many other countries, drivers in the 70+ age group have a higher accident rate per mile driven than middle-aged drivers. The rate of fatal road accidents per kilometer driven also increases rapidly between the ages of 70 and 74, and is highest for the 85+ age group. According to the National Highway Traffic Safety Administration (NHTSA), there were a number of trends for the 65+ age group in the USA between 2009 and 2018. The most noteworthy of these was the fact that the number of fatal road accidents increased by 30 percent during this period, with the number of pedestrian fatalities even rising by 65 percent (74 percent for men and 49 percent for women). Although the number of fatal accidents among cyclists aged 65 or over is relatively low, it nonetheless increased by 86 percent. Across the population as a whole, the fatality rate for senior citizens aged 65 and higher was than that for the younger age groups (Figure 7). Most of the senior citizens who die in road accidents in the USA are car occupants. According to the IHME, the same applies to several other non-European countries, including Australia, Canada, and New Zealand.

SITUATION IN THE EU

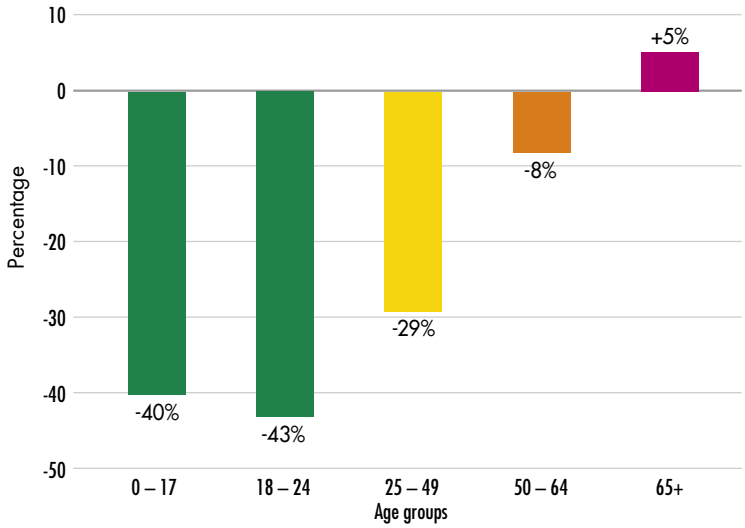
In the European Union (EU 28), 25,082 people died in road accidents in 2018. Compared to the 35,315 fatalities in 2008, this was a decrease of 29 percent. Of those who died in 2018, 7,274 were at least 65 years old, which accounts for around 29 percent of all fatalities (Figure 8). In 2008, the number of fatalities for this group was 7,397 – just under 21 percent. The decline in absolute numbers for this age group during this period is merely five percent, and the percentage of the total traffic fatalities for which they accounted increased considerably (Figure 9). Between 2010 and 2018, the number of traffic fatalities dropped for almost all

8 Percentage of Traffic Fatalities by Age Group in 2018



Source: CARE

9 Trend for Traffic Fatality Numbers by Age Group – 2010 to 2018



Source: CARE

age groups – among 18 to 24-year-olds, the figure even fell by 43 percent. Conversely, in the 65+ age group, five percent more people died in road accidents in 2018 than in 2010. This could be one consequence of the population across the EU becoming older with each year that passes.

In 2018, around 512 million people lived in the EU (EU 28). 100 million of these – 20 percent – were aged 65 or older. In 2014, this share was only 18 percent (around 95 million of almost 508 million). In this respect, the demographic shift mentioned in the introduction is in part responsible for the slower decline in traffic fatalities among senior citizens. However, this group is disproportionately affected overall – the percentage of all traffic fatalities for which they account has increased more than the percentage of the population who fall into this age group. This calls for a more detailed analysis of the statistics. A closer inspection reveals that around 40 percent of the women killed in traffic were in the 65+ age group. For men, the share is merely around 24 percent. However, the reason for this is that the number of younger male road users is higher, as is their willingness to take risks. There are also noteworthy findings with regard to types of road user. For example, 47 percent of the pedestrians killed in road traffic were in the 65+ group. Although there are no exact figures for pedestrians broken down by age group and distance covered, it is unlikely that senior citizens represent anywhere near half of all pedestrians or pedestrian journeys.

The picture is just as clear for the numbers of cyclists who suffered fatal injuries in accidents,

Prof. Walter Eichendorf
President of the German Road Safety Council (DVR)

Politicians and Those Who Play a Role in Society Must Take Action

Mobility is a crucial factor in being able to take part in the social aspect of life. Nowadays, older citizens are much more mobile than 20 or 30 years ago. Never before has personal mobility been such an important component in a high quality of life.

Having one's own vehicle is a symbol of freedom and independence, and is often associated with the notion of traveling or taking trips, or even just staying connected to people and society. Bicycles are also becoming more and more popular – both with and without electrically assisted pedaling. The percentage of journeys made on foot in the modal split also increases with age.

But as heartening as it is to see mobility in old age increasing, there is also a dark side to this development. Over the past few years, roughly a third of all the people killed in road traffic were older than 65. The number of cyclist and pedestrian deaths is particularly dramatic, with every second person being older than 65.

In light of this, politicians and those who play a role in society must take action to ensure that older people can use the roads safely. As our society ages, we need to restructure and simplify the infrastructure of our traffic system in every regard, from improving the design and operation of junctions through to a reduction in complexity. Providing sufficient time to cross and separate traffic light phases could increase both the sense of safety among older pedestrians and their actual safety levels as well. In order to account for the possibility of delays in perception processes, it is advisable to think about slowing down the flow of traffic in general and implementing a "forgiving" type of traffic system. We need a general overhaul of our road design to make traffic safe for pedestrians and cyclists. Districts with good local public transport connections, safe and short walking and bicycle paths, attractive places to sit, and enough safe crossing opportunities would enable people to be mobile and independent in older age.

Since accident statistics thus far indicate that older people are not usually the cause of the accidents they are involved in, there is currently no need to introduce a general compulsory test to assess their driving ability. Nevertheless, we need to keep an eye on how accident numbers develop, because from a statistical point of view, 75 is already considered to be the age where accident participation and accident fault intersect.

All road users should take particular care to look out for older people and consider their limitations. Older road users can also contribute to reducing their own risk of becoming fatally injured in road traffic. It is helpful to make oneself clearly visible – with appropriate clothing and reflectors, for example. After all, a reflective approach to life is one of the keys to improving road safety. If a person notices their sensory, cognitive or motor skills deteriorating with age in a way that could impact their driving ability, they need to think carefully about whether they should continue driving a car as normal or start to impose restrictions on themselves. A health check, driver safety training, or an accompanied practical evaluation could provide greater clarity on a case-by-case basis.

around 45 percent of whom are in the 65+ age group. When it comes to car occupants, however, just shy of 24 percent of all fatalities are in this age bracket. This makes unprotected road users a particularly significant group among senior citizens. A key factor in this is the higher level of vulnerability that comes with age – given an identical type of accident , the risk of suffering more severe or fatal injuries would be greater for senior citizens than for younger people. The healing process also takes longer, and often involves complications.

France is a good example in highlighting the accident risk for senior citizens during road use in the EU. According to the French Road Safety Observatory (ONISR), 3,244 people in France were killed in road accidents in 2019 – 849 of whom were senior citizens (around 26 percent). This represents a slight increase of 0.8 percent compared to 2018. Overall, the number of traffic fatalities among senior citizens in France increased by an average of 1.2 percent per year between 2010 and 2019. In general, the severity of road accidents among senior citizens is much greater than for the other age groups. For people under 65, there were four fatalities per 100 injuries, whereas this figure was eight for people aged between 65 and 74, and 16 for people aged 75 or over. Overall, 54 percent of the senior citizens killed in road accidents in France were car occupants, 30 percent were pedestrians, and nine percent cyclists. Three quarters of all the older pedestrians who were killed were hit by cars driven by people younger than 65.

POSITIVE OVERALL TREND IN GERMANY

In Germany, the data show positive results for the 65+ age group, despite the increasing number of people in this group across the population as a whole. The number of people killed in road accidents has been in decline, as has the number of those severely injured – although the latter figure only applies when measured in relative terms, not absolute numbers. For those with minor injuries, on the other hand, there was an increase in both absolute numbers and relative terms. Of the 1,037 senior citizens killed on the roads, 486 died in built-up areas, 487 in non-built-up areas, and 64 on freeways. In built-up areas, however, around twice as many senior citizens suffered severe injuries than in non-built-up areas and on freeways combined. Most of the senior citizens killed or severely injured in built-up areas were pedestrians and cyclists; in non-built-up areas just under 60 percent of the senior citizens who were fatally injured were car occupants, as were around 65 percent of the severely injured (Figures 10 to 12).

10 Senior Citizens Killed in Road Traffic by Year

Fatalities 65+	1970		2001		2019	
	Absolute	Per 100,000 population	Absolute	Per 100,000 population	Absolute	Per 100,000 population
Fatalities	4,016	49.5	1,283	9.1	1,037	5.7
Severe injuries	11,323	139.5	10,666	75.8	13,189	72.9
Minor injuries	16,519	203.5	26,400	187.7	38,218	211.3
Total	31,858	392.5	38,349	272.6	52,444	289.9
Population number age 65+	8,119,248*		14,065,722*		18,090,682*	

*Recorded on Dec 31 each year; 1970 = former Federal Republic of Germany, as of 2001 = whole of Germany Source: German Federal Statistical Office

11 Senior Citizens Killed in Road Traffic in 2019

Fatalities 65+	Non-built-up areas		Built-up areas		Freeways		Total	
Total	487	100%	486	100%	64	100%	1,037	100%
Car	287	58.9%	81	16.7%	46	71.9%	414	39.9%
Bicycle	55	11.3%	121	24.9%	1	1.6%	177	17.1%
Pedelec	48	9.9%	37	7.6%	0	0%	85	8.2%
Pedestrian	25	5.1%	208	42.8%	2	3.1%	235	22.7%
Motorcycle	41	8.4%	13	1.7%	4	6.3%	58	5.6%
Others	31	6.4%	26	5.3%	11	17.2%	68	6.6%

Source: German Federal Statistical Office

12 Senior Citizens Severely Injured in Road Traffic in 2019

Severely injured 65+	Non-built-up areas		Built-up areas		Freeways		Total	
Total	4,089	100%	8,414	100%	686	100%	13,189	100%
Car	2,665	65.2%	1,936	23.0%	605	88.2%	5,206	39.5%
Bicycle	480	11.7%	2,548	30.3%	0	0%	3,028	23.0%
Pedelec	337	8.2%	823	9.8%	0	0%	1,160	8.8%
Pedestrian	83	2.0%	2,183	25.9%	1	0.1%	2,267	17.2%
Motorcycle	331	8.1%	334	4.0%	31	4.5%	696	5.3%
Others	193	4.7%	590	7.0%	49	7.1%	832	6.3%

Source: German Federal Statistical Office

Marie Gautier-Melleray
Interministerial Delegate for Road Safety

The Difficult Issue of Mobility in Old Age

The huge societal challenge of an aging population also brings with it the no less important matter of the mobility of older people, which comes in so many different forms in modern times. Having been called upon to do more exercise in order to remain in good health, older people nowadays travel greater distances on foot or by bike – be that with a traditional bicycle or an e-bike. They are in better shape than before: whereas 24 percent of people aged over 85 in 2008 needed care, by 2015 this number had dropped to just 17 percent. The other side of the coin is the growing proportion of senior citizens involved in road accidents. These days, the 65+ age group makes up 20 percent of the population, but this group accounts for 26 percent of all traffic fatalities and 52 percent of pedestrians killed.

This shows that older people are especially at risk, and also particularly prone to injury: they suffer more severe injuries from accidents than younger people (for the under 65s there were only four fatalities per 100 injured people, but for the 65 to 74-year-olds there were eight, and for the 75+ age group there were 16 fatalities per 100 injured people).

Although older drivers lose certain abilities as they advance in age, they are generally much more careful drivers: they drive less or not all, drive more slowly and not as far, are more cautious, and consume less alcohol. This means that, more often than not, they are the victims rather than the perpetrators of fatal accidents on public roads: according to statistics, 65 to 74-year-olds are responsible for only eight percent of fatal accidents, and the over-75s for 9.5 percent, whereas 18 to 24-year-olds are responsible for 19.2 percent of such accidents.

As a result, reducing the number of older people who are caught up in accidents is an important concern for national road safety policy. It is essential that we make this age group – who prioritize the safety of their children and grandchildren when on the road – aware of their own vulnerability. We need solidarity and creativity from everyone in order to safeguard the rights of older people to enjoy safe mobility and to reduce the risks for themselves and for others.

2019 saw the trial of an initiative devised by the Delegation for Road Safety that was aimed at improving awareness of the issue of road safety among doctors, so that they might talk to older patients about it during their appointments. The project was implemented in collaboration with the French Medical Board (Conseil National de l'Ordre des Médecins), and is to be expanded across the entire territory. An agreement between the Delegation for Road Safety and the General Medical College (Collège de Médecine Générale) is currently at the signature stage.

In parallel to this, the Delegation is working on a more holistic approach to mobility for older people, together with scientists (researchers, physicians, sociologists, representatives, mobility experts, associations, etc.) and four pilot départements. The aim of this strategy is to shake up the old structures and bring about a fundamental change across the entire country, in order to enable and generate new behavior patterns in the context of mobility. This approach and the initial results of the project will be discussed at a national conference next June.

In my view, mobility is an essential factor in ensuring a good quality of life. It is a tool that helps to prevent dependency on others, and the lack of mobility options (or suitable ones) can lead to what is known as "social death" in older people. We have to solve this problem. The Delegation for Road Safety has also set itself the important goal of researching and compiling the underlying conditions required for a reliable, safe and responsible mobility concept, and of assisting with the implementation of this vision – with coexistence at the heart of that concept.

NUMBER OF SEVERE INJURIES ALSO INCREASES SIGNIFICANTLY

As mentioned above, the number of senior citizens killed varied drastically depending on the type of road use. For example, the absolute number of cyclists (including pedelec riders) aged 65 or over killed decreased by just 4 between 2001 and 2019, falling from 265 to 261, although the numbers had originally been dropping steadily until 2010, when they reached an all-time low of 188. Since then, the number has been increasing again. This represents a change from 1.9 to 1.4 for every 100,000 population in this age group. In relation to the number of senior citizens who died in accidents in the year in question, the percentage of these fatalities who were cyclists rose from 20.6 to 25.2. For pedestrians, there was a decline from 432 (2001) to 235 (2019). Accordingly, the number of pedestrians killed per 100,000 population for this age group dropped from 3.1 to 1.3. The percentage of all senior citizen fatalities accounted for by this group dropped from 33.7 to 22.7 percent.

This means that around half of the over-65s killed in road accidents were cyclists or pedestrians. In 2019, 57.3 percent of all cyclists killed were aged 65 or older; drilling down within the cyclist group to just the pedelec riders, the 65+ age group actually represented 72 percent. This age group also accounted for more than half of all pedestrian fatalities, at 56.3 percent. An even more nuanced analysis reveals that the risk increases even more when a road user reaches the age of 75. Among cyclists, 41.3 percent belonged to this age group alone, and the figure for pedelec riders was around half at 50.8 percent (for bikes excluding pedelecs, it was 39.1 percent).

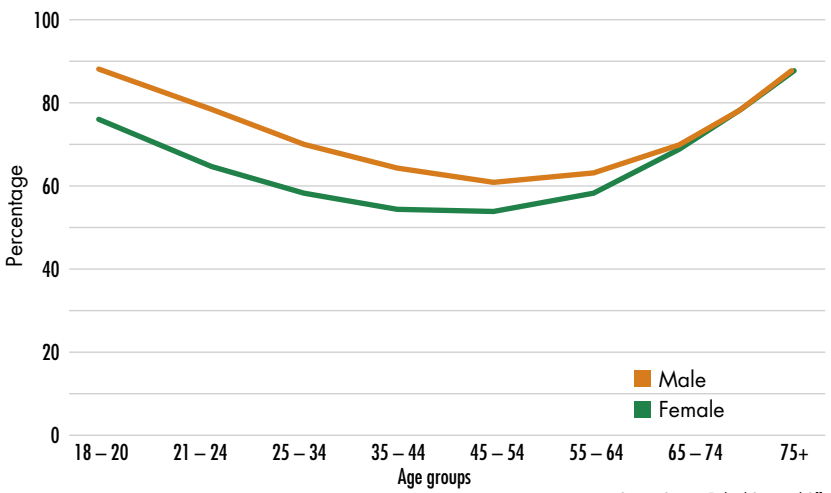
After the age of 65, the risk of being injured in road traffic increases significantly – especially if one is not very visible and has been seen too late. That is why older people and those who have difficulty walking are advised to apply reflective strips to their rollators and walking aids – and to their wheelchairs, if they use them

Among pedestrians, 42.4 percent of all road fatalities were likewise aged 75 or over. In comparison to 2001, this represents an increase of 20.2 percent for cyclists, and an increase of 8.7 percent for pedestrians. The analysis shows that accident statistics in Germany are largely comparable to those for the EU as a whole. Focusing on implementing road safety measures for senior citizens aged 75 or over who fall within the unprotected groups (pedestrians and cyclists) could potentially reduce the overall number of these traffic fatalities. This approach is further substantiated by the dramatic increase that has been observed in the number of people being severely injured in road accidents. Whereas the share of severely injured pedestrians aged 65+ stood at 26.7 percent in 2001, by 2019 it had risen to 33.7 percent, while for cyclists it rose by around 10 percentage points to 27.6 percent.

DRIVER ERRORS AS THE CAUSE OF ACCIDENTS

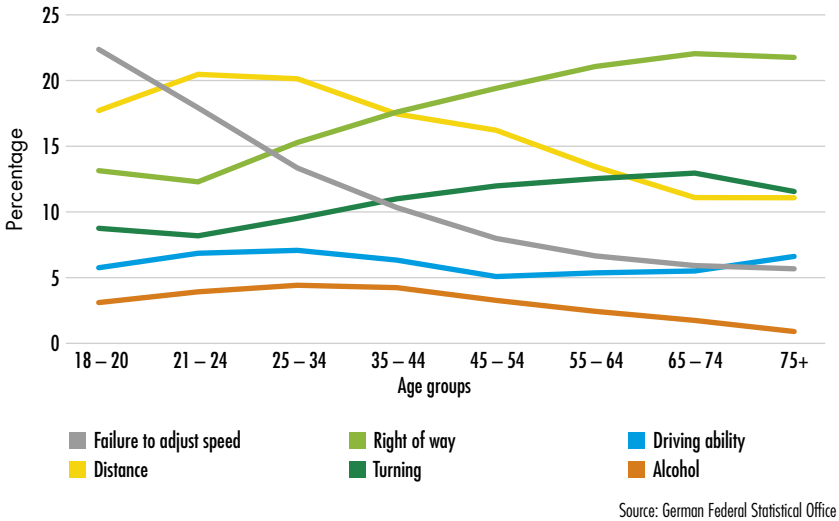
Behavior during road use changes as people advance in age, and there are clear differences in the type of driver error that leads to accidents resulting in physical injury. This starts with the party to whom the recording police officers assign the primary fault of the road accident. If we take the number of car drivers in a certain age group who were involved in accidents that resulted in personal injury and compare this figure to the number of accidents caused by the age group, the results make for interesting reading. Young, inexperienced drivers and senior drivers represent particular risk groups (Figure 13). All of the age groups display values of over 50 percent, as they include accidents that involve just one car and no other road users – also known as single-vehicle

13 Percentage of Driver Errors for Car Drivers in 2019, by Age Group



Source: German Federal Statistical Office

14 Types of Driver Error Made by Car Drivers in 2019, by Age Group



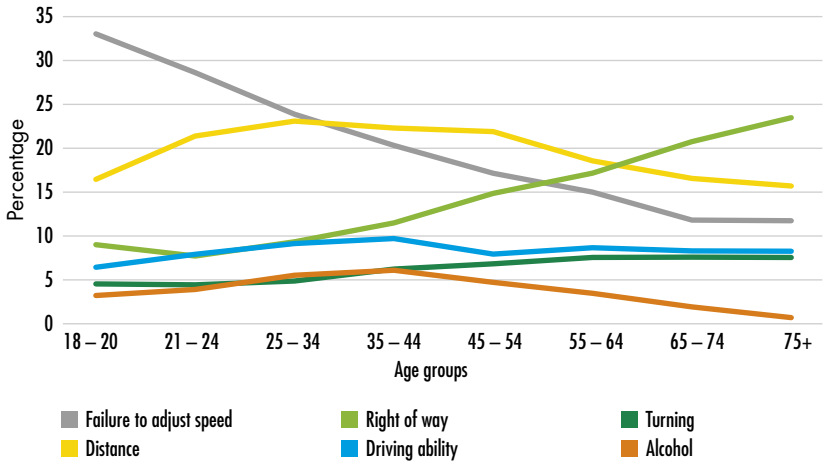
Source: German Federal Statistical Office

accidents. Furthermore, several types of driver error can occur in a single accident. Up to the age of 65, men are much more likely than women to cause an accident due to driver error. After the age of 65, this difference levels out.

There are significant differences to be observed when analyzing the type of car driver errors that lead to accidents resulting in personal injury. Figures 14 to 16 show a selection of the key causes of accidents/key car driver error types assigned by the police who recorded the accidents. There are differences in terms of location: in non-built-up areas and on freeways, people cause more accidents in complex traffic situations as they advance in age – especially due to violations of rights of way. The impact of impaired driving abilities is also particularly high in more complex traffic situations. Such age-related impairments are also prevalent in incidents in built-up areas. Another statistic that stands out is the increase in driver errors in accidents involving cyclists and pedestrians, which only play an extremely minor role in non-built-up areas.

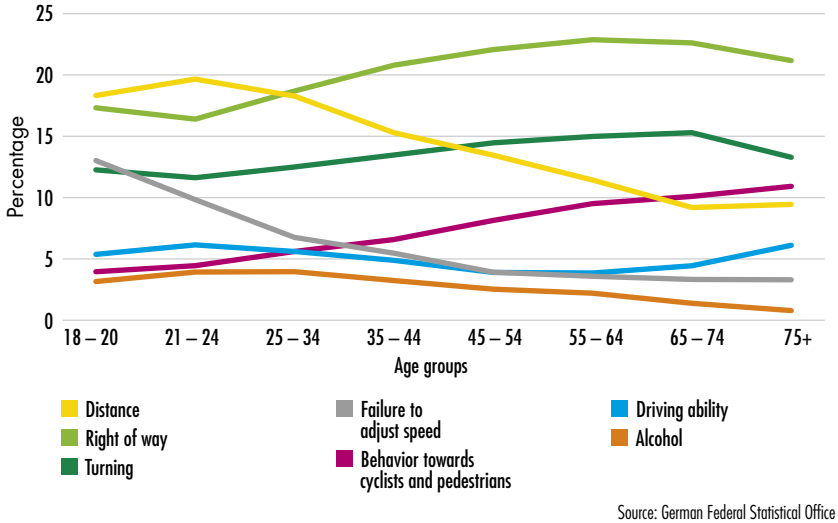
These data show that complex traffic situations need to be the primary starting point when devising measures for safer mobility for older car drivers. In addition to infrastructure optimization, in-vehicle assistance systems can also help with this issue. Ultimately, however, many accidents caused by violations of rights of way, that occur when turning, or that involve cyclists or pedestrians, are linked to physical or health-related limitations among the senior citizens responsible for the accidents. This issue is addressed in greater detail in the chapter on "The Human Factor" in this report.

15 Types of Driver Error Made by Car Drivers in Non-Built-Up Areas and on Freeways in 2019, by Age Group



Source: German Federal Statistical Office

16 Types of Driver Error Made by Car Drivers in Built-Up Areas in 2019, by Age Group



Source: German Federal Statistical Office

VEHICLE AGE, DRIVER AGE AND ACCIDENT RISK

In 2019, the police recorded more than 355,000 cars in Germany as being involved in a road accident resulting in personal injury. This represents around 0.75 percent of all the cars registered in the country. Overall, there is very little fluctuation in this percentage based on the age of the vehicle

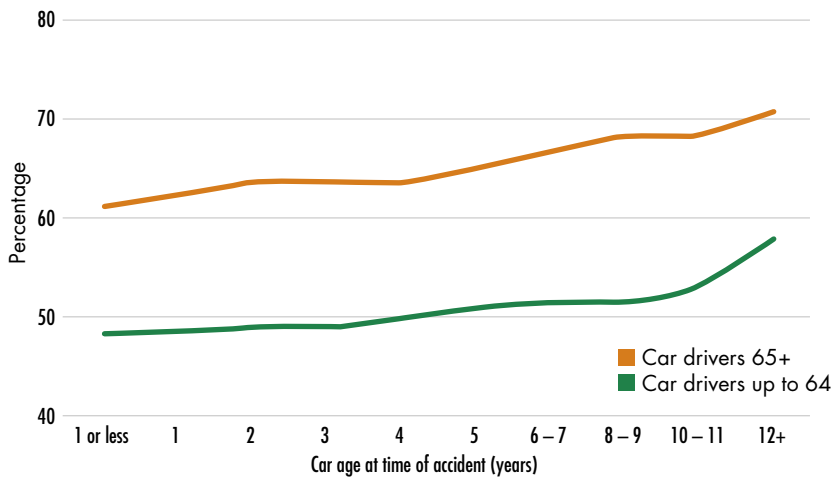
COMPLEX TRAFFIC SITUATIONS SHOULD BE THE FOCAL POINT

in question. At first glance, increased vehicle age does not appear to affect the risk of being involved in an accident that results in physical injury.

However, this observation fails to account for mileage. Given that the average annual mileage decreases considerably as the age of the vehicle in question increases, this suggests that the accident risk is greater for older vehicles. This picture becomes even clearer when the main causes of accidents resulting in physical injury are considered together with the vehicle age. For example, 49.8 percent of accidents involving a car less than a year old were actually caused by this car. Viewed in isolation from mileage, this figure increases with increasing vehicle age, reaching 59.4 percent for vehicles that are twelve years old or more. If we include the driver's age in this analysis, we can see that senior citizens once again cause the majority of accidents – a figure that increases to around 70 percent when the senior citizen in question is driving a vehicle that is at least twelve years old (Figure 17).

This analysis clearly shows that advances in vehicle technology have the potential to reduce the number of total accidents and the risk of accidents resulting in physical injury. These improvements benefit all age groups. However, the increase in the average age of the cars on the road is slowing the decrease in the number of traffic fatalities. The average age of all cars registered in Germany has been steadily increasing over the past 20 years, rising from 7.1 years in 2001 to 9.8 years at the start of 2021.

17 Main Perpetrators of Accidents Resulting in Physical Injury (Car Drivers) in 2019, by Vehicle Age



Source: German Federal Statistical Office

The fact that older car drivers score comparatively poorly in causing road accidents that result in physical injury is due a combination of several factors. In addition to the increasing physical limitations explored in the "The Human Factor" section of this report and the increased vulnerability that comes with age, these factors also include the decrease in annual mileage as drivers get older and the resulting reduction in regular practice. Cars suitable for senior citizens that come with modern assistance systems that help the driver without overwhelming them can lower the risk of accidents caused by such factors. Furthermore, the improved level of occupant protec-

Many towns and cities are characterized by old and new vehicles driving side-by-side

tion in modern cars reduces the risk of occupants being injured in case of an accident.

It is important to bear in mind that the number and type of motor vehicles currently on the roads cannot generally be used to draw any conclusions with regard to the mileage of said vehicles. Likewise, the ages of the drivers to whom the vehicles are registered is not a reliable indicator as to whether these people are the sole drivers of the vehicle in question. Instead, inclusion in accident statistics is based on mileage in relation to the individual road categories (built-up area, non-built-up area, freeway), as well as on age-related factors for the drivers. Traffic in general involves road users who cause accidents due to their behavior or the condition of their vehicle. The other road users get caught up in the accident more or less by chance. In order to determine the correlation between the age of the vehicle, that of driver, and road use in cases involving cars, a new approach has been devised.

This approach is based on all of the accidents resulting in physical injury that involved at least one car. In order to minimize the influence of the aforementioned behavior-based parameters and registration-related factors, the approach only considers cars involved in accidents where the main fault for the accident lay with the other par-

Greg O'Connor
Country Manager, Vehicle Testing New Zealand

Keeping Senior Drivers Safe on New Zealand's Roads

Staying safe on the roads in New Zealand is important for all motorists, particularly older road users. Despite having a similar sized land mass to Germany, the roading infrastructure in New Zealand is very different to the European model. The road network is designed around the country's mountainous geography and small population of just over 5 million people. With approximately 4.15 million registered vehicles and an ageing population there is an increasing number of vehicles being driven by older motorists. This is expected to continue and by 2034, it is projected that one in five New Zealanders will be aged 65 years or over.

Keeping senior drivers safe on the road and connected to their communities is an integral part of New Zealand's Road Safety Strategy 2020-30 "Road to Zero". Together with Waka Kotahi (the New Zealand Transport Agency) and Age Concern New Zealand, VTNZ (Vehicle Testing New Zealand – DEKRA's New Zealand based company) has committed to achieving the strategy's long-term vision of a New Zealand where no one is killed or seriously injured in road crashes. In 2019, 352 road deaths were recorded on New Zealand roads. This is disproportionately high compared to other OECD countries. Norway, with a similar road network and population, recorded only 117 road deaths. To address these numbers and the impact they have on road safety, the strategy's intermediate goal is to reduce the number of road deaths and serious injuries by 40%.

As we age, changes to our health and wellbeing can affect the way we drive. As part of ensuring older drivers are not putting themselves, or other road users at risk, they are required by New Zealand law to renew their driver licence when they turn 75 and 80, and every two years after that. A medical certificate is a compulsory requirement for renewal and, where recommended, a doctor may direct an applicant carry out a practical 30-minute On-Road Safety Test.

In 2015, VTNZ were appointed by NZTA as the service provider for New Zealand's practical driver testing and licensing services. The company is mandated to carry out all driving tests undertaken in New Zealand and ensure that all drivers, irrespective of their age, are confident, competent and safe. Of the 270,000 driver tests carried out each year, almost 2,000 are On-Road Safety Tests. Driving is intrinsically linked to personal independence and therefore, older people especially, have genuine anxiety around losing the ability to drive. To help mitigate this, VTNZ work closely with NZTA and Age Concern to ensure the process of licence renewal is easy to access and understand for older people, and that all people who are helping in the process are equipped to answer questions or offer other helpful resources.

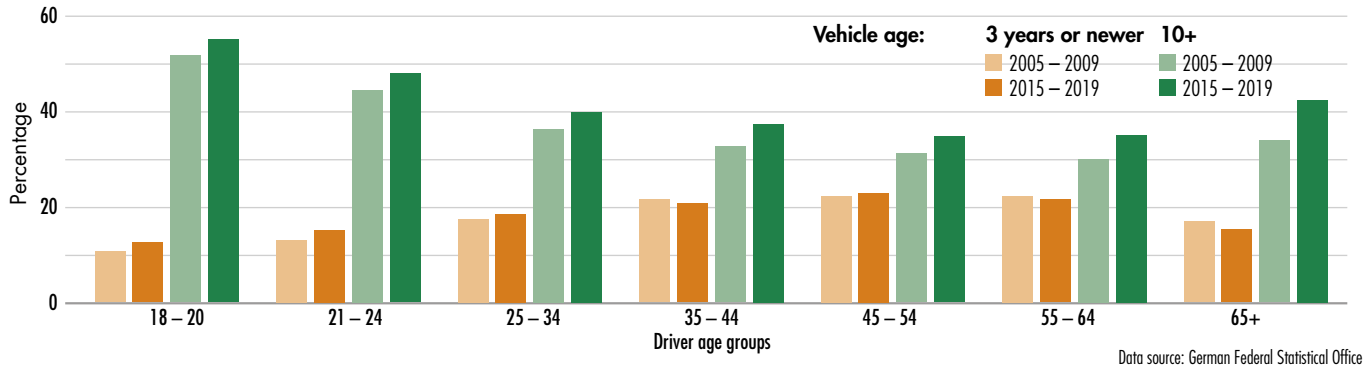
Staying socially connected becomes more important as we age. Being able to drive and carry out everyday activities independently of others helps strengthen that sense of belonging. In addition to providing the practical On-Road Safety Test at 56 VTNZ branches nationwide, there is also a remote service available to residents in rural communities. The test assesses an applicant's ability to confidently and competently demonstrate driving skills that will keep themselves and other road users safe on the road.

"It's really important for senior drivers who live outside our main city centres, or in rural parts of the country where there is no public transport, to be able to take the test. The On-Road Safety Test is carried out in their local community as this is where they are likely to do all their driving." says James Law, VTNZ Operations Support Manager.

VTNZ's main priority is to keep all New Zealanders safe on New Zealand roads. We continue to work alongside our Government and community-based partners to ensure older drivers can confidently contribute to and be part of their communities for as long as they can safely do so.

18

Car Accidents Resulting in Physical Injury, by Vehicle Age and Driver Age



Data source: German Federal Statistical Office

ty. What type of road user the other party falls into is not relevant. This group is a very good representation of car-related traffic events. Dividing this group into different driver ages and vehicle ages confirms previous findings (Figure 18).

The graph shows that, across all driver age groups, the percentage of cars that are at least ten years old has increased between the periods 2005-2009 and 2015-2019. This increase was greatest among senior citizens – at 8.6 percentage points. The percentage of newer cars (up to three years old) being driven by the 18-34 age groups increased, but it remained almost level among 35 to 65-year-olds. For drivers aged 65+, this percentage actually decreased.

This means that the accident statistics corroborate the findings from other statistics: the percentage of older people who drive older cars is increasing disproportionately. As people get older, they are less likely to replace their vehicles, as their annual mileage decreases and they are more likely to take the stance that the vehicle "still works" and thus does not need replacing. As a result, driver assistance systems are only making their way into the vehicles of senior citizens relatively slowly.

The Facts at a Glance

- **Taking an age group as a percentage of the population and considering it in relation to the frequency of accident involvement or the severity of injuries provides important indications of how relevant these statistics are within traffic events as a whole and for long-term changes.**
- **According to the Institute for Health Metrics and Evaluation (IHME) at the University of Washington in Seattle, the global number of 65 to 69-year-old road users killed in accidents increased by more than 65 percent between 1990 and 2019, rising from 39,000 to around 65,000. For the over-70s, the global rate increased by over 80 percent – from 82,000 to just under 150,000.**
- **According to the European Commission, the number of traffic fatalities in the EU decreased for almost all age groups between 2010 and 2018 – for 18 to 24-year-olds it even fell by 43 percent. Conversely, in the 65+ age group, five percent more people died in road accidents in 2018 than in 2010.**
- **Senior citizens are at a particularly high risk of suffering an accident when walking or riding a bike or pedelec.**
- **When it comes to implementing measures for safer mobility for older car drivers, we must start with complex traffic situations.**

Compelling Examples of Accidents in Detail

Health problems

VAN DRIVES INTO THE BACK OF CAR

Sequence of events:

On a federal highway structured like a freeway, a 72-year-old car driver was driving very slowly in the right-hand lane in daylight and good weather conditions. The driver of the van behind her noticed this too late, and drove into the tail of the car at around 100 km/h with almost no braking.

Persons involved in the accident:

Car driver and van driver

Consequences/injuries:

The car driver suffered fatal injuries;
the van driver was severely injured.

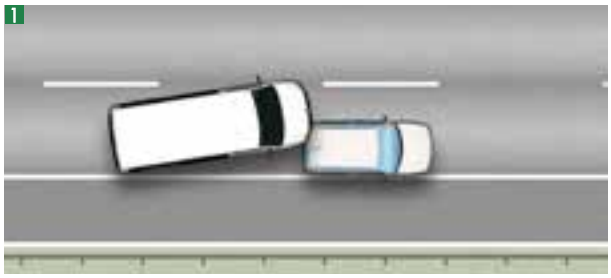
Cause/problem:

The car driver was driving in the right-hand lane of a federal highway, where the speed limit was 100 km/h. Even though there was a low volume of traffic, she had been driving very slowly over a long distance (between 0 and 18 km/h at the time of the collision). During the course of the accident reconstruction, the experts were able to rule out weather, traffic and technical defects in the vehicle as reasons why the car was being driven so slowly. It is presumed that the car driver was driving slowly for reasons relating to health problems on her part. It was not possible to determine whether the van driver had been distracted or if there was some other reason why he did not react to the car, which he should have been able to see from far away and in plenty of time.

Avoidance measures, mitigation of consequences/ strategy for road safety measures:

The accident would have been avoidable for the van driver if he had been paying the requisite amount of attention while using the road. An automated emergency braking system that is effective at the relevant speeds would have mitigated the consequences of the accident; an advance collision warning system may have been able to prevent the accident entirely.

The accident would have been avoidable for the senior citizen if she had either been driving at a speed suited to the prevailing visibility and road conditions or had steered her vehicle onto the hard shoulder. Regular health checkups, an honest appraisal of one's own abilities, and listening to advice from family and friends regarding one's ability to drive safely can help with such situations.



1 Sketch of the collision position

2 Impact markings at the collision site, skid marks from the car and braking marks from the van (straight)

3 Damage to car

4 Damage to van

5 Impact of driver's backrest against the back seat as a result of the collision

Mix-up between brake and gas pedals

CAR HITS A PERSON GIVING DIRECTIONS WHILE REVERSING

Sequence of events:

A 79-year-old car driver was backing out of her driveway. Due to the poor visibility, she was receiving directions from a second person on the other side of the road to help with the backup procedure. The car (which had an automatic transmission) accelerated backward suddenly, hitting the person stood on the opposite sidewalk who had been helping the driver to back up. This person was crushed between the car and the wall of some steps.

Persons involved in the accident:

Car driver and pedestrian

Consequences/injuries:

The pedestrian was fatally injured.

Cause/problem:

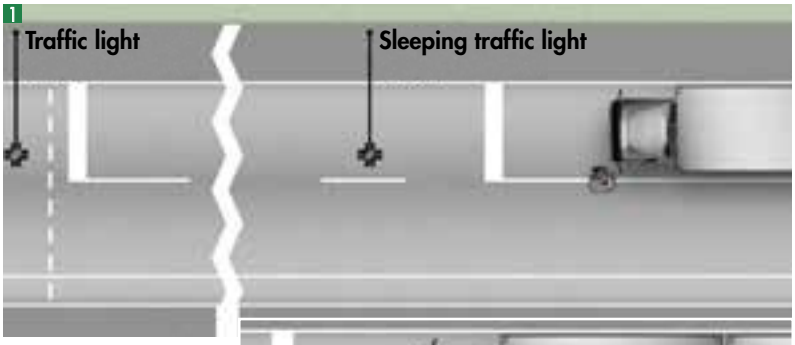
The technical inspection of the automatic car revealed no signs of any defects that could explain the sudden acceleration. Furthermore, the mirrors were set correctly and it was possible to activate the vehicle backup camera, so the driver should have been able to see both the wall and the person helping her to back up. It is presumed that either the 79-year-old driver mixed up her brake and gas pedals, or her foot slipped off the brake pedal while she was backing up.

Avoidance measures, mitigation of consequences/ strategy for road safety measures:

Regular health checkups, an honest appraisal of one's own cognitive and physical abilities, and listening to advice from family and friends regarding one's ability to drive safely can help with such situations.

People providing directions to maneuvering vehicles or helping to keep them safe should never stand directly behind or in front of the vehicle in question.

1 Sketch of the collision position
2 Poor visibility at the driveway
3 Collision position
4 Damage to car
5 View in vehicle backup camera
6 View in left side-view mirror



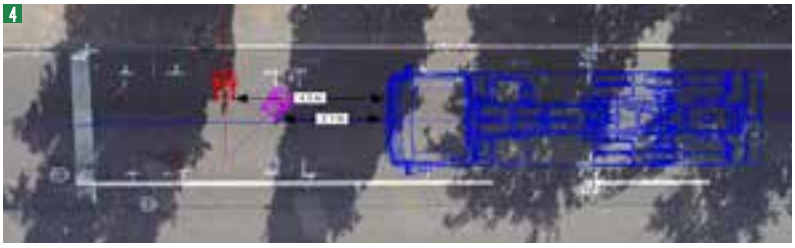
1 Sketch of the collision position

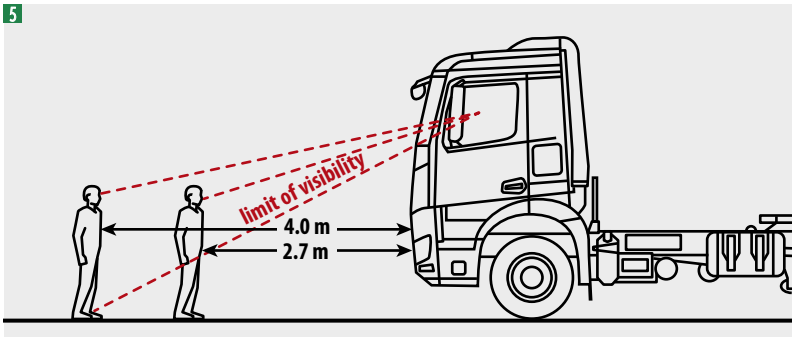
2 Sleeping traffic light and pedestrian light during road use

3 Final position of the rollator

4 Potential positions of the pedestrian and routes taken as the truck set off

5 View of the potential positions of the pedestrian from the truck when setting off





Confusing infrastructure

TRUCK HITS PEDESTRIAN WITH ROLLATOR

Sequence of events:

The driver of a truck-trailer combination was approaching a pedestrian crossing with traffic lights in a built-up area. About 50 meters before this pedestrian crossing, on the truck driver's side of the road, was a sleeping traffic light designed to help with the flow of traffic. The driver stopped before reaching this light. When setting off again, the driver did not notice an 80-year-old pedestrian with a rollator who approached from his right and started to cross the road approximately 2.7 to 4 meters in front of the truck. The truck hit the pedestrian and ran him over with the front left wheel.

Persons involved in the accident:

Pedestrian with rollator and truck driver

Consequences/injuries:

The pedestrian was fatally injured.

Cause/problem:

The sleeping traffic light is positioned about 50 meters ahead of the pedestrian crossing, and activates frequently to allow pedestrians and cyclists to cross the road. These users also use the space between the sleeping traffic light and the crossing itself to cross the road. This action is encouraged by the fact that this is the direct route between the train station and the bus stop. Even though he was crossing incorrectly, the pedestrian should have been visible to the driver if the driver had been looking properly.

Avoidance measures, mitigation of consequences/ strategy for road safety measures:

When installing crossing aids for pedestrians, care must be taken to ensure that these allow pedestrians to follow their most logical route as directly as possible. Diversions are generally avoided because they make life harder, especially for people who have difficulty walking. If the prevailing conditions at the site in question do not allow for the construction of a direct route, safety measures such as railings must be considered. Before crossing the road, people who have difficulty walking should take particular care to ensure that other road users have seen them.

The accident would have been avoidable for the truck driver if he had been paying the requisite attention to the road when setting off from the traffic light.

Following the accident, the police set into motion concrete plans for a safer redesign of the crossing (see page 62).

CAR HITS PEDESTRIAN WITH ROLLATOR

Sequence of events:

The driver of a car was driving through a 30 km/h zone in a built-up area in winter temperatures. He hit a 77-year-old pedestrian walking along the right-hand edge of the road with a rollator, in the same direction as he was driving. The pedestrian was walking next to the sidewalk, on the road itself.

Persons involved in the accident:

Car driver and pedestrian with rollator

Consequences/injuries:

The pedestrian was fatally injured.

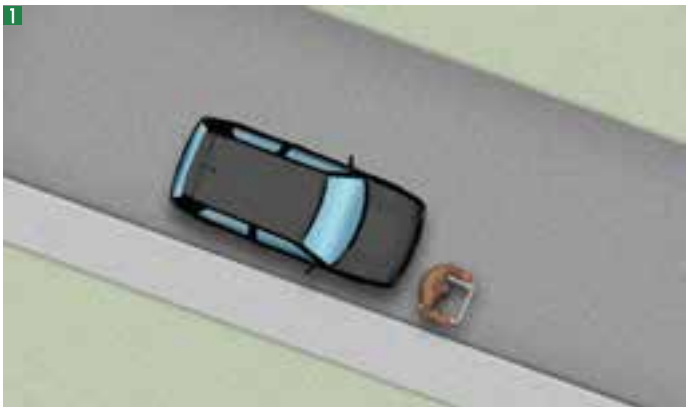
Cause/problem:

At the time of the accident, parts of the sidewalk were covered in frost. The sidewalk was also in poor condition (the surface was damaged). As a result of this, the senior citizen in question clearly felt safer walking on the road. This also meant he didn't have to navigate curbs with his rollator. Furthermore, there are clear indications that the car driver's visibility was impaired due to his windows being fogged/iced up.

Avoidance measures, mitigation of consequences/strategy for road safety measures:

Better maintenance of the sidewalk infrastructure (repairs to the surface damage) and changes to the winter road maintenance program would have made the sidewalk safer for the senior citizen and enabled him to use it without putting himself at an increased risk of falling.

For the car driver, the accident would have been avoidable if his visibility had not been impaired by fogged up and iced up windows. An automated emergency braking system with pedestrian recognition could potentially have prevented the accident if the sensors had not been impaired by the iced-up windows.



1 Sketch of the collision position

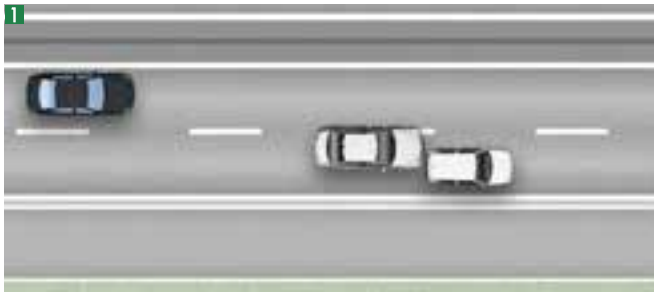
2 Overview of the accident site

3 Poor condition of the sidewalk (more frost present at the time of the accident)

4 Final position of car and part of rollator

5 Close-up of part of rollator

6 Damage to car



1 Sketch of the collision position

2 End position of the two cars primarily involved in the accident

3 End position of and damage to the car that braked suddenly

4 End position of and damage to the first car to crash into the braking car

5 End position of and damage to the second car to crash into the braking car

Driver overwhelmed by navigation system

MULTI-CAR COLLISION ON FREEWAY

Sequence of events:

The 74-year-old driver of a car was driving in the right-hand lane of a two-lane freeway at night. As he approached a junction, he slowed down suddenly. Despite initiating emergency braking procedures, the driver of the car behind him drove into his tail. The crash caused the second car to flip over. A third car approaching from behind also collided with the first car, despite initiating emergency braking and taking evasive action.

Persons involved in the accident:

Three car drivers

Consequences/injuries:

The driver and passenger of the car that braked suddenly and the driver of the first car to crash into them sustained severe injuries. The driver and passenger of the third car suffered minor injuries.

Cause/problem:

The analysis of the mobile navigation system in the car that braked suddenly showed that the driver had already covered 250 km, that the device was running on an outdated set of maps, and that the system had provided instructions to turn off the freeway that did not match the infrastructure at the site of the accident. It is probable that the driver was confused by the misleading instructions and had braked suddenly in order to work out which way to go. The driver of the second vehicle was unable to brake in time because he had either been driving too close to the first vehicle or not been paying sufficient attention.

Avoidance measures, mitigation of consequences/ strategy for road safety measures:

Satnav systems need to be kept up to date, as incorrect or unsuitable instructions can confuse and distract drivers, especially at complex junctions. At the same time, however, all drivers must take care to ensure that the instructions provided by their navigation systems do not lead them to engage in dangerous driving maneuvers. When planning a route, care must be taken to ensure that the journey does not exceed the maximum distance suitable for the driver's physical abilities, that regular breaks are taken, and that older people in particular avoid driving at dusk and in darkness whenever possible – especially on unfamiliar routes.

The accident would have been avoidable for the drivers of both the second and the third cars if they had been paying the requisite attention when using the road and/or maintained a safe distance from the vehicles in front of them. An automated emergency braking system that is effective at the relevant speeds would have mitigated the consequences of the accident; an advance collision warning system may have been able to prevent the accident entirely.

Car driving in wrong direction on freeway

HEAD-ON COLLISION BETWEEN TWO CARS

Sequence of events:

While driving on a freeway in the dark, the driver of a car wanted to overtake a truck-trailer combination as the two vehicles traversed a gradual bend to the right. As he pulled up alongside the truck, another car came toward him in the wrong direction, driven by a 79-year-old. Despite taking evasive action, the two vehicles collided head-on in the left-hand lane. Both cars were sent into a spin, before colliding with the truck and the concrete reservation respectively.

Persons involved in the accident:

Two car drivers and one truck driver

Consequences/injuries:

The drivers of both cars sustained severe injuries.

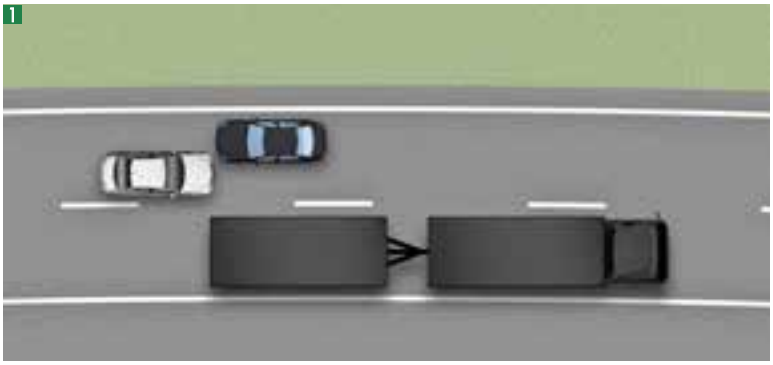
Cause/problem:

The driver of the car that was going in the wrong direction had visited a service station prior to the accident. It was not possible to determine why he drove onto the freeway in the wrong direction. The service station was located on the side of the southbound lanes. The traffic routing system within the grounds of the service station was ring-based. This layout, which is unusual for a German freeway, combined with the lack of sufficient signage, increases the risk of cars pulling onto the freeway in the wrong direction.

Avoidance measures, mitigation of consequences/ strategy for road safety measures:

At the time of the accident, it was dark and the weather was dry. It was the early hours of the morning, and the traffic volume was low. When combined with the unusual traffic routing system, this makes it likely that the senior citizen in question had not seen the turn-off that would have taken him onto the freeway in the right direction. Clear traffic routing systems with clear signage offer great potential for preventing this type of accident.

Regular health checkups, an honest appraisal of one's own cognitive and physical abilities – particularly with regard to seeing in the dark – and listening to advice from family and friends regarding one's ability to drive safely can also help to prevent these kinds of accidents. In future, Car2X and Car2Car systems will also potentially be able to provide real-time warnings in good time to prevent such mistakes.



1 Sketch of the collision position
2 Overview of the accident site
3 Car that had been driving in the wrong direction
4 Car that had collided with the car driving in the wrong direction
5 Wreckage, skid marks left by vehicle coming to a stop
6 Service station, starting point of journey in wrong direction

Efficiently Minimizing the Potential for Risk

Due to the physical and cognitive changes that come with age, senior citizens using the road find it harder to handle certain situations than they did when they were younger. Examples of such situations include changing lanes while overtaking, situations that are difficult to assess at junctions, turning maneuvers, conflicts on the road, and situations that require interaction with other road users. However, these drops in performance do not necessarily make senior citizens worse drivers; they can be compensated for in a number of ways, such as avoiding risky traffic situations and adopting a more defensive driving style. Specialized driving training courses and practical evaluations accompanied by experts can also help people to drive more safely.

People highly value having a driver's license in our society – which is especially true for older drivers. It provides individual mobility in many areas of life, and is a symbol of vitality, independence and the joy of driving. Its importance to a person's identity becomes particularly clear when an older driver's license is revoked: they feel "robbed" of an important document, and sometimes like they are "not a complete person anymore."

Studies have shown that even younger drivers tend to think of losing the right to drive as a traumatic experience – even more so than divorce, separation or unemployment. Typical negative consequences that older drivers can experience after losing their driver's license include symptoms of depression, and a deterioration in health and life satisfaction as a result of reduced social contact.

At the same time, the demographic shift represents an enormous challenge to the transport community. In most OECD (Organisation for Economic Co-operation and Development) coun-

tries, such as the USA, Canada, Japan, Australia, France, Italy and Germany, senior citizens are the fastest growing demographic of the population. According to the most recent UN population data, which was published in 2017, there will be more than 300 million people in the world aged 80 or over by 2040. By way of comparison, there were just 54 million in 1990, and 126 million in 2017. Likewise, senior citizens are the fastest growing group among driver's license holders in all industrialized countries, including Germany. As life expectancy increases, more and more older drivers are using the roads.

The desire to provide lifelong mobility in order to help senior citizens remain independent, take active part in society, and enjoy a high quality of life is directly at odds with the fact that the number of traffic accidents caused by people aged over 65 has been rising steadily for the past 20 years, thus presenting politicians and safety experts with an almost insurmountable dilemma. In order to prevent the aforementioned negative impact of losing one's driving license, older drivers need to be able to remain mobile for as long as possible and be assisted in this aim. At the same time, however, the government has a duty of care to the transport community in general, and cannot subject other road users to unnecessary and avoidable risks.

The key to devising effective road safety measures lies in reliably identifying which drivers can be presumed to represent a particularly high potential risk to all road users. A methodical approach to assessing this risk can be adopted by analyzing typical driver errors and causes of accidents, as well as typical age-related developments and changes in heath circumstances. This can provide us with important starting points for examination and consulting measures (enforcement/education) and networked design solutions (engineering).

THE POTENTIAL RISKS OF OLDER DRIVERS

As reported in the Accident Statistics chapter of this report, the official figures from the German Federal Statistical Office show that older people are involved with a high number of accidents relative to the short distances they travel compared to younger people. In addition to this, drivers aged 75 and over are often the main cause of road accidents in which they are involved. However, older drivers are more likely to use city roads and ordinary highways, on which accidents are more common, rather than freeways. They are also more susceptible to more serious injuries than younger or middle-aged road users when involved in the same kinds of accidents. Even minor injuries are more likely to be fatal for older people than for younger people, as the typical patterns of injury for the two age groups differ: for example, older people are more likely to suffer fractured hips or thoracic trauma.

Various studies have proven that complex road environments in particular can sometimes represent a huge challenge to older drivers. Such situations are made even more difficult when they involve junctions that are difficult to navigate or points where several different transport systems meet. This is also reflected in the results of extensive driving behavior surveys among older drivers, which indicate that navigating junctions and turning right and left are particularly dangerous situations for this demographic. It was also noted that senior citizens displayed unusual driving behavior when encountering cyclists and pedestrians, and tended to drive too fast when turning corners.

MAINTAINING MOBILITY IS A TOP PRIORITY

For Germany, the figures from the Federal Statistical Office paint a clear picture regarding accidents involving senior citizens as road users in 2019. According to these statistics, senior citizens were more frequently accused of ignoring rights of way when driving a car than under-65s (17.3 percent compared to 10.9 percent). "Making a turn, turning around, reversing, entering traffic, and driving off" was the next category, with 16.7 percent compared to 11.9 percent. Among older pedestrians, the most common cause of accidents was "incorrect behavior when crossing the road" – at 78.5 percent; more than one in five of the older pedestrians included in the statistics had been accused of this. In almost two thirds of the cases (63.3 percent), the prob-

19 Mistakes Made by Car Drivers per 1,000 People Involved in Accidents Resulting in Personal Injury in 2019, by Age Group (Selection)

	15 – 17	18 – 20	21 – 24	25 – 34	35 – 44	45 – 54	55 – 64	65 – 74	75+
Total mistakes made by drivers	830	832	745	656	602	575	615	710	876
Driving ability	149	48	51	46	39	29	32	39	58
- Under the influence of alcohol	108	25	30	29	25	17	15	11	5
- Drugs and narcotics	30	9	8	7	6	2	1	1	1
Incorrect use of the road	23	39	28	23	20	18	24	30	44
Failure to adjust speed	216	185	134	87	62	46	43	41	50
Distance	71	146	153	132	105	93	84	79	98
Overtaking	7	22	21	18	18	17	19	23	28
Right of way	67	111	93	100	106	112	129	156	190
Mistakes when making a turn	51	72	61	62	66	69	77	93	102
Mistakes when entering traffic and driving off	11	22	26	27	30	31	32	39	40
Incorrect behavior towards pedestrians	18	19	19	23	27	32	41	53	70

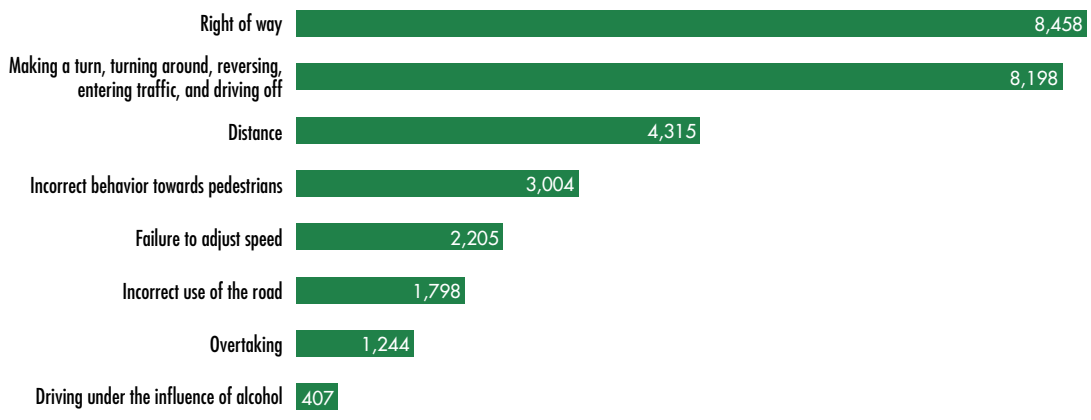
Source: German Federal Statistical Office

lem was "crossing the road without watching for traffic" (Figures 19 and 20).

There are a variety of possible reasons for making these kinds of mistakes when using the road, and in terms of preventability they range from "human errors," due to being mentally overwhelmed for example, to "deliberate disregard for the rules." The extent to which personal responsibility can be attributed for such situations can be determined more clearly by assessing the driver's information processing abilities – e.g. their perception and their cognitive and motivational processes – in combination with their capacity to act appropriately, which includes their application of the regulations and their control of their vehicle. Even if an older driver accepts the rules of the road in principle, they may still find themselves overwhelmed by difficult situations on the road, which can lead them to tend toward unsafe driving behavior.

Experts attribute the main cause of mistakes made by older drivers to the deterioration in per-

20 Mistakes Made by Senior Citizens (65+) When Driving a Car in 2019



Source: German Federal Statistical Office

formance that results from medical conditions and the biological aging process. The biological aging process affects everyone, regardless of any other medical conditions they may have, and is generally discussed in terms of cognitive and physical deficits. One aspect of the physical changes related to aging is a reduction in physical mobility; this manifests itself particularly as limitations in the ability to rotate one's neck and upper body, which can lead to problems at junctions and when turning.

The cognitive changes associated with aging mainly take the form of deterioration in a person's selective and divided attention, a decrease in the speed at which they process information, which in turn leads to slower reaction times, and the person requiring more time to carry out multiple activities. Age-related limitations in these cognitive processing resources affect the volume and complexity of information a person can handle at any one time, thus making the same driving task more strenuous for them to handle than it would be for a younger person. This, in turn, overloads older people more quickly in the form of tiredness and mental stress. This makes it harder for them to act according to the regulations and appropriately for the respective traffic situation, especially at complex junctions, at points with different rights of way, and when turning. This goes some way to explaining why older people are more prone to accidents, especially in these types of situations on the road. The ability to correctly judge speeds and distances also decreases with age.

DETERIORATION IN PERFORMANCE CAN LEAD TO MISTAKES WHEN DRIVING

Mar Cogollos
Director of AESLEME (The Association for the Study of Spinal Medullary Lesions)

Older People as Drivers

Our objectives in terms of road safety are closely linked to a social awareness of the main risks that need to be avoided in order to prevent road accidents (distractions, speed, alcohol and drugs, as well as peer pressure among younger people and a refusal among older people to acknowledge the loss of their own abilities). While it is true that, generally speaking, these risks apply equally to all road users, experience has shown us that dividing up informational and road education campaigns based on certain factors is essential if we want to maximize our chances of achieving the goal we have set ourselves – to establish personal and societal awareness of the problem.

One of the most important factors in this type of classification is the age of the road users. The reasons for this are obvious: when we are 19, we don't perceive risks in the same way that a 60-year-old would; our physical and cognitive condition as a 25-year-old is not the same as it is when we reach the age of 70; and a 50-year-old possesses more experience than an 18-year-old.

For the over-60s group, who we work with in our "Safe and protected mobility" campaign ("Desplázate seguro y protégeles"), the main challenge is making them aware of their role as grandparents. As many of this age group are in charge of taking their grandchildren to school (on foot or by car), they need to be aware that they are role models for the younger generation and must make safety their top priority at all times. However, the key task is to make them aware of the risks they are exposed to as car drivers when their abilities start to deteriorate. Of course, it goes without saying that we also understand how important cars are to the independence of those in this age group. As such, it is essential that we encourage older drivers to take the initiative to impose limits on themselves, such as not driving at night, not exceeding a certain mileage or number of car journeys within a given time frame, not taking passengers with them, or even giving up driving completely if this is necessary to protect themselves and other drivers, pedestrians, cyclists and passengers (family members, grandchildren, etc.).

By law, of course, older citizens are allowed to drive if they pass a test at an examination center (Centro de Reconocimiento, CRC). All we can do is heighten awareness and provide recommendations. At this point, it is also important to note that European regulations have lengthened the extension periods for this age group: while Spanish regulations previously required drivers over the age of 65 to renew their driver's license every two years, they are now only required to do so every five years.

Here at AESLEME, we believe that screenings need to be both more frequent and more thorough for drivers over a certain age. As such, we are continuing to ask people who visit a CRC to bring a report from their GP listing any illnesses or medical conditions they have. This is because of the effect that certain medications have on a person's fitness to drive (we are aware that this is an issue in terms of data protection law, but there appears to be no drive to find a solution to this issue at this time).

Together, we can all help to make our roads safer to use by observing the regulations, adapting our driving style according to our skills and abilities and, most of all, by being aware of the risks involved and the fact that any one of us could end up being the victim of a road accident.

Heart attacks at the wheel can have severe consequences both for the driver themselves and for all other road users

AN UNFORTUNATE COMBINATION OF DIFFERENT HEALTH-IMPAIRING FACTORS

In addition to the aforementioned normal changes that come with age, chronic illnesses also become more common as we get older. Examples of such conditions include cardiovascular diseases, diabetes mellitus and musculoskeletal conditions, all of which can impair a person's suitability to drive even without the added complications of aging. In addition to this, an intact sense of perception and good vision (usually defined as at least 70 percent in both eyes) are particularly important for road safety, and thus to anyone who wants to be allowed to drive a car. After all, it is estimated that our eyes are responsible for recording 90 percent of all traffic-related information. The problem, however, is that vision deteriorates with age – on average, a 61-year-old will possess 74 percent of the visual acuity of a 20-year-old, and an 80-year-old just 47 percent. And because problems with mesopic vision tend to develop gradually over the course of many years, older drivers often fail to notice them. Experts estimate that the mesopic vision of 22 percent of 60 to 69-year-olds and 34 percent of people aged 70 and over is impaired to such an extent that they are unable to drive safely at night for this reason alone.

RISK OF ACCIDENTS POTENTIALLY HIGHER FOR PEOPLE WITH MULTIPLE CHRONIC MEDICAL CONDITIONS

Like the visual senses, a person's acoustic senses also deteriorate with age. The risk of hearing loss increases as a person gets older. This is problematic in terms of road safety, especially when combined with multisensory deficits (vision, sense of balance, dizziness in old age). Many older drivers have multiple chronic conditions, including those that affect their metabolism – for example, it is not uncommon for an overweight senior citizen with high blood pressure to also suffer from diabetes. People with all types of diabetes can experience severe drops in performance if they suffer pronounced complications, such as visual impairments or paralysis as a result of a stroke. Type-2 diabetes must be regarded as a risk factor for cardiovascular diseases. Certain types of diabetes can lead to secondary conditions that affect the eyes, kidneys, nerves, and the blood vessels in the heart, brain and legs, which in turn lead to functional limitations.

In a study on the health of older drivers and its effects on road safety, a systematic analysis of 400 case studies archived by the Driver's License Office in Dresden, Germany, identified a number of risk factors found among drivers aged 65 and over who had displayed unusual driving behavior. The results of a government-prescribed driving suitability test were used to draw up a risk assessment. According to this, the probability of a negative result increased if the driver was older than 80, suffered from dementia or multimorbidity, or had been involved in a complex accident. However, individual conditions relating to eyesight, restrictions to movement, kidney conditions, diabetes or cardiovascular disease did not increase this probability. This could be partly due to the fact that there are suitable strategies in place to help people manage such conditions, and that positive personality traits commonly found in older people, such as conscientiousness, presumably increase the probability of them complying with doctor-patient treatment programs. This means that it is not the diagnosis of a medical condition itself that characterizes a car driver, but rather how they deal with that diagnosis. Incidentally,

the same also applies to temporary illnesses, regardless of how severe the symptoms are.

In addition to the typical deterioration in performance that comes with aging and limitations imposed by medical conditions, the effects of medication can also permanently reduce a person's ability to drive safely. In Germany, the Drug Prescription Report (Arzneiverordnungsreport) for 2017 showed that every person with insurance over the age of 65 took 3.9 doses of different medications per day on average (for people over 80, the figure was even higher at 4.6), and that older patients were particularly at risk of suffering undesirable side-effects. At the same time, older people are particularly likely to be prescribed benzodiazepines and medications that, although beneficial for countering sleeping problems and alleviating anxiety and restlessness, also come with a significant risk of addiction. Taking benzodiazepines for an extended period of time can lead to general cognitive deficits that are not fully reversible. The undesirable effects of such medication are indisputably relevant to the issue of road safety, and range from tiredness, lethargy and drowsiness to conditions that affect psychomotor functions such as reaction time and concentration.

In addition to this, older people are at increased risk of developing conditions that cause chronic pain, such as diabetic polyneuropathy, osteoarthrosis and tumor diseases. These conditions are often treated using narcotic painkillers, which can generate undesirable side-effects similar to those listed above. Consuming alcohol in addition to such medication, even in small amounts, can exacerbate the problem further and lead to unpredictable results.

According to the results of a survey conducted several years ago, another medication-related issue is the fact that older men are particularly likely to underestimate the potential risks of taking medication on their ability to drive safely. In light of this, it would seem that we need to raise awareness of this problem in order to improve people's self-control. This is a task that would be well-suited to general practitioners with the appropriate qualifications and training, for example.

POSSIBLE COMPENSATION STRATEGIES

Many older drivers are able to adapt their driving behavior to suit the deteriorating performance in their physical, cognitive and executive functions, particularly by implementing compensation strategies. There are two aspects to this. Firstly, the drivers in question start to avoid certain situations, such as driving in the dark, rush hour in towns and cities, busy roads, driving in poor weather conditions, and situations where the surroundings are difficult to assess. Secondly, they also reduce their speed in the respective situa-

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Driving with Dementia

Dementia leads to increasing deterioration of functions, some of which are closely linked to a person's fitness to drive. As a result, the risks associated with driving with dementia are high. The law on permission to drive in Germany states that persons with severe dementia and who have undergone drastic changes in personality as a result of aging processes can no longer fulfill the requirements for driving a motorized vehicle safely. According to the same law, however, persons with minor dementia who have not undergone changes in personality are still permitted to drive.

There is a consensus among scientists that moderate-to-severe and severe dementia preclude a person from being able to drive a motor vehicle safely. Whether or not risks pertaining to driving occur at the minor stages of dementia depends on the etiology of the respective dementia syndrome. For instance, people with early-stage Alzheimer's seem more able to continue driving than people with other forms of dementia (such as vascular and frontotemporal dementia), which can result in a much earlier loss of fitness to drive. One thing that is clear is that people with dementia will inevitably lose their fitness to drive at some point during the progression of the disease, and should thus give up driving sooner rather than later.

Fitness to drive should be checked as early as possible in the progression of the disease. This should be done in the form of a multidisciplinary, multifactorial test that also includes a practical observation of the person's driving behavior in an on-road situation. If the assessment of a driver with dementia confirms that they are still fit to drive, they must have regular follow-up checks every six to twelve months due to the advancement of their cognitive deficits caused by the disease.

When drivers with dementia are no longer fit to drive, they should be provided with empathetic support when it comes to giving up driving. Experience has shown that this can help counteract the psychosocial problems that are normally associated with someone having to give up their driver's license. These problems include limitations to the person's mobility, autonomy, function, participation in social activities, and mental health. The persons in question should be offered support at an early stage, for example by organizing alternative forms of mobility for them.

From a clinical perspective, it is important to inform drivers with dementia of the risks that their illness presents to road safety, and the fact that it will definitely render them unfit to drive at some point in the future. A failure to do this can be deemed malpractice. Furthermore, this advice should always be documented. Physical, mental and social activities are considered particularly important, as they help to prevent the onset of dementia.

Even though the problem is more widespread among other age groups, senior citizens are repeatedly found to be driving under the influence of alcohol when pulled over by police

tions, maintain greater distances to other vehicles for safety, and generally adopt a more defensive driving style. They may also use assistance systems to help them park and keep a safe distance to other vehicles.

However, there is still some question as to how realistic senior citizens are in judging their deteriorating performance, and thus to what extent they are able to consciously compensate for it. The literature contains contradictory results on this issue. While some experts claim that older drivers are good judges of their own abilities and behave responsibly, others believe that they do not see themselves as a risk factor, or that they consider themselves to be as good as or better than other drivers of the same age – what is known as the "better than average" effect. Such distortions of the way older drivers see themselves and judge their own abilities are likely one of the reasons why older drivers hardly ever give up driving voluntarily, even when there are deficiencies in their performance. Instead, they refuse to reassess their mobility behavior until they experience a critical event – such as an accident, being stopped by the police, or taking a suitability test assessed by the driving license authorities.

Drivers who have multiple medical conditions or severe limitations with respect to performance, or suffer side-effects from medication or combination effects may find their options limited in terms of compensation strategies. In cases where limitations on performance due to medication or medical conditions are combined with deficits in the driver's personality, such as a refusal to take the problem seriously or irresponsible behavior in response to information and advice provided by their doctor, the driver becomes a dangerous risk to road safety.

ASSESSING SUITABILITY FOR DRIVING

This combination of risk factors increases the probability of senior citizens displaying unusual driving behavior or becoming involved in accidents. However, in some countries, such as Germany, events such as this can lead to a driver being required to complete a driving suitability test. Tests like this are aimed primarily at ensuring that drivers meet the minimum physical and cognitive requirements for driving a motor vehicle safely.

Assessors at the driving license authorities evaluate these tests based on the opinions of experts such as doctors and psychologists who specialize in driving and traffic situations. The suitability requirements are tested and evaluated from a professional perspective before being compiled to make a report. This expert assessment provides an important basis for the driving license authority in question to determine the extent to which a driver represents a potential risk to other road users and decide whether or not the driver can keep their license.

Any administrative action taken is based on the facts at hand and their evaluation by the administrative authority in question. The word "facts" is used here in the legal sense, i.e. facts and circumstances that have actually been observed, rather than simply assumptions or speculation. Generally speaking, these take the form of unusual driving behavior or apparent errors while using the road, such as driving unusually slowly, unusual types of accidents, or odd behavior/observations when a driver is pulled over by traffic control officers. Concerns regarding a person's suitability to drive cannot be raised based on their age alone. It would also be just as inappropriate to make such a call based solely on knowledge acquired from the authorities regarding whether the driver in question wears a hearing aid, or the fact that they are a diabetic but follow their doctor's orders and have good control over their metabolic state, for example.

Whether or not a fact is relevant to a person's suitability to drive is determined using a carefully considered decision-making process, and can only be decided upon by the person responsible for applying the law – usually the qualified assessor employed by the driving license authority. Annex 4 of the German Driver's License Regulations (FeV) lists medical conditions and factors that affect a person's suitability to drive, as well as grounds for inclusion and exclusion in reaching a positive decision on driving suitability. The medical conditions listed in the FeV include visual and hearing impairments, limitations in movement, cardiovascular diseases, diabetes mellitus, kidney diseases, nervous system disorders (e.g. Parkinson's disease, epilepsy), mental disorders, alcohol, narcotics, and other psychotropic substances and medications.

In concrete terms, it is the degree to which a driver's performance is restricted, the type, severity, progression and treatment of their illness, and the strategies that can potentially be used to compensate for it that form the framework for the verdict, in addition to any other relevant risk factors. The facts relevant to the person's suitability to drive are usually obtained from the police, the courts and district attorneys. However, private individuals and doctors who have treated the person in question can also report any doubts regarding the person's suitability to drive to the driving license authorities.

A study of drivers aged 65 and over who had displayed unusual driving behavior showed that 85 percent of all cases led to the driver giving up their license or having it revoked. These drivers were also notable for being at the older end of the scale and suffering from multiple medical conditions. In cases where an accident had occurred, the driver in question was assigned the primary fault for the accident during the course of the police investigation, at least on a preliminary basis. The high number of drivers in this study who gave up their own license – around 70 percent – is also noteworthy. Only a small number of the cases included in the study had been reported by doctors, family, courts or attorneys. Most of the cases where doubt had been cast on a person's suitability to drive were reported by the police. The majority of these reports were submitted following a traffic accident. Furthermore, there were indications of some form of dementia in around one in five of the cases included in the study. It was not possible to dispel the doubts regarding the person's ability to drive in any of these potential dementia cases.

AGE-BASED EXAMINATIONS IN DIFFERENT COUNTRIES

Like Belgium, France and Sweden, Germany is one of the countries that has thus far not required driver's licenses for cars or motorcycles to be renewed, though this is now changing. The German Driver's License Regulations now state that driver's licenses issued after January 19, 2013, are valid for a period of 15 years, and older driver's licenses must be replaced by January 19, 2033. Limited-term licenses whose extension is contingent upon health checkups are issued for drivers of trucks and buses in license classes C1, C1E, C, CE, D1, D1E, D and DE, and also for drivers of taxis and rental cars used for passenger transport. In such cases, the driver's license is limited to a maximum term of five years, and is only issued to drivers who can prove that they meet special requirements with regard to their physical and cognitive suitability for the job.

OLDER DRIVERS OFTEN DO NOT SEE THEMSELVES AS A RISK FACTOR

There are no standardized rules at the European level for either medical examinations or the intervals required between them once a driver's license has been issued. In addition to this, some countries, such as Estonia, Finland, the UK and Ireland, check the effects of any medical condition that is subject to statutory disclosure – irrespective of the driver's age – in order to determine its relevance to the person's suitability to drive.

As a result of the situations outlined above, there are three different strategies with regard to the extension of driver's licenses and to how med-

ical conditions and typical age-related deterioration in performance are handled in the different countries:

1. The driver's license is valid for a fixed length of time, with no restrictions based on a person's calendar age. Accordingly, all holders of licenses issued on January 19, 2013, or later are subject to a 15-year limitation on the validity of their official document (driver's license for cars and motorcycles). The person's legal permission to drive is also extended at the same time that their documentation thereof (their driver's license) is renewed/extended. The EU member states that follow this model include Austria, Belgium, Germany and Poland.

THE APPROACHES TAKEN IN DIFFERENT EUROPEAN COUNTRIES FOCUS PRIMARILY ON ASSESSING A PERSON'S PHYSICAL AND COGNITIVE SUITABILITY

2. Driver's licenses are extended subject to a medical examination by (at least) one doctor, starting from a set calendar age threshold:

- Starting age 50: Italy
- Starting age 60: Portugal, Czech Republic, Luxembourg
- Starting age 65: Greece, Slovakia
- Starting age 70: Cyprus, Denmark, Finland, Ireland, Malta, Netherlands

3. Driver's licenses are extended – subject to a medical examination for all age groups (e.g. in Romania) – at periodic intervals, e.g. every ten years. The renewal period becomes more frequent as the driver's calendar age increases, and it is directly linked to medical examinations. For example, the frequency may increase from the age of 40 (Hungary), 60 (Lithuania) or 65 (Estonia, Spain).

An evaluation of scientific tests on the effectiveness of various screenings used to determine suitability to drive in different countries showed that, in European studies, the tests tended to have more of a negative effect on road safety – for both the general population and the respective senior citizens themselves. The tests correlated partially with an increase in the number of traffic fatalities among senior citizens using unprotected forms of transport, as restrictive measures can lead to older people using the roads more as cyclists or pedestrians, leaving them with less protection than they would have from a car. In addition to this, age-related screening among senior citizens often generates fear of the examination, as it can lead to people having to stop driving at a younger age and thus suffering a loss of mobility.

PROCEDURES IN SWITZERLAND, THE NETHERLANDS AND FRANCE

In Switzerland, the age for an obligatory medical check-up was raised from 70 to 75 on January 1, 2019. Drivers aged 75 and over must undergo a medical examination by a doctor of their choosing every two years; depending on the structure in the respective canton, this doctor may also be their GP. The person in question requires confirmation from their doctor that they are suitable to drive. They receive a letter from their canton when they are due to go for their check-up. From this point onward, they have three months to take the examination and submit the report from their doctor. The authority then uses this information as the basis for their decision on whether the person is suitable to drive. If necessary, the authority can mandate that the person needs to undergo another medical examination or complete a driving test. Likewise, the canton's authority can also limit driving permission for persons who are unable to meet the minimum medical requirements even when using compensation measures, rather than revoking their driving license completely. In such cases, the authority can set speed limits, specific regions or types of road, times of day (e.g. no driving at night) or vehicle types that the driver must use or observe, or mandate that they can only use specially adapted/customized vehicles.

The minimum medical requirements used to determine whether someone is suitable to drive are defined in Annex 1 of the Swiss Road Permit Regulations (Verkehrszulassungsordnung). Among other things, these regulations contain provisions on a driver's vision, neurological symp-

toms (no issues that impair consciousness or sense of balance), cardiovascular diseases (no risk of attacks, no significant anomalies in blood pressure), metabolic disorders (stable diabetes only), and organic brain dysfunctions (no dementia or similar symptoms). A failure to take the medical examination within the time frame provided can result in a person's license being revoked and not returned until they can provide confirmation that they have passed the medical examination and are suitable to drive.

In the Netherlands, the age for an obligatory medical check-up was raised from 70 to 75 in 2014. There are several steps to the process for extending a driver's license. Around four to five months before their license is due to expire, drivers must fill out a health declaration form (Gezondheidsverklaring). The form contains questions regarding restrictions to the driver's mobility and vision, any existing medical conditions and any medication they take. Once this form has been submitted, the driver receives an email with an invitation to attend a medical check up with either their GP or a specialist, depending on their health status. Once the check-up is complete, the doctor produces a report, which is sent to the Centraal Bureau Rijvaardigheidsbewijzen (CBR). One of the CBR's in-house doctors then assesses the information provided and evaluates the person's suitability to drive. This doctor may decide that an additional, more extensive examination is required. In addition to approving or rejecting a person's suitability to drive, the CBR can also issue a restricted approval. Restrictions may include a shorter term to the person's driver's license, a requirement that they use certain aids, such as glasses, or instructions that their vehicle must be converted in a certain way.

In France, there is no set threshold for when a medical check-up may be required. The reason given for this is that older drivers are involved in fewer accidents than drivers in other age groups. In addition to this, particular importance is placed on the mobility and autonomy of older people. The government also uses the lack of effectiveness of age-related tests as an argument for not making such tests mandatory. However, people must disclose any existing medical conditions they may have that are relevant to their suitability to drive, such as diabetes or epilepsy. If they fail to do so, they will be personally liable in the event of an accident. Their driver's license may also be revoked or not renewed.

In accordance with Article 221-14 of the French Road Traffic Act, family members are permitted to provide the authorities with information regarding a person's suitability to drive if they deem this to be necessary. Information on one's medical conditions and reports by family members must be submitted to the prefecture, which can prescribe an assessment based on their inspection of the facts at hand. The doctor determines a person's suitability to drive based on their physical, cognitive and sensory abilities, and can also carry out additional tests or seek advice from a specialist if necessary. Psychological evaluations must be conducted by a registered psychologist. The report remains valid for a maximum of two years, the driver's license for a maximum of five; the exact terms are defined by the authority for the respective département.

The examples show that the different approaches taken in different European countries are linked to the driver's calendar age, and focus mainly on assessing their suitability to drive based on their physical and cognitive performance. Not much consideration is given to assessing minimum theoretical or practical driving skills in a way that would give older road users the tools they need to maintain their mobility. In addition to this, there are no uniform standards for periodical health check-ups. There are stark differences between some of the countries in terms of the methods used to determine suitability (self-reporting, examinations, certification), the content and scope of the health check-up, the qualifications of those

In some countries, health and eye tests every few years are already a legal requirement for senior citizens

21 Overview of the Different Approaches Taken to Testing Suitability to Drive in Individual Countries (for People Who Already Possess a Driver's License)

Country	Age at first assessment	Renewal of driver's license	Procedure/regulations
Austria	No age threshold	License renewed every 15 years	
Belgium	No age threshold	License renewed every 15 years	No assessments
Bulgaria	No age threshold	License renewed every 10 years	No assessments
Croatia	70		Medical certificate
Cyprus	70	License valid for max. 3 years	Certificate from GP (incl. eye test) (Form TOM 153B)
Czech Republic	60	Valid until 65, 68 and every 2 years starting age 70	Examination by GP
Denmark	70	Valid until age 75, then new assessment required	Medical tests; if doctor is unable to confirm suitability to drive, practical driving test required Methods: Physical "functionality test," mini mental state examination (m-MMSE) Cognitive (clock drawing) test In case of cognitive weaknesses: Referral to GP, psychiatrist, geriatrician, neurologist for practical driving behavior evaluation
Estonia	Starting age 65	Up to age 65: Every 10 years (medical examination) Starting age 65: Every 5 years	Medical certificate issued by GP
Finland	70		Medical certificate (no older than 6 months)
France	No age threshold	License renewed every 15 years	No assessments, but points system used
Germany	No age threshold	License renewed every 15 years (Group 1 license)	No assessments, but points system used
Greece	65	Every 3 years (or earlier if recommended by doctor)	Two certificates of health (pathologist and ophthalmologist), plus "health booklet" or "report from a secondary medical committee"
Hungary[1)]	Starting age 40	Starting age 40: 10 years Age 40 to 59: 5 years Age 60 to 69: 3 years Aged 70 or older: 2 years	Examination by GP
Iceland	70		Regular medical examination
Ireland	70 (validity: 10 years for drivers under 60; until 70th birthday for drivers aged 60 and over)	Every 1 to 3 years	Certificate from doctor Certificate: Examination includes checks for visual and neurological limitations; deriving potential strategies for compensation, e.g. orthopedic recommendations or restrictions (e.g. only drive during the daytime, 30 km radius, speed limit)
Italy	50	Starting age 50: Every 5 years Age 70 to 80: Every 3 years Starting age 80: Every 2 years	Medical examination
Latvia[1)]	Driver's license must be renewed every 10 years	Starting age 60: 3 years	Examination by GP
Lithuania[1)]	60	Age 55 or younger: Valid for 10 years Starting age 60: Valid for 5 years Starting age 70: Valid for 2 years Starting age 80: Valid for 1 year	Examination by GP
Luxembourg	60	Age 70 or younger: Valid for 10 years Starting age 70: 5 years Starting age 80: 2 years	Medical certificate from GP or Société Nationale de Circulation Automobile (Exclusion criteria: Severe heart rhythm irregularities, narcotics or alcohol addiction, specific medications or combinations thereof)
Malta	70	5 years	Medical certificate (to be completed by doctor) Criteria: Vision, diabetes, neurological disorders, etc., plus recommendations for restrictions
Netherlands	70	(Up until this age, renewal required every 10 to 15 years without medical certificate) Starting age 70: Valid for max. 5 years Starting age 75: Medical certificate	Medical certificate from GP (vision, diabetes, kidney conditions, lung conditions, heart conditions, etc.)
Norway	80	Max. 3 years	Medical certificate from doctor Also: Doctors are legally required to report if a person will not be able to meet the health requirements for a driver's license for an extended period of time (min. 6 months)
Poland	No age threshold	License renewed every 15 years	
Portugal	60	Starting age 50: Valid for 10 years (No medical certificate required) Starting age 60: Every 5 years with medical certificate Starting age 70: Every 2 years	Medical certificate confirming physical and cognitive suitability to drive
Romania[1)]	License valid for 10 years	License renewed every 15 years	Psychological and medical certificate
Russia	No age threshold	License renewed every 15 years	
Slovakia	65	5 years	Medical certificate
Slovenia	80	Every 5 years	Medical certificate
Spain	65	Age 65 or younger: 10 years Starting age 65: 5 years	Medical and psychological examination conducted in a medical driving test center by an ophthalmologist, a psychologist and a GP
Sweden	No age threshold	License renewed every 10 years	
Switzerland	75	2 years	Medical examination of sight, hearing and general state of health As of 2020: Restrictions (certain routes/regions, speed limit)
Turkey	No age threshold		
UK	70	Every 3 years	Self reporting on health and vision (falsified information results in prosecution). Authority either decides on suitability to drive based on the information provided, or contacts a GP to arrange an examination or prescribes a driving test or eye test

[1)] No more recent information available for this country. Data taken from Europe Older Drivers 2015 Report, table on p. 40.

who determine suitability, and their position in relation to the driver (Figure 21). If the task of approving a person's suitability to drive is placed in the hands of their GP, this makes it difficult to maintain the principles of neutrality, independence and impartiality.

In addition to this, there are some countries that rely on certified organizations and others where the process of determining suitability is rooted in the country's general health system. In light of this, it is safe to assume that there is also significant variation in the rules that dictate how information and findings relevant to a diagnosis are consolidated into the final result. It does not seem clear to what extent the minimum requirements for these health check-ups as defined in Annex III of the European Driving License Directive are observed, especially since Point 5 of Annex III of this Directive permits the use of different regulations at the national level. Nevertheless, all EU member states are required to observe this EU directive and incorporate it into national law. However, the procedures currently being practiced should serve as a starting point for further harmonization, at least within EU member states.

CONDITIONS REQUIRED TO IMPLEMENT MEASURES FOR MAINTAINING INDIVIDUAL MOBILITY AND IMPROVING ROAD SAFETY

As indicated at the start of this chapter, the changes to the demographic pyramid and the fact that the percentage of younger people with driving licenses has increased mean that, in the long term, there are likely to be more senior citizens than ever behind the wheel on Germany's roads. One of the main challenges this presents is coming up with a way to help senior citizens retain their independent mobility while also minimizing the potential risks posed by older drivers. Experts recommend adopting a multi-pronged approach in order to prevent the apparent contradictions between these goals from becoming an issue. In addition to monitoring, advisory and certification measures (enforcement/education/examination), such an approach would also include design solutions (engineering; use of driver assistance systems) and integrative mobility concepts. Before we discuss these potential solutions, it is worth taking a top-down perspective of the factors and characteristics that place limitations on older drivers.

To start with, we need to differentiate between biological age and calendar age. While a person's biological age represents a diagnosis of their physical condition, their calendar age is based on their date of birth. There is no direct linear correlation between the two; the way different bodies age is too heterogeneous and affected by too many different factors. From the age of 35, arteriosclerotic processes start to affect the human vascular system, potentially impairing the performance of key organs. This natural change in the body determines a person's biological age, causing them to age faster or more slowly irrespective of their calendar age.

Due to the discrepancies between biological and calendar age, the different phases of aging are not defined according to the calendar, but are instead based on the abilities that the aging person still possesses in terms of various function and aspects of life. As a result of this, ever since the 1980s gerontologists have been more interested in a person's functional age, aiming to view aging as a developmental process with biological, social and cognitive components. The ICF system (International Classification of Functioning, Disability and Health) published by the World Health Organization (WHO) assesses overarching functions, abilities and resources, including factors relating to a person's personality, attitudes and habits. This offers a wider perspective for drawing conclusions on how a person manages their limitations.

Staying fit in old age significantly reduces the risk of an accident

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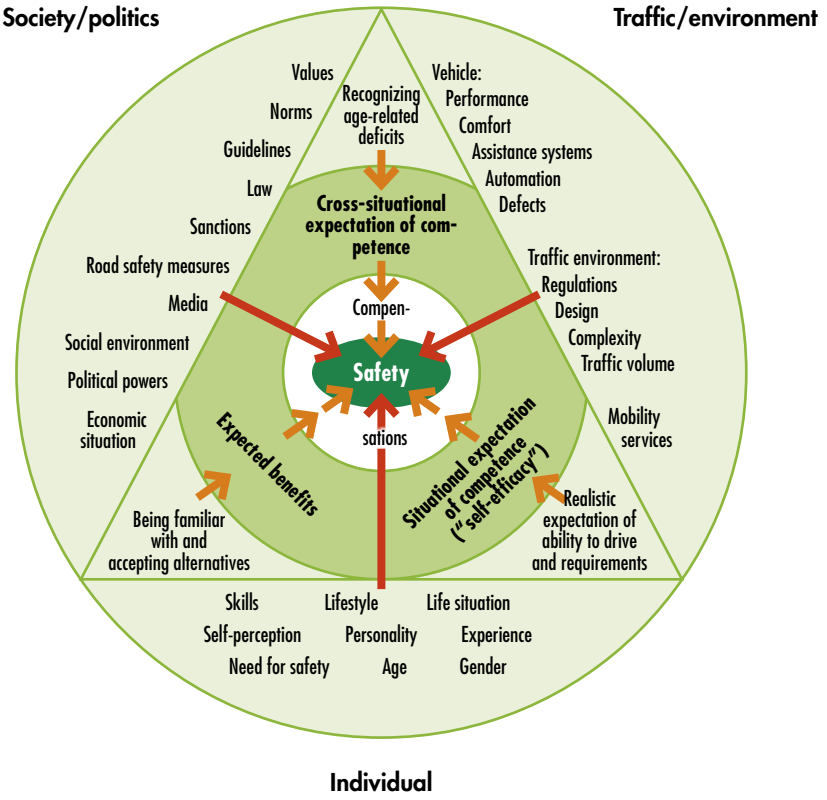
Road Use Behavior of Senior Citizens in Relation to Lifestyles and Life Situations

Safe mobility is a crucial prerequisite to the ability to fully partake in the social side of life. It improves health, quality of life and satisfaction with life among older people. As such, a key social concern is ensuring that older people can continue to use our roads safely for as long as possible – be it by car, bicycle, motorized two-wheeled vehicle, or as a pedestrian. Studies have shown that older people feel a strong connection to their cars. As a result of this, many older people will continue to get about using their cars in the future. Between 2008 and 2017, the annual mileage covered by car drivers aged 75 and over rose by almost 95 percent. Due to the demographic shift, it is expected that the number of accidents involving older people will also increase. This means that we need to act if we want to maintain and improve road safety for the older members of our population. The extensive evaluation research that has been conducted into this issue at an international level has led to one particular finding that is highly relevant: mandatory examinations of the physical and cognitive fitness of older car drivers in other countries have not led to improvements in safety for older citizens.

From a psychological perspective, the way road users behave is strongly shaped by a multitude of expectations and attitudes, some more conscious than others. These relate to how a person perceives their own abilities, the benefits that driving offers, the potential risks involved, and the potential reactions from their social environment (Figure 22). As shown in a study conducted by the German Federal Highway Research Institute, these expectations and attitudes form a noticeable risk profile that is typical for two lifestyle groups: "thrill-seekers" and "hostile characters" (together almost 33 percent of the population). This risk group is notable for the fact that they make up the highest percentage of persons involved in accidents and that, in part due to their highly positive perception of their own abilities, they have a pronounced emotional connection with their cars and are more likely to drive or cycle under the influence of alcohol. "Domestic characters," who are more likely to report health problems and impairments than other lifestyle groups, account for the lowest percentage of people involved in accidents. This group clearly demonstrates more pronounced compensation in their mobility behavior than the other five lifestyle groups.

Measures for improving the safety of older road users should take this finding into account and aim to alter the expectations and attitudes of older road users in order to make them more compatible with the requirements for safe mobility. From a psychological perspective, this can be achieved through various forms of safety communication (e.g. advice from GPs, awareness-raising campaigns), training courses and practical evaluations, while in terms of infrastructure, the design of the road environment and local aspects of traffic regulations and signaling systems can also play a role. Vehicle technology, such as driver assistance systems, are also helpful.

22 Factors That Influence the Safety of Senior Citizens When Using the Road



Source: Holte, H. (2018). Road Use by Senior Citizens

HOME

Limitations imposed by health conditions reduce mental and cognitive functionality, especially in people dealing with dementia, and losses relating to medical conditions dominate the functional age of those who suffer from them.

The gradual deterioration of sensory, cognitive and motor abilities and the associated limitations they potentially place on a person's mobility behavior often make it harder for older people to come to terms with these changes, to accept them, and thus to start considering the best ways to compensate for them. The aforementioned "better than average" effect plays a role here, but shame, placing a high subjective importance on owning a driver's license, and local mobility restrictions stemming from a lack of sufficient alternatives can also warp a person's judgment with regard to their own abilities. Nevertheless, a realistic assessment of one's overall situation is necessary in order to use the road responsibly. In principle, the success of training-based approaches and educational programs and the usage of alternative mobility concepts and technical aids, such as driver assistance systems, is defined by whether or not participants recognize and accept the usefulness of such services, and whether they are fundamentally prepared to move away from their old way of doing things.

PRACTICAL EVALUATIONS OFFER A WAY FORWARD

So how can the state of play with older drivers be incorporated into traffic policy and strategy perspectives and the actions required in order to improve road safety? First and foremost, it is important to note that older car drivers are not a special risk group per se when compared to younger motorists. Most senior citizens are able to compensate for their age-related sensory, cognitive and motor deficits by using their experience and adopting a defensive driving style.

However, there are signs that the number of unreported cases of older drivers who have either partially or completely lost the ability to drive safely is rising steadily. In light of such developments, we need to come up with solutions that are standardized and fair while also being proportionate and transparent. This was also the general tenor among Work Group III ("Senior citizens as road users") at the 55th conference of the German Council on Jurisdiction in Traffic, which was held in Goslar at the start of 2017. The work group argued that older drivers need to be given the tools to take responsibility for themselves and make sure that they check in good time whether they need to adapt to changes that might affect their ability to drive safely – and if so, how.

Deterioration in motor skills can also have a negative effect on road safety

In order to ensure that older drivers start to be more realistic in their assessment of their own abilities, the work group proposed the introduction of a qualified practical evaluation. The aim of such evaluations, according to the group, would not be to stop older people from driving, but rather to demonstrate the options available to them in order to help them stay safe and mobile. This would take the pressure off family members to raise any doubts about a person's suitability to drive, and the qualified feedback would enable senior citizens to implement measures that would help them retain their driving abilities.

ACCEPTING ACCOMPANIMENT WHEN DRIVING IS KEY TO SUCCESS

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Professional and Systematic Education for Older Drivers

There are currently approximately eight million car drivers in Poland who are aged 50 or over and have a driver's license of Category "B" or higher. Demographic forecasts for our country and Europe as a whole show that the number of these people in our population will steadily increase. As a result of this, the number of older drivers will also rise, potentially generating a whole series of problems in terms of road safety. Since aging is a natural process that develops progressively throughout the course of a person's life, taking away their ability to drive can result in social exclusion. This applies particularly to persons who live in small towns and villages.

Many older drivers first earned their driver's licenses several decades ago, and have not updated their knowledge or improved their skills since. These deficiencies are exacerbated by the biological and cognitive changes that progress with age. These have a significant impact on road safety. One effective way of improving this situation might be to introduce professional and systematic education for older drivers. This is why the Polish Motor Transport Institute has developed a special educational package comprising five modules under the name "Drivers 50+." This package contains training programs, materials for teachers, and a brochure with questionnaires that can be used to see how each driver perceives themselves. The package is intended for use by driver training units that carry out "B" category training for drivers aged 50 and over, so that the mobility of these drivers can be guaranteed for as long as possible without endangering other road users.

Our observations show that older people are the driver group with the fastest growth – in terms of both their numbers and their mileage. It is predicted that future older drivers will frequently undertake long journeys – more frequently than current older drivers. This presents a whole series of challenges for a number of parties, including vehicle manufacturers and road infrastructure planners. This is why the Motor Transport Institute is conducting test projects in the field of autonomous transport and innovative means of transport for persons with limited physical mobility. The common denominator in all these efforts is that they aim to improve the mobility of our society while also reducing the potential threats to road users and our natural environment.

As a voluntary tool for improving the accuracy of drivers' self-assessments, the practical evaluation starts with a data collection component, the aim of which is to observe a person's driving behavior and record and evaluate any mistakes they make based on standardized categories. In the second part of the evaluation, the results are explained to the driver and combined with suggestions and advice that can help them improve and maintain their driving abilities. As partners that offer a comprehensive range of services, Germany's "Technische Prüfstellen" (technical testing centers) and driving suitability certification centers would be the perfect choice for such tasks, as they are already required to adhere to the principles of neutrality, independence and impartiality and possess a certified quality management system. The role of the in-vehicle assessor could thus be played by either a traffic psychologist or an officially certified expert or examiner.

In addition to this, as an extension of the existing regulatory framework, a driving instructor could take on educational tasks such as preparing drivers for the practical evaluation or providing theoretical and/or practical refresher courses. The in-vehicle assessor would explain to the older driver where their strengths and weaknesses lie and give them tips on improving their driving behavior. In cases that represent potential risks, such as an accumulation of several mistakes, repeated gross violations of the rules of the road, and obvious repeated difficulties with driving maneuvers that are typically problematic among older drivers – such as turning, reversing, U-turns, entering and exiting traffic, maintaining a safe distance from other vehi-

Safe Mobility

"Safe mobility" is a program launched by the German Road Safety Council (DVR) for people aged 65 or older who are active road users, be it as car drivers, cyclists, pedelec riders or pedestrians. The aim of this program is to help older people retain a safe form of mobility. The program helps participants to determine for themselves what form their mobility takes, assists them in improving assessment of their own capability, and helps them to develop individual compensation measures. It is a modular seminar program that tackles all forms of mobility. The key topics in every session are hazardous situations during road use, old and new regulations, and how to approach one's own capability and health. The free sessions are hosted by specially trained tutors who work with the participants to determine their interests and answer their questions. The sessions are held all year round and throughout Germany in small groups (8 - 20 people), and are run by the DVR's partners (ACE, ADAC, ARCD, BVF, DVW, VCD).

cles, and navigating junctions and rights of way – it would be advisable to seek further clarification as to the causes of this behavior. This task could be handled by psychological or medical experts who work for the driving suitability certification authorities and specialize in traffic-related cases.

OBLIGATORY TESTS FOR OLDER DRIVERS

But what can we do if the number of accidents involving older drivers continues to rise, and on-demand testing and voluntary practical evaluations prove unable to stop this trend? How do we respond if, so to speak, people refuse to take responsibility for themselves? If that happens, we will need to rethink where we strike the balance between personal responsibility and government regulation. In such circumstances, implementing obligatory tests for older drivers would seem both professionally prudent and a proportionate response to the issue. This report proposes 75 as the minimum age for such tests. For drivers who have completed voluntary practical evaluations, this threshold for the mandatory test could be pushed back gradually, up to a maximum of five years. This would make 80 the entry age for the mandatory test. Linking the entry age to voluntary measures in this way would make the voluntary measures more appealing. These could also be expanded to include training programs to improve the driving skills of senior citizens, such as road safety training courses to help them navigate hazardous situations better, or informational and educational services. One example of this in Germany is the "Mobil 65+" program developed at the University of Leipzig. It teaches senior citizens about how the way their senses work changes as they get older and about the effects and side-effects of medications. It also covers exercises to improve physical mobility in the neck and shoulders for example, and relaxation exercises to increase resistance to stress. Another such training program is the "People & cars – Safety is a frame of mind" initiative ("Mensch & Auto – Sicherheit ist Einstellungssache") run by the German Senior Citizens' League (DSL). This initiative teaches senior citizens about how medication can affect their ability to drive safely, how to set their seats, seatbelts and mirrors correctly, and how to use driver assistance systems.

UNUSUAL BEHAVIOR MUST ALWAYS BE INVESTIGATED

The mandatory test could include both an examination of the person's driving behavior and a requirement for them to produce a certificate of health before the practical examination begins. This initial health check-up should provide guidance statements on the driver's cognitive functions ("no signs of dementia"), multimorbidity, health-related risk factors, and an eye test. If the doctor performing this check-up notices anything unusual, a certified and more in-depth examination would be required. The degree to which a driver's performance is restricted and the type, severity and progression of their health-related limitations and conditions need to be weighed up on a case-by-case basis by means of a full medical appraisal. This should also determine the options for and limitations of individual compensation strategies and, where applicable, provide information on any other associated risk factors. Such an appraisal requires the extensive expertise of the specialists at the driving suitability certification authorities.

Driving schools also offer driving fitness check-ups for senior citizens

ON-ROAD STUDY IN BIELEFELD

In an on-road study conducted and managed by the Bethel Evangelical Hospital in the German city of Bielefeld between 2017 and 2019, a sample of older drivers who responded to a newspaper advertisement were subjected to extensive neurological and traffic psychology tests. The study also collected data on health factors such as pre-existing conditions and medication taken, as well as the participants' histories and previous experiences of road use (annual mileage, accidents, etc.).

A total of 89 participants (33 women and 56 men) aged between 63 and 94 (average age: 77) were included in the study. Following a psychological evaluation of their driving behavior, which was completed by 85 of the participants, they were grouped into four categories based on standardized protocols that accounted for how they used the road; these four categories were also assigned to two overarching groups (fit or unfit, with the number of participants in each group noted in brackets).

Dimensions and Characteristics of a Driving Behavior Evaluation

Fit	Unfit
Fully fit to drive without further driving lessons (41)	Not yet fully fit to drive; driving lessons recommended (24)
Fully fit to drive with further driving lessons (16)	Not fit to drive (4)

Almost half of the sample group (41) passed the driving behavior evaluation without any concerns or observations of unusual behavior, and received positive feedback to this effect. 16 of the participants demonstrated repeated errors that were not severe enough to be deemed critical (e.g. changing lane without endangering others) and received a recommendation that they should take driving lessons in order to give them more training and eliminate the unsafe elements of their driving behavior. 24 of the participants demonstrated some major errors with regard to both vehicle operation and adaptation to the prevailing traffic situation. These behavioral traits were not exclusively caused by cognitive limitations such as slower reaction times; some were the result of the driver's personality and attitudes. For example, some of the participants allowed themselves "a little leeway" with regard to the timing of a red light, or regarded the rules for crosswalks as being open to interpretation.

While around half of the participants demonstrated mistakes in their road use, the traffic psychologist and the driving instructor were both of the opinion that these mistakes could be eliminated if the drivers were to take driving lessons that

REVOKING A PERSON'S LICENSE SHOULD ALWAYS BE THE LAST RESORT

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Chair of the Automóvel Club de Portugal (Automobile Club of Portugal)

Should We Place an Age Limit on Driving?

In a study on Portuguese car drivers conducted by the Observatory of the Automobile Club of Portugal (Observatório ACP), 84 percent of those surveyed were in favor of introducing laws that would make strict medical examinations mandatory for car drivers aged 65 and over in order to uncover health problems that could limit their fitness to drive. When discussions turn to over-65s, there is often a certain undertone of stigmatization toward older people. Strictly speaking, car drivers should take eye tests from the age of 40, as aging is something that affects us all, and this is the age where a person's vision starts to deteriorate.

While it is true that experience comes with age, it is often accompanied by a certain level of weariness and forgetfulness. This also applies when it comes to driving – and since driving is primarily a mechanical activity, car drivers often do not realize when their abilities are deteriorating and when they are no longer able to anticipate hazardous situations. On top of this, the many changes to the rules of the road and the introduction of new driver assistance systems cause drivers to pay less attention to the traffic situation around them.

Refreshing people's driving skills is a key factor for this age group. This is why the Automobile Club of Portugal has already been offering its members these types of training courses for years – as well as a full medical check-up when it comes to extending their driver's licenses.

Medical examinations are an important and necessary tool, albeit one that needs to be applied on a case-by-case basis, as everyone ages differently. Some of us may still have good reflexes when we reach the age of 75 – better than those of a 65-year-old car driver even – though obviously they cannot compare to those of a 30-year-old.

This makes driving in old age a controversial topic, and one that needs to be tackled objectively and, above all, responsibly. No-one wants to give up things they are used to enjoying or change their lifestyle. This is something that is hard for everyone. But it can be even harder to know that you have caused harm to yourself or others.

would give them training in specific maneuvers (e.g. turning and changing lanes). Only four of the participants demonstrated such severe erratic behavior in their driving that they were strongly recommended to stop driving altogether. Drivers generally only qualified for this group if the driving instructor had to intervene several times during the evaluation (e.g. by braking or taking over the steering of the vehicle), i.e. the test would have resulted in an accident if the instructor had not intervened.

The statistical analysis showed significant differences between the age groups in terms of the quality of their road use: 78.6 percent of the participants classed as "unfit" were aged over 75, and only 21.4 percent of those declared currently unfit to drive were under the age of 75. The results of the computer test were also reflected in the drivers' performance during actual road use: there was a strong correlation between the over-75s group and mistakes with regard to "risk-related self-control" (e.g. maintaining an appropriate speed), while the younger participants in the study showed no particular tendency towards such mistakes, and for the most part displayed an unimpaired ability to drive safely. However, the navigation of junctions (making turns, recognizing hazards), which accident statistics have already shown to be a common problem, often proved a particularly critical issue for both age groups during road use.

In summary, it is now possible to identify the individual strengths and weaknesses of older drivers. In addition to extensive findings on risk and safety factors, there exist a number of valid concepts for in-depth diagnosis that can be supported with the practical evaluation and driving behavior observation methods. Before taking severe steps such as revoking driver's licenses or testing people's suitability to drive, we should first offer them voluntary services based on individual consultation, such as on-road training, cognitive performance training and further medical examinations. There are already a number of tried-and-tested measures in this field that have been proven to have a positive effect. In order to make their use more widespread – on both a voluntary and an on-demand basis – we need to provide more incentives. Maintaining mobility should be the top priority. Obligatory measures should be introduced from the age of 75 based on the relevant evidence, and should focus on establishing minimum standards for driving motor vehicles safely.

Senior citizens shouldn't see practical refresher sessions at driving schools as a punishment – in fact, they are an opportunity to help them keep using the road safely

The Facts at a Glance

- **Older drivers in particular have many years of driving experience that they can rely on, and in many cases they can adapt their road use in order to stay safe and comply with regulations, even if their reactions and concentration levels are not as good as in the past.**
- **Personal "strategies" such as maintaining a greater distance to other road users, avoiding rush hour or driving in the dark, adopting a more defensive driving style, and using driver assistance systems can help to improve road safety among older drivers.**
- **Avoiding certain situations completely and reducing the amount one drives overall are also options that must be considered carefully. Avoidance leads to a drop in mileage, which in turn can lead to a decline in a person's driving skills.**
- **Road users aged 75 and over in particular display unusual behavior in their road use, though these traits can often be corrected, and training can help to eliminate them.**
- **Specific driver training courses with experienced instructors and qualified practical evaluations can go a long way toward helping older people to drive safely.**

Compensating for Errors With Cutting-Edge Technology

Many experts endorse the use and further development of assistance systems as a means of improving road safety for senior citizens. In addition to their many features and vehicle configuration options, these systems have the potential to compensate for age-related deficits and to reduce the frequency with which older drivers become involved in car accidents – or even cause them. However, technological support also protects senior citizens when they are using the road as pedestrians or cyclists.

Poorer vision, poorer hearing, slower reactions, and potential limitations to physical mobility – the physical conditions for safe road use do not usually improve with age. The reduction in performance brought about by biological aging processes and medical conditions is reflected in the increase in accident figures. Take Germany, for example: according to the Federal Statistical Office, "only" around 14 percent of all drivers involved in car accidents that resulted in personal injury in 2019 were aged 65 or over. However, in around 68 percent of the cases where such accidents involved older drivers, they were also the main perpetrators of the incident. Among car drivers aged 75 and over, this number was even higher, with three in every four having caused the accidents they were involved in. As explained in the "The Human Factor" chapter of this report, the most common driving errors among senior citizens were a failure to observe rights of way,

mistakes when making a turn, turning around, reversing, entering traffic, and driving off, and errors in judging distances.

In addition to changes in driving behavior, such as avoiding roads and times with higher traffic volumes, unfavorable weather conditions, driving at dusk or in the dark, and adopting a slower and more careful driving style, as well as infrastructural measures, road safety for older drivers can be improved by equipping vehicles with assistance, information and comfort systems designed with senior citizens in mind. The approaches used to tackle driving-related changes in performance can be grouped roughly into the following categories: active and passive safety, operation, comfort and driving. However, there is a lot of overlap between these different categories, and it is often impossible to draw a clear line between individual features or aids.

GOOD VISIBILITY AND TIDY COCKPITS

Senior citizens are a very appealing target market to the automotive industry for several reasons: the number of senior citizens driving cars is increasing continually, they are willing to purchase vehicles that are "specially adapted" for them, so that they can maintain their own mobility, and they have significant purchasing power in many countries. While none of the big manufacturers currently offer models explicitly designated as "senior citizen cars," this market is catered to by means of suitable designs combined with selected comfort and safety systems. The benefit of this approach is that it does not stigmatize particular vehicle models or users – in fact, its advantages benefit every age group.

When it comes to safety, direct and indirect visibility, driver assistance systems and passive safety elements all have an important role to play. The less a driver's direct line of sight is obstructed by wide columns or windows that are too small, the less relevant any physical limitations in the upper body and cervical spine or restricted fields of vision will be. The windshield in particular needs to fulfill a wide range of criteria. Reflections of the dashboard and other vehicle components need to be kept to a minimum in a variety of lighting conditions through judicious positioning and choice of materials. The area covered by the windshield wipers needs to be configured such that there is no notable "widening" of the A columns when it rains, or especially in snow. The position of the seat in relation to the windshield and, in particular, the position of the rear view mirror and the sensor/camera systems often fitted in this area must be designed to ensure that the driver has a good view of traffic lights in every direction without having to strain their body, regardless of how they adjust their seat. Large mirrors that distort the image as little as possible enable drivers to notice the traffic behind them more quickly and help to compensate for restrictions in how far they can look over their shoulders, even if they are not a complete substitute for this extra perspective. The interior design of the vehicle must help to ensure that the driver's view through the rear window via the rear view mirror is as unobstructed as possible.

A tidy cockpit, clear and legible instruments, and a simple, clearly structured user interface can help to make the driver's life a lot easier, reducing the number of variables they need to consider and thus improving their safety and comfort. Displays and display elements must have a high-contrast design in all their lighting states. Numbers and other characters and symbols need to be of sufficient size and easy to read with even just a quick glance. While driving, it must be possible for the driver to operate the vehicle's key functions, such as the light and wiper controls, heating and ventilation settings, and radio controls, via haptic feedback, i.e. without the need to look at them. Screen menus with one-button operation and touchscreens can quickly overwhelm the driver or cause a dangerous distraction.

The seriousness of this risk was reflected in a ruling made by the Higher Regional Court of Karlsruhe in spring 2020: it declared that touchscreens installed in vehicles, including those

NO MANUFACTURER PROVIDES CARS SPECIFICALLY DESIGNED FOR SENIOR CITIZENS

integrated by the manufacturer, were deemed in Germany to be electronic devices equivalent to smartphones, meaning that a driver is only permitted to operate them by hand if this can be done with "a brief glance at the device at an appropriate moment based on the road, traffic, visibility and weather conditions." The ruling was based on an accident caused by a driver who, during a rain shower, had become significantly distracted when attempting to adjust the windshield wiper interval via a submenu of the central screen integrated into the vehicle. This ruling is particularly relevant in light of the fact that automotive manufacturers are increasingly installing sensor fields, sliders and screens in place of traditional buttons and switches, and even saving on lighting for some control elements. This is not an approach that is likely to make such systems easier to operate, especially for senior citizens. If safety-related functions are being relocated into touchscreen systems, a voice or gesture-operated system would doubtless be a better option for keeping distraction times to a minimum.

Unfortunately, however, one thing is clear from looking at the new vehicles being sold right now: each manufacturer installs operating systems based on their own concept, all of which seem to adhere to a clear internal logic, have a gimmick or two to set them apart from the competition, and can be operated easily enough following an in-depth exploration of their functions. But for drivers who don't use their vehicle very often or switch between models from different manufacturers, the "intuitive operation" advertised by the manufacturer has its limits, especially in situations where the driver needs to act quickly. Voice commands and gestures also vary from one manufacturer to the next, and sometimes even within the same vehicle type if the vehicles have different infotainment systems. Clearly, safety always needs to be the top priority, regardless of the designer's ambitions and all the ergonomic and aesthetic aspects that need to be taken into account.

Many senior citizens make a conscious decision to switch to an automatic transmission

HOW SAFE ARE AUTOMATIC TRANSMISSIONS FOR SENIOR CITIZENS?

When it comes to purchasing a vehicle, there are some markets in which senior citizens should be asking themselves what is the right car for them: Should they switch to an electric drive or stick with a combustion engine? And should they opt for a manual or an automatic transmission? In Germany, for example, there has been a rapid increase in the market share for new vehicles with automatic transmission. According to the German Automobile Trust (Deutsche Automobil Treuhand), it was over 55 percent in 2020, compared to just under 28 percent in 2010. However, this is nothing in comparison to the USA or Japan, where automatic vehicles account for around 90 percent of the market. It is safe to assume that manual transmissions will continue to lose their relevance in time – especially as many modern assistance systems only work in combination with automatic transmissions, and electric drives eliminate the need for gear shifting.

Many senior citizens in particular opt for an automatic transmission because removing the need to shift gears manually takes some of the stress out of driving and can also help them to compensate for health-related limitations. The key question is, are vehicles with automatic transmission less safe given that, unless the brake ped-

al is actuated, they will move when the engine is running, and is the risk of unintentional acceleration greater? After all, it is quite common to read reports about older drivers who lost control of their automatic vehicles because they got the brake and gas pedals mixed up, or put the vehicle into reverse by mistake. To prevent these kinds of operator errors and the often resulting reactions of panic, senior citizens should ideally have a driving instructor show them the features of an automatic transmission before buying such a car, or take driver training courses to help them practice dealing with extreme situations. In addition to this, experts also advise switching to an automatic transmission as early as possible in order to allow drivers to get used to these systems before their cognitive capacities diminish significantly as a result of aging. All in all, however, there are plenty of benefits to automatics, as they allow drivers to concentrate more on what is happening on the road.

HUGE POTENTIAL BENEFITS OF DRIVER ASSISTANCE SYSTEMS

In terms of driver assistance systems, those that offer the greatest potential benefits, especially for senior citizens, are the ones that provide assistance in complex and taxing traffic situations. These include intersection assistants, blind spot warning systems, lane change assistants, night vision systems and automated emergency braking systems, as well as GPS systems with up-to-date maps and clear visual and acoustic instructions. Road sign assistants, which use cameras to detect the local speed limit and display it on the dashboard, also help drivers to compensate to a certain extent for deficits in their attention, and provide an added sense of safety. Vehicle backup cameras and parking assistants can also make stressful situations more manageable, thus improving safety. Particularly at dusk and in the dark, intelligent lighting systems and high-beam assistants can partially help compensate for the reduced ability to see in twilight and darkness that comes with age, as they allow the driver to focus more on the road and less on the high beam controls. E-call systems, especially those with an additional service call-out function, can help to increase a driver's overall sense of safety and reduce stress in accident and breakdown situations.

A 2019 study commissioned by the German Federal Highway Research Institute (BASt) took an in-depth look into the ways that driver assistance systems could help older drivers. The study also compiled information on the key age-related deficits that impact a person's driving abilities and assigned them to specific, requested driver assistance functions, or to appropriate systems (Figure 23). At the same time, the BASt's study also examined the factors that would help driver assistance systems to become widespread more quickly among senior citizens. The results showed that awareness of the various systems and, in particular, knowledge of their functions and limitations, were key factors here. A survey of the target demographic also identified factors that are preventing assistance systems from becoming widespread more quickly, including a fear of high repair costs in the event that a system malfunctions, and concerns over the lack of transparency from

23 Age-Related Performance Deficits and the Driver Assistance Functions That Can Help to Compensate for Them

	Performance deficit	Required function	Suitable driver assistance system
Information intake	Contrast sensitivity, glare sensitivity	Visual highlighting of other road users who are hard to spot in the dark; glare reduction	Night vision systems, intelligent lighting systems
Information processing	Speed of information processing and decision-making processes	Advance information on upcoming situations	Car2X technology
	Selective attention, judgment of speed	Steering attention to relevant road users	Intersection assistants
	Divided attention	Navigation	GPS
	Peripheral vision, divided attention	Signaling of road users in blind spot	Blind spot warning system/ lane change assistant
Psychomotor abilities/ handling	Psychomotor abilities	Stabilization of lateral control	Lane-keeping assistant
	Flexibility of neck/spine, coordination	Signaling obstacles, performing parking maneuvers	Parking assistant

Source: BASt, Fahrerassistenz- und Fahrerinformationssysteme (Driver Assistance and Information Systems), 2019

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The ACI's Service for Older Drivers: a Driver Assistance System for Added Protection

After Japan, Italy is the country with the highest proportion of senior citizens. Of a population of around 60 million, just over seven million – approximately 11 percent – are aged over 75 (source: Italian National Institute of Statistics (ISTAT), date: January 1, 2019). While the over-65s age group makes up 20 percent of the total population on average throughout Europe, in Italy it accounts for 23 percent of the population.

For senior citizens, the ability to drive a car is equivalent to a sense of independence and self-sufficiency. It also helps them feel like they still have an active and useful role to play in society. Unfortunately, as we age, our reactions are no longer what they were in our youth. When driving a car, longer reaction times increase the risk of becoming involved in and being unable to handle critical situations. Advanced driver assistance systems (ADAS for short) can compensate for this problem and intervene in situations that are difficult for the driver to handle, or if they make a mistake.

The ACI equips older people's vehicles with driver assistance systems to aid the driver. The requirement for older people to only drive vehicles equipped with such systems can be enforced by means of the regular examinations required to extend an Italian driver's license, in the same way that requirements to wear glasses while driving are. However, the doctor performing the check-up for the license extension must also be satisfied that the senior citizen in question is still of a fit physical and cognitive state to drive.

In order to avoid senior citizens feeling like they are being forced to buy a new vehicle, ADAS solutions can also be retrofitted in vehicles that do not have these systems fitted as standard. As was once the case with car radios, it is also possible to remove these systems from an old vehicle and install them in a new one. A notable example of this is the Mobileye system available under special conditions to ACI members and insurance policy holders, which provides all the usual ADAS functions: automatic emergency braking in case of sudden obstacles, intervention if the driver is not maintaining a safe distance to other vehicles, lane change assistant, detection of speed limits, etc.

vehicle manufacturers when handling the data collected by the systems. Clarification is required here, in every regard.

MANY SENIOR CITIZENS HAVE BEEN WON OVER BY THE BENEFITS OF ELECTRONIC ASSISTANT SYSTEMS

As recently as late 2020, DEKRA commissioned the market research and opinion polling company forsa to conduct a representative survey of around 2,000 randomly selected German motorists across all age groups on the topic of driver assistance systems. In the 65+ age group, 81 percent of men and 70 percent of women surveyed thought that the concept of assistance systems to aid drivers was either good or very good. By their own accounts, around 80 percent of the men in this age group and more than 60 percent of the women own vehicles that are equipped with assistance systems.

The usage of driver assistance systems differed significantly depending on the age and gender of those surveyed: older women aged 65 and over had less knowledge and experience of the systems listed in the survey than the average of all the motorists surveyed. By some distance, the system used most commonly by men and women aged 65 and over was the parking assistant (73 and 55 percent respectively), followed by high-beam/light assistant (42 and 29 percent), adaptive cruise control (37 and 19 percent) and lane departure warning system (33 and 17 percent). Overall, however, these usage levels were much lower than those for the 18 to 44 and 45 to 64 age groups. The greatest difference was in the usage of blind spot warning and lane change assistant systems. In the 18 to 24 age group, 48 percent of those surveyed said that they had used such a system before, while only 22 percent of senior citizens made the same claim. The difference was less pronounced among the women included in the survey, though only 22 percent of the women in the younger age group had used this system, compared to 14 percent of older women.

The drivers were also asked which driver assistance systems they would consider an absolute must in their next car purchase, if money were no object. Among men and women aged 65 and over, the parking assistant once again topped this list (87 and 84 respectively), followed by adaptive cruise control (74 and 59), blind spot warning system/lane change assistant (72 and 75 percent), advance automated emergency braking system (71 and 60 percent), and lane departure warning system (60 and 46 percent).

The operation of the assistance systems and the way they are activated and deactivated varies depending on the vehicle model. Across every age group, 83 percent of those surveyed agreed that it was necessary and sensible to make sure that the way these systems are operated is as uniform and standardized as possible in all cars – just like the turn signal controls. This opinion was shared by 89 percent of the 65-and-over age group includ-

ed in the survey, and 95 percent of those aged 75 and over.

The aim of the survey was not to establish the status quo for driver assistance systems in the German market, but rather to discover how much drivers knew about how assistance systems work and find out their wishes and expectations with regard to driver assistance. In this respect, the results of the survey clearly show that many people know nothing about assistance systems, and do not know what the names of the systems mean or which systems are actually installed in their own vehicles. Around 30 percent of those surveyed said that they did not have any assistance systems in their vehicles at all. It is difficult to reconcile this result with the information provided on the ages of the vehicles or even with general records of the cars registered on German roads. On the other hand, around ten percent of those surveyed said that they had experience of using exit warning systems and night vision assistants – systems that are currently only available in a very small number of vehicles. Overall, however, every age group thought that driver assistance systems offer great potential, and the drivers surveyed displayed a positive attitude toward considering such systems when buying their next vehicle.

In addition to the DEKRA survey conducted by forsa, there are also a number of other surveys and studies on this topic that have produced insightful results. For example, in its 2019 publication "Experiences of Advanced Driver Assistance Systems amongst Older Drivers," the National Centre for Social Research in London also came to the conclusion that senior citizens are generally open to the idea of driver assistance systems, but want them to be user-friendly and not too distracting. Senior citizens with multiple health limitations demonstrate greater levels of acceptance than those in full health. Furthermore, older drivers were of the opinion that the focus should be on systems that provide information acoustically rather than visually. At the same time, however, there was a fear of becoming "dependent" on an assistance system.

The results of an online survey of 1,328 persons aged 65 to 95, which were presented in September 2019 at the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications in Utrecht, also showed that there is good acceptance of driver assistance systems overall. However, acceptance levels for systems that actually intervene in the driving process were lower than for those that simply provide information. In this respect, it is notable that persons with a lower locus of control regarding the use of technology (in psychology, the locus of control is a person's subjective perception as to whether their behavior in certain situations is under their own control or affected by external forces) tended to prefer automatically intervening systems, as informational systems represented an additional stress factor or distraction to them.

PRACTICALITY AN IMPORTANT FACTOR WHEN CHOOSING A VEHICLE

In addition to the operation of the vehicle itself, drivers also highly value the level of ease when getting into and out of the car, when loading and unloading, and the level of comfort during the journey. Doors that open wide, large door frames and a raised seating position – that match the user's height – make it easier to get into and out of a vehicle. Interior handles in the top third of the A column or on the roof also provide an important aid. Furthermore, a high seating position also improves all-round visibility for the driver, which is an important safety consideration. Ergonomic seating design and user-friendly seat adjustment options, combined with suitable chassis suspension and

Vehicle backup cameras and warning systems are now fitted as standard in many modern vehicles

shock absorption, play a key role in ensuring a comfortable driving experience, thus helping the driver to remain alert and focused for longer.

Loading and unloading can be made easier by ensuring that the trunk has no rear wall. The optimum height, on the other hand, depends on how tall the user is. Although keeping the distance between the backrest and the end of the trunk space small reduces the volume that can be loaded into the vehicle, it also means that even persons with limited strength or upper-body mobility can push heavy items right up against the backrest. For vehicles with larger trunks, "trunk organizer" systems or trunk bags offer a simple and useful cargo securing measure. The length and agility of the vehicle also play a role, especially for drivers who mainly use their vehicles in built-up areas with narrow streets and limited parking space.

MAKING VEHICLES SUITABLE FOR SENIOR CITIZENS IS BECOMING INCREASINGLY IMPORTANT

Before buying a car, it is important to look into the aforementioned factors and test drive vehicles by a number of different manufacturers in order to determine one's own personal preferences and come up with a list of priorities. Insurance companies, automotive associations, senior citizens' associations and similar groups also conduct tests on how suitable current vehicle models are for use by older people, which can help drivers decide on the most useful criteria – or even the most suitable vehicle – for them. Even if someone has been driving the same brand of vehicle their entire life, that does not mean that the same manufacturer makes vehicles that are suitable for senior citizens. In order to remain both mobile and safe, it is important to be open to change.

Different manufacturers assign different levels of importance to the concept of designing vehicles with senior citizens in mind. Some manufactur-

Special "age simulation suits" enable automotive manufacturers to experience the needs of older people first hand and provide important insights for vehicle development

ers use “age simulation suits” when developing their vehicles. These suits, which are designed by gerontological experts, help young people to experience the physical limitations that come with aging. They simulate not only mechanical and haptic limitations, such as loss of strength, physical mobility and grip, but also deteriorations in eyesight, field of vision, hearing and coordination. These can be used to optimize common situations for senior citizens, such as operating a door handle, getting into and out of the vehicle, taking hold of and fastening the seat belt, turning the key in the ignition – or the significantly easier pressing of a starter button – and even the driving experience itself.

RIDER ASSISTANCE SYSTEMS ON PEDELECS

Sales figures for pedelecs have been rising steadily for years. Even despite the coronavirus crisis, they do not seem to have declined – quite the opposite in fact. One of the reasons for the electric bicycle’s success is the fact that it appeals to people of every age demographic. Older cyclists in particular can benefit from the vehicle’s intuitive handling, high average speed and ability to navigate inclines easily, all of which significantly extend the user’s radius of activity while ensuring that they get still a healthy amount of exercise. However, the rising number of pedelec accidents involving older riders indicates a definite need for rider assistance systems that either prevent accidents completely or at least minimize their severity, as this section of our population will continue grow.

One system that offers particular promise in this respect is the Bosch anti-lock braking system. This assistance system, described in detail in the 2020 DEKRA Road Safety Report, prevents overbraking on the front wheel of the pedelec. The significant benefit of the system is not so much that pedelec riders can keep steering during heavy braking, as the fact that it saves them from losing control when the front wheel locks up. This makes it safe for pedelec riders to use their front brakes with the maximum possible deceleration, without the risk of their front wheel slipping or them being thrown over the handlebars.

In order to determine other potential areas for improvement, safety-related driver assistance systems that have already proven effective in other vehicle classes were taken as the starting point for the SIFAFE research project, which focuses on safety- oriented rider assistance systems for electric bicycles. The systems needed to be evaluated in order to determine their suitability for use in electric bicycles, before being adapted and developed further. This process took into account both vehicle-related parameters (feasibility of installation, power requirements, robustness, cost) and transport science factors (effectiveness, user acceptance, distraction levels during operation). The objectives of the project were to analyze the potential of safety-related assistance systems

Prof. Fred Wegman
Delft University of Technology

Elderly at risk, not risky

Crash statistics in all countries clearly show a higher than average fatality and injury rate for elderly people. This can be mainly explained by the greater physical vulnerability of the over-75s. We also observe growing functional limitations with ageing, such as a decline in visual capabilities, a slower perception-reaction time, reduced flexibility of neck, less muscle strength, etc. However, we see limited evidence that a decline in visual, cognitive and sensory functions result in higher risks, unless serious deteriorations of various functions accompany ageing. Elderly compensate for functional limitations, for example by travelling under less demanding conditions. They prefer not to travel under night-time conditions, under poor weather circumstances or when it is busy on the road in peak-hours for example. Or they reduce task demand while driving by reducing driving speeds.

In other words: elderly are more at risk than that the higher fatality/injury rates can be explained by riskier driving. But a growing amount of elderly road users and their higher fatality and injury rates form a serious challenge when trying to reduce the number of people killed and seriously injured in road crashes. Modern societies do not accept a solution for road safety problems by reducing travel options of elderly people. On the contrary, it is seen as advantageous if elderly participate as long as possible in social life, and participating in (road) traffic is an important element of that. So, how can crash and injury risks for elderly road users be reduced?

The Safe System approach has a lot of ingredients that will result in safer circumstances for road users and more specifically for the elderly road user. A core element of the Safe System approach is speed management to levels that are safe, and serious injury will not occur in crashes. This is very important for vulnerable road users, such as (elderly) pedestrians and cyclists. Another important aspect of the Safe System approach is to make road traffic less complex and to carry out traffic tasks step by step. This will result in less errors by humans and reduce risks on the road. Elderly road users will profit a lot when designing and implementing a Safe System. First of all when designing the road environment, but also when designing ADAS: Advanced Driver Assistance Systems, when these support (elderly) road users.

for electric bicycles, design and build sample systems, and evaluate their performance.

In order to analyze cyclist safety, a pedelec accident and system effectiveness analysis was conducted during the course of the project. Unfortunately, there were weaknesses in both the interpretation of the results of this analysis and the conclusion that resulted from it. However, the analysis of the accident does allow us to conclude that the prioritized systems offer great potential for preventing a large number of accidents, or at least reducing the severity of their consequences. There is huge market potential in this respect: a survey of 300 users has shown that many of them would like such assistance systems. Likewise, there is a high level of acceptance for rider assistance systems among the general population. More than 80 percent of those surveyed said that they had a positive attitude toward rider assistance systems, and 66 percent were willing to pay up to an additional 300 euros to have such assistance systems on their electric bikes.

In the practical section, systems designed specifically with senior citizens in mind – such as lane departure and frontal collision warning systems – were rated as reliable by two thirds of the riders who participated in the test. The results of the riding tests, in which a variety of warning strategies were also evaluated, showed that haptic rider warnings in the form of vibrating handlebars were deemed to be particularly intuitive – even more so than visual and acoustic warnings. In one example of such a system, the right handlebar vibrates when the pedelec veers too close to the right edge of the lane, the left handlebar vibrates when the pedelec veers too close to the left edge of the lane, and both handlebars vibrate simultaneously when there is a risk of a frontal collision. Overall, the study shows that assistance systems can also help to improve safety on electric bicycles, and that there is a huge need for further research in this area.

24 Overview of the New Vehicle Systems Prescribed by the General Safety Regulation (Selection)

Prescribed systems	Implementation date/Details
Systems prescribed for vehicle classes M, N and O for the carriage of passengers and goods	
Intelligent speed assistance	All new vehicle types July 6, 2022, all first-time registrations July 7, 2024
Alcohol interlock installation facilitation	
Driver drowsiness and attention warning	
Reversing detection	
In addition to this, Class M_1 and N_1 vehicles (passenger cars and light commercial vehicles) must also meet the following specifications (selection):	
Emergency braking systems	During the first phase (all new vehicle types July 6, 2022, all first-time registrations July 7, 2024) the systems must brake automatically and independently in response to stationary and moving motor vehicles in front of the motor vehicle in which they are installed, at the minimum. During the second phase (all new vehicle types July 7, 2024, all first-time registrations July 7, 2026), these systems will also detect and independently brake for pedestrians and cyclists.
Emergency lane-keeping systems	All new vehicle types July 6, 2022, all first-time registrations July 7, 2024; for motor vehicles with hydraulic power assisted steering systems: all new vehicle types July 7, 2024, all first-time registrations July 7, 2026
Enlarged head impact protection zones	All new vehicle types July 6, 2024, all first-time registrations July 7, 2026
In addition to the general requirements and existing systems, such as lane-keeping warning systems and automated emergency braking systems, trucks and buses must be equipped with modern systems that detect pedestrians and cyclists close to the vehicle and can significantly reduce the blind spots around the vehicle. The regulation comes into effect on July 6, 2022 for new vehicle types, and on July 7, 2024 for new vehicles.	

Source: Regulation (EU) 2019/2144

ASSISTANCE SYSTEMS INSTALLED IN MOTOR VEHICLES ALSO PROTECT SENIOR CITIZENS WHEN WALKING OR CYCLING

When older people use the road as cyclists or pedestrians, their generally reduced perceptive faculties and slower reactions place them at a comparatively higher risk of becoming involved in an accident. Due to the increased vulnerability that comes with age, their risk of suffering severe injuries is also higher. The European Transport Safety Council's January 2020 PIN Flash Report 38 "How safe is walking and cycling in Europe?" clearly emphasizes this danger. According to this report, in 2018, people aged 65 and over accounted for around 47 percent of all the pedestrians

CUTTING-EDGE TECHNOLOGY ALSO HELPS OLDER PEOPLE MAINTAIN MOBILITY

killed in road accidents – around 2,435 fatalities. The percentage of cyclist fatalities that fell within the same age group was 44 percent – around 950 fatalities.

As a result, modern technology is becoming increasingly important in motorized vehicles, as motorists were the other type of road user most commonly involved in these accidents. The General Safety Regulation adopted by the European Commission in March 2019 aims to resolve precisely this problem. The Regulation will make a variety of safety-related driver assistance systems a legal requirement for new vehicles driving in Europe over a number of phases. It will be applied in two stages. Initially, the requirements will apply to all new vehicle types, before their scope is increased at a later date to include all new vehicles (Figure 24). Overall, the new regulations should represent an immense improvement in road safety for all road users. The benefit for senior citizens will often be twofold, as many of these systems will also help them maintain mobility in their old age.

The Facts at a Glance

- In addition to changes to driving behavior and infrastructural measures, another factor that can improve road safety for older drivers is ensuring that their vehicles are fitted with assistance, information and comfort systems that are suitable for senior citizens.
- Direct and indirect visibility and, increasingly, driver assistance systems also play a key role in terms of safety.
- It must be possible to operate any safety-related functions that might need to be used while driving without having to look at them for a long time, and they must provide haptic or acoustic feedback. Generally speaking, these requirements cannot be met with a touchscreen alone.
- Before switching to a vehicle with an automatic transmission, senior citizens in particular should practice navigating extreme situations in such a vehicle, ideally by taking a driver training course.
- A survey commissioned by DEKRA shows that senior citizens have a very positive attitude toward vehicles being equipped with assistance systems. However, they would also like such systems to work the same way in every car as far as possible – like the turn signal.
- Knowledge regarding the existence of assistance systems and their functions and limitations must be improved by means of awareness-raising campaigns and standardized terminology and communication. There is a lot of room for improvement here, especially when it comes to reaching senior citizens.
- In addition to the operation of the vehicle itself, senior citizens also highly value the level of ease when getting into and out of the car, when loading and unloading, and the level of comfort during the journey.
- Pedelecs are becoming increasingly popular, especially among senior citizens. The numbers of severe accidents involving senior citizens on pedelecs are showing an above-average increase. The development and introduction of rider assistance systems should go a long way toward improving safety in this area. There is a huge need for further research.
- The General Safety Regulation adopted by the European Commission in March 2019, which will make the installation of driver assistance systems mandatory in new vehicles, will improve road safety, especially for senior citizens.

Need for Optimization – in a Variety of Areas

In addition to vehicle-specific safety elements and the human factor, road infrastructure also has a key role to play when it comes to improving road safety for senior citizens – whether they are walking, cycling or driving. However, the focus must be on a design that is as self-explanatory, uncomplicated and forgiving of mistakes as possible, ensuring usability by means of regular maintenance, cleaning and snow clearing, and optimizing the infrastructure when weaknesses are detected.

Waitzstraße in Hamburg is a popular shopping precinct – but has also been the primary location for store window accidents in Germany for a number of years. Nowhere else in Germany, and perhaps nowhere else in the world, have so many people – most of them senior citizens – driven their vehicles into the display windows of the nearby stores when trying to park. The list of factors that make the street susceptible to such accidents is long. For instance, the combination of a high number of doctors' practices and the variety of attractive stores makes this a popular destination for the large number of active senior citizens who live in its catchment area. The many practical parking spaces positioned right in front of the stores also make life a lot easier for people who have trouble walking. At the same time, the busy, one-way street is relatively narrow, so reversing out of the angled parking spaces and onto the road is a highly complex task for persons with limited upper-body mobility, especially with the constant traffic. If they put their car in the wrong gear or hit the gas pedal by mistake (when twisting round to check the road for example), it only takes a moment for the car to end up crashing through a shop window.

INFRASTRUCTURE PLANNING MUST TAKE ALL FORMS OF ROAD USE INTO ACCOUNT

In order to reduce the risks created by such situations, structural measures have been implemented in the form of steel bollards with concrete bases to stop cars driving onto the sidewalk. Like many other road accidents involving senior citizens, the incidents on Waitzstraße have drawn a lot of attention from the media – which often results in

older people being presented as a danger on the road. But as has already been stressed many times in this reports, senior citizens are by no means the primary cause of hazards, and are in fact more likely to be at risk themselves – especially when using the road as pedestrians or cyclists. Nevertheless, such cases clearly demonstrate the role infrastructure plays in accident risks for certain user groups. Optimizations in this area must be approached with the primary objective of preventing accidents; measures that simply reduce the consequences of accidents should only be seen as a temporary solution.

TRAFFIC INFRASTRUCTURE FOR PEDESTRIANS MUST BE CLEAR AND FREE OF DIVERSIONS

On October 28, 2020, the German Road Safety Council (DVR) issued a ruling containing a number of proposals to improve safety for pedestrians in general, which had been drawn up with the aid of DEKRA and a number of other institutions. These proposals are aimed at pedestrians of all ages, though the DVR stressed that extra care must be taken to ensure that any improvements to road safety are compatible with the requirements of children, older people and people with limited mobility. A "design for everyone" would then automatically benefit all other pedestrians as well. The resolution declared it a fundamental requirement to ensure that the needs of pedestrians be taken into account wherever they are or can be expected to appear. It stated that, particularly on traffic-heavy roads in built-up areas, interconnected and fully accessible pedestrian traffic networks needed to be created, with safe crossings and direct connections that do not require any diversion. It also stated the importance of ensuring that infrastructure is clear and easy to understand – it needs to be as accessible, recognizable, comprehensible and free of visual obstructions as possible, for all road users.

The DVR says that, depending on the prevailing local conditions, light signaling systems, pedestrian crossings (crosswalks), central islands or protruding curbs must be used to make crossings safer. Wherever possible, the crossing facilities need to be designed to ensure that even persons with limited mobility, such as problems with their walking or vision, can cross to the other side of the road safely. In particular, this includes installing tactile elements, sunken curbs, and a high-contrast design for the road environment. Acoustic signals that are

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Chair of the German National Association of Senior Citizens' Organizations (BAGSO)

Road Use by Senior Citizens

Mobility is one of the key factors that determines a person's quality of life. That is why lifelong mobility is so important. Maintaining and cultivating this ability is a worthwhile endeavor, and here at BAGSO it is one of our key concerns. Many people's normal, everyday mobility radius changes drastically when they go into retirement: they travel shorter distances, more infrequently, and with less urgency. But they still remain mobile. In the late mornings and afternoons, the roads, sidewalks and plazas largely belong to us. The regular public transport in big towns and cities is great, but in villages and mid-sized towns, I have to walk a long way to get to the nearest station – a very long way, in fact. Citizens' buses, which are often run on a voluntary basis, can help with this. And in villages, you don't find yourself stumbling over e-scooters that have been left lying across the sidewalk with complete disregard for others. People who do that should be issued with a ticket like they would if they parked their car in the wrong place, as it is actually more dangerous.

Traffic lights must stay green for long enough to ensure that people carrying shopping bags with a limp can get across the road, not just early morning joggers. Driving a car is the ultimate multitasking challenge, and it helps to keep you sharp. But it is not an ability everybody retains their whole life long. It might be an idea to give people aged 75 and over two hours of driving lessons for their birthdays, as a test and a way of refreshing their skills. Only driving on rare occasions or simply diving straight into the most complicated and busy traffic situations is a poor alternative to this – it only makes the situation more dangerous and doesn't help at all.

Thanks to seat belts, restrictions on drinking under the influence of alcohol, and airbags, the number of fatal road accidents has been dropping since the 1970s. In houses and apartments, where there are plenty of obstacles, the trend is going in the opposite direction. Accidental falls at home lead to twice as fatalities than car accidents on the road, especially among older people. Slippery bathtubs, narrow bathroom doors, climbing on revolving chairs, and tripping on thick rugs are all dangerous hazards.

Exercise keeps the body fit, and moving your legs (or swimming) nourishes the brain and helps when driving, using crossings and at home. But you have to put the effort in yourself. It's true what they say: your bed is the most dangerous place you know. That's where most people die. Getting up in the morning is the most important thing you can do for your mobility. That and moving around – under your own steam.

For many years, Waitzstraße in Hamburg was the most accident-prone shopping street in Germany

suitable for the hard of hearing must be installed at light signals, and the fact that older people walk at slower speeds must be taken into account in traffic light switching cycles as a bare minimum. In addition to this, crossings and sidewalk areas need to be equipped with adequate lighting in order to improve the ability of other road users to see pedestrians in the dark. At the same time, lower driving speeds can help to prevent road accidents, or at least reduce the severity of any injuries suffered as a result of them. Especially for senior citizens and people who have difficulty walking, the green phase and the clearing time, i.e. the time between when the light turns red for pedestrians and when it turns green for road traffic, is too short at many pedestrian lights. Realistic walking speeds for senior citizens must be used as the standard when defining the switching intervals. An additional countdown display for the green light can help senior citizens to decide whether they still have time to cross the road or should wait for the next green phase – a measure that would in fact benefit pedestrians of all ages. In areas with a high volume of pedestrians and cyclists, traffic calming measures should be implemented.

SENIOR CITIZEN CYCLISTS

A glimpse at the statistics is all it takes to underline how at risk senior citizens are when they use the road as pedestrians: in both 2019 and 2020, the year of the coronavirus, the 65+ age group accounted for almost 60 percent of all the pedestrians killed in road accidents in Germany. The numbers were similarly high for cyclists in this age group, at 56 percent. As discussed in detail in the 2020 DEKRA Road Safety Report, "Mobility on Two Wheels," expanding the bicycle path network and maintaining bicycle paths are key factors in reducing the risk of such accidents. While more bicycle paths are in fact being built in many places, not all of these lanes provide their users with the level of protection required. In built-up areas especially, where there is rarely space for a structurally separate bicycle path between buildings, cyclists often have to use exclusive or non-exclusive bicycle lanes that require them to share road space with busy traffic. This means they are only separated from traffic by lines painted on the road surface, if at all, which become very difficult to see when old and faded. As on roads with no bicycle lane, this puts them at great risk of being hit by motor vehicles, especially trucks – or even being forced off the road or run over if the vehicle is turning right. On roads where cyclists have their own bicycle path, the main problems are when there is insufficient separation between this path and the sidewalk, and when driveways are poorly signposted. It is also not uncommon for bicycle paths to come to an end suddenly without any prior warning. In terms of road planning, a great deal of optimization is still required in this area.

Various EU countries already have large signs on selected sections of freeway to warn drivers and prevent them from joining the freeway in the wrong direction

CARS DRIVING IN THE WRONG DIRECTION ON FREEWAYS

One risk to road safety that should not be underestimated is senior citizens driving on the wrong side of the road. In 2012, the German Federal Highway Research Institute (BASt) published a study on "Cars Driving in the Wrong Direction on Freeways", covering 526 proven cases of cars driving on the wrong side of the freeway between 2005 and 2011. Senior citizens accounted for around a third of the cases where it was possible to retrospectively determine the age of the driver – a disproportionate amount. The authors of the study claimed that one possible reason for this statistic could be that younger people are more likely than older people to be able to "recognize when they have accidentally set off in the wrong direction and correct this mistake promptly." Likewise, the authors argued that the link between driving on the wrong side of the road and difficulties with orientation was most common among older peo-

ple (aged 65 or older) and when driving during the day. They also noted that cognitive and/or physical limitations could often play a role in the case of older people.

The results of the BASt study are also confirmed by similar studies conducted in countries such as the USA and Japan. For example, an investigation into cases of people driving on the wrong side of the road in the US state of Alabama shows that the probability of becoming involved in an accident resulting from driving on the wrong side of the road is almost seven times higher for drivers aged 65 and over than for younger drivers. A study in Japan showed that 52 percent of accidents resulting from driving on the wrong side of the road were caused by drivers aged 65 or older.

Generally speaking, it will never be possible to completely prevent such mistakes from occurring, especially not if drivers deliberately disregard the rules of the road, for example by deliberately driving onto the freeway in the wrong direction at a junction, performing U-turns on one-way carriageways, or driving under the influence of alcohol or drugs. Nevertheless, it is possible to significantly reduce the risk of people accidentally driving on the wrong side of the road by imple-

Antonio Lucas
Head of Road Safety at RACE (Real Automovil Club de España – Royal Automobile Club of Spain)

Changes to the Environment and the Road Infrastructure

One of the characteristics of modern, industrialized countries is that their populations have a higher life expectancy. In Spain, this is over 80 years old. 19 percent of Spain's population are currently older than 65, and forecasts indicate that by 2033, over-65s will account for up to 25.2 percent of the total population.

In terms of road safety, we must take into account the needs of older people in many regards, and also consider the fact that 28 percent of traffic fatalities in Spain were over 65 years old (despite making up only 19 percent of the population, as mentioned above). First and foremost, we need to consider the physical condition of older people and the impact this can have on injuries suffered in accidents. In studies conducted by the RACE, 58 percent of people over 65 said they had some kind of problem that could limit their mobility (physical mobility, vision or hearing). However, only one in five admitted that these physical problems impeded their own mobility. It is also important to consider the susceptibility to injury among older people when involved in severe road accidents. Severe injuries affecting internal organs and bones, which get weaker with age, are typical. This is evident from the fatality rate for people aged over 65, which is three times higher than for the rest of the population; in the 75 to 84 age group it is four times higher, and among over 85s even seven times higher.

Another focal point is adapting the environment and our road infrastructure, especially in urban areas. Over 75 percent of Spain's older population live in towns or cities, and a glance at the statistics for 2019 reveals that 43 percent of all traffic fatalities in Spanish towns and cities were older than 65. There is another figure that is even more disturbing: seven out of ten pedestrians who suffered fatal accidents in Spanish towns and cities were over 65 years old, though it should be noted that there was a significant increase in the percentage of over-75s in 2019.

The question of mobility habits among older people and how these are changing is also important. According to sociological investigations conducted by RACE, people aged over 65 make an average of three trips per day that involve them traveling for more than five minutes. The reasons for these trips are everyday errands, such as going shopping and visiting the doctor. This demographic makes 80 percent of these trips on foot, and 70 percent of them always follow the same route, such as when taking their grandchildren to school. According to studies conducted by RACE on the older demographic in Spain, the economic problems in recent years are responsible for the number of older people who take their grandchildren to school doubling within a short period of time, from 9.8 percent to 18.5 percent.

As these facts clearly demonstrate, lawmakers (particularly those at a municipal level) must make a conscious effort to incorporate older people into their mobility strategies. In order to do this, analyses must be conducted into adapting the environment to suit the needs of this group. RACE works with organizations such as the Spanish Institute for the Elderly and Social Services (IMSERSO), which is part of the Spanish Ministry of Social Rights and 2030 Agenda (Ministerio de Derechos Sociales y Agenda 2030), and local governments such as those in Valladolid, Castellón and Bilbao in order to promote mobility, accessibility and road safety in cities in accordance with the Vancouver Protocol on the mobility of older persons in cities.

Since the launch of the "Movilidad Senior, el camino de todos" campaign (Senior Mobility – the Road is for Everyone) in 2013, RACE has given training to over 21,700 people aged over 65 in its 288 courses, which are conducted in 16 cities throughout Spain. These courses promote road safety by teaching participants how to act safely on the road, and also highlight the important role the government plays in drawing up short and long-term measures to ensure accessible, safe mobility for our most vulnerable road users.

menting measures that help drivers to (intuitively) orient themselves correctly and within plenty of time. These measures should thus be taken into account when carrying out new road construction projects and during regular infrastructure inspections. Measures such as direction signs, road signs and/or markings can partially help road users to make sure they are joining roads and freeways in the right direction. Various EU countries already have substantial signage on selected sections of freeway to warn drivers and prevent them from joining the freeway in the wrong direction. Unambiguous, self-explanatory traffic routing and clear and comprehensible signs will be key approaches in reducing the number of people accidentally driving on the wrong side of the road. This means they also provide a way in which we can use infrastructure to reduce risks in general – everywhere and for all road users.

INTERMODAL ROUTING VIA DIFFERENT MODES OF TRANSPORT

However we choose to get from A to B, the future of mobility and traffic policy is being discussed at length all around the world. The discussion addresses trends and challenges such as social diversification, demographic change and cultural aspects, and looks at their significance for mobility and traffic from a socio-ecological perspective. One reoccurring question is what would a culture of sustainable mobility with multiple transport options look like for a society that is continuously aging and pluralizing and becoming more diversified.

One of the many problems, particularly in rural areas, is that for many people the concept of mobility has limited practicability unless they have their own car – especially those aged 65 and over. Even in the relatively densely populated countries of western Europe, the public transport services available in rural areas are often insufficient and cannot be relied on to ensure that people can get around independently. Likewise, the bicycle is not a viable alternative for traveling from small communities to the nearest mid-sized town – at least not in mountainous regions or over long distances. However, e-bikes are becoming increasingly popular as an alternative in such areas. In order to guarantee mobility for people without cars in rural, sparsely populated areas, alternative public transport services are thus required. "Flexible" forms of transport and "on-demand" services offer a potential way forward here.

In some cities and regions, the future has already arrived, offering the population "people movers" – driverless shuttle buses (albeit staffed with an assistant for now) that serve a predefined route and allow people to get on or off at set stops like a regular public bus. However, studies on the attitudes towards, acceptance of and intention to

A Best-Practice Example of Changes in Road Design

In road safety work, as in many other fields, it is important to learn from accidents, recognize key areas of risk, and implement improvements. One good example of this is the response to a fatal accident involving a truck and a pedestrian with a rollator, which is described in accident example 3 on page 26 of this report. At the time of the accident, the pedestrian light was positioned at a point where using it required a significant diversion to the natural route taken by the majority of pedestrians. At the same time, a sleeping traffic light ahead of the crossing itself that was designed to keep the bus stop clear emboldened pedestrians to take a direct route across the road, resulting in critical situations. Following the accident, the police reported the issue to the responsible city authorities and recommended that the section of road in question be redesigned. Moving the pedestrian light has proven to be a quick solution that makes the section of road much easier to navigate, takes into account the needs of pedestrians by providing them with a direct route, and thus improves safety levels. This example clearly shows how important good collaboration between the police, the traffic authorities, politicians and other authorities involved in road planning and infrastructure design can be – not to mention a desire to bring about improvements by increasing road safety.

use driverless shuttles among older people have thus far shown inconsistent results when it comes to the acceptance of such mobility services. Nevertheless, shuttle services – which in the future could even take people from their front doors to the nearest rail-based public transport station, for example – offer good prospects for keeping people connected to urban spaces, especially for older people living in rural areas. Driverless shuttles that carry people to conventional public transport service stops in rural areas may even prove a more manageable alternative to the current plan: the rapid, comprehensive shift of the multimodal model for road use in and between conurbations toward highly or fully automated driving.

INCLUSIVE MOBILITY CONCEPTS

The car plays a dominant role in allowing people to maintain the type of independent mobility that enables them to remain an active part of society well into their old age, especially in industrialized countries. Habit, the convenience and efficiency that this form of mobility offers, and secondary motives such as an enjoyment of driving and the need for individuality and independence all play a key role in the perceived attractiveness of the car for people of all ages. Older people's sense of satisfaction and perceived quality of life are also closely linked to this.

If we want switching to public transport to become an option, for example, we will need inclusive mobility concepts that incorporate the needs of older people as a matter of course. One of the initiatives that has been important in getting the ball rolling in this regard is the EU-funded TRACY project (Transport Needs for an Aging Society), which ran from 2011 to 2013. The objective of this project was to develop a plan of action that would help to tackle the challenges facing transport services in an aging society.

After compiling, analyzing and assessing the existing strategies for all forms of land transport in the EU member states and comparable countries (Switzerland, Norway, the USA, Australia, New Zealand and Japan), the TRACY team drew up proposed solutions for ensuring mobility for older people, and also defined the requirements for a transport system that is suitable for older people. In particular, the project stated that such a system must be easily accessible, easy to reach, available and barrier free, and also comfortable, comprehensible and efficient. It was also deemed important that older people feel welcome when using the transport system, and not be treated like a burden or a nuisance. Finally, the other characteristics defined in the report included a high degree of reliability, safety (in terms of both road safety and a sense of personal safety), usability and transparency.

The proposals formulated in the TRACY project can very much be seen as universal design solutions. It was recommended that the following maxim should always be applied when implementing a transport system in any area: even after letting go of automotive mobility, older people have the right to a transport system that helps them to maintain their quality of and satisfaction with life.

Nevertheless, driving will remain a key component of personal mobility for senior citizens in the future, and may even become more important for them. Even as the alternative services on offer continue to improve, the needs of older car drivers must be taken into account when planning and designing infrastructure – to an even greater extent than they are today.

The Facts at a Glance

- **Depending on the prevailing local conditions, light signaling systems, pedestrian crossings (crosswalks), central islands or protruding curbs must be used to make crossings safer, especially for older pedestrians.**
- **In light of the fact that more and more people aged 65 and over are using bicycles and pedelecs, the expansion of the bicycle path network in accordance with road safety concerns and the maintenance of bicycle paths must be made a top priority.**
- **In order to prevent cars from driving in the wrong direction on freeways as much as possible, suitable measures that help drivers to (intuitively) orient themselves in good time are required.**
- **Driverless shuttle services that take people from their front doors to the nearest rail-based public transport station, for example, offer good prospects for keeping people connected to urban spaces, especially for older people living in rural areas.**
- **If we want switching from cars to public transport and other services to become an option, we will need inclusive mobility concepts that incorporate the special needs of older people as a matter of course.**
- **The needs of the aging society must be assigned far greater importance in infrastructure planning, design and maintenance than they are in many places today. All forms of road use must be taken into account equally.**

Safe Mobility in Old Age Is a Social Obligation

Every year, statistics from all over the world reconfirm an unpleasant constant: older road users are at particularly high risk of suffering an accident on the road. This applies especially to senior citizens who use the roads as pedestrians or cyclists. This means we need to act fast, particularly in light of the fact that, due to the demographic shift forecast for the next decades, the percentage of the general population who are aged 65 and over will continue to rise. There are plenty of areas to focus on, as this report has shown with its many examples, particularly with regard to the human factor, technology and infrastructure.

Around 30 percent of all traffic fatalities that have occurred in the EU in recent years were aged 65 or over, and among pedestrians and cyclists, senior citizens even accounted for around half of all those killed on the road. These few facts alone – which have not changed much over the years – illustrate the often life-threatening dilemma older people face when using the road in any capacity. If the United Nations' forecasts prove accurate, the situation could get even worse in many parts of the world. According to these figures, one in four residents in Europe and North America will be aged 65 or over by 2050, for example. In view of the increased vulnerability that comes with age (i.e. the higher risk of suffering severe or fatal injuries compared to younger people involved in an identical type of accident), there is a danger that the number of road accident victims in the 65+ age group will rise even further.

There are a wide range of measures that can be used to counteract this trend, as detailed in the previous chapters of this report. One of the challenges will be to devise a way to help senior citizens retain their independent mobility well into old age while also minimizing the potential risks posed to them – and occasionally posed by them. The best preventive approach to counteracting this problem would seem to be a combination of various solutions. This means we need to consider monitoring, advice and appraisal measures just as seriously as vehicle technology and infrastructure design solutions and inclusive mobility concepts.

When it comes to improving road safety for senior citizens, many experts are in favor of the use and further development of assistance systems that compensate for age-related deficits and can help to reduce the number of accidents older drivers are involved in, or cause – due to driver errors for example. As a survey commissioned by DEKRA has shown, the 65+ age group is very open to the idea of electronic assistants. However, it is important to note that it will take a long time

for vehicles with assistance systems to achieve a high level of market penetration. For new safety systems, this will take an average of 15 years after they become a mandatory requirement. The results of a study commissioned by the German Federal Highway Research Institute (BASt) and published in January 2020 are also of interest in this context. These show that, in 2017, electronic stability control (ESC), brake assist and cruise control were the systems most commonly installed in vehicles in Germany, at 83 percent, 77 percent and 48 percent respectively. Meanwhile, new systems such as automated emergency braking, lane departure warning system and blind spot warning system still had very low installation rates, in some cases under five percent.

Since infrastructural measures like structural changes to the road also often take a long time to get from the planning stage to implementation, for now we need to focus on the human factor if we want to achieve fast positive results with regard to road safety, especially that of senior citizens. The fact is that age-related limitations on cognitive processing resources have a significant impact on the amount and complexity of information a person can handle at any one time. This makes dealing with a driving task more strenuous, which in turn leads more quickly to overloading in the form of tiredness and mental stress. This makes it much harder for senior citizens to act according to the regulations and appropriately for the respective traffic situation, especially at complex junctions, at points with different rights of way, and when turning. This goes some way to explaining why older people are more prone to accidents, especially in these types of situations on the road. The ability to correctly judge speeds and distances also decreases with age – particularly when other health-related limitations become a factor.

Generally speaking, in order to improve road safety for senior citizens, a proactive strategy that takes all types of mobility into account is required at international, national, regional and local levels. The explicit objective of this strategy must be to enable senior citizens to retain safe, personal mobility – and we must all make a social commitment to achieve this aim.

DEKRA's Demands

The focal point of all considerations must be how we can enable older people to maintain their mobility safely.

- **In order to ensure that they use the roads safely, older people must be provided with structured, intensive education on their performance and limitations.**
- **Regular practical evaluations should be mandatory for senior citizens over the age of 75; these play an important role in helping them maintain their skills.**
- **All the relevant players in the health care system must be given awareness training and the qualifications to provide older people with advice regarding whether it is safe for them to drive.**
- **Clear regulations are required for doctors on how the dilemma between maintaining doctor/patient confidentiality and potentially overlooking an acute safety risk should be handled – this applies to all road users, not just older ones.**
- **In order to increase the number of potential compensation options through driver assistance systems, it should be possible to make permission to drive contingent upon the use of certain systems, so that personal mobility can be retained in situations that would otherwise result in a person's driving license being revoked.**
- **In the interests of safety, the market penetration of driver assistance systems, some of which can compensate for the increased risks to which older drivers are exposed, must be improved further. In order to achieve this, substantial awareness-raising work is required, especially for older people.**
- **The operation of all safety-related vehicle functions, particularly driver assistance systems, needs to be standardized as far as possible, so that they can be operated as intuitively as possible regardless of vehicle model.**
- **Anyone buying a pedelec – in particular older people – should be provided with in-depth advice and the opportunity to familiarize themselves with the unusual way they work before buying.**
- **Pedelec manufacturers should offer a "learner mode" for first-time pedelec riders that enables them to voluntarily reduce the power of the electrically assisted pedaling while they get used to the vehicle.**
- **Depending on the prevailing local conditions, light signaling systems, pedestrian crossings (crosswalks), central islands or protruding curbs must be used to make crossings safer, especially for older pedestrians.**
- **In light of the fact that more and more people aged 65 and over are using bicycles and pedelecs, the expansion of the bicycle path network in accordance with road safety concerns and the maintenance of bicycle paths must be made a top priority.**
- **In order to prevent cars from driving in the wrong direction on freeways as much as possible, suitable measures that help drivers to (intuitively) orient themselves in good time are required.**
- **Particularly in rural regions, models must be developed to enable older people to retain their mobility without having to drive a car themselves.**

Any Questions?

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