European Commission

Thematic Report

Main factors causing fatal crashes

This document is part of a series of 20 thematic reports on road safety. The purpose is to give road safety practitioners and the general public an overview of the most important research questions and results on the topic in question. The level of detail is intermediate, with more detailed papers or reports suggested for further reading. Each report has a 1-page summary.

Contract:	This document has been prepared in the framework of the EC Service Contract MOVE/C2/SER/2022-55/SI2.888215 with National Technical University of Athens (NTUA), SWOV Institute for Road Safety Research and Kuratorium für Verkehrssicherheit (KFV).
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Referencing:	Reproduction of this document is allowed with due acknowledgement. Please refer to the document as follows: *European Commission (2024). Road safety thematic report – Main factors causing fatal crashes. European Road Safety Observatory. Brussels, European Commission, Directorate General for Transport*.

Contents

1. Summary

Crash contributory factors include an array of human, technical and organisational factors that interact within a complex and dynamic traffic environment. The Safe System approach stipulates that system design should anticipate, prevent and forgive human errors, so that safety does not depend on the behaviour or actions of an individual driver. Infrastructure and vehicle design, traffic laws and their enforcement, and the promotion of safety culture are important layers of the safe system, together with post-impact care for the mitigation of crash consequences.

In this context, addressing a number of risk factors is considered fundamental for the reduction of fatal and serious crashes: speeding, driving under the influence of alcohol, distraction and other psychoactive substances, and non-use of protective equipment. Other important contributory factors are fatigue, traffic rules violation (e.g. red light running, illegal crossing or overtaking), infrastructure deficiencies, inappropriate speed limits, unsafe vehicles, and inadequate enforcement.

- Speeding is a contributory factor in ~30% of fatal crashes, and a reduction of 10 km/h of the initial speed may result in ~50% reduction in fatal accidents.
- Alcohol is involved in ~25% of fatal crashes in Europe. The fatal crash risk of driving under the influence of drugs ranges between 1.3 and >5 times higher than that of a sober driver.
- 2-10% of European drivers are engaged in hand-held phone use at any moment, while the self-reported frequencies of hand-held, hands-free use and texting are much higher. Distraction significantly affects lateral control of the vehicle, visual attention and reaction time. Drivers often engage in compensatory behaviours (e.g. reducing speed, increasing distance from the vehicle ahead etc.) but these are mostly ineffective in counterbalancing the impaired reaction time. Distraction plays a role in 5 - 25% of crashes in Europe. The impact of distraction on crash risk ranges from ~1.5 increase for hands-free use, to ~2.5 increase for operating vehicle systems, to 3-3.5 increase for hand-held use, and eventually to >6 increase for texting.
- Seat belt wearing rates in rear seats and helmet use among riders of powered two-wheelers (PTWs) are still low in several EU countries. Non-use of seat belts is associated with ~25% of European fatalities; in several countries the figure is much higher. It is estimated that 900 deaths per year could be avoided in the European Union if 99% of car occupants wore seat belts.

These results indicate that addressing the above causes of fatalities in Europe, through safe-by-design thinking, i.e. prevention, control and mitigation of the consequences of these errors, can contribute significantly towards the ambitious EU targets of halving fatalities by 2030 and eliminating them by 2050.

2. Identifying the main factors causing fatal crashes

2.1 Crash causation

In the EU around 20,400 people were killed in road crashes in 2023, a 1% decrease compared to 2022 as traffic levels fully recovered after the pandemic. The EC is committed to the Vision Zero targets of halving traffic fatalities by 2030 and eliminating them by 2050. In this context, it is crucial to have a full understanding of the main factors that cause traffic fatalities.

It is often identified in the literature that human factors are contributory factors to ~95% of crashes, whereas infrastructure factors and vehicle factors contribute to ~30% and ~10% of crashes. This approach is driven from a liability perspective, which focuses on the events of the crash and the actions taken by its participants; it is the approach widely taken by traffic police and insurance investigations (Hauer, 2020), both interested in ‘blame attribution’. In contrast, in-depth accident investigations are largely driven by a systems perspective, in which human, technical and organisational factors interact within a complex, dynamic, and often loosely regulated traffic environment.

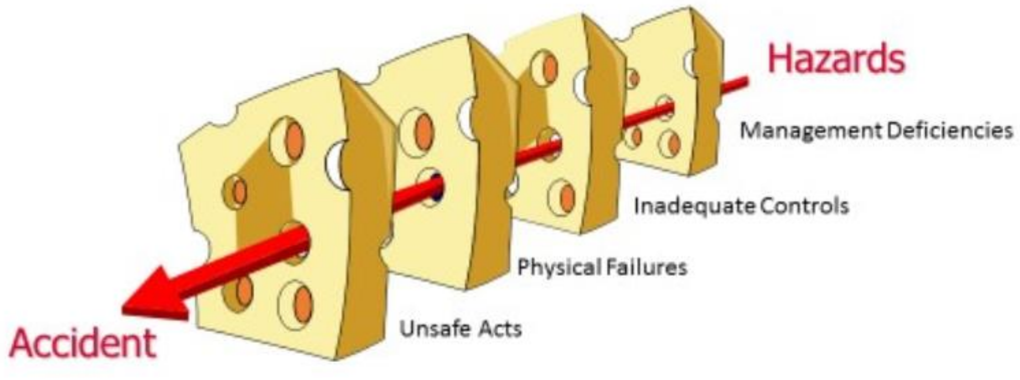
The Safe System approach recognises that humans are imperfect drivers and at the same time vulnerable to serious traffic injuries and fatalities, and therefore postulates that the systems should be designed, maintained and operated in a way that anticipates and forgives human error. Accordingly, the pillars of a Safe System approach include safe roads and roadsides, safe speeds, safe vehicles, and safe road users, all of which must be addressed in order to eliminate fatal crashes and reduce serious injuries (WHO, 2018).

The term ‘human factors’ encompass a number of factors including individual characteristics, including demographics, knowledge, skills, experience, personality traits, attitude /perceptual / motivational factors, disease or impairment, and the resulting observed risky driving behaviour. The latter may concern speeding (exceeding speed limits or inappropriate speed for the conditions), driving under the influence of drugs or alcohol, non-use of protective equipment, inattention or distraction, drowsiness, harsh manoeuvring, tailgating, illegal crossing or overtaking, misjudgement and observation errors, or traffic rule violations (EU-DSS, 2023).

Among all the potential causes, addressing a number of specific risk factors is considered fundamental for the reduction of fatal and serious injury crashes (WHO, 2023) : speeding, driving under the influence of alcohol and other psychoactive substances, non-use of motorcycle helmets, seat belts, and child restraints, and distracted driving. These factors are not only highly prevalent in fatal crashes but are also associated with more severe safety outcomes; therefore, further efforts are needed to prevent, control and mitigate their impacts. Alongside the above key risk factors, unsafe infrastructure, unsafe vehicles, inadequate post-crash care, inappropriate speed limits and inadequate traffic laws / enforcement may trigger or exacerbate the prevalence and impacts of human behaviour. At the same time, the design of self-explaining and forgiving road infrastructure and safety technology equipped vehicles, together with the effective education and enforcement of credible traffic laws, can prevent and mitigate human errors and foster safety awareness and positive safety culture among road users.

It has been well established in safety science that many of the errors that humans make are – apart from mistakes (random or systematic, due to lack of knowledge, skills or experience) or intentional violations - in fact ‘latent errors’, i.e. errors resulting from systems and routines that are *designed in way that humans are disposed to making errors* (Reason, 1990). Moreover, the ‘Swiss cheese’ model (see Figure 1) demonstrates that accidents are a result of the alignment of several failures along sequential layers of the safety management system, where human action is the last layer of the system.

__Figure 1.__ Swiss Cheese model of accident causation. Source: Reason (1990)



In this sense, human factors as crash contributor factors should be considered as causes that could have been avoided through system design and safety culture, thereby not placing a disproportionate share of responsibility on road users. More specifically, system design should anticipate, prevent and forgive human errors. This way, latent errors can be prevented, by making safety independent from the actions or choices of individual humans. This implies a highly proactive approach, in which interventions are made as early on the chain as possible.

2.2 Data on crash causation

In this section, data is presented aiming to demonstrate the prevalence of the main contributory factors to fatal crashes across Europe. However, it is often difficult to rank these key contributory factors in terms of importance. The share of reported contributory factors varies to some extent in different countries. Indicatively, in the OECD/ITF Road Safety country profiles (ITF, 2023), it is reported that:

- In France in 2020, according to police reports and in-depth crash investigations (CEREMA, 2021), speed was one of the causes of 29% of fatal crashes. The share of alcohol-related fatalities has remained stable at around 30% since 2000. It was estimated that 21% of all road deaths occurred in a crash with a driver under the influence of illegal drugs. Moreover, at any given time during daytime, 2.5% of passenger car drivers, 6% of light-duty vehicle drivers and 4.5% of heavy vehicle drivers used a handheld or ear-mounted phone, while this was a cause in 2-4% of fatal crashes (CEREMA, 2021). Moreover, 24% of car occupants killed were not wearing a seat belt or the seat belt was not appropriately buckled when the crash occurred.

- In Germany, inappropriate speed was a factor in about 34% of fatal crashes in 2020. Alcohol was cited as a contributory factor in around 4 -5.8% of fatal crashes. An assessment conducted in 2019 showed that 3% of passenger car drivers use their smartphones while driving, 2% type on their smartphone and have at least one hand off the steering wheel and the view off the road ahead.
- In Greece in 2018, it was estimated based on police reports that about 18% of fatalities were directly related to excessive or inappropriate speeds, and almost 23% of road fatalities were attributed to drink driving.
- In Austria in 2020, 32% of all road fatalities were caused by inappropriate speed, while alcohol was involved in 8% of fatalities. In a recent study[1], it was found that distraction (lack of attention, lack of concentration and simply overlooking other road users) was the presumed leading cause of 21.5% of all road fatalities in 2020.
- In Poland, speed remains one of the leading causes of crashes and contributes to 42% of fatalities, while 13% of traffic fatalities were alcohol-related in 2020. Based on data from 2016, around 4% of drivers in passenger cars use hand-held mobile phones.
- In Spain in 2020, inappropriate speed contributed to 25% of fatal crashes. 61% of fatally injured drivers on interurban roads were administered drug tests, with 19% testing positive. On urban roads, 62% of fatally injured drivers were tested, with 31% testing positive. Distraction, including the use of mobile phones, radios, DVDs, witnessing a previous crash, looking at the environment, absent-mindedness and sudden illness or indisposition, was a factor in 31% of fatal crashes in 2020. Moreover, 27% of car and van fatalities aged 12 and over were not wearing seat belts on interurban roads, while this figure jumps to 37% of deaths on urban roads.
- In Slovenia, 34% of total road fatalities were caused by excessive speed. Official data attributed around 0.4% of traffic crashes to drivers under the influence of drugs.
- In Finland, according to reports from road crash investigation teams, speeding or inappropriate speed contributes to 30% of all fatal crashes. In 2020, 26% of casualties were injured in drink-driving related cases. While 49% of car or van occupants killed were not wearing a seat belt.

It is important to note that the reporting methods of the above data vary considerably. Most countries report on the basis of police data, which have several limitations: most importantly, no formal methods

[1] https://www.kfv.at/ablenkung/

to identify contributory factors are implemented. Moreover, it is not known whether multiple risk factors are recorded in a single crash, or only the main cause per crash is reported. Therefore, the above figures are not directly comparable; moreover, it is likely that the above figures are an under-estimation of the magnitude of these contributory factors in most countries. Furthermore, the lag in releasing the yearly official figures in most countries does not allow assessing the most recent situation.

The pertinent method for determining crash causation is that of in-depth accident investigation, led by a multi-disciplinary team of investigators, but only a few countries systematically perform such investigations, and these are only on a sample of all fatal crashes – for economic and logistics reasons. Most importantly, there are very few attempts to perform in-depth investigations at European level on the basis of a common investigation methodology. The establishment of the European Road Safety Observatory (ERSO) came with the presentation of an important methodological framework and the implementation of a pilot study of crash causation in Europe, based on data from 997 fatal crashes in 6 countries. The main results are reported in Thomas et al. (2013).

In that study, it was found that, in terms of general causation factors[2], timing errors, i.e. situations where the road user did not act when they should have done, or on the contrary acted too quickly, were the most common (namely 51% of car drivers, 42% of motorcyclists, 68% of pedestrians and 46% of cyclists); these timing errors may result from driver distraction, alcohol/drug influence, or fatigue resulting in late reactions. Speed errors were observed in 15% of car drivers, and in 26% of motorcyclists.

Table 1 shows the more detailed analysis of specific causation factors; a temporary person-related function accounts for 25% of fatal crash causes – out of which a total of 52% is attributable to inattention (22%)/ distraction (30%), a total of 19% is attributable to fatigue or sleepiness and 17% is attributable to driving under the influence. Another 16% of fatal crash causes is accounted for by interpretation errors – out of which 44% are faulty diagnosis or error in mental model, e.g. a lack of situational awareness.

One of the particularities of in-depth studies is that the attributed contributory factors are based on detailed causation models, looking

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[2] General causation factors are defined as 'nine classes of contributory factors that together are taken to describe all types of physical interaction and which characterise an action' immediately before the crash, and are separated into specific risk factors that precede both chronologically and within the causation chain.

backwards at the source of the inappropriate driving behaviour – and including important factors like fatigue or mental errors that can not be identified by the police. In most cases, more than one sources of error may be involved in the manifestation of a certain risk factor (e.g. a speed error may be caused by a faulty diagnosis of the road layout, which is due to an abrupt change in infrastructure design, inexperience resulting from insufficient training, or all of these at the same time). Therefore, the shares of risk factors from crash causation data cannot always be interpreted in a straightforward way, and cannot be directly related to the key factors involved in fatal crashes as reported by the police.

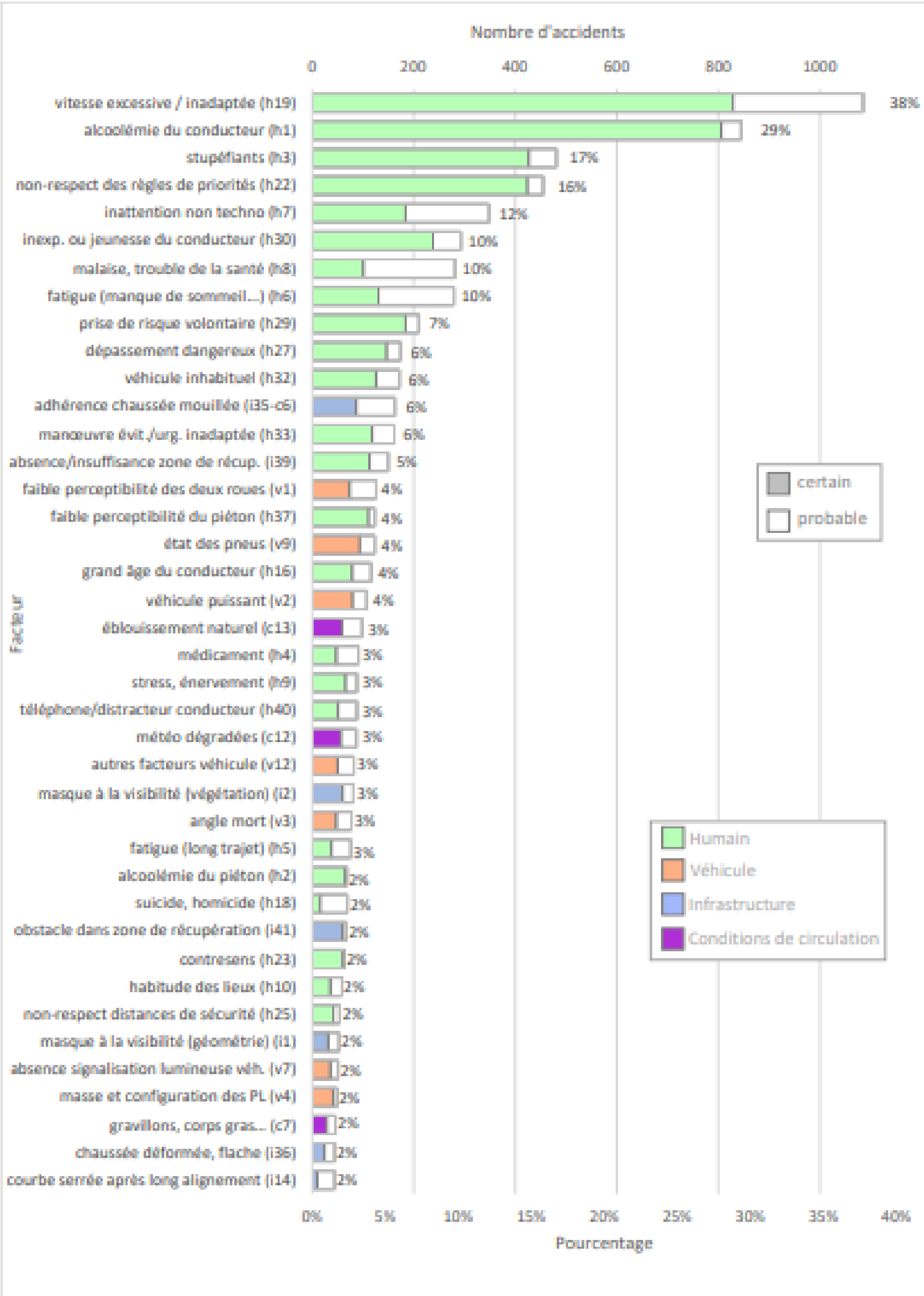
Nevertheless, the data and information in Table 1 clearly indicate that the five main risk factors in fatal crashes can be well distinguished as standing out from the entire pool of possible fatal crash causes, and therefore particular emphasis should be given to addressing them.

Table 1. *Main contributory factors of fatal crashes in Europe (Adapted from Thomas et al., 2013)*

Contributory factor		Share of crashes
Temporary person related function		25%
	Distraction	30%
	Inattention	22%
	Under influence	17%
	Stress	15%
	Not illness related	9%
	Fatigue	12%
	Circadian rhythm	6%
	Extensive driving	1%
	Other	7%
Interpretation		16%
	Faulty diagnosis - error in mental model	44%
	Misjudgement of time-distance	18%
Communication		15%
Planning		13%
Design of traffic environment		12%
Experience and training		4%

In a French report on causes of fatal crashes (CEREMA, 2021), an exhaustive list of human, vehicle and infrastructure related contributory factors were ranked in terms of causation frequency. The results are presented in Figure 2 Similar in-depth investigation results are available for accident causes in general or for specific road user groups in particular, also in other European countries, e.g. for cyclists in the Netherlands (Boele-Vos et al., 2017), for Heavy Goods Vehicles in Germany (Schindler et al., 2022).

Figure 2. *Contributory factors present in more than 2% of fatal crashes in France (Sample size N= 2878 crashes) (Source: CEREMA, 2021)*



In the following sections, a comprehensive review of the state of the art and recent available data is given on the identified main causes of fatal crashes, with focus on: i) their mechanism of affecting driving behaviour; ii) their prevalence among road users; iii) their impact on road safety in terms of accident occurrence, severity and risk; and iv) the main interventions that can be made to prevent these causes and mitigate their consequences. The detailed description of measures for tackling them is beyond the scope of this Thematic Report; the reader is referred to ERSO (2021, 2021a, 2021b, 2021c) for more details.

3. Key elements of factors causing fatal crashes

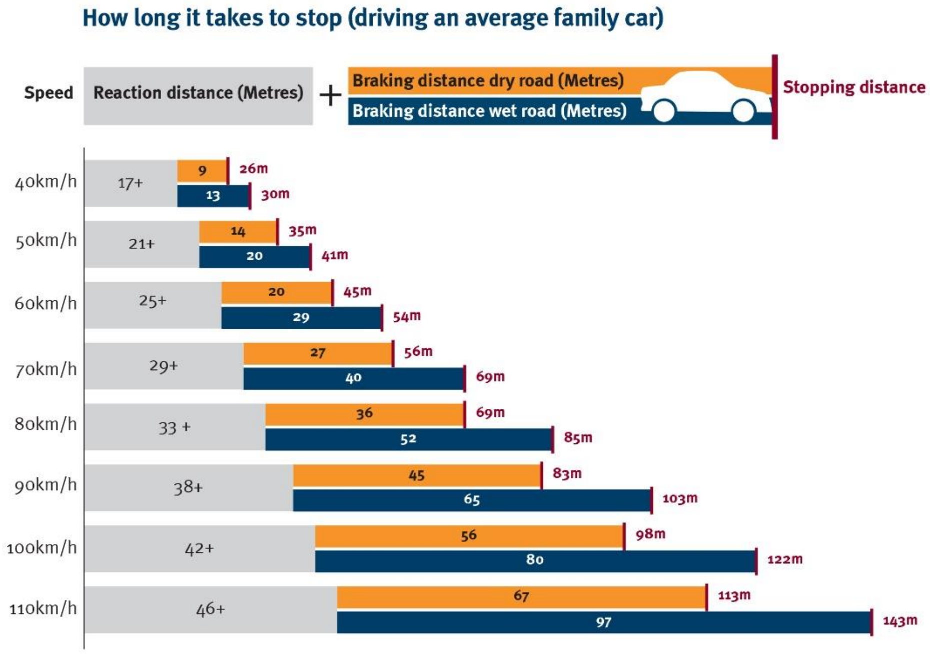
3.1 Speeding

3.1.1 Mechanism

There are several reasons why road safety outcomes are affected by speed (EC, 2021):

- High speed results in less time to react to an unexpected event, for the same driver reaction time, because the distance covered before the reaction is greater at high speed. High speed also increases the braking distance, as the latter is proportional to the square of the speed (see Figure 3).
- The higher the speed of any given approaching vehicle the less time there is for other road users to react and avoid a collision.; in this case, other road users may also often overestimate the time left to react.
- High speed results in narrower field of vision for the driver. For instance, at 130 km/h, a driver has only an angle of about 30°, which limits considerably their ability to detect and assess hazards (OECD/ECMT, 2006).
- Obviously, higher impact speed means higher amount of energy released during the crash, and more severe injuries.

***Figure 3.** Reaction distance and stopping distance for different driving speeds. Source: Queensland Government (2023)*



3.1.2 Prevalence

Several recent studies and reports have reported on the prevalence of speeding in Europe. Table 2 shows data collected and published by the EC project Baseline on speeding on European roads on 2023. While there is large variability in the degree to which countries monitor speed limits, as well as on the methods for monitoring, the report concludes that:

- On urban roads, between 27% and 79% of observed vehicle speeds are higher than the speed limit.
- On interurban / rural roads (non-motorways), between 7% to 71% of observed vehicle speeds are higher than the speed limit.
- On motorways, between 11% and 60% of observed vehicle speeds on motorways are higher than the speed limit.

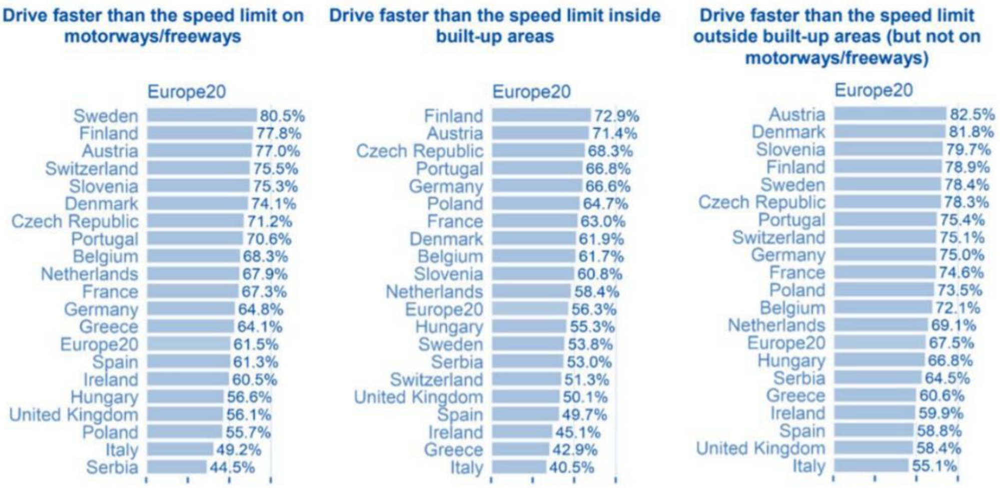
Table 2. *Observed mean speeds (free flow) and proportion (in %) of observed speeds lower than the speed limit for cars during weekdays/daytime on urban, rural roads and motorways (Source: Van der Broek et al., 2023)*

Country	Urban roads		Rural roads		Motorways	
	Mean speed	% within speed limit	Mean speed	% within speed limit	Mean speed	% within speed limit
AT	50	57	85	89	121	81
BE	-	40	-	52	-	56
BG	52	45	64	93	116	89
CY	56	26	69	46	98	47
CZ	50	57	89	55	134	40
FI	54	42	83	43	109	45
EL	47	59	68	84	109	78
IE	58	25	91	89	106	88
LV	52	41	97	29	-	-
LT	54	36	93	47	118	77
MT	45	70	60	74	-	-
PL	61	21	91	52	126	54
PT	44	73	97	36	124	44
ES	42	51	94	43	121	51
SE	47	66	70	52	108	44

Moreover, self-reported speed limit exceedance rates are in many cases higher than the observed ones. The ESRA[3] survey results (Holocher & Holte, 2019) showed that in 2018, 56% of European car drivers indicated that they had deliberately driven faster than the speed limit in built-up areas at least once in the previous month (67% on rural roads and 62% on motorways). The differences between countries lie on a range between 44-80% of drivers on motorways, 55-82% of drivers on interurban / rural roads and 40-73% of drivers on urban roads (see Figure 4).

[3] www.esranet.eu

Figure 4. *Self-reported speeding behaviour of car drivers (at least once over the previous 30 days) (Source: Holocher & Holte, 2019)*

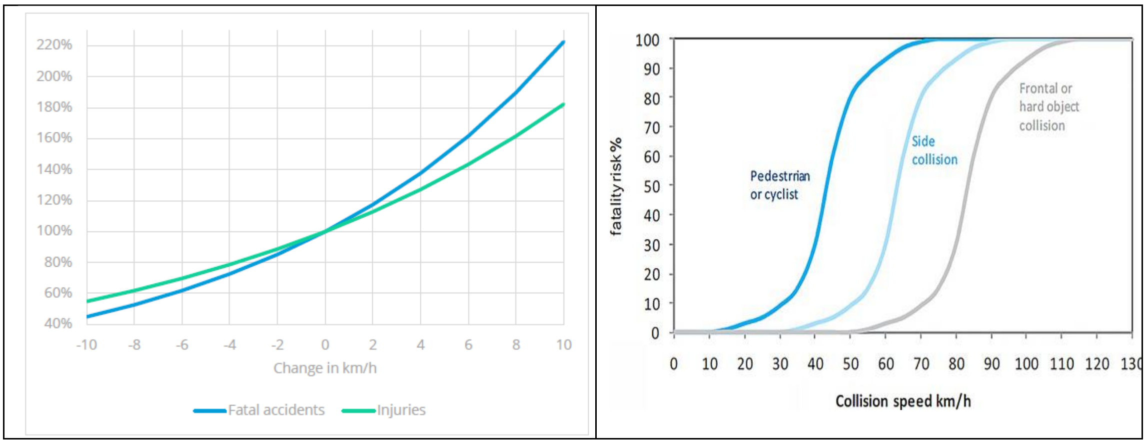


3.1.3 Safety impacts

The Safe System approach stresses the human body tolerance to a collision as a function of impact speed (see Figure 3); a pedestrian or cyclist can tolerate up to ~30 km/hour, while a car occupant can tolerate 50-70 km/h impact speed in side collisions, and 70-90 km/h in frontal or hard object collisions (Yannis & Papadimitriou, 2021 based on Tingval and Haworth, 1999).

Moreover, a speed increase of 10 km/h leads to a doubling of the risk of injury crash, and even higher risk of fatal crash (see Figure 5).

Figure 5. *Relationship between speed change and crash rate (left panel) – relationship between impact speed and fatality risk (right panel).*



Sources: Van den Berghe & Pelssers (2020) based on coefficients of exponential model in Elvik et al. (2019); Yannis & Papadimitriou, 2021 based on Tingval and Haworth, 1999

Accordingly, it is estimated by ETSC that reducing the average speed by 1 km/h on all roads across the EU would save over 2000 lives per year (Adminaité-Fodor & Jost, 2019). WHO further suggests that a pedestrian who is hit by a car travelling at 65km/h is four times more likely to be killed compared with a car travelling at 50km/h (WHO, 2018).

The impact of speed on road safety outcomes is largely estimated on the basis of the 'Power Model' (see Eq.1); this suggests that the number of fatal accidents, serious injury accidents (including fatal accidents), and all police reported injury accidents (including fatal and serious injury accidents) change in proportion to, respectively, the fourth, third and second power of the relative change in the mean speed of traffic" (Aigner-Breuss et al., 2017).

$$\frac{Accidents\ after}{Accidents\ before} = \left(\frac{Speed\ after}{Speed\ before}\right)^{Exponent} \quad (1)$$

A re-analysis of the Power Model (Elvik, 2013) indicates that the relationship between speed and road safety does not only depend on the relative change in speed, but also on the initial speed of traffic: a 25% speed change from 20 km/h to 15 km/h will have lower effects than the same reduction from 100 km/h to 75 km/h.

Additionally, Elvik's analysis resulted in exponential functions that fitted *"the data extremely well and imply that the effect on accidents of a given relative change in speed is largest when initial speed is highest"* (Elvik, 2013, p. 854). The analyses suggest that a reduction of 10 km/h of the initial speed results in ~50% reduction in fatal accidents and a 28.9% reduction in injury accidents when reducing the initial speed by 10 km/h.

3.1.4 Interventions

There are four main areas of intervention for speeding:

- Speed limits and their enforcement: while speed limits balance between mobility, safety and environmental considerations, the human body's physical tolerance to traffic impacts should be the backbone of credible and safe speed limits. The Dutch Sustainable Safety approach (Wegman & Aarts, 2005) indicates that speed limits should be defined on the basis of the type of traffic conflicts that can be observed on the network (frontal, lateral or at-angle, between cars and unprotected road users etc.), so that traffic participants are not exposed to intolerable speeds. Dynamic speed limits, taking into account traffic or weather conditions are also very effective (Daniels & Focant, 2017). At the same time, enforcement of speed limits, either by means of police patrolling or by means of speed cameras has proven to be very effective in preventing speeding and fostering a compliant culture among drivers.

- Road infrastructure design should encourage appropriate speed selection by self-explanatory roads with clear functionality (through, distributor or access road) without abrupt changes (i.e. maintaining design consistency). Moreover, credibility of speed limits particularly in urban or semi-urban settings can be enhanced with infrastructure arrangements e.g. road narrowings, speed humps or roundabouts.
- Vehicle technologies like Intelligent Speed Adaptation or Adaptive Cruise Control can help drivers maintain a safe speed and comply with the posted speed limits.
- Awareness raising and education are important additional tools for a sustainable safety culture, and should be promoted not only by authorities, but also vehicle manufacturers, fleet managers, companies, schools. Rehabilitation programmes for speeding offenders are also found to be effective.

3.2 Alcohol & drugs

3.2.1 Mechanism

Alcohol and drugs may impair several functional capabilities critical for safe driving, including reaction time, tracking ability, proper speed management, vision, divided attention, and vigilance (EC, 2021). In a general review of the effects of alcohol on cognitive driving tasks, Garrison et al. (2021) conclude that:

- deficits in aspects of visual perception begin at a Blood Alcohol Concentration (BAC) of 0.3 g/L
- impairments in vigilance start at a BAC of 0.3 g/L
- deficits in divided attention and sustained attention start at BACs between 0.5 g/L and 0.8 g/L
- problems with dividing attention over several tasks begin at a BAC of 0.8 g/L.

The mechanisms by which alcohol and drugs (legal and illegal) affect the human body, the extent to which they impair driving, and the duration of the impairment differ greatly among drugs and among individuals (Compton, 2017).

3.2.2 Prevalence

It has been estimated that about one quarter of road fatalities in Europe are alcohol related (European Commission, 2018). There is no recent overall estimate of the number of drug-related casualties in Europe.

In the DRUID-project, the prevalence of alcohol (and other drug use) in the driving population was assessed in 13 European countries, by means of roadside surveys in the period between January 2007 and July 2009. In total, 50,000 blood or oral fluid samples from 50,000 consenting drivers were analysed. The results indicated that alcohol was present in 3.48% of road users and a combination of alcohol with drugs or medicines in 0.37% (Houwing et al. 2011). In the same project a cross-sectional survey was conducted to determine the prevalence of alcohol (and other drugs) in drivers seriously injured (between October 2007 and May 2010) or killed (between January 2006 and December 2009) in road traffic accidents in 9 European countries. Alcohol was detected in 14.1-30.2% of the seriously injured drivers and in 15,6 – 38,9% of the killed drivers (EMCDDA, 2012).

Moreover, the BASELINE project (collected an alcohol KPI in European countries, and found that the share of drivers that are not within the legal alcohol limit range between 0.1-2.7% when calculated on the basis of random roadside breath testing, between 0.3-9.1% when calculated through questionnaire surveys, and 4% when calculated by police enforcement (not random). The latter can be explained by the fact that police may implement more targeted roadside checks focusing on high risk days, areas etc.

Another indicator of alcohol use in traffic is the share of alcohol offenders per country, i.e. driver with a BAC level higher than the legal BAC limit. Table 3 provides an overview of the share of alcohol offenders among drivers that were tested for alcohol at roadside police checks in Europe (ETSC, 2022). The share of alcohol offenders that were caught by the police during roadside police checks varies between 0.6% in and 8.3%.

Table 3. *Roadside alcohol breath tests per 1000 inhabitants and the proportion of those above the legal limit (Source: ETSC, 2022)*

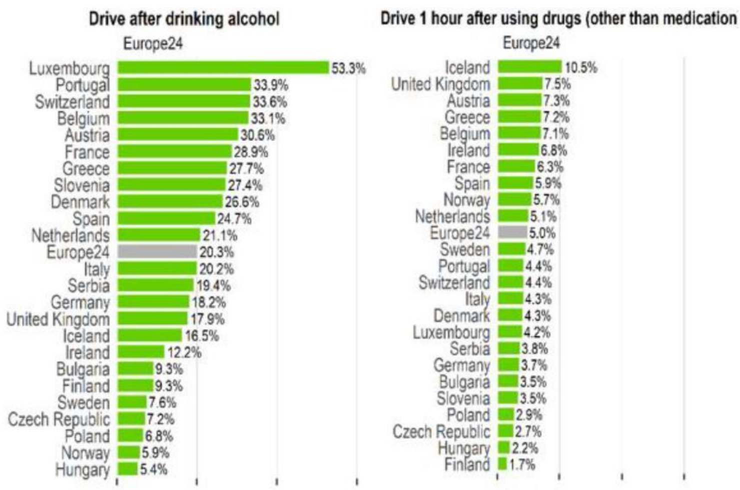
Country	Roadside Police breath tests per 1000 inhabitants	% above legal BAC limit
AT	155	2.1
CY	31	8.3
EE	576	0.8
FI	71	2.3

FR	109	3.2
HU	185	1.2
IE	18	0.6
SE	33	2.3
PL	219	1.2
PT	160	2.2

It is noted however that the comparability of this data is limited, and there is insufficient information about their accuracy; countries have very different enforcement practices in terms of frequency, spatial and temporal coverage and reporting procedures, and therefore results may not be representative of country prevalence.

The self-reported driving under the influence is even higher than the above rates. The ESRA study revealed that between 5-34% of European drivers declared driving after drinking alcohol in the last month, while between 1.7-10.5% of European drivers declared driving after using drugs (other than medication) – see Figure 6.

Figure 6. *Self-declared use of alcohol, drugs and medicines (Source: Achermann Stürmer et al., 2021).*



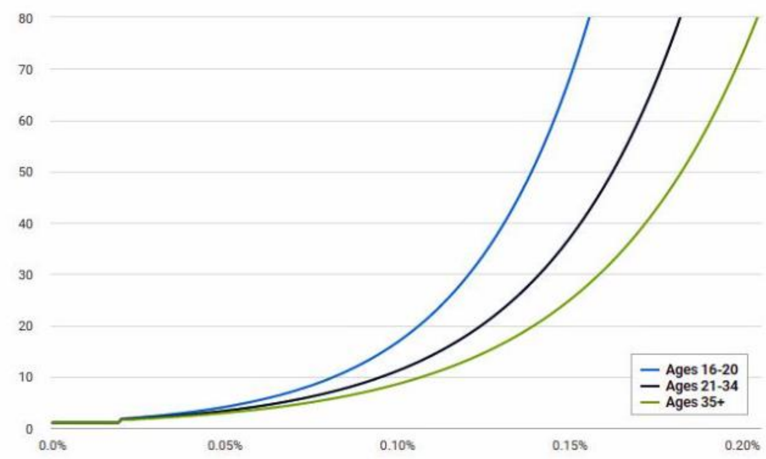
It is also interesting to note that a higher number of controls does not necessarily imply a higher number of offenders. In fact, the increase in enforcement is expected to initially result in more offenders observed; however, as the perceived degree of apprehension increases – with systematic enforcement – an eventual behaviour change may be occurred, reflected as fewer offenders observed.

3.2.3 Safety impacts

Regarding the impact of alcohol, impairment of driving skills can start from BACs as low as 0.01-0.02%. The risk for drivers with a BAC of 0.5 g/L is estimated to be about 2-10 times higher than that of a sober driver; at 1.0 g/L the risk is 5-30 times higher, and at 1.5 g/L around 20-200 times higher (see Figure 7; Voas et al., 2012; EC DG-MOVE, 2022).

Generally, the risk of a crash increases considerably when a driver is impaired by a combination of alcohol and drugs. A meta-analysis of SWOV (2020) reports that a combined use of alcohol and drugs may increase crash risk by 20-200%.

Figure 7. *Relative risk of fatal accident involvement at various BACs compared to zero BAC (Voas et al., 2012, 2005).*



Regarding the impact of drugs use on road safety, Table 4 shows the crash risk increase for illegal drugs as found in several meta-analyses (SWOV, 2020), with focus on fatal crashes. The highest increase in fatal crash risk is associated with amphetamines, followed by cocaine, opiates and cannabis.

For both alcohol and drugs, several confounding factors will also affect crash risk, including patterns of use, reasons for use, dose ingested, mode of administration, tolerance, and driver characteristics (Beirness et al., 2021).

Table 4. *Risk increase for several groups of illegal drugs (Source: SWOV, 2020)*

Drug	Crash severity	Risk increase	95% Confidence Interval
Amphetamines	Fatal (Elvik, 2013)	5.2	(2.6 – 10.4)
Cannabis	Fatal (Elvik, 2013)	1.3	(0.9 – 1.8)
	Fatal and injuries (Rogeberg & Elvik, 2016)	1.4	(1.1 – 1.6)
	Fatal and injuries (Els et al., 2019)	2.5	(1.7 – 3.7)
	Fatal and injuries (Rogeberg, 2019)	1.3	(1.2 – 1.4)
Cocaine	Fatal (Elvik, 2013)	3.0	(1.2 – 7.4)
Opiates	Fatal (Elvik, 2013)	1.7	(1.0 – 2.8)
Multiple drugs	All crashes (Hels et al., 2011)	5 - 30	-
Combination alcohol & drugs	All crashes (Hels et al., 2011)	20 - 200	-

3.2.4 Interventions

A main direction for preventing alcohol and drug use while driving is the reduction of their consumption in the general population, through pricing, taxation or marketing regulations. Traffic measures and policies that are important include (EC, 2021):

- BAC limits and their enforcement: Lowering BAC limits is found to have a positive effect on reducing alcohol related crashes. However, this is most effective when combined with systematic randomised alcohol tests.
- Awareness campaigns and rehabilitation programmes have been found important in leading to behaviour change, especially for recidivist drivers. Organisational safety culture can play an important role among professional drivers. Providing affordable alternative means of transport (e.g. taxi or ride-sharing options) can significantly reduce drink-driving, especially in suburban or rural areas.
- Vehicle technologies, namely alcohol interlocking, can significantly reduce the risk of recidivism. Moreover, various in-vehicle systems may assist in identifying signs of alcohol or drug impairment (e.g. drowsiness detection), and the mitigation of its consequences on driver performance (e.g. collision warning, lane departure warning etc.)

3.3 Distraction

3.3.1 Mechanism

Distracted driving is defined as a diversion of attention from the main driving tasks that are critical for safe driving, towards a competing in-vehicle task, or to other internal or external activities. The nature of distraction can be:

- motor (e.g. holding a mobile phone)
- visual (e.g. looking at a mobile phone or in-vehicle screen),
- auditory (e.g. listening to loud music),
- cognitive (e.g. conversing, daydreaming).

Its source may or may not be related to technology, to something inside or outside the vehicle, self-initiated or imposed (EC, 2021).

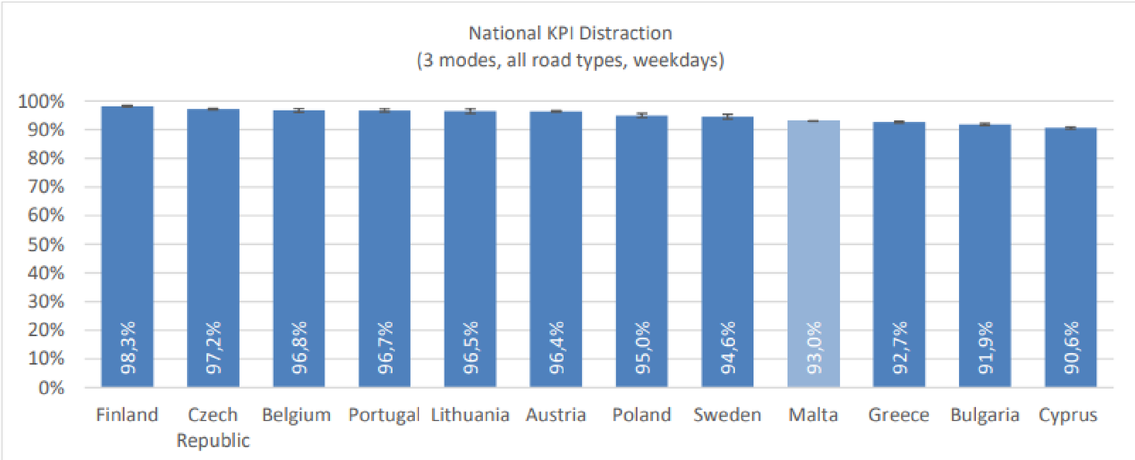
Distraction or inattention while driving leads drivers to have difficulty in lateral control of the vehicle (e.g. swerve more), have longer reaction times, and miss information from the traffic environment. At the same time, drivers implement a number of compensatory behaviours, by reducing their speed, increasing the headway from the lead vehicle – however in most cases these are not sufficient to counterbalance the impaired driving performance.

The extent of the negative impact of distraction on driving behaviour depends on numerous factors. The main ones are the type or source of distraction, and the traffic context (e.g. distracted driving may be less detrimental in quiet traffic conditions). The timing, intensity, resumability, complexity, duration, frequency and residual effects of the distracting activity also play a role, together with personal characteristics such as age and driving experience (Kinnear & Stevens, 2018; SWOV, 2020).

3.3.2 Prevalence

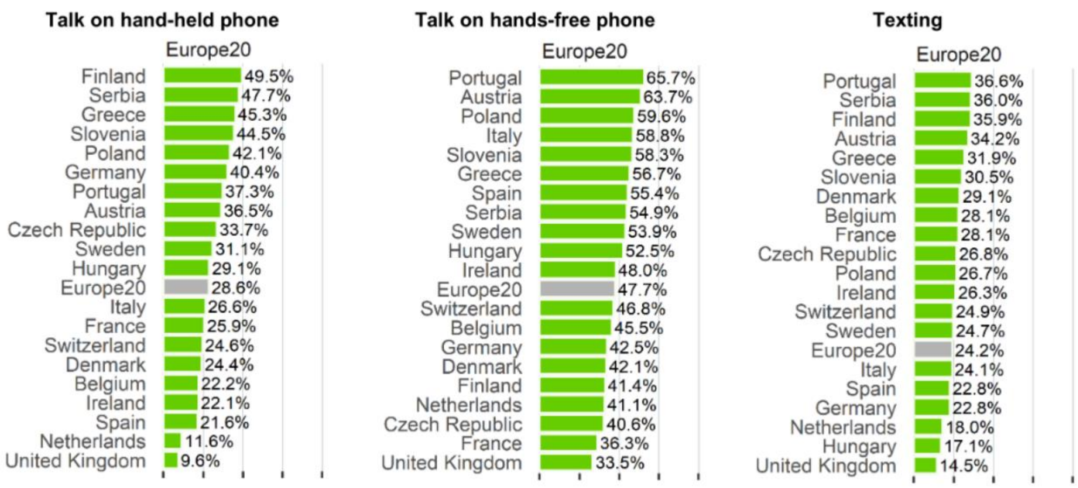
The BASELINE project estimated a KPI for distracted driving (as the percentage of drivers not holding a mobile phone whole driving) and collected data for a number of European countries. Figure 8 summarises the KPI estimates for 2022, for all transport models, all roads, on weekdays (Boets, 2023). It is shown that hand-held mobile phone use while driving ranges from 2% in Finland to 10% in Cyprus.

***Figure 8**. Percentage of drivers not holding a mobile phone while driving (Source: Boets, 2023)*



According to the ESRA study, between 10-50% of European drivers self-report that they have talked on a hand-held mobile phone while driving at least a few days in a month, between 33-66% have talked on a hands-free phone and between 15-37% have texted while driving (see Figure 9).

***Figure 9.** Self-declared percentage of drivers who were distracted while driving at least a few days a month (Pires et al., 2019).*



It is generally estimated that distraction plays a role in 5 - 25% of crashes in Europe. (Hurts et al., 2011 in: European Commission, 2018). This is mainly based on older studies and in-depth crash investigations in which extreme forms of distraction are documented. This is likely to be an under-representation. The in-depth study of Thomas et al. (2014) found that distraction was a contributory factor in 8.3% of fatal crashes and inattention was a contributory factor in 5% of fatal crashes.

3.3.3 Safety impacts

The vast majority of studies agree that driving performance is impaired by distraction, with the main effects being the increased reaction time, the increased time with eyes-off-the-road and the lateral control variability. However, few studies have been able to quantify the effects of distraction on actual road safety outcomes.

The European Road Safety Decision Support System (https://www.roadsafety-dss.eu/#/) includes in-depth reviews and meta-analyses of several sources of distraction. Their findings related specifically to the effects of distraction on crash occurrence or crash risk can be summarized as follows[4]:

- Hand-held phone use results in significantly higher crash risk (Ziakopoulos et al, 2018). Most of the results available in the literature come from naturalistic driving studies in the US. Key figures of interest are: a 3.6 increase in accident risk (Dingus et al, 2016) and a 2.7 increase of accident risk in Norway (Elvik, 2011). Dialling and texting are associated with higher risk than simply talking.
- Texting in particular is associated with a 6.1 increase in crash risk (Dingus et al., 2016)
- Hands-free phone use results in potentially higher crash risk, although some studies suggest none or opposite effects (Ziakopoulos et al., 2018b). Key figures of interest are: a 1.66 increase[5] of accident risk in Norway (Backer Grøndahl & Sagberg; 2011).
- Interaction with vehicle systems has been found to increased (x2.5) crash risk (Dingus et al., 2016) – however these tasks are found to be self-regulated to some extent (Perez et al., 2015). The types of activities may vary from button to touch screen or voice controls, for navigation or entertainment purposes. Voice controls and head-up displays are less impairing than manual modes.
- Conversation with passengers has not been associated with increased crash risk (EC,2021). It is likely that this type of cognitive competing task can be self-regulated by drivers and passengers.
- Outside factors were found to increase crash or near-crash risk by 3.9 (Klauer et al., 2014); Advertising signs in particular were found to significantly increase the occurrence of crashes in Greece (Yannis et al., 2012).
- Inattention / daydreaming, listening to music: existing research results are inconclusive. A vote-count analysis on inattention

[4] The reported numbers correspond to odds ratios (unless mentioned otherwise).
[5] This number expresses a relative risk.

indicated that crash risk and injury severity may vary – possibly compensatory behaviours or the cognitive nature of this distraction source lead to non-identifiable safety consequences in some cases.

3.3.4 Interventions

- Education, awareness raising campaigns and training programmes in the general population are a common way of targeting distracted driving, however their effects are limited due to the large penetration of smartphones and entertainment / navigation systems in the vehicles, especially among young people. Organisational safety culture by companies or employers in general can have more positive effects among professionals / employees.
- Vehicle technologies, namely Advanced Driver Assistance Systems (ADAS) can prevent the consequences of distraction through collision warnings, Autonomous Emergency Braking or Lane Keeping Assistance. Recently a lot of focus is placed in distraction detection systems, which use eye-tracking detect off-road gaze behaviour, but these systems are still under development.
- Infrastructure design can play an important role in preventing distraction from roadside advertising, through regulations and avoidance of digital or highly luminous billboards. Moreover, it can contribute to the mitigation of the consequences of distracted driving, through longitudinal rumble strips that alert drivers in case of lane departure.

3.4 Use of protective equipment[6]

3.4.1 Mechanism

Seat belt and helmet wearing are generally not associated with increased crash risk, but it are significantly associated with the severity of road crashes (Anderson, 2017).

3.4.1.1 Seat belts

The main function of a seatbelt is to reduce the risk of injury of an occupant of a vehicle in a crash; it restrains the occupant to the vehicle, thereby enabling the occupant to "ride down" (less violently) as they are coupled to the vehicle's deceleration through the restraint system. An unrestrained occupant continues to move at the vehicle's pre-impact speed while the vehicle begins to decelerate as a result of the crash.

[6] Child restraints are not included in this report for the economy of space. The reader is referred to the ERSO thematic report on 'Seat belts and child restraints'

This uncontrolled motion will result in an uncontrolled impact with the vehicle interior, or in the worst case, an ejection from the vehicle, fully or partially (EC, 2022).

3.4.1.2 Helmets

Helmets aim to reduce rider injuries in the event of a motorcycle or bicycle crash, by providing additional impact and abrasion protection to the head. Despite their overall similar appearance, there is a wide range of helmets available, tailored for different users, purposes or cost – the main two categories for powered-two-wheeler (PTW) helmets are open-face and full-face designs, while cycle helmets are typically open-face. The head protection concept of dissipating the energy from a blow to the head area of a motorcyclist is the same in all designs (Reed, 2018).

3.4.2 Prevalence

Seat belt wearing rates vary considerable among European countries. The Baseline project estimated that the KPI of the share of drivers that correctly use their seatbelts on weekdays ranges between 70% and 92%, while for Heavy Goods Vehicle drivers it ranges between 34% and 92% (Van den Broek et al., 2022).

The WHO report on Road Safety (2018) includes the seat belt wearing rates shown in Table 5. It is noted that, while front seat wearing is >95% in most countries, there are several countries with lower rates. Regarding rear-seat wearing, the figures are notably lower and widely dispersed, ranging between 15-93%. Helmet wearing rates for PTW riders are generally very high, with the exception of Greece (75%) and missing data for a few countries. This data should be considered with some caution, as in most cases they are based on roadside surveys with different methodologies (sampling, measurement etc.).

Table 5. *Use of protective equipment in European countries, 2016 (WHO, 2018)*

Country	% of drivers wearing seat belt (front)	% of passengers wearing seat belt (rear)	% of PTW riders wearing helmet (driver)
Austria	95.00	93.00	100.00
Belgium	92.20	85.50	99.00
Czechia	98.00	72.00	
Denmark	96.00	91.00	98.00
Finland	95.00	85.00	98.30
France	98.00	88.00	98.00
Germany	98.00	99.00	99.00
Greece	74.00	23.00	75.00

Country	% of drivers wearing seat belt (front)	% of passengers wearing seat belt (rear)	% of PTW riders wearing helmet (driver)
Hungary	82.80	38.50	92.30
Ireland	94.00	74.00	99.90
Italy	61.90	15.40	98.00
Lithuania	97.00	30.00	
Netherlands	96.60	82.00	99.90
Poland	96.00	76.00	99.00
Portugal	95.70	77.20	97.60
Spain	90.50	80.60	99.00
Sweden	96.00	90.00	97.00

In the ESRA survey (20 European countries in 2018) 83% of European respondents said they had always worn the seat belt as a driver in the previous 30 days (ranging from <70% in Greece, to 90% in Ireland). In the same study, only 63% of the European respondents say that they had always used the seat belt as a rear-seat passenger in the previous 30 days (Nakamura et al., 2020).

While the percentage of non-use of seat belts is relatively small in most European countries, data from the CARE database indicate that there is still a 13.3% of car occupant fatalities where no seat belt had been worn, whereas for more than 50% of the fatalities it is not known whether a seat belt had been worn. The ERSO estimates that the share of car occupant fatalities where no seat belt had been worn is estimated between 25-50% (ERS0, 2022). A study from the United Kingdom shows that more than a quarter of car occupants killed in 2017 were not wearing seat belts (ETSC, 2019), and a Norwegian study (Ringen, 2019 in Elvik, 2020) showed that between 2005 and 2010 45% of car occupants that were killed did not wear a seat belt.

3.4.3 Safety impacts

3.4.3.1 Seat belts

Høye (2016) estimated that the risk of having a fatal crash in Norway is more than 8 times higher for unbelted drivers compared with drivers wearing a seat belt. This difference in fatal crash risk is further explained by the fact that not using seat belts correlates with other risk factors such as drink-driving, speeding, night-time driving, and previous traffic offences.

Moreover, the use of seat belt reduces the risk of being killed or severely injured by 60% among front seat occupants and by 44% among rear seat occupants. Seat belt usage among rear seat occupants significantly affects the safety of belted front seat occupants; unbelted rear seat occupants can double the fatality and injury rate for belted front seat occupants (Anderson, 2017).

ETSC (2017) estimates that 900 deaths per year could be avoided in the European Union if 99% of car occupants wore seat belts.

3.4.3.2 Helmets

The safety effects of helmet are typically estimated in terms of fatality or injury risk, as well as in terms of head impact criteria (HIC) values in biomechanical or simulation studies (Reed, 2018).

The magnitude of fatality risk between helmeted and un-helmeted PTW users varies between studies but overall helmets are found to reduce the risk of death among PTW users. The results for facial injuries sustained in a PTW crash are also positive with the exception among smaller PTW users, where the prevalence of open face helmet use is suspected to be greater.

More specifically, a major meta-analysis (Hoye, 2016) estimated a significant reduction of fatal injuries with helmet wearing, ranging from 24% in light PTWs to 64% in small PTWs. Significant impacts were also estimated for head, neck, brain and face injuries.

Two recent meta-analyses (see Reed, 2018) estimated a significant reduction of 44-50% in head injuries by helmet wearing on cyclists. Deck et al. (2012) compared the performance of 32 ISO-compliant helmet types in terms of their ability to prevent brain injury from frontal, rear and lateral impacts.

3.4.4 Interventions

- Vehicle technology has provided important systems that can prevent non-use of seat belts. Seat belt reminders are alarm systems that detect whether a seat belt is not fastened while driving and give visual and audible warnings; they have been found to be highly effective on seat belt wearing rates. Seat belt ignition interlocks have also been tested as a very effective measure, however their acceptance among car occupants is very low and they are not deployed as of today.
- Education campaigns and enforcement are useful tools to increase the use of protective systems.
- Regarding helmet wearing in particular, universal helmet laws and quality standards are equally important.

4. Further reading

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