European Commission

Thematic Report

Speed and speeding

Mobility and Transport

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 (2025). Road safety thematic report – Speed and speeding. European Road Safety Observatory. Brussels, European Commission, Directorate General for Transport*.

Contents

Summary

Driving at excessive or inappropriate speed is a major threat to safety on the road. It is estimated that 10 to 15% of all crashes and 30% of all fatal crashes are the direct result of speeding or inappropriate speed. The faster someone is driving, the higher the risk of a crash, but also the higher the severity of the crash and the probability that the crash is fatal. If pedestrians are hit by a car driving at 30km/h they have 90% chance to survive, whereas when the car drives at 50km/h this percentage reduces to 20. Another important factor influencing the crash risk is differences in vehicle speed. The less the speeds of vehicles differ from each other, the lower the risk of a crash.

The main factors affecting the outcome of speed-related crashes are: the design of the road and the roadside, the safety systems in vehicles, and differences in mass between the colliding vehicles/road users. The probability that an unprotected road user (pedestrian, cyclist, motorcyclist) will die in a collision with a passenger car or truck is much higher than that for the occupants of a vehicle.

Speed limits differ between European countries but whatever the speed limit is, many drivers regularly exceed them. Depending on the European country, 24 to 77% of the passenger car drivers were found to exceed the speed limit on urban roads. For rural roads this was 4 to 71%, and for motorways this was 1 to 66%. There are five main reasons why people drive too fast: (1) adapting to the speed of surrounding traffic; (2) being in a hurry; (3) enjoying driving fast; (4) out of boredom; and (5) being unaware that they are driving too fast.

Preventing speeding requires a combination of measures, including:

- setting appropriate speed limits,
- adequate design of road infrastructure,
- enforcement of speed limits,
- vehicle technology, and
- education and communication

Speed limits must incorporate the principle of injury minimisation. It depends on the interaction and possible conflicts between different road users and road design features (e.g. curvature, presence of a median barrier). Speed limits should be credible for drivers, and infrastructural characteristics (e.g. road width, type of pavement and roadside) are crucial for increasing credibility.

The introduction of 30 km/h speed limits in cities can save lives, alongside significant positive effects on the environment, energy consumption and public health, including reduced fuel consumption and

increased walking and cycling. Scientific evidence demonstrated that city-wide 30 km/h speed limits on average reduced fatalities by 37% in fatalities in road crashes, 18% in emissions, 2.5 db in noise pollution and 7% in fuel consumption, while hardly affecting travel times. It was highlighted that a city-wide 30km/h speed limit is a single road safety measure with significant quick and important benefits with low implementation cost and high potential for upgrading urban road safety culture.

Enforcement of speed limits has been shown to be effective in reducing crash and injury risks, in particular section control systems. Safety systems in cars, such as intelligent speed assistance or electronic stability control can prevent speeding or reduce the consequences of speeding. Education and communication are particularly important in combination with and supporting other measures.

1. What is the problem?

1.1 Excessive and inappropriate speed

Traditionally, two types of speed are considered problematic for road safety:

- Excessive speed: driving at a speed higher than the maximum allowed;
- Inappropriate speed: driving too fast given the traffic situation, infrastructure, weather conditions, and/or other special circumstances.

Driving at excessive or inappropriate speed is called 'speeding'.

Internationally, the following indicators are often used in analysing traffic speed (Aigner Breuss et al., 2017): (1) speed limit; (2) average speed of the traffic; (3) speed below which 85% of the drivers drive ("V85"); and (4) speed dispersion (range).

The focus of this thematic report is on speed and speeding by car and van drivers; other vehicle types are discussed in other thematic reports of the European Road Safety Observatory.

1.2 Share of road crashes resulting from speeding

In general, expert literature agrees that an estimated 10 to 15% of all road crashes and 30% of fatal injury crashes are the direct result of excessive or inappropriate speed (Adminaité-Fodor & Jost, 2019; OECD/ECMT, 2006). A recent study found a similar proportion of fatal

injury crashes for high-income countries (28%) but a larger proportion for low- and middle-income countries (57%) (Fondzenyuy et al.2024). Often however, speed is not the direct cause but a contributing or aggravating factor. There are no good estimates of the percentage of crashes where this is the case.

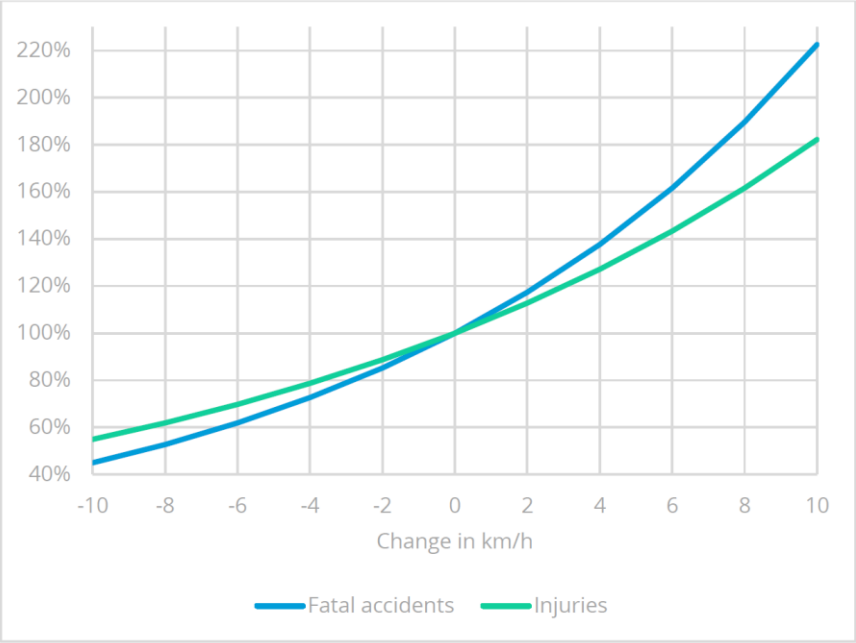
1.3 Effect of speed on road safety

As a key risk factor in road traffic, driving speed is associated with the number of crashes as well as with the severity of crashes (IRTAD, 2018; OECD/ECMT, 2006; SWOV, 2021). There are several reasons why crash risks increase with speed:

- A driver driving at high speed has less time to respond to an unexpected event than when driving at moderate speed. Although the reaction time remains the same, the distance covered before a driver reacts is larger at higher speeds.
- At higher speeds, the braking distance increases because it is proportional to the square of the speed.
- When a vehicle approaches at higher speed, there is less time left for other road users to avoid a collision. At excessive speed, other road users often overestimate the time they have to react.
- The drivers' field of vision narrows as they drive faster. At 130 km/h, the driver has only an angle of about 30°, which means that drivers are able to estimate far fewer potential hazards.

Figure 1 shows the relationship between speed change and change in crash risk for injury crashes and fatal crashes. This figure illustrates that a speed increase of 10 km/h leads to a fatal crash risk that is 220% of the original one, which means that the risk has more than doubled. The increase in risk is higher for fatal injuries than for non-fatal injuries (see also Section 1.5).

Figure 1. *Relationship between speed change and crash rate (Van den Berghe & Pelssers, 2020, based on Elvik et al., 2019)*



The European Transport Research Council (ETSC) estimated that reducing the average speed by 1 km/h on all roads across the EU would save over 2,000 lives per year (Adminaité-Fodor & Jost, 2019).

1.4 Impact of speed differences on road safety

In addition to speed in absolute terms, the difference in speed between vehicles (or speed dispersion or variation) also has an influence on the crash rate. Speed differences result in more encounters with other road users and also in more lane-changing and overtaking manoeuvres; this increases the risk of crashes (Aarts & Van Schagen, 2006; Elvik, Christensen & Amundsen, 2004; Hauer, 1971).

Kloeden et al. (2002; 2001) found an increase in the crash rate among motorists driving faster than average, especially in an urban environment. Quddus (2013) even found that for motorways in and around London the differences in vehicle speeds were strongly associated with the number of crashes. While the mean speed of all vehicles remains the same, the difference inspeed between vehicles increases by 1%, and the number of crashes increases by 0.3%.

1.5 Impact of speed on crash severity

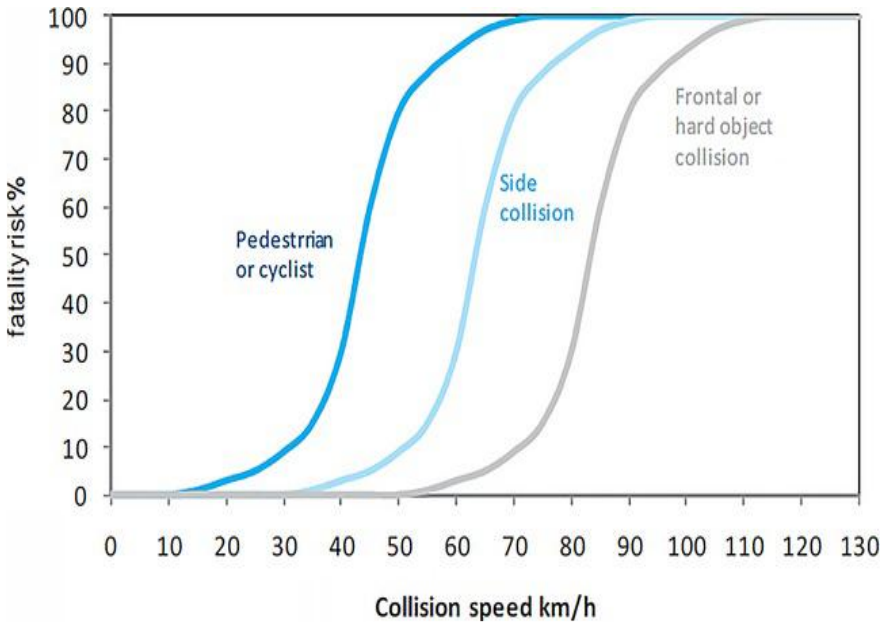
Speed does not only have an impact on crash risk, but also on crash severity. For occupants of modern passenger cars (with crumple zone,

airbags and seatbelts), the risk of being fatally injured is low below 50 km/h and very high from 100 km/h onwards (Elvik, 2009). In this context, 'speed' is defined as the vehicle's impact speed at the time of the collision, not the speed limit or the speed driven before the collision.

Most experts explain this phenomenon by referring to the absorption of the kinetic energy of the vehicle. However, Stipdonk (2019) pointed out that the force on the body results from the 'amount of movement' of the body, which in turn is proportional to the square of its velocity. This explains that even if vehicles have a perfect crumple zone that absorbs virtually all kinetic energy, they still cannot prevent occupants from being killed when speeds are high. It is not the energy dissipation that poses the danger, but the deceleration, the thrust and the force on the body during the collision.

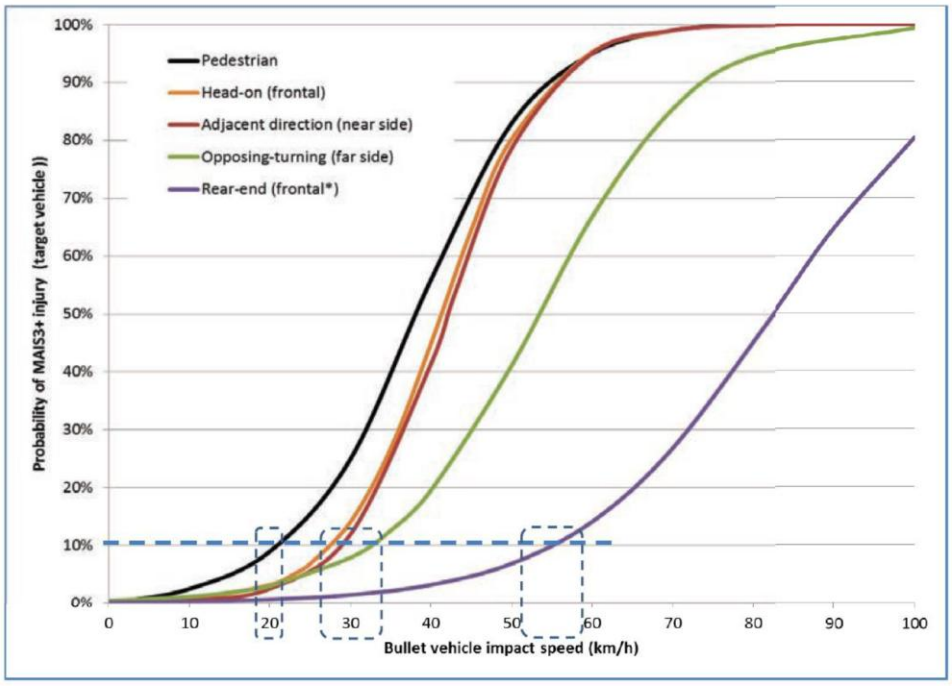
In a collision between a car and an unprotected road user - pedestrian, cyclist, driver of a powered two-wheeler – the risk of serious injury to the latter is much higher than for the car occupants (WHO, 2023a). After all, unprotected road users do not have crumple zones, airbags and seatbelts, although recently powered two-wheelers are occasionally fitted with airbags. At an impact speed of 70 km/h the risk of fatal injury is 16% for a car occupant, and 38% for a pedestrian; at 80 km/h, this probability increases to 33% for car occupants and 61% for pedestrians (Elvik, 2009). Based on in-depth research of crashes in France, Martin and Wu (2018) found that pedestrians almost certainly die when they are hit by a car driving faster than 80 km/h. In contrast, when they are hit by a car driving less than 40 km/h their risk of dying was fairly low. The risk of dying doubles when hit by a car travelling 40 km/h instead of 30 km/h. In addition, research of Yannis & Papadimitriou (2021, based on Tingval and Haworth, 1999) shows that 90% of cyclists and pedestrians survive when hit by a car travelling at approximately 30 km/h, while when hit by a car travelling at approximately 50 km/h only 20% survive. Yet another example comes from the World Health Organization (WHO, 2023c): a pedestrian who is hit by a car travelling at 65km/h is 4.5 times more likely to be killed compared with a car travelling at 50km/h.

Figure 2. *Relationship between impact speed and fatality risk (Yannis & Papadimitriou, 2021 based on Tingval and Haworth, 1999)*



The impact of speed on injury severity also depends on the type of collision. Jurewicz et al. (2016) mapped the probability of a serious crash (injury level MAIS3+) for five common passenger car collision types: car-pedestrian collisions, frontal car-car collisions, lateral car-car collisions (same direction of travel), collisions with oncoming traffic when turning off, and rear-end collisions. The results are shown in Figure 3. The authors concluded that the critical impact speed for serious injuries is 20 km/h for pedestrian collisions, 55 km/h for rear-end collisions and 30 km/h for the other types of car collisions.

Figure 3. *Relationship between the impact speed and the probability of severe injury (MAIS3+) for different types of car collisions. (Jurewicz et al., 2016)*



1.6 Factors influencing the impact of speed

Several factors influence the effects of speed and speeding on road safety:

- **Road and roadside design characteristics**. Speed is not equally dangerous everywhere. Driving 100 km/h on a motorway designed for high speeds is less risky than driving the same speed on a curvy rural road. But for any given location, the risk of road crashes and their severity increases if the average speed increases (and the other conditions are unchanged).
- **Safety systems in vehicles**. Most cars are equipped with a range of safety systems (crumple zones, ABS (automatic braking system), ESC (electronic stability control), seatbelts, airbags) and increasingly also with intelligent safety systems such as EBS (electronic braking system) and ADAS systems (speed warning, ISA (intelligent speed assistance), ACC (adaptive cruise control). These systems can prevent speeding, prevent cars crashing when driving at high speeds, or reduce the impact of crashes.
- **Differences in mass**. In the event of a collision between two vehicles, occupants of the lighter vehicle are significantly worse off than occupants of the heavier vehicle. Mass differences are obvious when we look at trucks and buses on the one hand and passenger cars on the other, but there are also large differences in mass within passenger cars: the mass of a large SUV can be

three times higher as that of a small city car. The mass differences in a collision between a motor vehicle and a cyclist or pedestrian are of an entirely different order. In such cases the masses differ from a factor of 10 (light cars) to almost 700 (for trucks of 50 tons).

- **Vulnerability**. Older road users are physically more vulnerable than young road users. Their chance of surviving a crash at a similar impact speed is therefore considerably smaller than for younger people. Whether or not children are more vulnerable when hit by a car is not certain. Shim et al. (2025) found that they are not, but Henary et al. (2003) found that they are.

2. How many people speed and why?

2.1 The prevalence of speeding

Speed limits are not the same in all European countries. ETSC (Adminaité-Fodor & Jost, 2019) reported that in urban areas, 35% to 75% of European drivers do not observe the speed limit. Outside built-up areas this is the case for between 9% and 63% of the drivers and on motorways between 23% and 59% of the drivers.

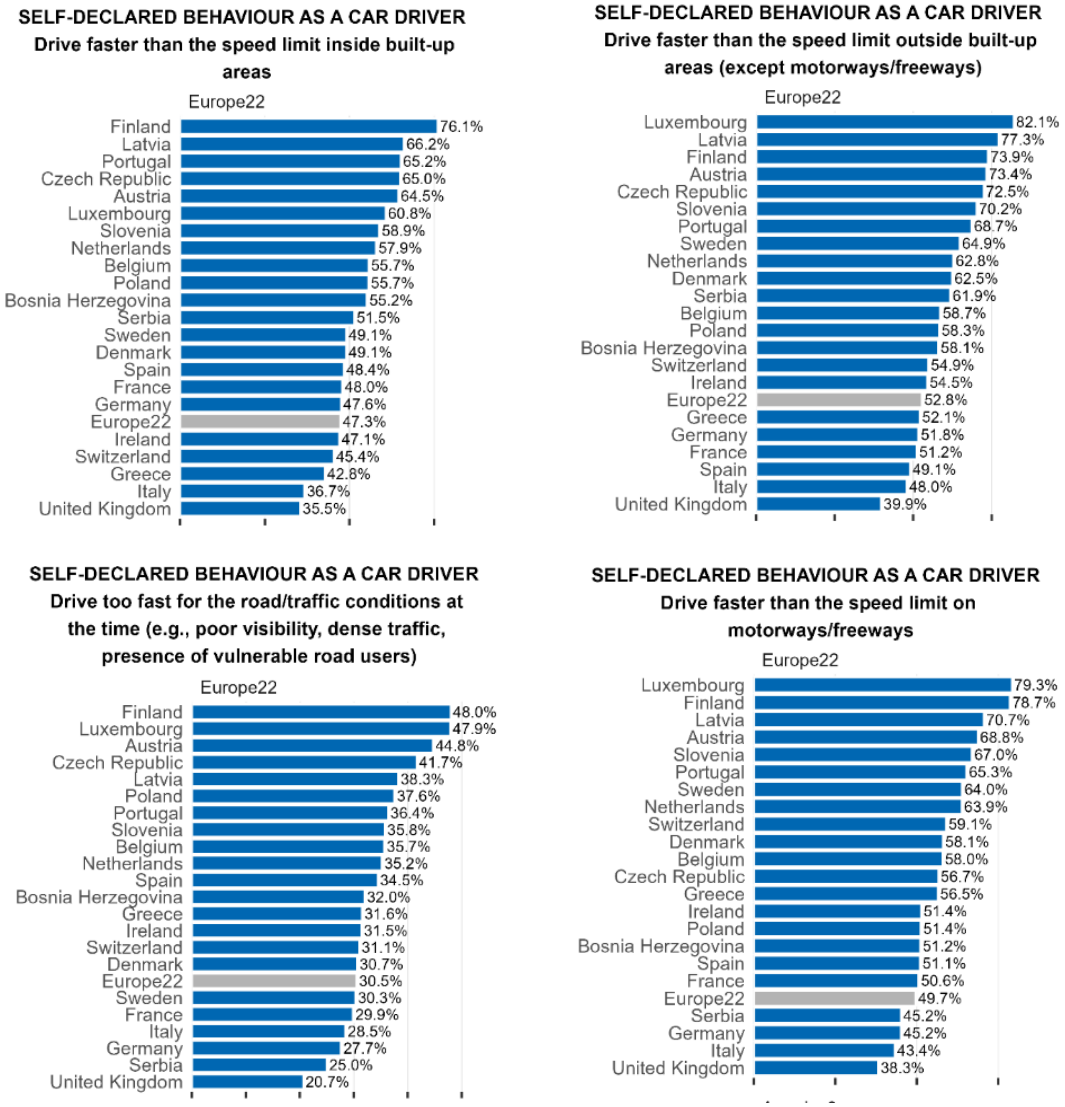
The large ranges indicate that there are large differences between countries. Results of recent observations in 20 European countries (Van den Broek, Aarts & Silverans, 2023; Folla et al., 2025) found similar ranges and confirmed the differences between European countries: on urban roads 24 to 77% of the passenger car drivers were observed to exceed the speed limit, on rural roads 4 to 71% and on motorways 1 to 66%. These data relate to daytime during weekdays. Figure 4 displays the differences in observed speed compliance between the countries (Folla et al., 2025).

ESRA3 survey results (Harkin, Nikolaou, Yannis, & Surges, 2024; www.esranet.eu), based on self-reports from 22 European countries, showed that in 2023, 47% of European car drivers indicated that they had exceeded the speed limit in built-up areas at least once in the previous month (53% on rural roads and 50% on motorways). Additionally, 31% reported driving too fast for the road or traffic conditions. The differences between countries for self-reported *speeding behaviour* are displayed in Figure 5.

Figure 4. *Observed speed compliance by passenger cars during weekdays/daytime (Trendline Dashboard; Folla et al., 2025)*

Note: Data were collected in the framework of the KPI Trendline project.

Figure 5. *Self-reported speeding behaviour of car drivers - at least once over the previous 30 days, by country (Harkin et al., 2024)*



2.2 Differences between drivers

Although excessive and inappropriate speeds are widespread phenomena, there are differences between drivers: Harkin et al. (2024) report that young drivers generally drive faster than older drivers and men generally drive faster than women. Webster & Wells (2000) additionally report that drivers who travel for work generally drive faster than drivers who travel for other reasons.

2.3 Reasons for speeding

Most people do not speed all the time. The main reasons for observing speed limits are concerns for road safety, the willingness to obey the law, and the risk of a fine. On the other hand, the main reasons for driving too fast are (1) adapting to the speed of surrounding traffic; (2) being in a hurry; (3) enjoying driving fast; (4) out of boredom; and (5) being unaware that they are driving too fast (SWOV, 2021).

Åberg et al. (1997) pointed out that most drivers want to drive at the same speed as the other drivers on the road. They also noted that drivers often overestimate the speed of these other drivers. This may therefore partially explain the number of speeding violations. As with other traffic behaviours, the social norm (individual perception of how other people behave or think they should behave) is therefore very important in speeding offences.

Being unaware of speeding happens when drivers do not know how fast they are allowed to drive or how fast they are actually driving. According to Haglund & Åberg (2000) many drivers prefer to rely on subjective assessment of their speed rather than looking at their speedometer. Typical situations which could easily lead to unintentional speeding are (SWOV, 2021):

- After prolonged driving at a high speed, e.g. on motorways, drivers start underestimating their own speed and tend to drive faster and faster without noticing.
- When downshifting from a relatively high speed to a considerably lower speed, e.g. when leaving the motorway, when entering an urban area, or when a straight road stretch is followed by a series of curves.
- When there is only little peripheral information (information from the immediate environment) to which drivers can relate their speed, e.g. at night, in fog, on open roads in a flat landscape.
- In high-wheeled cars, such as an SUV or other jeep-like car, which leads to distorted speed perception and underestimation of the own speed.

Surveys have shown that speeding is more socially accepted than other traffic violations (see for instance Meesmann et al., 2017). ESRA3 results show that 13% of European car drivers consider it acceptable to exceed the speed limit on motorways, 10% on rural roads, and 5% in built-up areas. Additionally, 3% considered it acceptable to drive too fast for the road or traffic conditions (Harkin et al., 2024). It is interesting to note that these figures are much lower than the observed or self-reported numbers (see Section 2.1): so even when people consider speeding not acceptable, they nevertheless speed regularly.

3. Which measures prevent speeding?

In the Stockholm Declaration on road safety (Ministerial Conference on Road Safety, 2020) Paragraph 11 stresses the need for speed limits and law enforcement to prevent speeding. The declaration states:

> *"Focus on speed management, including the strengthening of law enforcement to prevent speeding and mandate a maximum road travel speed of 30 km/h in areas where vulnerable road users and vehicles mix in a frequent and planned manner, except where strong evidence exists that higher speeds are safe, noting that efforts to reduce speed in general will have a beneficial impact on air quality and climate change as well as being vital to reduce road traffic deaths and injuries"*

The WHO lists reduction of vehicle speeds as one of the key measures to improve pedestrian safety (WHO, 2023a). Measures against (excessive) speed are possible and necessary in several areas: appropriate speed limits; adequate road infrastructure; enforcement of speed limits; vehicle technology; and education and communication. Structural improvement of speed behaviour requires a combination of these measures. The second edition of the WHO Speed Management Manual (WHO, 2023b) provides many practical examples of effective measures in these areas.

3.1 Speed limits

Setting appropriate speed limits on roads is a crucial step within a speed management policy. The limit generally is a balancing act between considerations of safety, mobility, impact on the environment, and the quality of life of local residents (OECD/ECMT, 2006). Historically, it was customary to set a speed limit by measuring the 85th percentile of the speed on a road (or V85, the speed not exceeded by 85% of the drivers). This was considered as a good indication of a speed limit to be imposed. However, behavioural observations and the high number

of speed-related traffic crashes have shown that one cannot always rely on the judgement of drivers to set a suitable speed limit.

This is why other approaches have emerged for determining the appropriate speed limit, based on the principle of injury minimisation. Such approaches have been promoted by, for example, the Safe System Approach (ITF, 2016; ITF, 2022), Vision Zero in Sweden (Tingvall & Haworth, 1999), and Sustainable Safety in the Netherlands (SWOV, 2018). Table 1 provides a summary of the recommended maximum speed limits for different types of roads with different types of possible conflicts based on this injury minimisation principle. A detailed set of recommended speed limits can be found in SWOV, 2018.

Table 1. *Recommended maximum speed limits based on the Safe System Approach (EC, 2020)*

Type of infrastructure and traffic	Recommended maximum speed limits (km/h)
Urban roads with possible conflicts between cyclists and pedestrians (VRU) and motorised vehicles.	Default 30 (though could be lower e.g. 20 in highly mixed traffic e.g. in city centres, or around schools)
Urban/suburban roads with fully segregated protection for cyclists and pedestrians (including at intersections) but with remaining intersections risking side impact for cars.	50
Rural roads without median barrier protection risking possible frontal impacts.	70/80 (though lower limits may be needed if the road in question is used regularly by pedestrians or cyclists)
Protected "through" roads i.e., with no possibility of a side impact or frontal impact (only impact with the infrastructure) but other factors e.g. high traffic volumes.	100
Fully protected "state of the art" motorways.	120/130

Numerous studies have shown that when speed limits are decreased, the average speed also decreases which in turn leads to a reduction of the number of casualties (Elvik, 2019; IRTAD, 2018). An example of a successful speed limit initiative at national level is the reduction of the speed limit from 90 km/h to 80 km/h on rural roads in France in July 2018. The estimated number of lives saved by this measure is between 300 and 350. The overall reduction in the number of fatalities is 10% (CEREMA, 2020; Carnis & Garcia, 2023).

Furthermore, an increasing number of cities in Europe have implemented city-wide 30 km/h speed limits (with the exception of

some main axes) which led to significant safety benefits. More precisely, evaluation results from 17 different cities across Europe (including Paris, London, Brussels and Helsinki) demonstrated that the newly introduced city-wide 30 km/h speed limits have led to significant reduction (on average): 37% of road crash fatalities (Yannis & Michelaraki, 2024). Another study conducted by Van Erpecum et al. (2024) implemented a meta-narrative evidence synthesis and highlighted the effectiveness of 30 km/h speed limits on motorized vehicle speed, traffic volumes, and injuries, collisions or casualties. These findings were also confirmed by simulation studies which, alongside road safety, demonstrated a significant subsequent increase in active travelling (pedestrians, cyclists and e-scooters) and Public Transport passengers, as mobility conditions become more user-friendly to vulnerable road users (Yannis & Michelaraki, 2025).

In addition to road safety considerations, city-wide 30km/h speed limit can also benefit the environment through the reduced direct and indirect emissions. Higher speed limits in urban areas are associated with higher speeds and more harsh accelerations and decelerations. According to Yannis & Michelaraki (2024), calmer and slower driving can decrease emissions by 18%, noise pollution levels by 2.5 dB and fuel consumption by 7% (on average). Furthermore, Brink et al. (2022) found that after the implementation of 30 km/h speed limit, road traffic noise dropped by an average of 1.6 dB during day and 1.7 dB at night. Similarly, Cleland et al. (2020) indicated that after the installation of a 30 km/h speed limit, noise emissions decreased by 1.5 to 4.8 dB (dB), with average values around 3 dB.

In a case study implemented by Madireddy et al. (2011), it was found that 30 km/h speed limits resulted in reductions of approximately 25% in CO_2 and NO_X emissions. Moreover, Litman (1999) studied the cost and benefit of traffic calming measures, such as the implementation of a 30 km/h speed limit in urban areas. It was found that environmental savings in CO, HC, and NO_X, in the range of 13%, 22% and 48%, respectively, were achievable. In parallel, the introduction of lower speed limits has minimum or no impact on average traffic speed (especially during the day) and in some cases makes traffic more fluid due to lower speed variations and less start/stops at junctions.

When all effects are co-considered the overall benefit is very high as demonstrated at related Cost-Benefit Analyses (Roussou et al. 2024). Interestingly, Haworth et al. (2001) modeled the travel time costs associated with a national decrease in the general urban speed limit. They found that reducing the default speed limit on arterial and collector roads or local streets by an assumed 5 km/h reduction in average travel speed would prevent an estimated 3,000 casualty

crashes per year, with an increase in average travel time per trip of less than 10 s.

According to a Welsh Government report published by Davis & Jones (2022), the direct estimated cost of introducing the 30 km/h default will be £32.3 million. In the first year, it is estimated that the road crash casualty savings at 20mph will be just over £92 million; nearly three times higher than the implementation cost. Over a three-year period, the benefits are estimated to be between 8–9 times higher than the implementation cost (£275.8 million). Reduced speed limits were also associated with cost-savings of $15 USD per resident to the healthcare system (Jiao et al., 2019). An interesting finding by Jones & Brunt (2017) estimated that if all current 30 mph limit roads in Wales became 20 mph limits, 1,200 to 2,000 casualties would be avoided and 6 to 10 lives would be saved each year.

Overall, scientific evidence demonstrates that city-wide 30km/h speed limit is a single road safety measure with significant quick benefits with low implementation cost and high potential for upgrading urban road safety culture.

3.2 Road infrastructure

Ideally, road infrastructure should ensure that roads are 'readable', so that road users understand how fast they are supposed to drive. Much of this has to do with road categorisation. Each road category should be recognisable by means of particular infrastructural features, so that drivers know which type of road they are on and, hence, what speed is suitable/allowed.

Within the Sustainable Safety concept, three types of roads are distinguished (SWOV, 2018):

- Through roads: roads intended for handling high capacity traffic at high speed (100-130 km/h). Slow traffic is not allowed on these roads. The carriageways are also physically separated from each other.
- Distributor roads: roads connecting the 'through roads" and the 'access roads'. The speed is set at 80 km/h outside built-up areas and 70 or 50 km/h inside built-up areas. Slow and fast traffic must be separated from each other.
- Access roads: roads providing access to residential areas, business parks, etc. The speed is set at 30 km/h inside built-up areas and 60 km/h outside built-up areas. Since the residential function is paramount on these roads, additional speed reduction measures such as speed humps are often in place.

Speed limits must be credible to drivers (Aarts et al., 2009). The idea is that the speed limit needs to match the image that is evoked by the road infrastructure and by the immediate surroundings. Specific features may elicit lower or higher driving speeds (Table 2).

Table 2. *Road and roadside features influencing speed limit credibility (Van Schagen & Aarts, 2020)*

Road/roadside feature	Effect on speed choice
Number of lanes	More lanes → higher speeds
Lane width	Wider lanes → higher speeds
Median	Median present → higher speeds
Hard shoulders	Hard shoulder present → higher speeds
Road markings	Edge lines and central lines → higher speeds
Type of pavement	Even surface (asphalt) → higher speeds
Openness of surroundings	Open surroundings → higher speeds

Variable speed limits (fixed limit but differentiated by, e.g., time of day) and dynamic speed limits (based on real-time traffic, weather or pollution conditions) can strengthen the credibility of speed limits. It is also important to inform drivers regularly about the speed limits, by road signs and by real-time messaging on the road or in vehicles.

To encourage lower speeds, physical speed inhibitors such as speed humps, raised platforms, crossings and refuge islands can also be very effective, especially for low to moderate speed environments in cities towns and villages (WHO, 2023b). A roundabout automatically leads to lower speeds and can therefore also be considered as a physical speed inhibitor. To establish a maximum effect, it is important that these speed inhibitors are implemented at the correct locations with the right dimensions. If, for example, a speed hump is too low or the distance between speed humps is too great, there will be little effect (SWOV, 2021).

3.3 Speed enforcement

Police checks on compliance with speed limits deter speeding at different levels. On the one hand, a fine will discourage drivers from committing the same offence again (specific deterrence). On the other hand, drivers who have not yet been fined will also tend to avoid speeding when they feel the chance of being caught is high (general deterrence). The subjective chance of being caught depends not only

on the actual number of checks, but also and especially on drivers' perception of the presence of checks.

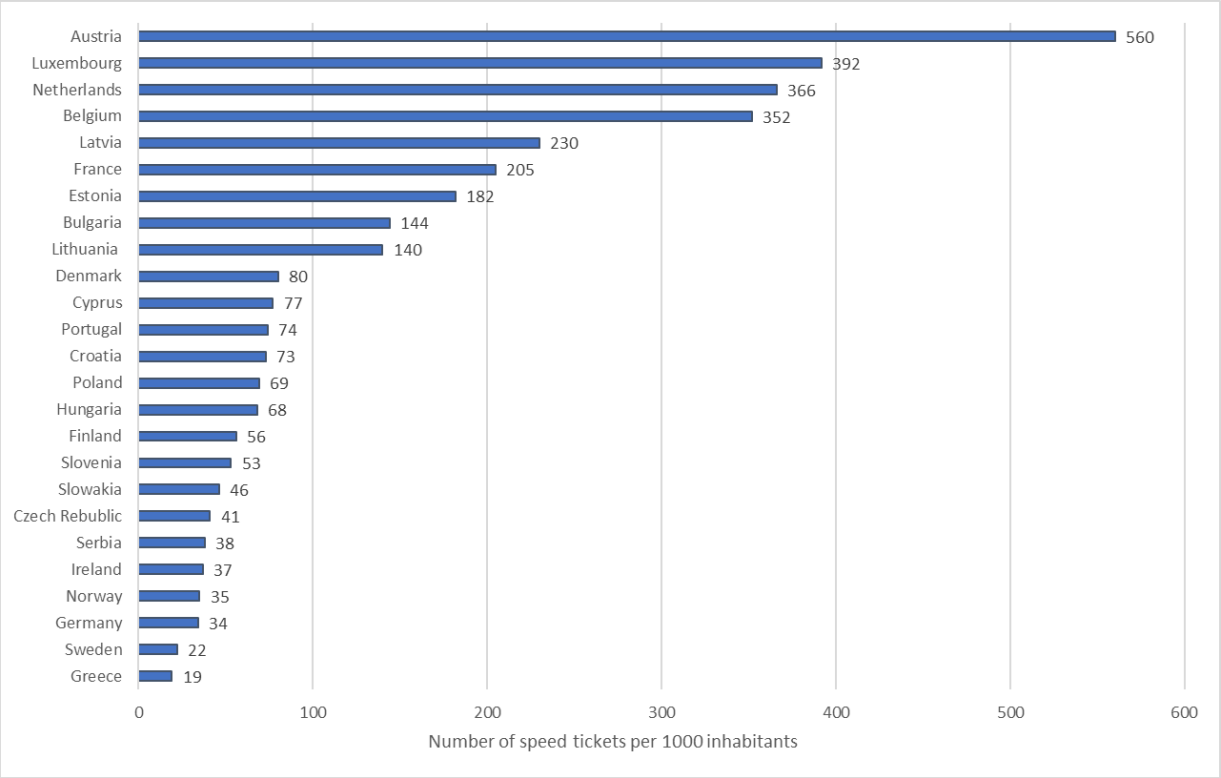
Ideally, speed enforcement should be based on a thorough analysis of traffic crashes and the role of speed. However, the OECD also stresses that other avenues should not be overlooked (OECD/ECMT, 2006). If speed checks are carried out at certain points and times only, the expectation of being caught may be reduced. Drivers should be made aware that speed limits must be observed at all times and everywhere and not only in dangerous places and hours where more crashes occur.

Most studies confirm that radar controls have a positive influence on the speed being driven and on crash incidence. Estimated reductions of crashes range between 5% and 69% (Pilkington & Kinra, 2005). The preventive effects are generally greater for more serious crashes. Even larger effects result from the application of section control, in which the average speed over a road segment is measured (De Ceunynck, 2017; Pilkington & Kinra, 2005). A meta-analysis (Høye, 2014) shows that fixed speed cameras reduce the number of crashes on road sections on average by about 20%, while the average effect for section controls is about 30%.

The effectiveness of checks also depends on the follow-up to the infringement. It is important that each recorded violation is followed by a fine (Goldenbeld et al., 1999). Otherwise, the effectiveness and credibility of the controls will be reduced. The detection equipment is often set in such a way that there is a margin of tolerance with regard to the speed limit. The use of such margins of tolerance serves to filter out minor, unintentional violations and to deal with the possible unreliability of the equipment. A disadvantage of this approach is, however, that it may strengthen drivers' opinion that a minor offence is not so serious.

Figure 6 displays the number of yearly speeding tickets from 25 European countries. There are huge differences between countries. By far the most speeding tickets were issued in Austria (560 per 1,000 inhabitants), followed by Luxembourg (392), Netherlands (366) and Belgium (352).

Figure 6. *Number of speeding tickets per 1000 inhabitants in 2020 (Carson, Jost & Meinero, 2022)*



Note: Data of countries are not completely comparable: see Carson, Jost & Meinero, 2022, p20.

3.4 Vehicle technology

There are several in-vehicle tools that can help drivers not to exceed the speed limit.

First of all, drivers can access information about the current speed limit via devices in their vehicle (such as a GPS or smartphone). However, such systems do not always take account of dynamic speed limits or temporary arrangements, and therefore carry the risk that they may overstate the speed limit in some places. There is also a risk that the speed limits in these systems are no longer up to date. Furthermore, most new cars are equipped with a speed limiter or cruise control which can ensure that drivers do not drive unconsciously faster than the speed limit. While there are currently no regulations regarding speed limiters in passenger cars, there are for trucks and buses. The speed of trucks (>3.5 tonnes) and buses is limited to 90 km/h. For recent coaches this limit is 100 km/h.

Distance and time headways between vehicles are important factors for both total traffic flow and safety on certain road segments. Short headway distances and times between vehicles adversely affect safety, as there may not be enough time to stop or avoid another vehicle in

case of an emergency. Adaptive Cruise Control (ACC) systems can help prevent short headways by monitoring and maintaining a safe tracking distance to a vehicle ahead and automatically adjusting the vehicle speed. This is especially useful in stable driving conditions, such as on motorways and other high-speed roads when a vehicle can sometimes follow another vehicle for a longer period of time (Reed, 2017).

ISA (Intelligent Speed Assistance) is a system that determines the position of a vehicle and compares its speed with the local (static or dynamic) speed limit and gives feedback to the driver. This comparison is based on a road map containing the speed limits and/or by means of traffic sign recognition. Observation studies and field experiments have shown that ISA leads to a reduction in driving speed and a reduction in the number of fatal crashes (Carsten, 2020; Theofilatos & Macaluso, 2017). A specific challenge relates to knowing the correct speed limits in all circumstances on all roads, especially if they deviate from the normal situation. Under the European *Vehicle General Safety Regulation* (EU, 2019), an overridable ISA is required on all new vehicle models since July 2022 and on every newly sold vehicle since July 2024. Car manufacturers can choose from four types of feedback: an acoustic warning, a vibrating warning, haptic feedback through the acceleration pedal, or automatic reduction of the speed of the car. It must be possible to switch off the ISA, but as a default ISA must be switched on at each vehicle startup.

3.5 Intelligent roadside Transport Systems (ITS)

Despite the growth of real-time information on speed limits provided to nomadic devices and vehicles, roadside information panels on speed limits and weather-related warnings can still play an important role in speed management. Weather-related systems as well as controlled motorways are based on a set of technologies capable of automatically feeding information into central traffic control centers, which can use this information for speed-information panels and dynamic lane control signs as well as speed camera’s (WHO, 2023b).

Dynamic lane control signs are used to indicate speeds that are deviant from the standard speed limit in case of congestion, incidents upstream or bad weather conditions that require a lower speed. These dynamic signs appear to have an important signaling effect; speed limits on dynamic control signs lead to more homogeneous speeds, a decrease in the number of crashes and incidents and fewer intensive braking (SWOV, 2021).

3.6 Education and communication

Education and communication are essential for making road users familiar with the traffic rules and regulations, making them aware of the risks in traffic, and creating understanding for and acceptance of (less popular) road safety measures.

On its own large-scale, mass-media **publicity campaigns** hardly affect actual behaviour. They can have an added value, supporting other measures such as legislation and enforcement. For example, Delhomme et al. (2009) found that awareness campaigns work much better (or even only) in combination with such additional measures. Speed campaigns are often combined with increased enforcement. In those cases, it is impossible to isolate the effect of the publicity campaign (e.g., see the inventory of Pilgerstorfer & Eichhorn, 2017). A personal and local form of publicity is often more effective in realising behaviour change, at least temporary (Phillip, Ulleberg & Vaa, 2011; Van Schagen et al., 2016).

Young people exhibit the strongest tendency for risky behaviour and are an important target group for education and communication about the effects of speed. While this could begin as early as secondary school, it should certainly be addressed during **driver training**. Training should focus on recognising dangerous situations, ways to avoid them, and driver limitations (OECD/ECMT, 2006).

Another important target group for educational measures are people who have committed serious speed offences. **Rehabilitation courses** can be proposed or imposed by the courts as an alternative or additional penalty. Both positive effects on reoffending (e.g., Ipsos MORI et al., 2018) and absence of effects (e.g., Blom, Blokdijk & Weijters, 2019) have been reported.

Companies can also raise awareness about speed, e.g. as part of a company's **safety culture** policy. Employees who make trips for work sometimes appear to be more inclined to drive faster than when they are driving for other reasons (see Section 2.2). In some cases, those responsible within companies themselves also need to be made aware so as not to impose undue time pressure on their employees which may force them to drive too fast.

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