

Speed and Technology: Different Modus of Operandi

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Abstract

Within Vision Zero as a strategy, it is imbedded the fact that injuries occur when the mechanical energy reaches individuals at rates that entail forces in excess of their thresholds for injury. Therefore, according to Vision Zero, there are three main strategies to eliminate fatalities and severe injuries due to road crashes: protect people from exposure of harmful energy, reduce the risk of events with harmful energy, and protect people from harmful energy in the event of a collision. Controlling speed is therefore of the task of utmost importance in a strategy such as Vision Zero.

A traffic enforcement camera, or “speed camera,” system has the possibility to control speed in a road system, and it has the possibility to affect its road users both at a macro and a micro perspective. In a micro perspective, it primarily concerns how effective the cameras are locally at the road sections where the enforcement is focused on, while at a macro perspective it is more focused on how the camera enforcement system and strategies, possibly together with the overall enforcement strategy, affects attitudes and norms related to driving with excessive speed. Experience worldwide has proven the effectiveness of automated speed cameras in reducing speed and, in turn, crashes and injuries.

In this chapter, firstly the rationale behind speed limits, speed management, and speed compliance strategies will be explored and analyzed, in particular from a Vision Zero perspective. Secondly, various different approaches to speed camera systems in Europe, in Sweden, Norway, the Netherlands, and France, will be analyzed and further explored. Finally, based on similarities and differences in approaches in these countries, in the last section some aspects concerning the setting of speed limits, speed management strategies that underpin the choice of camera technology, and modus of operandi, safety effects of and attitudes toward cameras, will be explored and discussed.

Keywords

Vision Zero · Public policy · Speed limits · Speeding · Traffic safety cameras · Speed cameras · Traffic enforcement cameras

Introduction

Speed limits and speed monitoring and enforcement are a rather sensitive topic in most countries. To a significant extent, this is due to what people perceive is the primary goal with the road safety work, namely, the reduction of accidents, or to reduce crashes as many people prefer to express it. In this traditional approach, most of the attention is focused on people’s behavior due to the fact that in-depth studies have shown that 90% of all accidents are due to human factors (Evans 2004). In this traditional context, speed becomes one risk factor, among others, used to explain the occurrence of an accident, and many times other factors such as distraction, fatigue, alcohol, and drugs seem to be more obvious and significant.

In October 1997, the Riksdag (the Swedish Parliament) adopted Vision Zero as a new long-term goal and strategy for road safety in Sweden (Swedish Parliament 1997; Belin et al. 2011). Imbedded in Vision Zero as a strategy is the fact, which was revealed by William Haddon already in the 1960s, that injuries occur when the mechanical energy reaches people at rates that involve forces in excess of their injury thresholds (Haddon 1968, 1980). Therefore, according to Vision Zero, there are three main strategies to eliminate fatalities and severe injuries due to road crashes: protect people from exposure of harmful energy, reduce the risk of events with harmful energy, and protect people from harmful energy in the event of a collision. To control the speed is therefore of the utmost important task in a strategy like Vision Zero.

Speed as one important risk factor is a valid logic in the context of a more traditional approach, but if the problem that one tries to solve is not accidents per se but rather the outcome in terms of fatalities and serious injuries, the speed instead becomes the core of the entire road safety work. People do not suffer from injuries due to distraction, fatigue, alcohol, and other factors. To put it bluntly, as long as one's speed is low, they will survive a crash even if they are driving impaired due to operating under the influence. Speed limits and speed monitoring and enforcement therefore play an important role both traditionally and from a Vision Zero perspective, however, from rather different angles.

Change of speed and its relation to accidents and the severity of injury is one of the most researched topics in the field of road safety. According to Elvik (2009), change of speed and road safety could be described in terms of different power functions, where the power function is greater for higher levels of severity. For example, a reduction of average speed by 10% will reduce fatalities by approximately 40%, serious injuries by 30%, and accidents with minor injuries by 10%.

There are several ways to control the speed in the road transport system – for example, speed limits and a variety of speed-reducing devices. The State of Victoria in Australia is an innovator for road safety practices on a global scale. For example, Victoria was the first jurisdiction in the world to introduce the compulsory use of seat belts, back in 1970, and random breath testing (RBT) in 1976 (Trinca et al. 1988). True to their tradition, in 1989 the State of Victoria started to implement a large-scale automatic speed camera program (Bourne and Cooke 1993). This was the first time in the world that extensive use had been made of this technology (Sagberg 2000). After this, quite a number of jurisdictions around the world have followed.

In this chapter, firstly the rationale behind speed limits, speed management, and speed compliance strategies will be explored and analyzed, particularly from a Vision Zero perspective. Secondly, the different approaches to speed camera systems in Europe, namely, in Sweden, Norway, the Netherlands, and France, will be analyzed and further explored. And then finally, based on similarities and differences in approaches in these various countries, in the last section some aspects concerning the setting of speed limits, speed management strategies that underpin the choice of camera technology, and modus of operandi, safety effects of and attitudes toward cameras, will be explored and discussed.

Setting Speed Limits

The speed limit constitutes the legal objectives for the monitoring and enforcement, similar to the blood alcohol limits establishes legal objectives for how much alcohol a road user is allowed to have in their blood while driving. This is something people mostly accept and take for granted; however motives and criteria that underpin a speed limit system are paramount for its legitimacy and thereby also important for public control and sanctions.

In a Swedish context, it is obvious that motives that underpin a speed limit system have evolved and change over time. In 1907, the Swedish Government launched the first road traffic regulation for automobiles. The regulation stipulated, among other things, that motor vehicles were not allowed to drive faster than 15 km/h in urban areas and 25 km/h in rural areas. During the period 1910–1930, the maximum speed limit was increased to 35 km/h in urban areas and 45 km/h in rural areas (Swedish Parliament 1906). The use of the automobile was heavily regulated primarily because it was seen as an unwelcome element in a transport system which mainly consisted of horse transports. In the 1930s, an opinion was raised against these static speed limits. The advocates argued that the vehicles and the roads had a higher standard and therefore were designed to allow a much higher speed. It was better, according to the advocates, to put the entire responsibility on the individual to adjust their speed according to the situation. Therefore, a new speed regime with free speed, both in urban and rural areas, and with a significant proportion of self-responsibility was introduced in 1936 (Swedish Parliament 1936).

After World War II when the number of cars rapidly increased and along with this, the number of fatalities increased dramatically, the epidemic situation forced the Swedish Government to take a variety of different steps to improve the road safety situation. The experts were not sure that the freedom for the driver to choose their own speed was such a good idea. Besides, it was difficult for the police to enforce inappropriate choice of speed, and the police needed clearer guidelines regarding which speed to allow. The elected officials responded to that request, and the first step was to re-regulate the speed in urban areas. In 1955 a new default speed that stipulated 50 km/h in urban areas (this speed limit is still in place) was introduced (Swedish Government 1955). During the years 1960–1967, temporary speed limits for the rural roads were introduced – especially during holidays. The speed limits were 80, 90, or 100 km/h. In 1968, a trial with general differentiated speed limits was introduced and the idea was to allow higher speed on roads with higher standards. In 1971 a default 70 km/h speed limit for rural roads was introduced. The debate about having speed limits or not vanished from the agenda and was replaced by a discussion of which criteria the speed limits should be based on (e.g., on what roads should the responsible traffic authorities allow 90 km/h or 110 km/h).

One of the most important criteria when the speed limits first were discussed was the drivers' acceptance. The advice was that the speed should be around 85th percentile which means the speed 85% of the vehicles not are exceeding (see Fig. 1, the evolution of speed limit system).

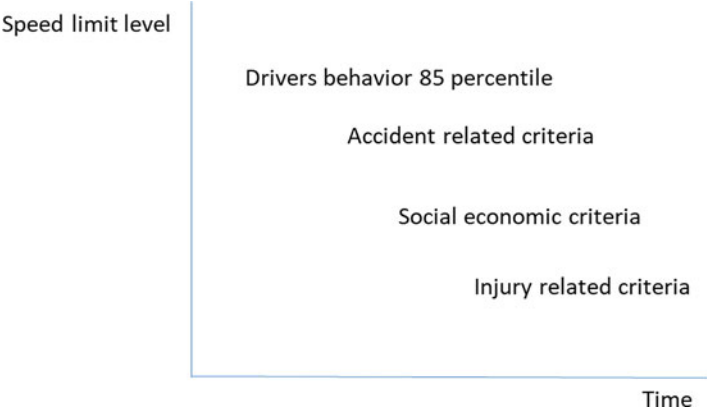


Fig. 1 Evolution of important speed limit criteria in Sweden

Soon it became obvious that alignment routing, passing sight distance, and accident rate needed to be considered before a speed was decided, and these accident-related criteria have dominated since the 1970s (Swedish Government 1978). In the 1980s, the experts advocated that speed limits should be established from a cost-benefit perspective (Carlsson 1976). The idea was that one could calculate an optimal speed limit for different road environments. This method has never been implemented in reality, though.

According to Vision Zero, road users’ tolerance against external violence should be the basic design parameter for the speed. Based on this design parameter, it has been suggested that the risk for different crash types should set the maximum speed. For example, in the situation where there are risks for crashes with cars and unprotected road users, the speed limit should not be higher than 30 km/h and for risks for head-on collisions (i.e., cars to cars) at a speed not higher than 70 km/h (<https://www.roadsafety.piarc.org/en/road-safety-management-safe-system-approach/safe-system-elements>).

A speed management system in order to achieve safe speed in the long run is summarized in Fig. 2. First, one needs some long-term principals which appear in Table 1. However this might be difficult to achieve in the short term; therefore jurisdictions have to allow a higher speed than what is appropriate from a Vision Zero perspective. These should however only be short-term considerations. Irrespective of if the speed limit is established based on long-term safety principals or short-term practical considerations, the governmental authorities need also to ensure that the traffic complies with the speed limits, which is the last step.

Influencing Road Users’ Speed Behavior

Kinetic energy is one of these risks in our society that people do not feel and therefore do not have a natural perception of, in comparison with the risks of such things as snakes, spiders, heights, etc. pose. Therefore the speed that people choose is largely dependent

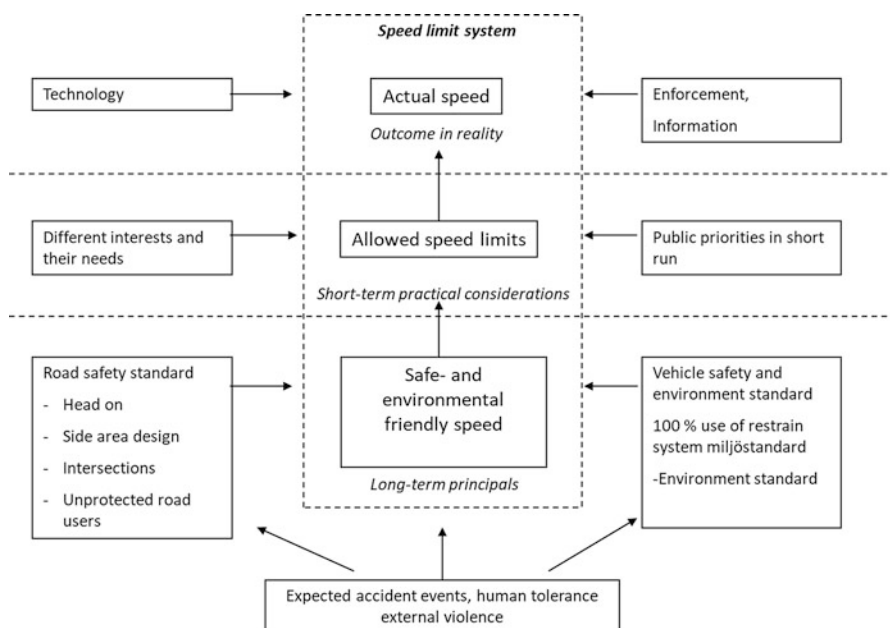


Fig. 2 Speed management system in order to achieve safe speed according to Vision Zero and environment

upon stimuli from the environment such as the road environment, weather, surrounding traffic, and posted speed limits, among other factors. To know intellectually about the risk will also be important. Control interventions such as manual and automated enforcement have significant impact on people's compliance with the speed limits. Risk for sanctions in terms of fees and losing the driving licenses are also important. A couple of important questions are therefore important to discuss; who should be the target group for the enforcement and how are the interventions supposed to work?

Firstly, if the speed limit is set according to the 85%, already a large majority of the traffic will comply with the speed limit. Therefore, enforcement is aimed to influence 15% of the road users. As early as in the 1950s, the expression "people drive as they live" was coined (1953 Års Trafiksäkerhetsutredning 1954). Therefore, these 15% was blameworthy, and the enforcement should focus on this risk group, especially those who are driving too fast. What underpins this high-risk strategy are of course that these groups are, individually, more risky from a road safety perspective. Even though the criteria for setting the speed limits have changed, the most popular enforcement strategy is still to focus on the high-risk groups. However with such approach, one might end up in what researchers refer to as the "public health paradox," (Rose 1981) namely, a more general effect on road safety is obtained if instead of focusing on a small population of speeders, efforts are made to influence the larger normal population who are only speeding little too much. The individual strategy has its advantages (Rose 2001), and it very probably fits well in with how

Table 1 Speed limit system in Sweden, Norway, the Netherlands, and France. Extracted from ETSC (2019)

	Sweden	Norway	Netherlands	France
Proportion (in %) of observed speeds of cars and vans higher than the speed limit on 50 km/h urban roads and mean observed driving speed on these roads in free flow traffic.	46.5 km/h mean speed; 65% below the speed limits	49 km/h mean speed; 54% below speed limits	N/A	49.4 km/h mean speed; 54% below speed limits
Proportion (in %) of observed speeds of cars and vans higher than the speed limit on rural non-motorway roads and mean observed driving speed on these roads in free flow traffic.	Speed limit 70 (2016) 68.3 km/h mean speed; 45% below the speed limits	Speed limit 70 69 km/h mean speed; 57% below the speed limits	N/A	
	Speed limit 80 (2016) 81.9 km/h mean speed; 42% below the speed limits	Speed limit 80 77.4 km/h mean speed; 58% below the speed limits		
	Speed limit 90 (2016) 88.9 km/h mean speed, 52% below the speed limits			Speed limit 90 (2016) 81.6 km/h mean speed; 69% below the speed limits
				Speed limit 110 (2016) 105.2 km/h mean speed; 81% below the speed limits
Proportion (in %) of observed speeds of cars and vans higher than the speed limit on motorways and mean observed driving speed on these roads in free flow traffic		Speed limit 100 (2017) 100.1 km/h mean speed; 47% below the speed limits	Speed limit 100 (2011) 98.6 km/h mean speed; 53% below the speed limits	
	Speed limit 110 (2016) 111.6 km/h mean speed; 40% below the speed limits	Speed limit 110 (2017) 102.3 km/h mean speed; 66% below the speed limits		Speed limit 110 (2016) 103.3 km/h mean speed; 70% below the speed limits

(continued)

Table 1 (continued)

	Sweden	Norway	Netherlands	France
			Speed limit 120 (2011) 113.8 km/h mean speed; 65% below the speed limits	
				Speed limit 130 (2016) 121.8 km/h mean speed; 72% below the speed limits

Unlike Victoria, Australia, the studied countries camera programs are primarily based on fixed cameras, and the number of cameras per million inhabitants varies between 41 (Norway) and 135 (Sweden) cameras. Speeding tickets per 1,000 inhabitants varies between 8 (Sweden) and 391 (the Netherlands)

the police interpret the law and prioritize their operations, namely, to catch offenders. However from a general road safety perspective, they would see more benefit if they influence a large proportion of the normal population.

Secondly, which also to some extent reflect the choice between the high-risk strategy or the population strategy, what is the appropriate mechanism for influence. According to Kahneman (2011), human behavior is based on two different systems, namely, system 1 and system 2. System 1 is fast and automatic, emotional, and unconscious. System 2 is slow, calculating, and conscious. Our enforcement strategies are, mostly implicitly, based on an idea about what system actually influences the road users' behavior. If one believes that the road users are rational and are carrying out conscious calculations about the costs and benefits of speeding, one refers speeding to an action originating from system 2. However if one thinks that speeding is an automatic and unconscious behavior, they believe it stems from system 1. Later in this chapter, speed camera systems in Victoria in Australia and Sweden will be discussed, and it appears that Australia based their system more on system 2 and Sweden on system 1 theory on road user behavior.

Manual Enforcement or Technology

Especially if the goal with the enforcement strategy is to catch those who deliberately violate the law and traffic rules, and therefore put themselves and others in danger, covert manned enforcement seems to be an appropriate strategy. Manual enforcement might also be an option within a more population-focused strategy however in this case based on an overt strategy. However according to some researchers, it is difficult for a police organization to maintain a high-profile manned enforcement over a long period of time (Bjornskau and Elvik 1992). This adaption



Fig. 3 Adaptation process police enforcement

process can be seen in Fig. 3. However technology creates new options. Regardless of strategy, automated enforcement can be put in use 24/7/365 and therefore deal with some of the negative effects and costs of manual enforcement.

Different Modus of Operandi

Many jurisdictions around the world have defined speed and speeding as important factors to control in order to focus on improving the road safety situation or even in the long run achieving a safe system. Many jurisdictions are also using an automated speed camera system to achieve these goals. However there are differences in the design of these systems and the way these systems are set up and operate. In other words, different ideas and strategies underpin these systems. In a study (Belin et al. 2010), speed camera system in Sweden and Victoria, Australia, was explored and compared. First, at least in early 1990, the lack of road safety was seen as caused by unappropriated behavior, and speeding was one of the most important. According to this study, the approach adopted in Victoria was based on the concept that the drivers are rational and they strive for driving as fast as possible and they are doing deliberate calculations of the cost and the benefits and therefore are choosing a speed where these are in balance. Based on an earlier section, it seems that the Australian system is grounded in the theory that speed behavior is emanating from system 2. Second, the Australian seems to have expanded their high-risk group “police model” with the focus on offenders to a large population. Regardless of who and where, speeding is a blameworthy behavior and needs to be detected and punished. Therefore the aim was to catch a large proportion of the drivers that exceed the speed limit, so that they experience the consequences, specific deterrence, and avoid re-offending and in turn tell others that they have been caught and suffered punishment, resulting in a general deterrence. The overall aim appears to be to establish a social norm that speeding is a serious offense along with supporting the introduction of large-scale camera surveillance. This was supported by broad informational campaigns with the aim to upset and outrage the viewers. Victoria was a forerunner in the beginning of 1990 when they took this new technology from demonstration phase to implementation of a large-scale speed camera system. However Sweden, Norway, the Netherlands, and France followed and gradually implemented their own large-scale speed camera system. In this section, these systems will be described and explored. Based on available data, focus will be on the systems operation in 2015.

Method and Data

A literature review was done in the literature databases Scopus and TRID, primarily focusing on studies from 2008 to 2019. Scopus is the world's largest bibliographic database, focusing on scientific articles in all subjects. TRID is an integrated database that combines the records from TRB's Transportation Research Information Services (TRIS) Database and the OECD's Joint Transport Research Centre's International Transport Research Documentation (ITRD) Database. TRID provides access to more than 1.25 million records of transportation research worldwide. In addition to the searches in the databases, a request about gray literature was made from personal contacts.

In addition to the literature review, data from a study about speed enforcement in Europe done by ETSC (European Transport Safety Council) was used, ETSC (2016, 2019). ETSC is an independent nonprofit organization based in Brussels dedicated to reducing the numbers of deaths and injuries in transport in Europe. The report shows that methods on the levels of speed enforcement differ greatly between EU member states.

To compare attitudes in different countries, data from ESRA (E-Survey of Road Users' Attitudes) is used. ESRA is a joint international initiative of research centers and road safety institutes across the world, and in its first stage (ESRA1 2015), the project has surveyed road users in 38 countries on 5 continents, and in ESRA2 (2018–2019), 48 countries participated. ESRA data is collected through online panel surveys, using a representative sample of the national adult populations in each participating country (at least $N = 1,000$ per country). It is a jointly developed questionnaire, which is translated into national language versions. The themes covered include self-declared behavior, attitudes and opinions on unsafe traffic behavior, enforcement experiences, and support for policy measures. The survey addresses different road safety topics (e.g., driving under the influence of alcohol, drugs, and medicines, speeding, distraction) and targets car occupants, motorcycle and moped drivers, cyclists, and pedestrians. The aim of ESRA is to collect comparable data on the road safety situation and culture indicated by the road users' past and habitual behaviors, attitudes, beliefs, perceived norms, and values. The ESRA data is used as a basis for a large set of road safety indicators. These indicators provide scientific evidence for policymaking at national and international levels (see <http://www.esranet.eu>).

Four countries in Europe (Sweden, Norway, the Netherlands, and France) with different *modus operandi* and different levels of enforcement were selected and investigated in more detail, regarding *modus operandi*, level of speed enforcement, attitudes, and traffic safety effects.

Speed Camera System in Sweden, Norway, the Netherlands, and France

In a couple of reports from the European Transport Safety Council (ETSC) (ETSC 2016, 2019), data has been assembled concerning a variety of countries' speed control methods systems and speed camera system and their characteristics. Based on this, some interesting findings are summarized in Tables 1 and 2.

Table 2 Speed camera program and its characteristics in Sweden, Norway, the Netherlands, and France in 2015. Extracted from ETSC (2016)

	Sweden	Norway	Netherlands	France
Inhabitants	9, 7 million	5, 1 million	16, 9 million	66, 4 million
Total number of cameras (in operation)	1315	341	852	3953
Fixed cameras	1300	317	642	2180 886 (empty boxes)
Proportion of fixed cameras	99%	93%	75%	78%
Time over distance cameras	0	24	24	100
Owner responsibility	No	No	Yes	Yes
Speeding tickets from camera	78,423	90,524	6,609,418	12,728,539
Cameras per million inhabitants	135	41	50	60
Tickets per 1000 inhabitants	8	17,5	391	192

The speed limit, the mean speed, and the compliance of speed limits differ between the studied countries. All countries have 50 km/h, but it seems that Sweden has lower mean speed and higher compliance of the urban speeds compared to Norway and France. When it comes to rural roads, however, Sweden seems to have, compared with Norway and France, a lower compliance with the speed limits. The same pattern can be found when it comes to compliance with speed limits on motorways.

Even though all four countries studied based their camera operation on a system of fixed cameras, there are differences in the manner in which the owners of a vehicle are regulated, the number of traffic tickets, and number of cameras, and this might reflect strategic differences in the modus of operandi between these countries.

Firstly, both in Sweden and in Norway, in order for the government to assert liability for a speeding violation, the driver must be identified by a photograph. In the Netherlands and France, at least for the less severe speeding violations, it is sufficient to identify the car via the number plate and send a ticket to the owner of the car. If the owner hasn't driven the car, he or she will need to file a report as to who the actual driver was. Owner or driver liability could be a sensitive legal issue (SOU2005: 86), and, at least from a Swedish point of view, the government has not seen any possibilities to put any type of liability on the registered owner of the car for speeding violations. According to Swedish legal experts, owner liability conflicts with Swedish legal tradition. Driver versus owner responsibility could therefore have a large impact on how a camera system can operate from an administrative point of view and that might, at least partially, explain the number of traffic tickets that are issued. Secondly, there are large differences between Sweden and the rest of the countries in terms of the number of cameras per million inhabitants and how many traffic tickets are issued per 1,000 inhabitants. Sweden has about 2.5 more cameras per inhabitants however at the same time 50% less tickets issued per 1,000 inhabitants than in Norway. The Netherlands has similar number of cameras as Norway and France; however 49 times more tickets per 1,000 inhabitants are

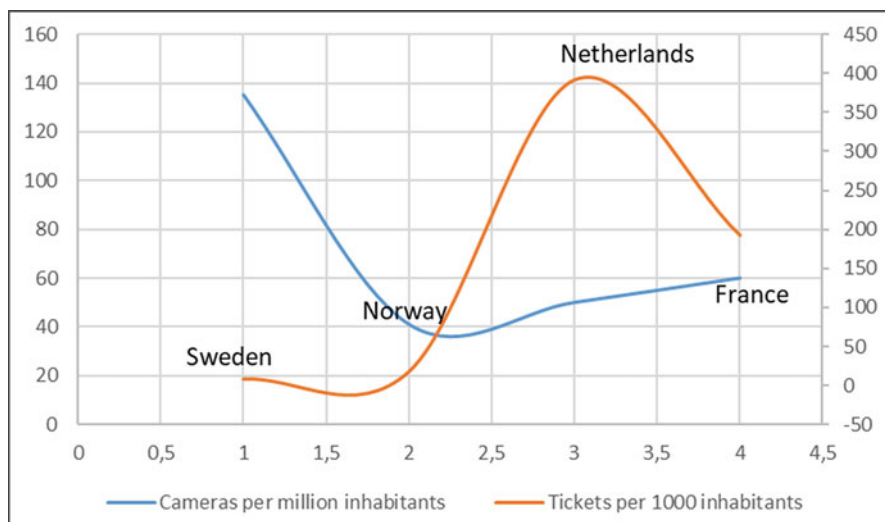


Fig. 4 Cameras and speeding tickets per inhabitants in Sweden, Norway, the Netherlands, and France. (Data from Table 2)

issued in the Netherlands than Sweden. The number of cameras and tickets per inhabitants is summarized in Fig. 4. Apparently, Sweden is at one extreme and the Netherlands is at the other.

Attitudes to Speeding and Enforcement

The different enforcement strategies in the four countries might lead to differences regarding attitudes and self-reported behavior in relation to speeding. Based on data from ESRA (2015), some comparisons of Sweden, Norway, the Netherlands, and France are made. As shown in Fig. 4, the number of speeding tickets per 1,000 inhabitants differs between the countries and especially between Sweden and the Netherlands. In ESRA, questions about perceived risk versus actual risk (self-reported) are investigated. Car drivers were asked to indicate their perceived likelihood of being checked by the police for speeding and how many times they have had to pay a fine for speeding during the last 12 months (Fig. 5). In Sweden it is only 2% that report that they have had to pay a fine at least one and in Norway 4%, while in the Netherlands it is about 15% and 11% in France. The pattern is the same for perceived risk with low values for Sweden and Norway, and higher for the Netherlands and France. In France, about 55% of the car drivers think it is a big chance of getting caught by the police, in the Netherlands 35%, while in Sweden and Norway it is only almost 20%.

Self-declared excessive speed behavior in Sweden, Norway, the Netherlands, and France is shown in Fig. 6. Answers from 1 (never) to 5 (almost) always, the figure reports 4–5 (often). Sweden and Norway show somewhat higher levels of self-

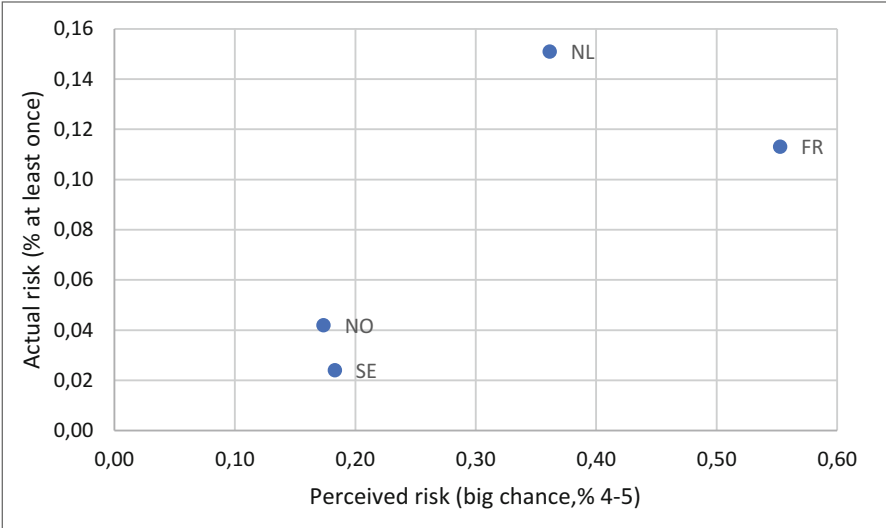


Fig. 5 Perceived versus actual risk. Perceived risk: On a typical journey, how likely is it that you (as a CAR DRIVER) will be checked by the police for respecting the speed limits (including checks by police car with a camera and/or flash cameras)? (1 = very small chance to 5 = very big chance). Actual risk: In the past 12 months, how many times have you had to pay a fine for violating the speed limits? (% of at least once). ESRA (2015)

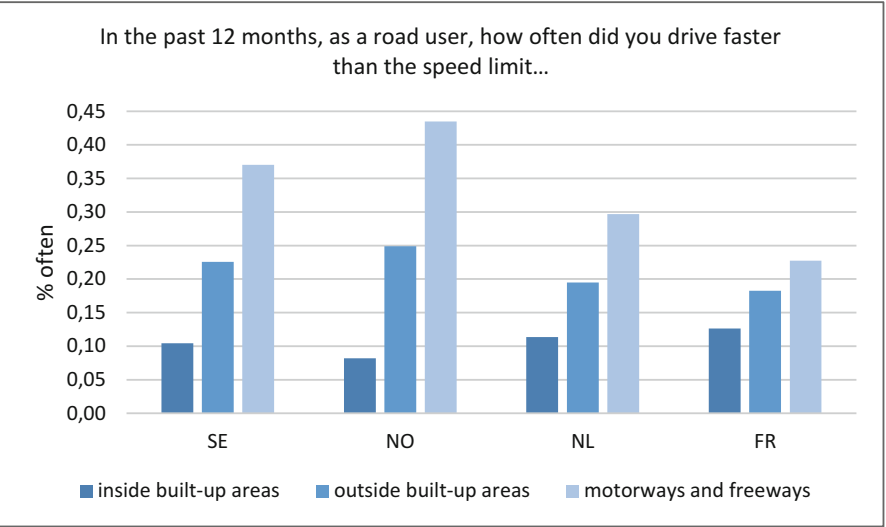


Fig. 6 Self-declared speeding behavior. ESRA (2015)

declared speeding behavior outside built-up areas and on motorways. Inside built-up areas, the trend is opposite with slightly lower reported levels of speeding for Sweden and Norway than for the Netherlands and France.

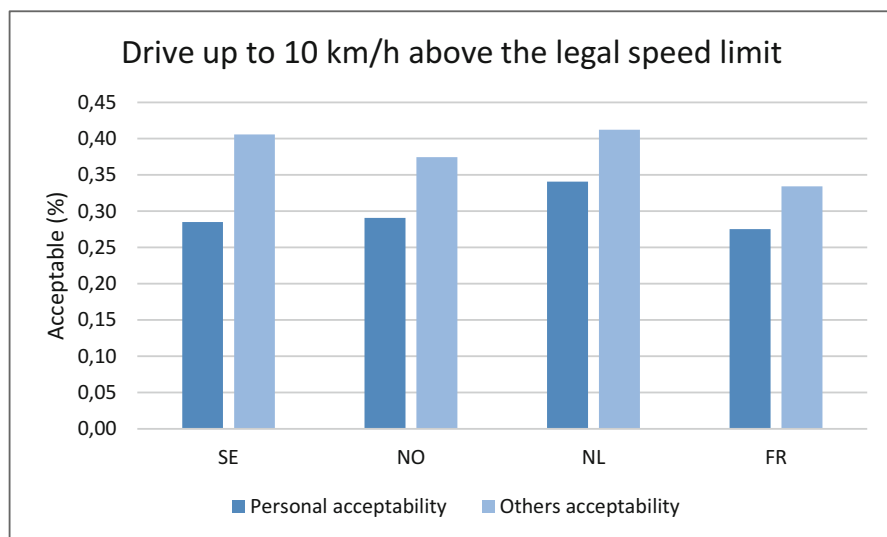


Fig. 7 Personal versus other's acceptability of speeding: "How acceptable ... is it for a CAR DRIVER to ... ?". % of road users who indicate driving faster than the speed limit as acceptable (% 4–5). ESRA (2015)

In Fig. 7, personal versus other's acceptability of low-level speeding, up to 10 km/h above the legal speed limit, is shown. Answers are on a scale from 1 to 5, where 1 is "unacceptable" and 5 is "acceptable," and the figure shows % answering 4 and 5. It is a rather similar pattern among the countries, with around 30% answering that they personally think it is acceptable to drive up to 10 km/h above the legal limit, while they think that others found it more acceptable (35–40%). The Netherlands has slightly higher values than France, Sweden, and Norway.

In Fig. 8, personal acceptability of unsafe traffic behavior in relation to higher levels of speeding in different situations is shown. Answers are on a scale from 1 to 5, where 1 is "unacceptable" and 5 is "acceptable," and the figure shows % answering 4 and 5. In general, it is more acceptable to exceed the speed limit by as much as 20 km/h on motorways/freeways and not acceptable in urban areas, school zones, and residential streets. On motorways/freeways, Sweden has the highest acceptability for high-level speeding, but on residential streets, France has the highest. In urban areas and school zones, none of the countries found it acceptable.

Traffic Safety Effects of Speed Cameras

Experience worldwide has proven the effectiveness of automatic speed cameras in reducing speed and, in turn, crashes and injuries. Section control, sometimes referred to as "average speed control" or "distance control: trajectory" (using the

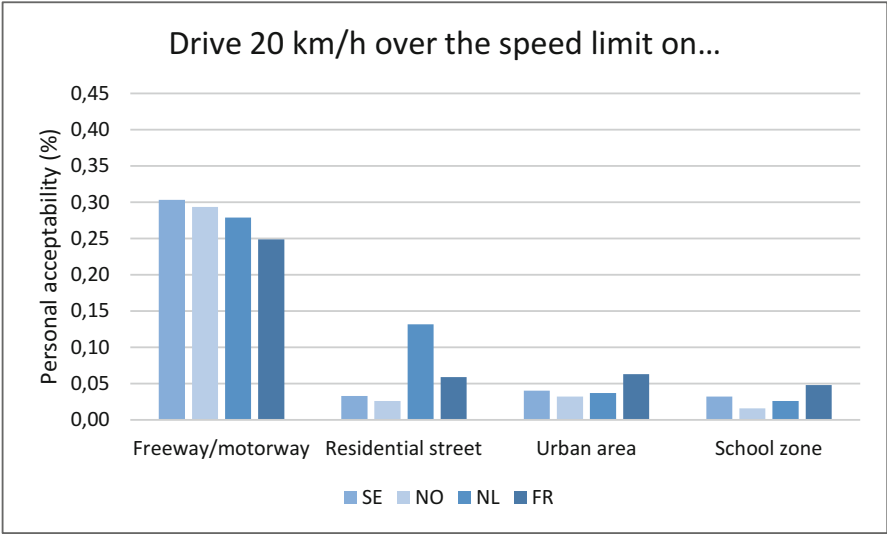


Fig. 8 Personal acceptability of speeding: “How acceptable do you, personally, feel it is for a CAR DRIVER to...?”% of road users who indicate driving faster than the speed limit as acceptable (% 4–5). ESRA (2015)

measurement of the average speed over a section of road), is a relatively new measure, which seems to be very effective not only in reducing speed but also in contributing to more homogenized traffic flow (ITF 2018).

Comparison Between Section Control and Spot Speed Cameras

In Høye et al. (2019), effects of spot speed cameras and section control are studied. For fixed speed cameras, the mean speeds are reduced by 6%–15% within 500 m from the speed camera. For section control, studies in Norway (Ragnøy 2011) showed that section control reduced the mean speed over the section enforced by 11%, similar as the effects at the fixed camera sites. In a literature review by Soole et al. (2013), it was shown that section control reduced mean speeds between 8% and 28%. One advantage with section control compared to spot speed cameras is that mean speeds decrease over a longer part of the road section.

Looking at traffic safety effects, Høye et al. estimate in a meta-analysis that the number of injury crashes were reduced by 19% (–24, –14) and the number of fatalities by 51% (–72, –12) for spot speed cameras. The closer to the cameras, the larger effects on injury crashes. For section control, the injury crashes were reduced by 27% (–36; –16) and the number of fatalities and seriously injured by 54% (–63; –42).

For spot speed cameras, Høye et al. (2019) estimated that with larger distance from the camera, the effects on mean speed tend to be smaller. Looking at effects on mean speed in the near vicinity of the speed camera (< 250 m), the mean speed

decreased by 11%; within 500–750 m after the speed camera, the mean speed decreased by 5%; and between 1,000 and 1,250 m after the camera by about 3%. For longer distances, the effects were smaller, and around 2,000 m after the camera, the mean speed decreased by only 1.4%. The number of personal injury crashes decreased by 18% in the near vicinity of the speed camera (<250 m); by 12%, within 500–750 m after; and by 7% at 1,000 and 1,250 m after the camera.

Change of Speed Distribution

Soole et al. (2013) concluded that section control is effective in reducing mean speed, P85, and speed variations between vehicles, and in many studies referred to in Soole et al. (2013), the decrease in P85 was greater than the decrease in mean speed. Similar changes are seen for spot speed cameras in the immediate vicinity surrounding the cameras (Vadeby and Forsman 2017), which suggests a change in the shape of the speed distribution. Overall, P85 decreases more than the average speed, and the proportion of serious offenses decreases more than total offenses. Figures 9 and 10 show the speed distribution before and after new speed cameras are installed on rural roads with a speed limit of 90 km/h (spot speed cameras at camera sites and between camera sites). Before the cameras were introduced (red line), about 60% of all cars complied with the speed limit at the camera sites and about 50% between camera sites. After the cameras were introduced, 90% of the cars complied with the speed limit at camera sites and 60% between sites. Comparing the change in the speed distributions, this was more pronounced at camera sites (Fig. 9). For high speeds, there was a larger displacement to the left after the cameras were introduced.

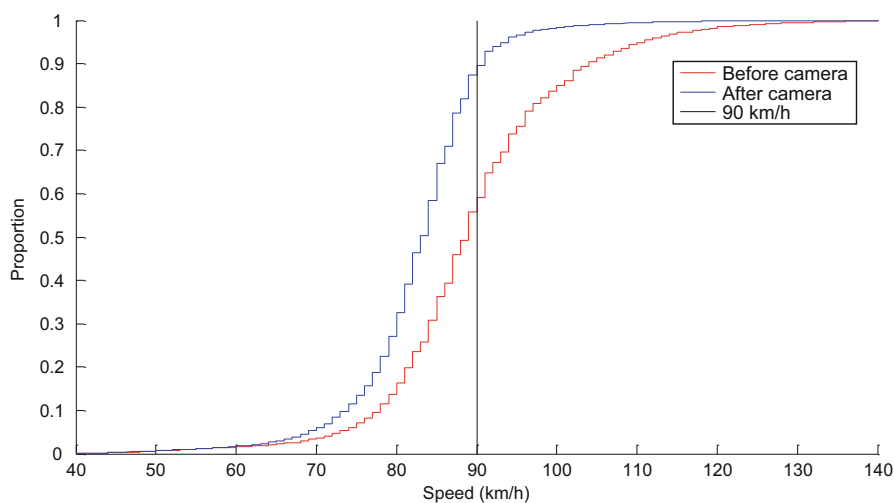


Fig. 9 Effect on driving speed at camera sites of new speed cameras on roads with a speed limit of 90 km/h. Speed distribution for all cars before and after new cameras

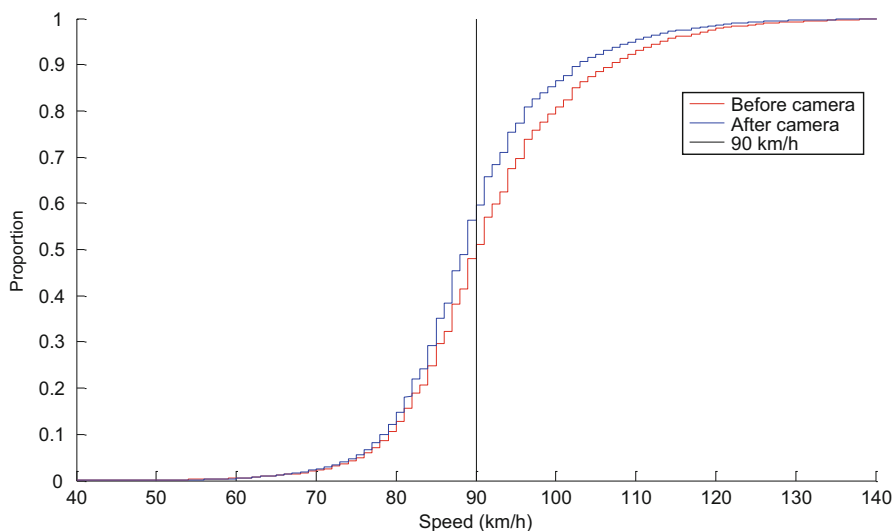


Fig. 10 Effect on driving speed between camera sites of new speed cameras on roads with a speed limit of 90 km/h. Speed distribution for all cars before and after new cameras

Experience from the Netherlands, Sweden, Norway, and France

Sweden

In Sweden, spot speed cameras are used, but the cameras are located along road sections and placed in succession with the aim to lower the speed along the entire road section.

Evaluations of the Swedish speed cameras (STA 2009; Larsson and Brüde 2010) have shown that they decrease mean speed by 4.3% (−3.6 km/h) taken over all camera road sections and speed limits. The reduction at camera sites varies between 7% and 12% depending on speed limit. Between cameras, the reduction was smaller, maximum 5%. It was also shown that the speed cameras reduced the 85th percentile (P85) more than the mean speed, by 5.9% (−5.5 km/h). Similar patterns, with larger decreases for higher speeds, have been found in terms of speed compliance, meaning that those who drive the fastest are most influenced by speed cameras. The proportion of drivers who exceed the speed limit decreased by approximately 34%. As regards traffic safety, Larsson and Brüde (2010) showed that the number of fatalities was reduced by 30% and the number of people killed or seriously injured (KSI) by 25%.

Norway

In Norway, both section control and spot speed cameras are used. Cameras are located on roads with a high injury crash record, and since 2009 there is a criterion

on speed (mean speed above the speed limit) and for crash costs (at least 30% above average crash costs on similar roads in Norway). It is possible to install speed cameras at sites that meet one of the criteria.

In Høy (2014b, 2015), the safety effects of spot speed cameras were investigated for speed cameras installed between the years 2000 and 2010. The study showed that on road sections between 100 m upstream and 1,000 m downstream of the cameras, the number of injury crashes decreased by 22%. For longer road sections (3.1 km), the effects were smaller. Ragnøy (2002) evaluated the effects on speeds and concluded that depending on the speed limit and mean speed in the before situation, as well as the distance to the camera, the effect of speed cameras on mean speed varies from -1.4 km/h to -7.1 km/h.

For section control (14 road sections of whom 8 were in tunnels), Høy (2014a) showed that the number of injury crashes decreased between 12% and 22%. An earlier evaluation of Ragnøy (2011) showed that mean speed decreased by 11% at the enforced road section, similar effects as at the near vicinity of the spot speed cameras.

The Netherlands

In the Netherlands, speed cameras are used to register speeding offenses, and the vehicle owners are identified based on vehicle registration number. There are mostly spot speed cameras, both fixed and mobile; however at some motorways, section control has been introduced. The guidelines for where the cameras should be placed states that they should be located at roads with a relatively high number of crashes, where there is a plausible connection between crashes and speed and where there is a relatively high percentage of speeders.

The effects of mobile speed cameras were studied by Goldenbeld and Van Schagen (2005). Their study showed that mean speed decreased with 4 km/h from 82.6 to 78.6 km/h and the percentage of speed offenders decreased from 27.4% to 15.6% on the roads with mobile speed enforcement. The number of personal injury crashes involving motorized traffic decreased by 21%. Effects of regression to the mean were not considered in the analysis, and it is therefore likely that the real effect is somewhat smaller.

France

Automated speed cameras were introduced in France in 2003, following a decision by President Chirac in 2002 to make road safety one of the three major national priorities during his mandate. Fixed and mobile speed cameras were implemented progressively, and between 2003 and 2009, about 1,700 fixed speed cameras were implemented, supplemented by more than 900 mobile cameras. All fixed cameras had a sign identifying its presence approx. 1 km ahead of the camera. In the beginning, it was a central decision to decide exactly where the cameras were to

be placed, and they were installed at points in the network with the most traffic. Later on the locations were decided upon at the local level taking the characteristics of the infrastructure and levels of crash risk into account. Between 2002 and 2005, the mean speeds fell by 8.9 km/h on secondary roads and by 7.7 km/h on two- or three-lane highways (two-way roads). Fatalities decreased by 25–35% in rural areas, 38% on urban motorways, and 14% on urban roads (ITF 2018). Viallon and Lamon (2013) showed that the French speed camera program reduced the proportion of fatal crashes attributable to high-level speeding (>20 km/h over the limit) from 25% to 6% over the period 2001–2010 and increased the proportion attributable to low-level speeding from 7% to 13%.

Discussion

In this chapter, speed limits, speed management, and different methods to influence speed behavior has been analyzed and explored. Vision Zero as a policy framework has guided this analysis. The second part of the chapter covers an analysis of Sweden, Norway, the Netherlands, and France speed camera program, or safety camera system which at least Sweden prefer to name it. This analysis also includes a discussion around related traffic safety effects, self-reported behavior, and attitudes.

First, to analyze speed compliance, the speed limits and what criteria that underpins the choice of specific speed limits need to be discussed. In a Swedish historical context, it is obvious that the speed setting rationale has evolved over the years. In practice therefore, there is a mix of speed limits based on different criteria and speed setting regime. It is also obvious that, over the years, every regime drives down the speed limits. The 85-percentile regime implemented in the 1960s has higher speed claims than speed limits set according to Vision Zero. From a safety point of view, this could see as a paradox because at the same time both the infrastructure and the cars have become safer. One explanation could be that safety as a value, within a transport policy framework, has been strengthened over the years and that speed limits are seen as an integrated part of the road transport system rather than only an instrument to limit some road user choice to drive at very high speeds. However from a strict compliance perspective, lower speed limits might increase the proportion of drivers who violate the speed limit (Vadeby and Forsman 2014). Although it is difficult to draw any firm conclusions, it seems that the speed limit sign itself is the most important factor influencing the drivers' choice of speed regardless of the design of the environment and the vehicle. Even if one is on a motorway in a car that can do more than 200 km/h and the speed sign shows 80 km/h, many drivers will comply with the speed sign to a large extent. Without the speed sign, one could expect rather higher speed. Setting the speed limits according to people's actual behavior in order to increase compliance seems therefore rather awkward. Vision Zero is a policy innovation which differs from a traditional approach to road safety in several respects. These differences are also evident when it comes to setting the speed. Traditionally, the speed limit system is seen as an instrument to lower the risk and make the road transport system safer. Based on a

Vision Zero approach, the speed limit system and its different speed limits are seen as a labeling of the safety thresholds. If you as a driver keep within the speed limits, as it is posted and below, then you can expect, if an accident occurs, that you will survive and without any serious injuries. This is radical change in the mind-set when it comes to speed and speed limits, and these ideas are more in line with the society dealing with toxicological substance, for example. These substances are accepted if they are kept below the threshold for serious impact on humans. Although a system like this is complicated and there are lots of trade-offs when it comes to details, this type of system could be easier to communicate to the public. In this context, speed and speed limits are a safety regulation factor. Safe (and environmentally friendly) roads and vehicles enable to facilitate higher speeds regardless of the driver's behavior.

Second, irrespective of what criteria that underpins speed limits, the drivers' speed compliance is an important issue including drivers speed choice and motives. One important dimension is the target group for different interventions, namely, risk groups or population-based strategies. Most countries are most likely carrying out both these strategies; however historically, especially in the more advanced countries, it seems that strategies aiming to increase compliance with speed limits are being advanced with a more population-based strategy. Another important dimension is if drivers' choice of speed is a result of a deliberate calculation of the cost and benefits (the "economic man," an idealized person who acts rationally, with perfect knowledge and who seeks to maximize personal utility) of speeding, or if the choice is more a result of unconscious habits and social norms. In public policy in general and in road safety in particular, the theory about the economic man does have a dominant position. However, due to new research, especially relating to nudging, new perspective has emerged, and the Swedish safety camera system is probably a good example of nudging in practice.

Third, there is a strong ongoing discussion about digitalization automation and new technology in our society. Although these trends could result in completely new products and service, many times it is most cases rather replacements of existing products and services. Speed enforcement is such public service that has gone through a large change from manual enforcement to camera surveillance. Productivity and efficiency are important drivers for this to happen. Finally, speed limit system, speed management, theory about human behavior, use of new technology, and public policies such as Vision Zero are all factors that influence how different jurisdictions manage their speed camera program and its characteristics. In this chapter, we have shown that even though Sweden, Norway, the Netherlands, and France all are countries in Europe, the way that they operate their camera program has both similarities and differences. It seems that all these countries have invested primarily in fixed camera systems. However the systems scale and how they operate are different. It is difficult to evaluate and compare these systems from a safety point view, at least from a macro perspective.

A speed camera system has the possibility to affect the society and its road users both at a macro and at a micro perspective. In a micro perspective, it is primarily about how effective the cameras are locally at the enforced road sections, while at a

macro perspective it is more about how the camera enforcement system, possibly together with the overall enforcement strategy, affects attitudes and norms related to speeding. Experience worldwide has proven the effectiveness of automatic speed cameras in reducing speed and, in turn, crashes and injuries. In this chapter where Sweden, Norway, the Netherlands, and France are compared, it is shown that there are large discrepancies in the camera enforcement strategies of the four countries. Looking at the number of cameras, Sweden has 135 cameras per million inhabitants while the other three countries have between 40 and 60 cameras per million inhabitants. If instead the number of speeding tickets is compared, Sweden has only 8 tickets per 1,000 inhabitants, while Norway has 18, France 192, and the Netherlands 391. One interesting question is how these differences affect both the actual outcome of the system in terms of speeds, crashes, and injuries and, however, also the norms and attitudes in the society. In all four countries, evaluations of the camera system are performed; however the evaluation methods are different and the results therefore not exactly comparable. Looking at mean speed, in Sweden the mean speed decreased by about 4% looking at an entire enforced road section, however, with larger effects near the cameras. The Netherlands showed decreases of about 4 km/h as an effect of mobile speed cameras; however the evaluation does not clarify at what distances from the cameras. In France, a general mean speed decrease of about 8 km/h between 2002 and 2005 was seen, attributed primarily to the effects of speed cameras (ITF 2018). In Norway, it was shown that section control decreased average speeds by 11% over the entire enforced road section (Ragnøy 2011), similar effects as in the near vicinity of spot speed cameras. Looking at the reduction of injury crashes, Sweden shows a decrease of severe crashes by 25% and of fatalities by 30%, Norway and the Netherlands a reduction of all injury crashes by about 20%, and France reductions of fatalities by approximately 30% in rural areas. If the differences between injury level in the investigations are considered as estimated by the power model (Elvik 2013; Elvik et al. 2019), it is not possible to show any major differences between these four countries in a micro perspective.

The enforcement strategies and in particular the number of cameras and speeding tickets issued also affect the attitudes and norms of the road users. Results from ESRA show that when car drivers were asked to indicate their perceived likelihood of being checked by the police for speeding, car drivers in Sweden and Norway report much lower perceived risk than the Netherlands and France. In France, about 55% of the car drivers think it is a big chance of getting caught by the police and in the Netherlands about 35%, while in Sweden and Norway it is only about 20%. The pattern is very similar to the number of issued tickets per 1,000 inhabitants. When looking at how many times car drivers that report they have had to pay a fine for speeding during the last 12 months, it is a similar relationship where only 2% in Sweden report they have had to pay a fine at least one and in Norway 4%, while in France 11% and the Netherlands about 15%.

The ESRA survey also investigates self-reported behavior in relation to speeding. In all four countries, it is a similar pattern, where about 30% answering that they personally think it is acceptable to drive up to 10 km/h above the legal limit. The

Netherlands has slightly higher values than France, Sweden, and Norway. Looking at more severe speeding in different situations, it is shown that in general, it is more acceptable to exceed the speed limit by as much as 20 km/h on freeways and motorways and not acceptable in urban areas, school zones, and residential streets. This pattern is the same among the four countries, even though the reported level differs somewhat. On motorways/freeways, Sweden has the highest acceptability for high-level speeding, but on residential streets, France has the highest. In urban areas and school zones, none of the countries found it acceptable to exceed the speed limit by 20 km/h.

In conclusion, the different enforcement strategies regarding the number of cameras and speeding tickets issued has the possibility to affect the society and its road users both at a macro and micro level. Locally, in a micro perspective on the enforced roads, the effects of speed cameras are rather similar among countries, and differences can probably be explained by the type of camera (spot speed or section control), distances between cameras, and local conditions. In a macro perspective, the perceived risk and self-reported risk of getting caught in a speed check is correlated with the number of issued speeding tickets. Though the perceived likelihood of being checked by the police differs between the studied countries, self-reported speeding behavior is rather similar. Therefore, an important aspect that needs to be analyzed and discussed is how to optimize a speed camera system from a road safety point of view. There are two problems that might occur. First, even though a speed camera program delivers lower speed locally, a low amount of fines might hinder the possibility of also affecting a general speed compliance culture. Second, if the system issues many fines, after a while the drivers might regard these fines as simply an extra charge which they are forced to pay – but it will have little or no effect on their speed behavior. A speed cameras system could become primarily a revenue-raising system rather than a road safety instrument. A hypothesis could be that Sweden might not operate their system optimal from a safety point of view and need to increase the number of fines issued. On the other hand, it may be that from a safety point of view in the Netherlands, too many fines are issued. The public perception about raising revenue does matter, considering that it can hinder the implementation of statutes and programs, and it generally has an impact on people's general attitudes.

References

- 1953 Års Trafiksäkerhetsutredning. (1954). *Trafiksäkerhet I* (SOU 1954:38). Stockholm: Victor Pettersons bokindustri aktiebolag.
- Belin, M. A., Tillgren, P., Vedung, E., Cameron, M., & Tingvall, C. (2010). Speed cameras in Sweden and Victoria, Australia – A case study. *Accident Analysis and Prevention*, 42(6), 2165–2170. <https://doi.org/10.1016/j.aap.2010.07.010>.
- Belin, M.-Å., Tillgren, P., & Vedung, E. (2011). Vision zero – A road safety policy innovation. *International Journal of Injury Control and Safety Promotion*, 19, 1–9. <https://doi.org/10.1080/17457300.2011.635213>.

- Bjornskau, T., & Elvik, R. (1992). Can road traffic law enforcement permanently reduce the number of accidents? *Accident Analysis and Prevention*, 24(5), 507–520.
- Bourne, M. G., & Cooke, R. C. (1993). Victoria's speed camera program. *Crime Prevention Studies*, 1, pp. 177–192.
- Carlsson, G. (1976). *Är nuvarande hastighetsgränser optimala från trafikekonomisk synpunkt? – Ett diskussionsunderlag*. Rapport nr 23. Linköping: Statens väg- och trafikinstitut (VTI).
- Elvik, R. (2009). *The Power model of the relationship between speed and road safety*. Update and new analyses. Report 1034. Institute of Transport Economics, Oslo.
- Elvik, R. (2013). A re-parameterisation of the Power Model of the relationship between the speed of traffic and the number of accidents and accident victims. *Accident; Analysis and Prevention*, 50, 854–860.
- Elvik, R., Vadeby, A., Hels, T., & van Schagen, I. (2019). Updated estimates of the relationship between speed and road safety at the aggregate and individual levels. *Accident Analysis and Prevention*, 123, 114–122. <https://doi.org/10.1016/j.aap.2018.11.014>.
- ESRA. (2015, 2018). <http://www.esranet.eu>
- ETSC. (2016). How traffic law enforcement can contribute to safer roads. PIN-flash report 31. Brussels: European Transport Safety Council.
- ETSC. (2019). *Reducing speeding in Europe*. PIN-flash report 36. Brussels: European Transport Safety Council.
- Evans, L. (2004). *Traffic safety*. Bloomfield: Science Serving Society.
- Goldenbeld, C., & van Schagen, I. (2005). The effects of speed enforcement with mobile radar on speed and accidents. An evaluation study on rural roads in the Dutch province Friesland. *Accident Analysis and Prevention*, 37(6), 1135–1144.
- Haddon, W. (1968). Changing approach to epidemiology prevention and amelioration of trauma – Transition to approaches etiologically rather than descriptively based. *American Journal of Public Health and the Nations Health*, 58(8), 1431.
- Haddon, W., Jr. (1980). Advances in the epidemiology of injuries as a basis for public policy. *Public Health Reports*, 95(5), 411–421.
- Høy, A. (2014a). Evaluation of the crash effects of section control TØI Report 1339/2014. (In Norwegian, summary in English.)
- Høy, A. (2014b). Evaluation of the crash effects of speed cameras TØI Report 1384/2014. (In Norwegian, summary in English.)
- Høy, A. (2015). Safety effects of fixed speed cameras – An empirical Bayes evaluation. *Accident Analysis and Prevention*, 82, 263–269.
- Høy, A., et al. (2019). Trafikksikkerhetshåndboken/The handbook of road safety measures. (In Norwegian), online. <https://tsh.toi.no/>
- ITF. (2018). *Speed and crash risk*. ITF research report. Paris: International Transport Forum.
- Kahneman, D. (2011). *Thinking, fast and slow*. New York: Farrar, Straus and Giorux.
- Larsson, J., & Bråde, U. (2010). Road safety effect of speed cameras established in 2006 – Analysis of injuries in 2007–2008. (In Swedish, summary in English.) VTI Rapport 696. Linköping: VTI.
- Ragnøy, A. (2002). Automatic traffic control (ATK). Speed effects. TØI-report 573. (In Norwegian.)
- Ragnøy, A. (2011). Section control. VD Rapport no. 1. Statens vegvesen, Vegdirektoratet. (In Norwegian.)
- Rose, G. (1981). Strategy of prevention: Lessons from cardiovascular disease. *British Medical Journal*, 282, 1847–1851.
- Rose, G. (2001). Sick individuals and sick populations. *International Journal of Epidemiology*, 30(3), 427–432.
- Sagberg, F. (2000). Automatic enforcement technologies and systems – The “Escape” Project Contract N°: RO-98-RS.3047, working paper 7.
- Soole, D. W., Watson, B. C., & Fleiter, J. J. (2013). Effects of average speed enforcement on speed compliance and crashes: A review of the literature. *Accident Analysis and Prevention*, 54, 46–56.

- Swedish Government. (1955). Government Bill 1955:172 New Traffic Regulations Renewed Commitment to Vision.
- Swedish Government. (1978). Government Bill 1978/79:36 om allmän differentierad hastighetsbegränsning m.m.
- Swedish Parliament. (1906). Swedish Parliament Protocol 1906 ak, number 59. Decision on new legislation on road traffic.
- Swedish Parliament. (1936). Swedish Parliament Protocol 1936 Fk, number 46. Decision on new legislation on road traffic.
- Swedish Parliament. (1997). Swedish Parliament Protocol 1997/98:13. Decision on Vision Zero for road traffic safety.
- Swedish Road Administration (STA). (2009). *The effects of automated road safety cameras on speed and road safety* (Publication no. 2009:162). Borlänge: Swedish Road Administration.
- Trinca, G. W., Johnston, I. R., Campbell, B. J., Haight, F. A., Knight, P. R., Mackay, G. M., McLean, A. J., & Petrucelli, E. (1988). *Reducing traffic injury: a global challenge*. Melbourne: Royal Australasian College of Surgeons.
- Vadeby, A., & Forsman, Å. (2014). Evaluation of new speed limits in Sweden: A sample survey. *Traffic Injury Prevention*, 15(8), 778–785. <https://doi.org/10.1080/15389588.2014.885650>.
- Vadeby, A., & Forsman, Å. (2017). Changes in speed distribution: Applying aggregated safety effect models to individual vehicle speeds. *Accident Analysis and Prevention*, 103, 20–28. <https://doi.org/10.1016/j.aap.2017.03.012>.
- Viallon, V., & Laumon, B. (2013). Fractions of fatal crashes attributable to speeding: Evolution for the period 2001–2010 in France. *Accident Analysis and Prevention*, 52, 250–256. <https://doi.org/10.1016/j.aap.2012.12.024>.

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