World Health Organization

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GLOBAL ROAD SAFETY PARTNERSHIP

WORLD BANK GROUP

SPEED MANAGEMENT

A road safety manual for decision-makers and practitioners

Second edition

GOOD PRACTICE

SPEED MANAGEMENT

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Contents

Preface

Road traffic injuries are a major public health problem and a leading cause of death and injury around the world. Each year approximately 1.3 million people die and millions more are injured or disabled as a result of road crashes, mostly in low- and middle-income countries (LMICs). As well as creating enormous social costs for individuals, families and communities, road traffic injuries place a heavy burden on health services and economies. The cost to countries, many of which already struggle with economic development, may be as much as 5% of their gross national product. As motorization increases, preventing road traffic crashes and the injuries they inflict will become an increasing social and economic challenge, particularly in LMICs. If the present trend continues, road traffic injuries will increase dramatically in most parts of the world over the next two decades, with the greatest impact falling on the most vulnerable citizens.

Appropriate and targeted action is urgently needed. The *World report on road traffic injury prevention*, launched jointly in 2004 by the World Health Organization (WHO) and the World Bank, identified improvements in road safety management and specific actions that have led to dramatic decreases in road traffic deaths and injuries in industrialized countries active in road safety. The use of seat-belts, helmets and child restraints, the report showed, has saved thousands of lives. The introduction of speed limits, the creation of safer infrastructure, the enforcement of limits on blood alcohol concentration (BAC) while driving, and improvements in vehicle safety are all interventions that have been tested and repeatedly shown to be effective.

The international community must continue to take the lead to encourage good practice in road safety management and the implementation of the interventions identified above in other countries, in ways that are culturally appropriate. To speed up such efforts, the United Nations General Assembly has passed a number of resolutions urging that greater attention and resources be directed towards the global road safety crisis. These resolutions stress the importance of international collaboration in the field of road safety.

These resolutions also reaffirm the United Nations' commitment to this issue, encouraging Member States to implement the recommendations of the *World report on road traffic injury prevention* and commending the collaborative road safety initiatives taken to date. They encourage Member States to focus on addressing key risk factors and to establish lead agencies and coordination mechanisms for road safety. These were further encouraged through the Moscow Declaration (2009), Brasilia Declaration (2015) and the Stockholm Declaration (2020).

To contribute to the implementation of these resolutions, WHO, the Global Road Safety Partnership (GRSP), the FIA Foundation and the World Bank have collaborated to produce a series of manuals aimed at policy-makers and practitioners. This manual on speed management is one of them. Initially published in 2008, it has been updated to include new evidence and case studies. These manuals provide guidance to countries wishing to improve road safety organization and to implement the specific road safety interventions outlined in the *World report on road traffic injury prevention*.

The manuals present simple, cost-effective solutions that can save many lives and reduce the shocking burden of road traffic crashes around the world. We encourage all to use these manuals.

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Abbreviations

AEB	autonomous emergency braking
BAC	blood alcohol concentration
BIGRS	Bloomberg Philanthropies Initiative for Global Road Safety
BRT	bus rapid transit
ESRA	European Survey Research Association
GPS	global positioning satellite
GRSF	Global Road Safety Facility
GRSP	Global Road Safety Partnership
IFRC	International Federation of Red Cross and Red Crescent Societies
iRAP	International Road Assessment Programme
ISA	intelligent speed adaptation
LMICs	low- and middle-income countries
NGO	nongovernmental organization
OECD	Organisation for Economic Co-operation and Development
PTWs	powered two- and three-wheelers
RRW	random road watch
SDG	Sustainable Development Goal
SL	speed limiter
SR4S	Star Rating for Schools (iRAP) (app)
WHO	World Health Organization
WRI	World Resources Institute
WTW	Walk This Way (Viet Nam)

Executive summary

The management of speed remains one of the biggest challenges facing road safety practitioners around the world and calls for a concerted, long-term, multidisciplinary response. The speed at which a vehicle travels directly influences the risk of a crash as well as the severity of injuries sustained, and the likelihood of death resulting from that crash. This manual advocates for a strong and strategic approach to creating a Safe System, with speed management at its heart. Reducing motor vehicle speeds in areas where the road user mix includes a high volume of vulnerable road users, such as pedestrians and cyclists, and on non-divided rural roads, is especially important.

Speed management is essential to improving road safety. However, improving compliance with speed limits and reducing unsafe driving speeds are not easy tasks. Many drivers do not recognize the risks involved and often the perceived advantages of speeding outweigh the perceived problems that can result.

Easy, quick and relatively low-cost travel is important for people's work and personal lives as well as for economic development. Over the past few decades, industry has manufactured vehicles that can travel at increasingly higher speeds, while the construction of more extensive road networks and related services have also facilitated reduced road transport times. However, these increasing speeds have come at a cost, in terms of increased road traffic fatalities and injuries, congestion, noise and emission levels.

While much action is taking place at local level in some countries to find strategies to manage speed, more work needs to be done to convince policy-makers and the public of the risks posed by speeding, as well as the many significant benefits of speed management. Countries should develop a comprehensive and integrated policy package of speed management interventions based on a thorough assessment of their particular context. Such packages are likely to include setting credible speed limits that are consistent with Safe System principles; robust, sustained speed enforcement; engineering and road design interventions; new vehicle technologies to limit speed; and public education programmes that focus on at-risks groups, and which directly support enhanced speed enforcement programmes. This document outlines a number of evidence-based interventions shown to be effective at tackling speed and likely to form part of such a package. Different approaches and messages are likely to be required for different segments of the driving population in order to increase awareness about the risks of speeding and the benefits of appropriate speed management strategies.

Many LMICs have serious and, in some cases, worsening numbers of road fatalities and injuries. Several research projects have clearly identified inappropriate speed as being a particular problem. This manual provides advice and guidance for policy-makers and road safety practitioners in these countries and draws on the experience of a number of countries that have already initiated speed management strategies. Lessons from successful and unsuccessful projects are used to illustrate the advice provided.

Strategies that work in one country may not necessarily transfer effectively to another. The manual attempts to reflect a range of experiences from around the world but does not offer prescriptive solutions. Rather, it is hoped that the manual can act as a catalyst for local initiatives and actions to improve road safety. It provides a base of information which stakeholders can use to generate their own solutions and develop advocacy tools, legislation and enforcement programmes to manage speed that will work with the audiences they are trying to reach.

This manual provides evidence on why speed management is important and explains which interventions in managing speed are most effective. In this context it provides information on the following core interventions:

- establishing speed limits appropriate to all road users;
- building or modifying roads to include features that reduce speed;
- enforcing speed limits;
- using in-vehicle technologies;
- raising awareness about the dangers of speeding.

Finally, it guides the user on how to best implement, monitor and evaluate these interventions.

If every country in the world were to implement speed management as part of a broader set of road safety interventions, much progress towards global road safety goals could be made. The road safety benefits of lowered travel speeds include:

- greater time to recognize hazards;
- reduced distance travelled while reacting to hazards;
- reduced stopping distance of the vehicle after braking;
- increased ability of other road users to judge vehicle speed and time before a crash;
- greater opportunity for other road users to avoid a crash; and
- less likelihood that a driver will lose vehicle control.

In addition, speed management has many benefits in other areas of transport and environmental policy such as less air pollution, fuel consumption and noise pollution. Lower speeds improve the quality of the environment for walkers and cyclists, contributing to the creation of liveable communities and helping to reduce noncommunicable diseases as a result of increased exercise and reduction in pollution.

Overall, evidence-based speed management efforts are key tools for any road safety management framework using the Safe System approach and are also major elements to improve environmental and health outcomes and overall quality of life.


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Introduction

The WHO, World Bank, FIA Foundation and Global Road Safety Partnership (GRSP) produced a series of good practice manuals, following the publication of the *World report on road traffic injury prevention* in 2004, which provide guidance on implementation of interventions to address specific risk factors in road safety. The topics covered in the initial series of manuals were: helmets (2006), drinking and driving (2007), speed management (2008), seat-belts and child restraints (2009), data systems (2010), pedestrian safety (2013), road safety legislation (2013), powered two- and three-wheeler safety (2017) and cyclist safety (2020). In addition, WHO produced a road safety technical package, Save LIVES (2017), which presents results on 22 evidence-based interventions related to speed management, leadership, infrastructure, vehicles, enforcement and post-crash care.

Why are these manuals being revised?

Since the series of manuals was first published, the scientific evidence base relating to various risk factors and the effectiveness of interventions have continued expanding. Contemporary research has refined our knowledge about specific risk factors, such as distracted driving, and vehicle impact speed and risk of death for pedestrians. New issues and practices have arisen, such as a tropical helmet standard and an anti-braking control standard for motorcycles. New and existing interventions have been implemented and evaluated, with increasing application in LMICs. Research attention and policy response have also increasingly been applied to emerging road safety issues including e-bikes, drugs other than alcohol, fleet safety, urban mobility, micro mobility options, air and noise pollution, public transport and technological advances.

As a result of these developments, the good practice manuals required revision so that they can continue to be key references for road safety policy implementation and research. This is particularly important, given the emphasis placed on road safety within the framework of the 2030 Agenda for Sustainable Development and because of the global impetus to reduce road deaths and injuries, resulting from the declaration of the two United Nations' Decades of Action for Road Safety (2011–2020 and 2021–2030). The manuals have been revised to reflect these developments as they continue to be valuable resources providing evidence-based and cost-effective solutions to save lives and reduce injuries. An extensive literature review has informed the revision and updating of all the manuals, and additional information has been collated to allow more contemporary case studies to be showcased. In addition, the need to broaden the topics covered in the manuals to include aspects such as qualitative research methods and participatory approaches to designing and evaluating interventions was identified. An emphasis on shifting traditional thinking away from blaming road users towards more contemporary frameworks, such as the Safe System approach, is key in the revised manuals. An area requiring ongoing consideration is decolonizing knowledge and practice within the road safety field.

A review of the evidence on risk factors and interventions was conducted for revision of this manual. The review utilized text mining techniques to gather evidence on risk factors and outcomes of interventions. This technique creates computational algorithms for reading and extracting texts from a large volume of information in a short period of time. The review was limited to January 2008 to December 2019, with the understanding that the previous manual had drawn on the evidence that existed before January 2008. Only papers in English, French, Portuguese and Spanish were included in the literature review. Studies excluded were those presented in conference proceedings, editorials and draft papers. The full search generated 1390 abstracts relevant to speed management, which were screened to produce 42 full studies for critical review for this manual. Ultimately, 37 of these studies were considered. The two experts who conducted the literature review categorized the effectiveness of speed management interventions into the following groups – proven, promising, insufficient evidence, ineffective and potentially harmful – based on existing best practices in road safety. The Advisory Committee reviewed the categories and refined them based on the existing best practices in road safety policy and their expert knowledge.

This document is a companion manual of the *Guide for Safe Speeds* published in 2023 by the World Bank's GRSF and WRI, which presents a new approach for setting safe speed limits, the Roads-for-Life framework. This framework is specifically tailored to the typical types of roads present in LMICs but may also be successfully implemented in high-income countries. The *Guide for Safe Speeds* examines the risks in different road environments, i.e. (inner) cities, city outskirts, towns and villages, as well as in non-built-up areas and roadwork zones. It also offers a set of evidence-based solutions for managing speeds in the fields of road infrastructure, enforcement, education and communication, as well as vehicle technology, including general information on costs and the road environments where they can be used most effectively. Examples and approaches directly relevant to decision-makers and practitioners working in the fields of road safety, mobility, urban design, and organizations supporting speed management initiatives are provided. The *Guide for Safe Speeds* is available free of charge on the GRSF website (https://www.roadsafetyfacility.org/reports).

Safe System approach

In keeping with recommendations from the Stockholm Declaration *(1)*, which was the result of the Global Ministerial Conference on Road Safety held in 2020, and the Global Plan – Decade of Action for Road Safety 2021–2030 *(2),* the efforts to improve road safety should be based on the Safe System approach.

The Safe System approach (Fig. 1) recognizes that road transport is a complex system and places safety at its core *(2)*. This approach also recognizes that humans, vehicles and the road infrastructure must interact in ways that ensure a high level of safety *(3)* as it:

- anticipates and accommodates human errors;
- incorporates road and vehicle designs that limit crash forces to levels that are within human tolerance to prevent death or serious injury;
- motivates those who design and maintain the roads, manufacture vehicles and administer safety programmes to share responsibility for safety with road users, so that when a crash occurs, remedies are sought throughout the system, rather than solely blaming the driver or other road users;
- pursues a commitment to proactive and continuous improvement of roads and vehicles so that the entire system is made safe rather than just locations or situations where crashes last occurred; and
- adheres to the underlying premise that the transport system should produce zero deaths or serious injuries and that safety should not be compromised for the sake of other factors such as cost or the desire for faster transport times.

Fig. 1 Safe System approach

Source: Based on *(3).*

The role of speed management in the Safe System approach

Speed management is a central part of a safe road system as there is a clear relationship between impact speed and fatality probability. The risk of a fatal outcome varies dramatically for different crash types. Most vulnerable road users such as pedestrians or cyclists can typically survive impact speeds up to only 30 km/h, above which the chance of survival decreases dramatically. A similar impact speed applies to other unprotected road users such as those using powered two- and three-wheelers (PTWs). At intersections, side impacts at or below 50 km/h are survivable for vehicle occupants, but the chance of death increases significantly above this speed. For head-on crashes, road users in modern vehicles with good quality safety features can generally survive an impact at 70 km/h with another vehicle of equal mass (Table 1).

Table 1 Survivable impact speeds for different crash scenarios

Type of road/road section	Safe System speed
Roads/road sections with possible crashes between cars and vulnerable road users	Max. 30 km/h
Roads/road sections with intersections with possible side-on crashes between cars	Max. 50 km/h
Roads/road sections with possible frontal (head-on) crashes between cars	Max. 70 km/h
Roads/road sections with no likelihood of side-on or frontal crashes between cars	Max. 100 km/h

Sources: (4, 5).

In a Safe System, speeds need to be at or below the above critical threshold levels to reduce the risk of death or serious injury. If higher speeds are required, then better quality infrastructure (including, for example, separation or barrier protection systems to prevent head-on crashes) is necessary to support the increase in operating speed and protect all road users. Reaching these safe speeds through safe design and enforcement to increase compliance by road users and eliminate death and serious injuries are the ultimate objectives of a Safe System.

Promoting a successful speed management strategy following the Safe System approach clearly has many benefits. The most obvious one is the reduction in the number of deaths and injuries resulting from crashes. But speed not only affects road safety; it also has a huge influence on many other indicators for societal well-being – environment, health, equality, accessibility and economy.

The following can be achieved through effective speed management:

- reduction in road traffic fatalities, injuries and related socioeconomic costs;
- improvement in other areas of transport and environmental policy such as air pollution, fuel consumption and noise pollution;
- improvement in the quality of the environment for walking and cycling, contributing to the creation of livable communities; and
- reduction in occurrence of noncommunicable diseases as a result of increased exercise and reduction in pollution.

This is also reflected in the United Nation's 2030 Agenda for Sustainable Development *(6)* which was adopted in September 2015 and contains 17 Sustainable Development Goals (SDGs). These SDGs, with their 169 targets, should balance social, economic and environmental factors of sustainable development and include two targets related to road safety, one in Goal 3 and one in Goal 11 (Fig. 2). These targets underline the importance of road safety policy to global health and development, and the need for all countries to prioritize action towards achieving results.

Fig. 2 Road safety-related SDGs and targets

SDG 3: Ensure healthy lives and promote well-being for all at all ages

Target 3.6: By 2020, halve the number of global deaths and injuries from road traffic accidents

SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable

Target 11.2: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons

Source: (6).

In this context, the Save LIVES technical package was developed for road safety practitioners and decision-makers to decrease the number of road traffic deaths and serious injuries in their countries *(7).* It is an evidence-based inventory of priority interventions with a focus on **S**peed management, **L**eadership, **I**nfrastructure design and improvement, **V**ehicle safety standards, **E**nforcement of traffic laws and post-crash **S**urvival.

Implementing a national speed management strategy should be high on the agenda in any country. A speed management strategy describes a long-term (e.g. 10-year duration) effective framework for implementing safe speeds for the whole road network in a country. It should be based on the Safe System approach and cover the main focus areas as well as goals and objectives of speed management. A speed management strategy is usually set at a national level in line with the national road safety programme and any other high-level agendas that cover road safety issues, such as the national transport strategy.

The checklist in Box 1 summarizes the steps needed to implement a speed management strategy.

Box 1 Key steps in setting up a speed management strategy

1. Assess the existing speed management status and identify speed-related problems

- evaluate casualty data and impact of speed on these data, taking into account underreporting and data reliability;
- study the current legal and organizational framework;
- assess existing road design and engineering, enforcement, vehicle technology as well as education and communication practices;
- determine myths and falsehoods about speed in the general public as well as at the stakeholder level.

2. Select safe speed limits for different types of roads considering Safe System survivable speeds (see Table 1)

3. Engage high-level key stakeholders and gain political support

- establish a working group that includes key ministries, agencies and organizations to achieve a smooth and successful process when developing, implementing and promoting the speed management strategy;
- foster coalition building across these many different stakeholders;
- brief politicians in key ministries and their direct staff regularly on the benefits and successes of speed management for safety and other important outcomes.

4. Develop, implement and promote the speed management strategy

- use an evidence based and data led approach;
- include a powerful vision for the stakeholders to understand the meaning and purpose of the strategy;
- provide an overview of the focus areas of the strategy (e.g. legal and organizational/administrative framework; speed data collection and evaluation; research needs, road engineering; vehicle technology; enforcement; education and communications) and the main challenges in these areas;
- be results focused, with concrete goals and objectives in the different focus areas;
- assign concrete responsibilities and resource estimates to each objective;
- include monitoring and evaluation for sustained improvement.

5. Monitor and evaluate the speed management strategy

- begin the process at the start and define what data need to be collected when developing the strategy;
- collect “before” data (before the implementation of the strategy is started);
- collect the necessary data throughout the running time of the strategy;
- improve/adapt the strategy based on monitoring and evaluation results.

In the absence of a national speed management strategy, regions or cities should not wait, but should develop their own strategies based on the steps outlined in Box 1. However, the ultimate objective should be for national uniformity that follows the good practice approaches to managing speeds outlined in the following modules.


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Module 1
Why is addressing speed management necessary?

1.1 Context and magnitude of the problem related to speed

According to the WHO Global Health Estimates 2019 *(8)*, approximately 1.3 million people died in 2019[1] as a result of road traffic crashes, with 92% of road traffic deaths occurring in LMICs, and road traffic injury death rates being highest in the African Region. WHO Global Health Estimates rank deaths due to road traffic injuries as the 12th leading cause of death, accounting for 2.3% of total deaths in 2019 *(8).* Even within high-income countries people from lower socioeconomic backgrounds are more likely to be affected by road traffic crashes *(9).* Therefore, road safety is recognized in two SDGs, which were adopted in 2015: SDG 3: Good Health and Well-being; and SDG 11: Sustainable Cities and Communities *(6).*

Speed-related road traffic deaths form a significant proportion in HICs as well as in LMICs. For example, in New Zealand speeding is involved in around 60% of fatal crashes *(10),* and in India, almost 70% of road traffic deaths were caused by speeding *(11).* Thus, speed is at the core of the road crash injury problem worldwide and a top contributing factor in fatalities and serious injuries. There is no other behavioural risk factor that has such an impact on road safety as speed, because it influences the likelihood of a crash occurring, and the severity of the crash outcome as well as crash exposure *(12–15).* To appropriately address the speed problem, the United Nations Global Road Safety Performance Targets include, in Target 6, to: "by 2030, halve the proportion of vehicles travelling over the posted speed limit and achieve a reduction in speed related injuries and fatalities."

Poor speed selection, commonly interpreted as "speeding", is thus the single most important contributor to road fatalities around the world *(16).* Speeding can be due to excessive speed (i.e. driving above the speed limit) or inappropriate speed (i.e. driving too fast and in an unsafe manner for the road conditions or road environment, although within speed limits).

Extensive research has been conducted on the outcomes of excessive speed, as this is a problem common to all countries. A study among Organisation for Economic Co-operation and Development (OECD) countries showed that, typically, 40% to 50% of drivers were driving above the posted speed limits *(17).* A study that focused on the credibility of an 80 km/h speed limit for different rural roads and assessed the effects of characteristics of the road and its environment as well as the effects of person and personality characteristics showed that on average, drivers wanted to drive 10% faster than the limit in force *(18).*

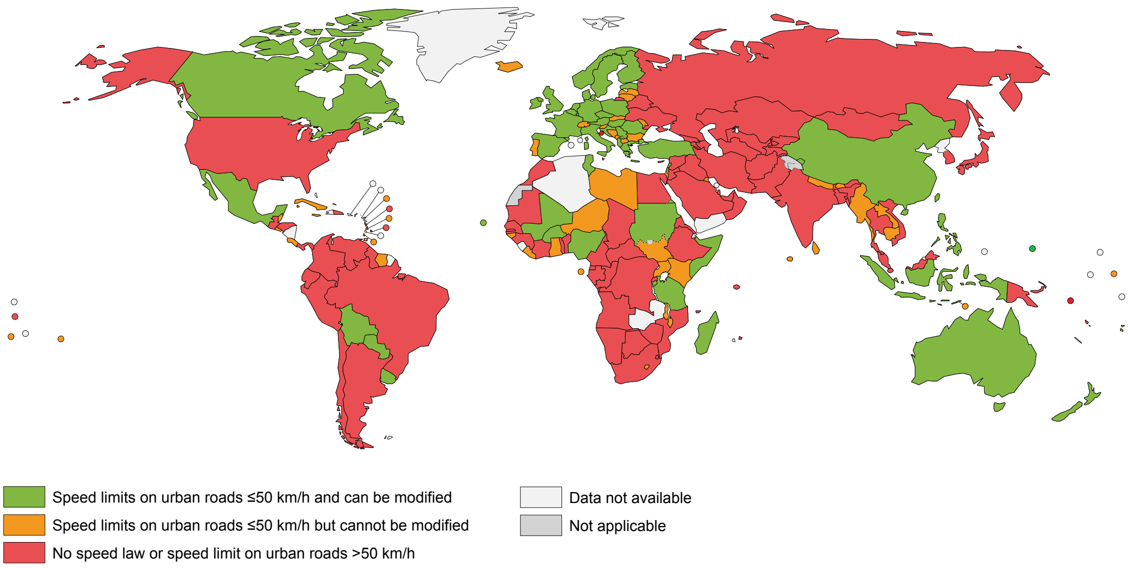
[1] WHO Global Health Estimates is being updated with expected release later this year (2023), and the estimated road traffic deaths might change.

The legal setting and enforcement of speed limits is a key component of comprehensive speed management. Therefore, WHO, in its *Global status report on road safety 2018 (12),* performed a worldwide assessment of legislation on speed laws based on the following three best practice criteria:

- presence of a national speed law;
- urban speed limits not exceeding 50 km/h (based on research, lower limits are recommended for urban areas, and 30 km/h for residential areas and areas with high pedestrian activity); and
- local authorities having the power to modify speed limits (to adapt to different contexts).

The results demonstrate that 169 countries (representing 97% of the world's population) have set national speed limit laws; however, only 46 of these countries (representing 3 billion people) have laws that meet all three best practice criteria (Fig. 1.1). Fig. 1.1 shows that the presence of best practice laws is more common in high-income countries (50%) than middle- or low-income countries (37% and 13%, respectively).

Fig. 1.1 Countries with speed laws meeting best practice, 2017



Source: (12).

Enforcement plays an important role in ensuring compliance with speed limits, as discussed in Module 2. Combinations of both manual and automated enforcement methods, such as fixed camera and mobile in-vehicle fitted devices, can increase the probability of detecting violations and reducing speeding. In this context the *Guide for determining readiness for speed cameras and other automated enforcement (19)* assists jurisdictions to check whether they are prepared to move to such automated methods. The WHO *Global status report on road safety 2018* showed that a total of 157 countries conduct speed enforcement activities *(12).* Of these, only 90 countries indicated use of some automated methods. However, for the majority of countries, manual speed enforcement remains the dominant method of enforcement. As such, only 30 countries rated their enforcement of speed laws as "good".

1.2 Speed as a key risk factor in road traffic injuries

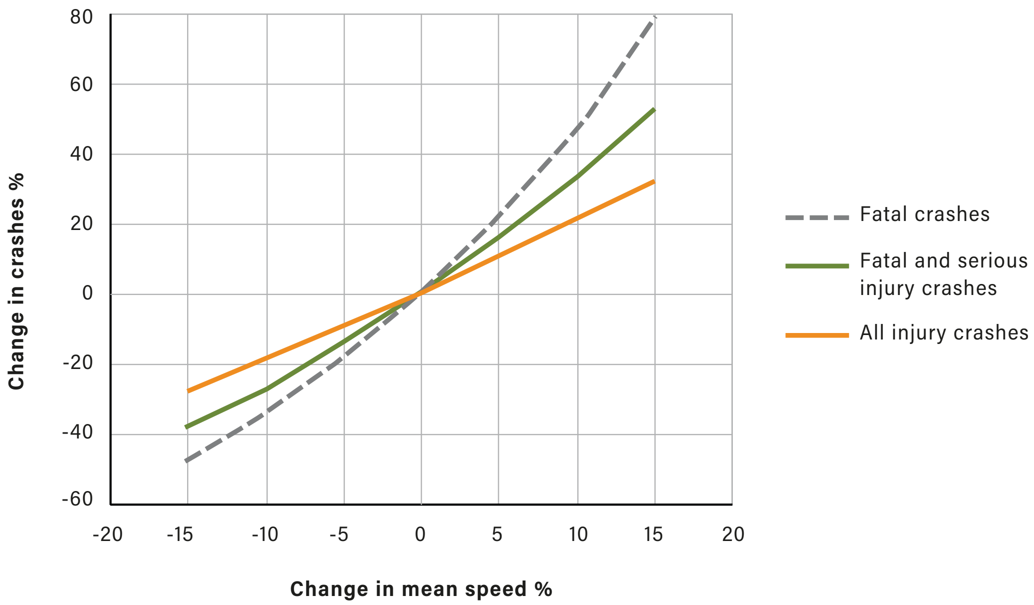
1.2.1 Speed and crash outcome

Speed has been identified as a key risk factor in road traffic injuries, influencing both the risk of road traffic crashes and the severity of the injuries that result from them. Higher speeds lead to a greater risk of a crash and a greater probability of serious injury if one occurs *(20).*

The speed at which a vehicle travels directly influences the risk of a crash as well as the severity of injuries sustained, and the likelihood of death resulting from that crash. Even small reductions in speed affect the risk of fatal and serious crashes. An accepted principle (the so-called "power law") is that every 1% increase in mean speed produces a 4% increase in the fatal crash risk and a 3% increase in the serious crash risk *(13)*. A 5% reduction in average speed can reduce the number of fatalities by 20% (Fig. 1.2) *(13).*

More recent research suggests that the relation between crash risk and speed is exponential, and not a power law *(14, 15, 21, 22).* This means that a change in speed has an even greater impact on higher severity crash outcomes, especially in high-speed environments. Additionally, a very small change in speed has a dramatic impact on fatal crash outcomes. It is often underestimated how severely serious crashes are influenced by speed. Higher speeds increase crash probability by reducing a driver's capacity to stop in time: by reducing manoeuvrability of the vehicle; by making it impossible to drive through curves or around corners if the speed is too high for the friction available; by reducing the driver's field of vision; and by causing others to misjudge gaps in traffic. For example, a vehicle travelling above the speed limit gives pedestrians who wish to cross the road a smaller gap than they expect based on the distance between the pedestrian and the vehicle *(23).*

Fig. 1.2 Relationship between percentage change in mean speed and the percentage change in crashes



Sources: (13, 17).

This relationship results both from the laws of physics and the cognitive abilities of the driver to deal with unexpected (but often predictable) circumstances. With higher travel speeds, the impact speed in a crash increases, as do the forces that the vehicle and occupants must absorb. Higher speeds also mean that road users have a lesser opportunity to take preventive actions.

The evidence also indicates that "moderate speeding" makes a large contribution to serious road crashes – comparable to the contribution of more extreme speeds – because it is so common *(24).*

There is much research from around the world (but mainly conducted in higher income countries) that clearly demonstrates the relationship between speed and risk. Greater speed increases crash, injury and fatality rates, and decreasing speed reduces these rates.

1.2.2 Speed, energy transfer and injury

Harmful injury is the result of "energy interchange". During a crash, injury results from the transfer of energy to the human body in amounts and at rates that damage cellular structure, tissues, blood vessels and other bodily structures. This includes kinetic energy, for example when a motor vehicle user's head strikes the windshield during a crash. The higher the speed the greater the amount of kinetic energy that must be absorbed by the impact, Hence, there is more likelihood of serious injury or death. Regardless of whether the kinetic energy is generated by a motor vehicle crash, a gunshot or a fall, the force to which human tissue is subjected on impact is the product of the mass and velocity involved. The kinetic energy to be absorbed equals one half of mass multiplied by the square of velocity – illustrating that the effect of velocity is greatly enhanced as velocity increases. The level of damage to the body will depend on the shape and rigidity of the colliding surface or object, but velocity usually plays the most critical role *(20).*

Vulnerable road users, such as pedestrians, cyclists, as well as two- and three-wheelers, have a high risk of severe or fatal injury when motor vehicles collide with them. This is because they are often completely unprotected or, in the case of a motorcyclist, have very limited protection. The probability that a pedestrian will be killed if hit by a motor vehicle increases dramatically with impact speed *(25–29).* Research shows that adult pedestrians have a 90% chance of surviving crashes at speeds of 30 km/h or lower *(30)* – with some studies showing as much as a 99% chance of survival *(28).* That probability is reduced to 50–80% when the impact speed is 50 km/h. Generally, the risk of pedestrian death increases more rapidly for any small increase in the impact speed between 30 and 70 km/h. A meta-analysis of 20 studies assessing the risk of fatality for pedestrians reported that for every 1 km/h above 30 km/h that speed increases, the chance of pedestrian death increases by 11% *(26).* It is within this context that a speed of 30 km/h is recommended in areas with high pedestrian traffic.

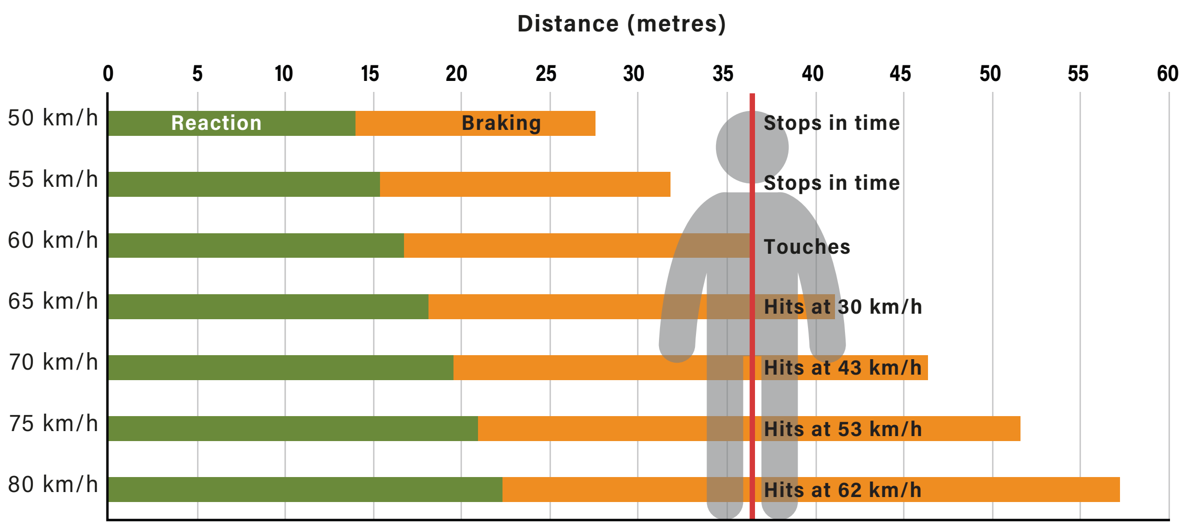
The unpredictable nature of human behaviour in a complex traffic environment means it is unrealistic to expect that all crashes can be prevented. But if greater attention was given to the tolerance of the human body to injury when designing the transport system, there could be substantial benefits when crashes do occur, meaning they might not lead to serious injury or death. Most traffic systems, however, are not designed on the basis of human tolerance. Separating cars and pedestrians by providing footpaths is very often not done. Speed limits of maximum 30 km/h in shared-space residential areas are often not implemented. Historically, car and bus fronts have not been designed to provide protection for pedestrians against injury at collision speeds of 30 km/h or more.

Higher speeds could be possible if the interface between the road infrastructure and vehicle was well designed and crash protective – for example, by the provision of adequate protection on the sharp ends of roadside barriers (crash cushions) or adequate pedestrian protection (e.g. pavements and safe crossing options). However, most road systems allow for much higher speeds without protective barriers between vehicles and roadside objects.

1.2.3 Speed and stopping distance

The higher the speed of a vehicle the greater the stopping distance required, and hence the increased risk of a road traffic crash. For instance, when travelling at 80 km/h on a dry road, it takes around 22 m to react to an event (the distance travelled during a reaction time of approximately 1 second) and a total of 57 m to come to a standstill (Fig. 1.3). If a child runs onto the road 36 m ahead of the car, the driver would most likely kill the child if driving at 70 km/h or more, hurt the child if driving at 60 km/h and avoid hitting the child if driving at 50 km/h. However, if the child runs out on to the road 15 m ahead of the driver, the probability is that the child would be fatally injured at 50 km/h and all higher speeds *(17)*. In this context it must be noted that the reaction time varies from one person to another. 1 second is the minimum reaction time. In other studies, the reaction time is estimated to be around 1.5 seconds, which obviously leads to longer reaction and thus stopping distances.

Fig. 1.3 Stopping distance driving an average family car on a dry asphalt road (reaction time for this figure: 1 second)



Source: (17).

Higher speeds not only increase the stopping distance but also reduce a driver's visual field and peripheral vision *(31, 32)*. This is because there is a greater perceptual and cognitive demand on road users at higher speed (given a faster flow of information), as well as a need to concentrate on a point further along the road at higher speeds. As shown in Fig. 1.4, the visual field of the driver is reduced when the speed increases. At 50 km/h, the driver has a field of vision covering less than half of that at 30 km/h. As a result, a driver's capability to detect a potential danger on the road or at the roadsides reduces dramatically with increased speed.

Fig. 1.4 Peripheral vision at 30 km/h (left) and at 50 km/h

Source: Toronto Police Traffic Services.

1.2.4 Differences in speed

The relationship between differences in speed (i.e. the different speeds which road users such as cars and trucks or cars and bicycles travel at on the same road section) and crash risk is rather complex. Both the average speed on a road, and differences in speed influence road safety. Roads with a large speed variance (i.e. large differences between the speeds of different road users such as cars and trucks, cars and scooters, or bicycles and pedestrians) are generally less safe than roads with a small speed variance in terms of injuries sustained *(33).* The higher the speed differential, the greater the injury. The same is true of crashes between vehicles of similar mass at specific points on the road (e.g. car versus car at an intersection), where the evidence is clear that the probability of a serious injury – along with impact angle – depends on the speed differential, or the change in velocity during a crash. Similarly, there is evidence that there is increased crash risk as congestion levels start to increase (e.g. on a freeway at the start of a peak period), where fast-moving traffic may impact with slow traffic with high speed differentials resulting in high energy. Thirdly, there is good evidence for an increase in risk from speed differential when manoeuvring vehicles are considered as part of the differential speed. The first studies in this field were conducted in the 1950s and 1960s and found that the slower *or* faster a car drives compared with the other vehicles on the road, the higher the crash risk *(34)*. Newer research shows that vehicles driving faster than average have a higher crash rate while vehicles driving slower were found not to have an increased risk *(35, 36).*

However, the impact of other forms of speed variation (including different speeds for various vehicle classes, such as trucks and cars) is far less clear *(37).* Still, the assumed increase in risk from speed differences at route level is often used to justify the 85th percentile speed approach to speed limit setting. In Module 2 it is clearly shown why this is not good practice and why the 85th percentile should not be used in the process of setting safe speed limits.

1.3 The wider benefits of lowering speed limits

As discussed, the benefits of lowering speed limits to appropriate levels go well beyond reducing crashes, saving lives and preventing serious injuries for all types of road users. The resultant improvements in both real and perceived safety and comfort for people using roads have positive impacts across all indicators for societal well-being – environment, health, equality, accessibility and economy – all based on good evidence. In addition, all of these benefits have direct or indirect economic benefits that can often be measured.

Therefore, the Stockholm Declaration on road safety in February 2020 *(1)* recognizes and highlights the link between road safety and wider societal benefits and connects it to the SDGs *(6)* already presented in the introductory chapter of this manual. For example, one of the clauses states the following:

> *"... Acknowledge that the overwhelming majority of road traffic deaths and injuries are preventable and that they remain a major development and public health problem that has broad social and economic consequences which, if unaddressed, will affect progress towards the achievement of the SDGs ..."*

1.3.1 Environmental benefits of lowering speed limits

Lower speeds can have immense positive impact on the environment through lowering emissions directly and indirectly. The United States Department of Energy specifies 50 mph (80 km/h) as the optimal fuel economy speed for most vehicles, whereas fuel usage increases rapidly above this speed. It is not only the speed of the vehicle that causes higher emissions, but also intense acceleration and deceleration. Higher speed limits in urban areas are associated with rapid and aggressive acceleration and deceleration *(38).* Slower and calmer driving reduces carbon monoxide emission rates by up to 17%, volatile organic compounds emission rates by up to 22%, and oxides of nitrogen emission rates by up to 48%, depending on the gear engaged and the driver's aggressiveness *(39).* Vehicle speed was found to be a strong contributing factor to the degree of heavy metal contamination, such as cadmium, lead, zinc and nickel, in road dust *(40).*

1.3.2 Health and liveability benefits of lowering speed limits

Lowering speed limits can also result in broader health impacts, in addition to reducing deaths and serious injuries. These include benefits relating to reduced noise pollution and increases in active travel (and links to reduced obesity and other benefits). Using active transport modes also improves mental health *(41)* and reduces the risk of more than 25 chronic diseases thus increasing longevity *(42).* The largest source of noise in urban areas is traffic-induced noise, which accounts for 80% of all communal noise sources. In urban areas with speeds between 30 and 60 km/h, reducing speeds by 10 km/h would cut noise levels by up to 40%. Reducing 113 km/h (70 mph) and 97 km/h (60 mph) speeds to 64 km/h (40 mph) on urban freeways would cut noise by up to 50% *(43).* A comparative risk assessment in Lausanne, Switzerland, estimated that 4700 years of life lost were attributable to road traffic noise in 2010 *(44). T*he study compared the current situation in the city, which includes 30 km/h speed limits in certain areas, with a reference scenario (without any 30 km/h speed limits). The study shows that the lower speed limit scenario is estimated to prevent one cardiovascular death, 72 hospital admissions from cardiovascular disease as well as 17 diabetes cases annually *(45).*

Over the last decades, road designs catered largely to motorized traffic and did not protect all road users or consider the function of streets as public spaces. Practitioners are now moving beyond the idea that there is always a trade-off between safety *or* speed. Within a "movement and place" framework *(46)* both mobility and safety issues can be solved together, rather than placing them in conflict. Setting speed limits that are appropriate for the needs of a road as a "place" as well as the "movement" creates much more liveable and thriving locations *(47).*

Safe speeds can improve accessibility and reduce the disconnection caused by roads that become urban barriers. High levels of motorized traffic and high traffic speeds not only discourage walking but limit social contacts between residents on opposite sides of the road. In both urban and rural areas, such severance can prevent children from safely crossing from their homes to get to school or prevent safe travel by workers between homes and nearby workplaces.

1.3.3 Travel benefits of lowering speed limits

In many cases, lowering speed limits has been prevented because of fears that this measure will increase overall travel times and congestion. Generally, research shows that any increases in travel times and congestion are negligible, and in some cases, they can even be improved through reduced speed limits *(48).*

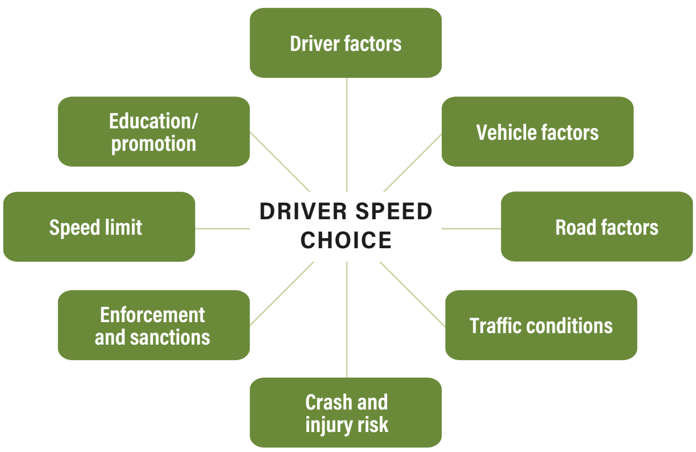
It is often not understood that in many urban areas, average speeds are already significantly lower than the speed limit due to congestion. The actual speeds in the top 25 most congested cities in the world are well below 30 km/h *(49)*. Vehicle speeds are also constrained by intersections, which often require vehicles to slow or stop. Lowering the speed limit can sometimes actually improve travel times by smoothing flow and reducing bottlenecks. Similarly, outside of urban areas, speeds are often lower than the speed limit due to adverse road alignment (curves), poor road surface conditions or other factors. Optimal speeds from an economic perspective are defined as those with the lowest costs associated with safety, emissions, journey time and other related factors. These optimal speeds are often lower than current actual speed limits *(50).*

There is good evidence that lowering the speed limits on controlled-access highways can actually increase the throughput of traffic, reducing journey times *(51).* Drivers can travel at lower speeds with small spacings, keeping a relatively high and stable throughput (less "stop/start" traffic or "shock waves"), especially at the onset of congested conditions and during congested traffic times, which not only has positive effects on congestion, but also on road safety.

1.4 What are the factors which influence speed?

There are many reasons why individual drivers speed. In addition to the speed limit posted on a road, a driver's speed can be influenced by many other factors (Fig. 1.5).

Fig. 1.5 Risk factors affecting speed choice



Source: (52).

Some of the factors impacting a driver's speed choice, like vehicle factors (e.g. sports car) or traffic conditions (e.g. rush hours) might be more obvious than others. Some are more complex, like enforcement and sanctions (e.g. the large influence of perceived vs real enforcement tolerances on speed choice). More details on these issues are available in the study *Effective speed management (52).*

Of special interest because of their complexity are driver factors. These are either modifiable, meaning a driver can take measures to change them, or non-modifiable, which means they cannot be changed by the driver. Non-modifiable risk factors include the driver's age and sex: in most countries male drivers and young drivers are more likely to speed and are therefore overrepresented in speed-related crashes. Modifiable factors that may influence speed choice include the driver's BAC, inattention or fatigue *(53, 54)*. Other driver risk factors include peer pressure as well as personal perceptions about social norms/community norms related to speeding. For some drivers travelling at higher speeds offers the immediate "reward" of either sensation/thrill *(23, 55)* and/or a shorter journey time (as a perception, if not in practice). This benefit is reinforced every time a driver undertakes a journey and travels above the speed limit without any adverse consequence. Importantly, while speeding is involved in a very high percentage of serious and fatal road crashes, from an individual driver's point of view, the chance of having a serious crash as a result of exceeding the speed limit is quite low, so the speed-crash threat may be less of a consideration by drivers compared with the speed-penalty threat *(56).*

Unconscious personal bias makes most drivers consider themselves above average in terms of skill *(57).* Up to 90% of drivers think they are an above average, low-risk driver *(58).* For that reason, drivers believe they can travel above the limit and not place themselves at high risk. In any event, many regard the limits as arbitrary and do not fully understand the greater risks associated with even small increases in speed.

The circumstances of individual trips can influence a driver's choice of speed. When an individual is under pressure or feels the need to rush, unsafe speeds may be selected. Sometimes drivers and riders speed just for fun. Drivers will frequently claim that they were unaware of the speed limit, hence the need for adequate signs. Importantly, some researchers believe that people always tend to optimize the level of risk behaviour they engage in, such that they choose to drive faster on "safer" roads, especially if they perceive little risk of enforcement activity *(59).*

Additionally, an important factor in many countries is pressure that is applied by fleet managers and employers to be more productive (i.e. drive faster) while (public) transport and fleet operators as well as the drivers themselves come under pressure to stick to challenging timetables, and even race to pick up passengers and goods *(60).*

Relation between speed and gender

The Academic Expert Group, formed for the 3rd global ministerial conference on road safety, identified gender among the areas affected by road safety, together with health, equity, poverty, environment, employment, education and sustainability of communities *(61).*

While overall more men than women die in road crashes globally, women are more vulnerable as they are more likely to be injured or killed than men in crashes of equal or similar severity *(62).* According to WHO *Global status report on road safety (12),* three times more men than women die in road crashes globally. Men die on the roads mainly as car drivers and motorcycle riders, while women are killed mainly as pedestrians and car passengers. The main reason behind these figures is considered to be men's driving behaviour, reflected by a tendency to be involved in a road crash earlier in their driving career; proneness to drive at higher speed; exhibition of risky driving behaviour; and having less regard for traffic laws *(63)*. Young at-risk male drivers may have limited awareness of the consequences of their high-risk behaviour *(64).*

On the other hand, women have less risky driving habits, preferring a calmer driving style, lower speeds and better respect for traffic rules *(65, 66)*. In addition, women's travel patterns differ very much from men's and are characterized by trip-chaining (linking several destinations in the same journey such as travelling from home, stopping to take a child to school, and then continuing on to work) and more often comprise walking as a commonly used mode of commuting *(67)*, making them more vulnerable *(68).*

A study of young drivers on road safety attitudes and on driver behaviour in nine different European countries showed that the level of risk perception during driving is the same for male and female drivers. However, young men and women differ in the level of concern about this risk of a crash, with males being less concerned. This suggests that the main difference between these two groups is not strictly related to judgment of the perceived risk probability but rather to the level of concern experienced about the consequences of the risk. This difference between risk perception and worry could also explain differences in the frequency of car crashes between young male and female drivers *(69).*

One additional important factor is that cars are designed for men and not for women. The crashworthiness of cars has, until recently, mainly been developed based on an average male, as the most frequently used crash test dummy is based on an "average" male human body. For speed-related crashes this means that the smaller stature of women puts them at greater risk of lower body injury and death during a car crash. It is well established that females have a higher whiplash injury risk in rear impacts compared with males *(70).*

1.5 Summary

Research from around the world clearly demonstrates that higher speeds lead to a greater risk of a crash and a greater probability of serious injury if a crash occurs. Speed-related road traffic deaths form a significant proportion in HICs as well as in LMICs. For example, in New Zealand speeding is involved in around 60% of fatal crashes, and in India almost 70% of road deaths were from speeding. Thus, speed is a key contributing factor to road fatalities and serious injuries worldwide.

There is a strong relationship between impact speed and fatality probability. Most vulnerable road users such as pedestrians or cyclists can typically survive impact speeds up to only 30 km/h, above which the chance of survival decreases dramatically. A similar impact speed applies to other unprotected road users such as those using PTWs. This is because they are often completely unprotected or, in the case of motorcyclists, have very limited protection.

The benefits of speed management go much further than reducing crashes, saving lives and preventing serious injuries for all types of road users. Managing speed has positive impacts across all indicators for societal well-being – environment, health, equality, accessibility and economy – all based on good evidence.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Module 2
Evidence-based speed management interventions

2.1 Overview of evidence-based interventions

Speed management encompasses a range of integrated interventions, which together bring road users to a safe and appropriate speed and consequently reduce the number of road traffic crashes, serious injuries and deaths.

Safety must lie at the heart of speed management, yet governments and those involved in speed management at local level frequently face challenges when balancing mobility and safety. However, shifting the emphasis towards safety is at the heart of the Safe System approach – a system that underpins successful speed management in high-performing road safety countries such as Sweden, and in local communities that have successfully implemented local speed management activities.

Governments are increasingly recognizing the need for action to address the problem of speed because of its contribution to their road safety problems, high pollution levels, or both. With appropriate political support, speed management strategies can make a real contribution to achieving the goals of improved road safety, reducing environmental impacts, moderating energy consumption and increasing liveability and population health.

Speed management needs to employ a range of approaches which include setting and enforcing appropriate laws, modifying roads and making use of vehicle technologies (Table 2.1). Speed management should always be considered in land-use and multimodal transport planning. The Global Plan for the Decade of Action for Road Safety 2021–2030 underlines that multimodal transport and land-use planning are important starting points for implementing a Safe System. In this context, policies that lower speeds should be implemented, and the needs of pedestrians, cyclists and public transport should be prioritized *(2).*

Table 2.1 Approaches to speed management

I. Consider speed in all land-use planning and multimodal transport activities
II. Establish speed limits appropriate to the road users
III. Build or modify roads to include features that influence speed
IV. Enforce speed limits
V. Use in-vehicle technologies
VI. Raise awareness about the dangers of speeding

Source: Based on *(16).*

Defining concrete interventions requires the consideration of local factors such as the traffic mix and volume on particular roads. For example, speed management in countries with a high proportion of pedestrian deaths, as in many African countries, may comprise different interventions than those used in areas where most deaths are among motorcyclists. For optimal effectiveness, these interventions should be implemented in combination, and based on a thorough assessment of the country or local circumstances. Garnering political will at national and/or local levels, and coordination across responsible authorities to implement these interventions are critical for success.

A systematic review of scientific literature and evidence from January 2008 to December 2019 was carried out, resulting in an additional 37 full studies considered in this update. The effectiveness of interventions relates to the reduction of fatalities or injuries as well as other measurable change(s) in the behaviour of the road users targeted by the intervention. The assessment of effectiveness and impact was made using several tools developed in evidence-based medicine and policy research. Based on this extensive review, Table 2.2 provides an overview of existing interventions to manage speed and a rating of their effectiveness according to the following groups:

- **Proven:** Evidence from robust studies, such as randomized controlled trials, systematic reviews or case-control studies, shows that these interventions are effective in reducing fatalities or injuries, or in bringing about desired behaviour change.
- **Promising:** Evidence from robust studies shows that some benefits have resulted from these interventions, but further evaluation from diverse settings is required and caution is thus needed when implementing these interventions.
- **Insufficient evidence:** Evaluation of an intervention has not reached a firm conclusion about its effectiveness.
- **Ineffective:** Evidence shows that the intervention did not result in a reduction of fatalities or injuries.
- **Potentially harmful:** Evidence shows that the intervention could result in an increase of fatalities or injuries.

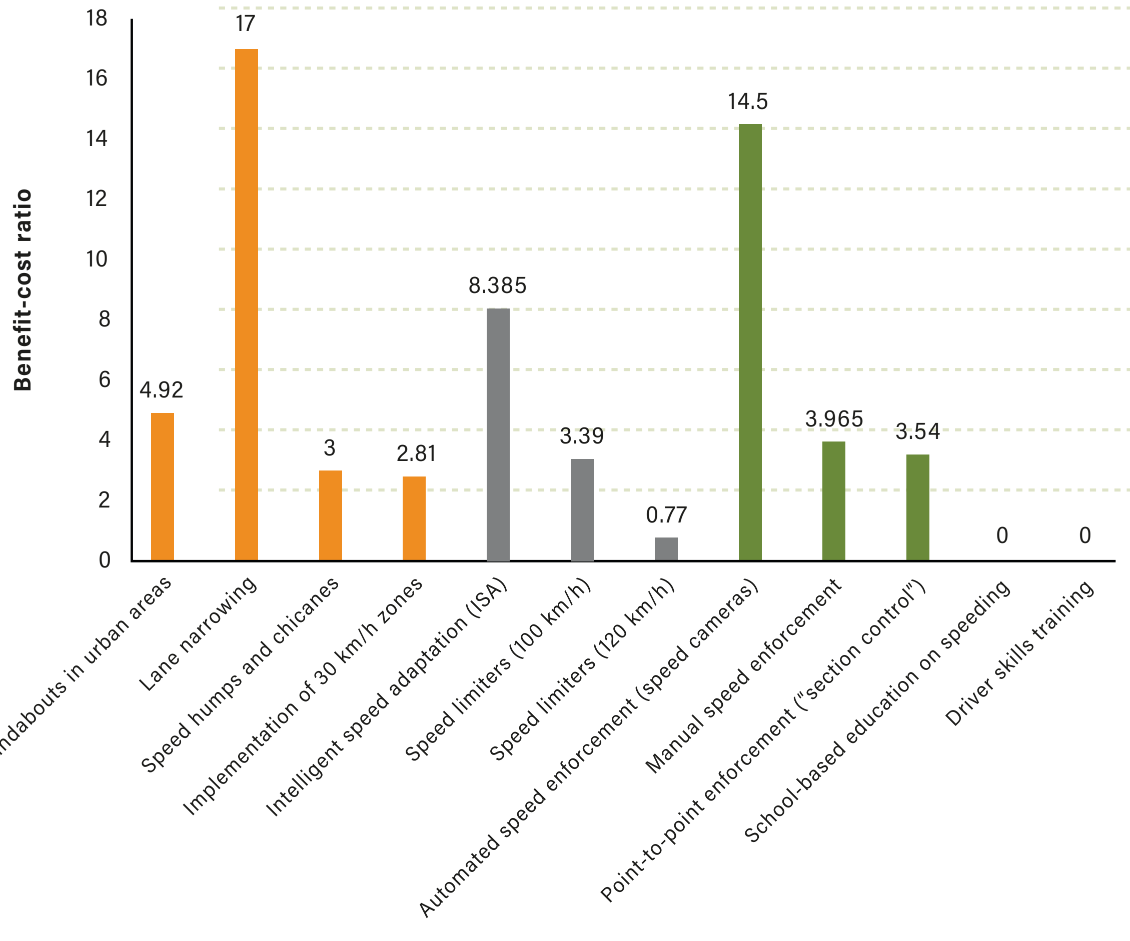
It is strongly recommended that all speed management activities are based on "proven" or at least "promising" interventions.

Table 2.2 Speed management interventions

Intervention	Proven	Promising	Insufficient evidence	Ineffective	Potentially harmful
Establishing speed limits appropriate to the road users (see Section 2.2.1)					
Setting speed limits for new and existing roads based on Safe System principles	✓				
Implementation of 30 km/h zones	✓				
Setting speed limits based on the 85th percentile					✓
Building or modifying roads to include features that reduce speed (see Section 2.2.2)					
Increasing travel speed without improving quality of infrastructure					✓
Speed humps and chicanes	✓				
Lane narrowing	✓				
Refuge islands and kerb extensions	✓				
Footpaths and cycling lanes	✓				
Raised pedestrian crossings	✓				
Pedestrian bridges					✓
Pedestrian fencing			✓		
Raised intersections	✓				
Roundabouts	✓				
Gateway treatment at entrances to towns and villages	✓				
Enforcing speed limits (see Section 2.2.3)					
Manual speed enforcement	✓				
Automated speed enforcement	✓				
Point-to-point enforcement ("section control")	✓				
Using in-vehicle technologies (see Section 2.2.4)					
Speed limiters (SL)		✓			
Intelligent speed adaptation (ISA)		✓			
Autonomous emergency braking (AEB)		✓			
Raising awareness about the dangers of speeding (see Section 2.2.5)					
Stand-alone public campaigns (TV, newspapers)				✓	
Public campaigns supporting enforcement initiatives		✓			
School-based education on speeding				✓	
Driver skills training					✓

Fig 2.1 shows a summary of the benefit-cost ratios for various speed management interventions. This figure clearly shows that a sole focus on education or public campaigns to manage speed often will not achieve the required results. Often a mixture of interventions is needed, mainly depending on the types and mix of road users, to make speed management successful across the road network. Simple and – compared with education or public campaigns – much more sustainable road engineering measures such as lane-narrowing, speed humps, raised platform crossings, refuge islands and medians are very effective – especially for low to moderate speed environments in cities, towns and villages. Many vehicle technologies also support speed management effectively. Therefore, many countries, including those in the European Union, require heavy vehicles to be speed limited. The European Parliament has mandated intelligent speed adaptation (ISA) for all new vehicles from 2022 onwards, as this technology has promising road safety benefits, as well as positive effects on fuel consumption and emissions.

Fig. 2.1 Benefit-cost ratios for various road engineering, vehicle engineering and behaviour change interventions for speed management



Source: (71).

2.2 Description of evidence-based interventions

Economic growth and mobility go hand in hand. Thus, for many LMICs, increasing vehicle speeds to increase mobility is an important economic objective. However, when speeds increase and there are no subsequent improvements in infrastructure to support these higher speeds and to protect vulnerable road users, crash risk will increase. This will lead to increased costs of crashes, countering the economic benefits of increased mobility. Economic improvement can only be achieved if road safety is increased to prevent the increased costs of crashes.

In many countries freeways are the fastest, but also the safest roads, as they maintain safe mobility through high-quality infrastructure, such as roadside and median protection (for example, through barrier systems), on- and off-ramps (slip roads), no at-grade intersections and prohibiting their use by pedestrians or slow-moving vehicles. In situations where there is no access control and no provision of adequate infrastructure measures, severe crashes will undoubtedly increase if speeds increase. This highlights the importance of provision of infrastructure to meet the needs of all road users as increases in speed without subsequent improvements in infrastructure has harmful impacts.

2.2.1 Establishing speed limits appropriate to the road users

Setting speed limits based on Safe System principles

Setting speed limits at national, urban and local levels appropriate to the current use of each road – with a special focus on vulnerable road users – is an important step in reducing speed. The following need to be taken into account when establishing speed limits *(20)*:

- the type and mix of all road users, especially vulnerable road users;
- the safety quality of the existing road infrastructure; and
- the crashworthiness and crash avoidance capabilities of vehicle fleets.

As already shown in the introductory chapter to this manual, a safe speed on roads with possible conflicts between cars and pedestrians, cyclists or other vulnerable road users is, at maximum, 30 km/h (Table 1). To achieve these safe speeds, local authorities (e.g. the mayor of a city) should have the legislative power to reduce limits as needed to better protect all those who use the roads. In addition, drivers should be informed of limits through signposting the legal speed limit on roads and rigorously enforcing the law. Adequate signposting is especially important at the entrance to cities, towns or villages (see Section 2.2.2 on gateway treatments).

Traditional approaches for setting speed limits often prioritize vehicular traffic flow as well as efficiency and are usually employed in reaction to speed-related crashes or in reaction to perceived safety issues. They often involve an uncoordinated, non-empirical trial-and-error approach to setting speeds with broad aims for reducing crashes and travel times. Such approaches usually rely on a functional road classification, which groups all roads in functional classes that mainly depend on the access and mobility they provide for motorized traffic. Newer approaches go beyond traditional functional road classification to include additional context, such as land use and actual road use as well as road user and traffic types. These approaches are based on Safe System survivable speeds and consider the fact that roads should not only provide mobility for (mainly) motorized transport of people and goods, but also respect the mobility needs of vulnerable road users such as pedestrians and cyclists. Often the demands on a road change several times along its length such as a multilane road entering from a non-built-up area in a suburban environment. In these situations, it is especially important to understand the competing demands on the road and try to find the right balance between them. The speed limit setting approach needs to guarantee safe speeds for all road users reflecting the levels of safety and needs of various road users instead of prioritizing traffic flow.

The speed limits need to be supported by infrastructure solutions to provide "self-explaining roads" and to help ensure that motorized road users understand the speeds they should use and thereby improve compliance.

The safety benefits from a change in the speed limit will depend on the magnitude of change and the level of compliance. A speed limit reduction of 10 km/h produces around a 15% reduction in injury crashes, and up to around a 40% reduction in pedestrian fatalities and serious injuries, but in the right circumstances, the benefits can be even greater *(13, 15).*

Implementation of 30 km/h zones

To protect vulnerable road users there is growing support for the implementation of 30 km/h in urban areas *(20, 72, 73).* This is also reflected by the recommendations of the Academic Expert Group *(61).* As indicated in Module 1, pedestrians have a good survival chance when hit by a vehicle with a speed of up to 30 km/h, but above this speed the chance of survival reduces drastically. Thus, the implementation of 30 km/h zones leads to a significant reduction in serious injuries to pedestrians of more than 70% and to high benefits for other road users such as cyclists (*14, 74, 75).*

Box 2 The emerging effects of Spain's new 30 km/h urban speed limit

In May 2021, Spain introduced a new speed limit of 30 km/h on single-lane urban roads in towns and cities. A first evaluation of crash data for the year 2021 compared with 2019 shows that the number of deaths in road crashes on urban roads has decreased by around 25%, which means 97 fewer deaths. The number of fatal pedestrian crashes went down by 32%. With regard to cyclists, the reduction was equal to 48%. These first results communicated by the General Traffic Directorate of Spain are very promising, and the impact of the 30 km/h urban speed limit across the country will be further assessed over time.

Source: (76).

Setting speed limits based on the 85th percentile

The speed at which 85% of free-flowing vehicles travel at or below is called the 85th percentile speed. The 85th percentile speed is often used by traffic engineers as the basis for road design. In many countries it is still used as the primary tool for setting speed limits, and as a reason against lowering or enforcing limits. This is bad practice as speeds selected by the majority of drivers are not safe in any absolute sense, as drivers do not consider all the relevant costs and benefits when they make their speed choices. Also, drivers' subjective assessments of risk, and the relationship between speed and risk, are likely to be inaccurate. Setting and enforcing speed limits lower than the 85th percentile speed is feasible, sustainable and produces safety benefits. Therefore, countries that have already adopted the Safe System approach have discontinued the use of 85th percentiles for speed limit setting.

The 85th percentile is, however, an excellent way of identifying when speed limits and road design do not match, and the design of a road is inappropriate for the posted speed limit. For example, if on a wide inner-urban residential road the speed limit is lowered from 50 km/h to 30 km/h, without any changes to the road design for the motorized vehicles at all, the 85th percentile speed of motorized vehicles on this road measured after the introduction of the lower limit will still likely be close to 50 km/h. This shows that the road design is not matching the desired speed limit. In the short term this could be solved by increased speed enforcement, but in the long-term the design of the road and its environment should be changed by adequate inner-urban road safety engineering solutions as shown in Section 2.2.2, to reduce the 85th percentile speed.

2.2.2 Building or modifying roads to include features that reduce speed

A large range of engineering treatments has been shown to be of use in speed management. A broad overview of available treatments is given below. These treatments include engineering or re-engineering the road to encourage lower speeds or make the road and its environment more forgiving or "self-explaining". There are also treatments that aim to separate road users, particularly vulnerable road users, such as pedestrians and two-wheeled vehicles, from potential crashes that could cause death or serious injury.

A range of physical features have been developed by road safety and traffic management engineers which encourage or force drivers to lower their speed. Many of these treatments have the effect of making it feel uncomfortable to drive in excess of the legal or recommended speed. Some examples include speed humps or platforms across the roadway and road narrowing or raised intersections that signal to drivers that conditions are changed such that they should slow down.

Speed humps and chicanes

Speed humps are raised sections of pavement, with various forms available for different road types and speed environments. If carefully designed and placed with the correct height, inclination and width, they result in minimal disruption for residents regarding noise as well as emergency vehicles in terms of response time.

Source: National Association of City Transportation Officials (United States).

Chicanes slow vehicles down through horizontal deflection (or movement) of vehicles. The design varies depending on the degree of speed control desired, as well as the operating environment.

Well-designed speed humps and chicanes are effective, especially in urban environments. They may be used as part of integrated traffic calming, but also at high-risk locations, e.g. where pedestrians and other vulnerable road users need to cross the road. Reductions for all injury crashes of around 35% are achievable, with even higher benefits (around 70% reduction in fatal and serious pedestrian injury) for pedestrians and other vulnerable road users *(14, 77).*

Source: New York City Department of Transportation.

Lane narrowing

Wider roads invite drivers to select higher travel speeds. This may be because the perceived margin for error is greater. So, narrower lane widths tend to slow traffic speeds *(78).* Narrowing the roadway for motorized traffic will therefore assist speed reduction in an area. Even narrowing the perceived lane width can achieve slower speeds. This can be done with painted markings on the road.

Source: GRSF (© B Turner).

Refuge islands and kerb extensions

Refuge islands and medians can assist pedestrians in crossing the road by allowing a staged crossing and simplifying decision-making. Kerb extensions can also improve pedestrian safety by reducing the crossing distance and the area and time in which pedestrians are at risk. This is particularly helpful for older or disabled pedestrians who may have difficulty choosing a safe gap in traffic at a conventional crossing point. These interventions also result in narrower lanes, thereby contributing to lower speeds *(75).*

Source: New Zealand Transport Agency (© J Ward).

Footpaths and cycling lanes

In many situations in rural and urban areas there will be no footpath provision or availability (e.g. because of parked vehicles) for the large numbers of pedestrians walking from point to point. They will often be forced to walk on the carriageway. The provision or availability of footpaths or cycling lanes is a highly effective means of removing the pedestrians/cyclists from a medium- to high-speed carriageway. Where footpaths or cycling lanes are not in place/available and pedestrians walk on the

Source: Deparment of Public Works and Highways, Philippines, 2021.

road, educating pedestrians to walk as far off the road as possible and in the direction facing oncoming traffic is necessary; or freeing up the dedicated infrastructure by installing, for example, bollards to prevent vehicles from parking. The installation and availability of footpaths show benefits of up to 60% in crash reductions for pedestrians *(14, 74, 79).* Cycling lanes adjacent to traffic show reductions of around 15% in cyclist injuries *(80, 81)*. More comprehensive interventions such as cycling boulevards show even higher benefits *(82).*

Raised pedestrian crossings

Raised pedestrian crossings are speed humps with a flat top prioritizing pedestrians over motorists. They slow vehicles down and increase the visibility of pedestrians due to the increased height. They often have a marked pedestrian crossing on top. On wider roads a central refuge island can be provided as well. In advance of the raised pedestrian crossing additional humps can be used to further reduce vehicle speeds. This treatment shows substantial safety benefits for both motorized road users and pedestrians (65% and 75% respectively) *(82, 83).*

Source: GRSF (© Alina F Burlacu).

Box 3 Why pedestrian bridges often won't solve the problem

Pedestrian bridges can give drivers the sense that no vulnerable road users will be present and remove caution about unexpected occurrences at the side of the road. They prioritize high vehicle speeds and uninterrupted traffic flow over vulnerable and active user access. Therefore, they should be implemented very carefully and selectively based on the conditions and requirements of the surrounding environment. They are also extremely expensive compared with at-level crossings and can present issues of comfort, access and personal security. Forcing people to climb stairs discourages passage or even makes it impossible for elderly or disabled persons. When pedestrian bridges are poorly lit, women in particular feel unsafe. Because they can present a risk to personal security, a significant increase in crossing distance and time, and require climbing a ramp and/or stairs, many people opt not to use them *(84, 85)*. Therefore, they do not offer the perceived safety benefits.

Pedestrian bridges are rarely appropriate in cities where the priority should be accessibility for vulnerable road users rather than higher vehicle speeds. They tend to increase risks as they are rarely used by vulnerable users and give the false impression to drivers that they can increase their travel speeds as separating people from the road reinforces the prioritization of personal motor vehicles.

In Mexico City, the boroughs with the most pedestrian bridges have the highest rates of traffic crashes. These involve pedestrian and hit-and-run crashes, 27% of which occur within 300 m of a pedestrian bridge *(86)*. In Nairobi, 43% of crashes involving a pedestrian happen within 500 m of a pedestrian bridge *(87, 88).*

Pedestrian fencing

Source: Road safety toolkit (iRAP).

Pedestrian fencing is frequently used to ensure pedestrians follow the crossing pattern for a road to prioritize vehicular traffic flow, sometimes even when it does not fit with the necessary travel and accessibility needs of the location. Where necessary, carefully selected and placed fencing that also contributes to the placemaking value of an urban area, such as plants or planters, can be used to help guide foot traffic and increase the buffer between people walking and heavy traffic. However, the locations and reasons for implementing pedestrian fencing should always be based on a strong study, diagnosis and understanding of the road in question, and only when options such as lowering speeds to safe levels are not feasible. They should never be applied simply as a tool to prioritize fast and uninterrupted vehicle flow. However, there is insufficient evidence at this time to recommend this intervention unequivocally.

Raised intersections

Source: City of Cambridge, United States.

Raised intersections are raised sections of pavement with ramps designed to reduce speeds to required levels (typically 50 km/h in the absence of vulnerable road users, and lower where they are present). The whole intersection can be raised or, alternatively, raised sections can be placed in advance of the intersection. Benefits of around 40% reduction in injury crashes are likely with this intervention with higher benefits for vulnerable road users *(77, 83).*

Roundabouts

Source: GRSF (© Alina F Burlacu).

Roundabouts are effective in reducing the severity of crashes at an intersection because they require traffic to deviate from a straight path and therefore slow down to undertake the manoeuvre. The reduced speeds of travel through an intersection that a roundabout can achieve, together with the non-right-angle nature of side-impact crashes because of the geometry of the roundabout, result in reduced crash severity. Effective roundabout installation also relies on careful design of approach islands, clearly visible signs and markings, and effective public information campaigns about how they should be negotiated by drivers. Catering for cyclist, pedestrian and motorcycle movements at roundabouts requires careful design, because drivers may fail to notice them as they concentrate on the "give way" task inherent in travelling through a busy roundabout *(88).* Well-designed roundabouts can reduce severe crashes by up to 80% *(89, 90).*

Gateway treatments at entrances to towns and villages

Gateways are devices used to mark a threshold – usually to a village or higher risk location on the road – where lower speeds are required from drivers. Gateways rely on highly visible vertical treatments to capture driver/rider attention and usually include:

Source: World Bank.

- large signs conveying the message that it is an entry to a location where pedestrians and other vulnerable road users are about to be encountered in greater numbers;
- pavement markings to narrow the perceived width of the carriageway, including painted central medians, for a short distance at least;
- large speed limit signs showing the lower speed limit that applies;
- other pavement markings to indicate clearly that a threshold is being crossed into a different environment; and
- architectural and rural treatments such as picket fencing or gates, earth mounds and rock walls.

Markings can also be used to indicate an approach to a pedestrian crossing, or other changed traffic conditions where drivers should slow their vehicles in the interest of safety.

Gateway treatments are often quite cheap to install but produce substantial benefits and show reductions of around 40% in fatal and serious injuries *(91, 92, 93, 94).*

2.2.3 Enforcing speed limits

Enforcement is essential to make speed limits effective. Where countries have changed their speed limits but have taken little action to enforce them, there have been very limited benefits *(95).* The enforcement of speed limits takes different forms in different contexts and can include manual and automated approaches. A systematic review of effective interventions for unintentional injuries and mortality impact assessment among the poorest billion population found that the road traffic safety intervention that has the potential to save most lives is speed enforcement (> 80 000 lives saved per year across 84 countries) *(96).*

Manual speed enforcement

Different manual enforcement methods are available. First, there is stationary observation using a laser speed detection device (may use a marked or unmarked police car/motorcycle). Either the operator in low traffic volume areas will stop the offending driver, or police further down the road will undertake the stop and take enforcement action. Laser speed detection devices allow the speed of individual vehicles to be checked with no risk of speeds from other vehicles being mistakenly detected.

Source: GRSP.

Second, there is mobile speed enforcement where a marked or unmarked patrol car is equipped with a mobile mode radar that allows a police officer driving on a road to detect the speed of surrounding vehicles or vehicles approaching the patrol car from the rear. Mobile mode radar is ideally suited to rural or urban roads with lower traffic volumes. Mobile speed enforcement is effective. When undertaken with sufficient frequency and delivered randomly, it deters speeding behaviour widely across the road network. A study conducted in the Netherlands in 2005 demonstrated speed reduction not only occurred on the roads subject to mobile radar enforcement, but also on adjacent roads, with mobile enforcement creating a spillover effect *(97).*

Manual speed enforcement has the added benefit of providing an opportunity for police to conduct other high value road policing activity such as breath tests, seat-belt, child restraint, driver licence and vehicle safety checks. Manual enforcement has the value of immediately stopping the unsafe behaviour, providing immediate feedback and taking enforcement action against offending drivers.

Automated speed enforcement

Automated speed enforcement can use fixed and mobile cameras which may either be visible (overt) or hidden (covert) with the strongest effects on casualty crashes when a mix of overt and covert mobile enforcement was accompanied by high awareness levels of mobile publicity *(98)*:

- Fixed cameras are installed in a specific roadside location, usually in a box mounted on a pole or gantry.
- Point-to-point cameras, average speed enforcement or "section-control" cameras are placed at intervals on highways and measure the average speed of vehicles passing between cameras.
- Mobile cameras are installed in vehicles and are operated by appropriately trained and authorized personnel and randomly deployed across a road network. Mobile cameras are most effective when they are operated in unmarked vehicles. Use of unmarked cameras that are difficult to see are highly effective at creating networkwide speed suppression as speeding drivers cannot predict where speed cameras will be operating and when operated on an "anywhere, anytime" basis have proven highly effective *(99).*
- Signed or conspicuous fixed speed cameras do generate speed reduction at their site of operation and are effective when used at specific locations where speed reduction is essential, such as at high-risk crash locations, near intersections or near schools. However, evidence has shown that drivers will increase speed after passing marked speed cameras and travel more quickly than before passing the camera creating what has been referred to as a "kangaroo effect" *(100).* It is for this reason that marked cameras should be supported by randomly deployed unmarked cameras and manual enforcement to suppress speeds across the entire road network.

Ensuring that police deployment practices are random and unpredictable as to time and location is highly effective at generating general speed suppression. If enforcement is predictable, speeding drivers will become aware of where and when enforcement is likely to operate and only adjust their behaviour at those sites or times. Random road watch (RRW) is an enforcement resource management technique that randomly schedules levels of police enforcement with the aim of realizing long-term, widespread coverage of a road network. Speed offenders are stopped and penalized by police. A RRW programme in Queensland, Australia, generated a 31% reduction in fatal crashes on the roads included in the programme *(101)*. The benefit-cost ratio for the programme was estimated to be 55:1.

It should be noted that automated speed enforcement requires complex support systems such as enabling legislation, accurate vehicle and driver licence databases, efficient infringement processing systems and rigorous enforcement of the visibility of vehicle registration plates as well as a variety of other enablers. The requirements that need to be in place to successfully operate automated enforcement systems are explained in detail within the *Guide for determining readiness for speed cameras and other automated enforcement (102).*

If these support systems exist in a country, automated speed enforcement is highly effective.

Box 4 Introduction of speed cameras in New South Wales, Australia

The evaluation of the first 28 speed cameras introduced in the state of New South Wales, Australia, showed a 71% reduction in speeding and an 89% reduction in deaths at the speed camera locations *(23).* This is also underlined by an extensive review of 35 studies, which found that in the vicinity of camera sites, the pre/post reductions ranged from 8% to 49% for all crashes and 11% to 44% for fatal and serious injury crashes *(103).*

Effective speed penalties include fines and driver licence demerit points that increase as the speed detected over the speed limit increases. No matter which enforcement method is used, the consequences for violating speed limits should be clearly stated in related laws and regulations and should include meaningful penalties. Additional penalties such as immediate driver licence suspension when high speeds are detected (e.g. more than 25 km/h above the speed limit) also generate effective deterrence. Effective penalty systems applicable to speeding drivers are explained in the *Guide to the use of penalties to improve road safety (104).*

As well as ensuring that fines are appropriate to act as a deterrent to breaking the law, in many countries – notably where legislation has not previously been accompanied by enforcement – high levels of enforcement will be needed to persuade the public that breaking the law in the future may well result in a swift penalty *(23, 104)*.

Making sure that police officers use appropriately calibrated speed detection devices is important. Equally important is ensuring that minimal enforcement tolerances are applied (i.e. enforcing speeding from as close to the speed limit as technically possible) and ensuring any tolerance remains unpublished offers significant speed reduction benefits. Casualty crash rates increase exponentially for individual vehicles that increase their speed. While high-level speeders are dramatically more likely to be involved in casualty crashes, the majority of drivers just marginally violate the speed limits (low-level speeding). Therefore, cumulatively, the majority of speeding-related casualty crashes are deemed to be caused by low-level speeding; this is confirmed by the findings of Australian research *(105).*

Despite extensive evidence of the importance of addressing low-level speeding, speeding enforcement, especially of low-level speeding, is often dismissed by mass and social media as being a pretext for "revenue raising" *(106).* There is anecdotal evidence that the police are reluctant to take enforcement action for low-level speeders. Police need to be educated about the importance of applying a minimal enforcement tolerance.

Where camera-based operations cannot be introduced in the short term, effective compliance can be achieved (particularly in urban areas) with widespread use of hand-held laser devices.

Behavioural change will occur when the public perceive there is a high risk of being detected speeding, and that detection will lead to penalties. There is a strong relationship between the volume of enforcement (the size of the dose) and the effect on serious crash reduction (*107).* High volumes of speed enforcement are required to generate population-based deterrence.

The use of a mixed model of manual speed enforcement, speed cameras, overt and covert deployment, combined with the promotion of the enforcement activity through a communication programme that supports and explains the enforcement is a highly effective and cost-effective speed management intervention *(1, 108).*

2.2.4 Using in-vehicle technologies

Collision speed and the shape and structure of vehicles involved in a crash affect personal injury or other types of damage. Lots of research goes into improving vehicle shells with safety in mind. Vehicle design is outside the scope of this manual, but there are technologies that can be adapted to vehicles to improve drivers' speed compliance.

Speed limiters (SL)

Speed limiters are a measure that seeks to prevent the competitive nature of commercial freight (and bus) operations that might result in a lack of speed compliance. This equipment is required by legislation on trucks and buses in a number of countries, including in Europe and Australia. The European Union initially required limiters on trucks and buses over 12 tonnes and specified maximum speeds – 90 km/h for trucks and 100 km/h for buses. The requirement for these limiters has been extended to light commercial vehicles (over 3.5 tonnes) and small buses. In order to investigate the effects of an in-vehicle SL on urban and rural roads including freeways field trials were carried out in three European countries. The results showed that the effects of the SL were greatest in free driving conditions. However, the SL also had effects in congested traffic. Momentary high speeds were suppressed effectively, which resulted in less variation of speeds *(109).*

Intelligent speed adaptation (ISA)

ISA refers to technology in a vehicle that enables it to "know" the relevant speed limit from an onboard and updateable database of speed limits, and a global positioning satellite (GPS) system advising where the vehicle is located. The system then provides feedback to the driver about whether the current speed exceeds that limit (Fig 2.2).

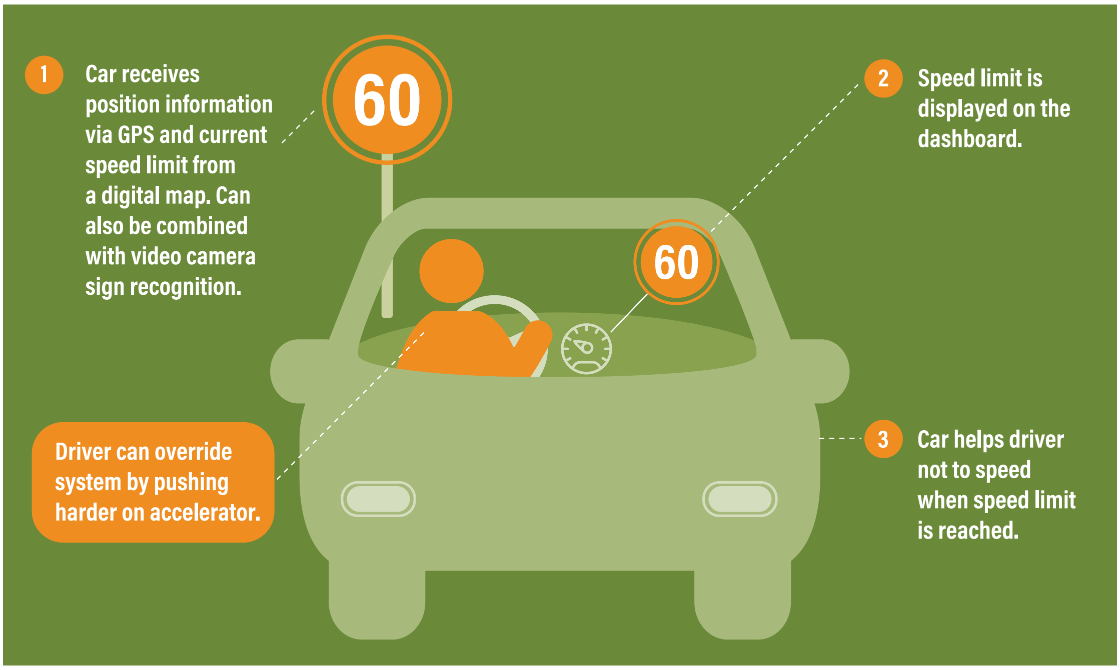
There are three major types of ISA:

- informative – giving information to the driver;
- voluntary supportive – driver can choose to set the maximum speed; and
- mandatory supportive – intervenes at all times when the vehicle exceeds the speed limit (but driver has an override).

Transport companies are increasingly using GPS tracking systems to monitor their vehicle fleet, as well as driving speeds. Used in a vehicle, the device allows a driver to plot the best directions to a location, but it could also allow employers to track their movements. This provides peace of mind for customers transporting high-value goods such as electronic and computing components. Some employers are now requiring vehicles to be fitted with speed alert and/or SL devices to give drivers feedback, or to directly constrain the vehicles to predetermined speed limits.

There are many issues surrounding reliability of speed limit data, the acceptability of mandatory supportive ISA and the substantial technical and policy decisions required from government before ISA can be required by regulation. However, informative ISA is likely to be supported by consumers and the infrastructure, and new vehicle features needed for its introduction are under development. It is now possible to install simple and cheap ISA systems in some types of private vehicles which could provide a base for voluntary tracking of speed compliance. Some insurance companies have pilot programmes with in-vehicle speed monitoring systems leading to reduced property and personal injury insurance premiums. Discussions could be undertaken with insurance companies with a view to encouraging further pilot programmes in different countries. The European Union-funded research project PROSPER carried out field trials in 10 European countries and calculated reductions in fatalities of between 19–28%, with larger benefits on urban roads and if more interventionist forms of ISA are applied *(110)*. An earlier study in the Netherlands showed that ISA could reduce the number of hospital admissions by 15% and the number of deaths by 21% *(111)*.

Fig. 2.2 What is intelligent speed adaptation?



Source: European Transport Safety Council.

Autonomous emergency braking (AEB)

Autonomous emergency braking can help drivers avoid or mitigate collisions with other vehicles or vulnerable road users. The three versions of AEB (city, inter-urban and pedestrian) help provide constant monitoring of the road ahead and can assist the driver by automatically applying the brakes if they do not respond immediately to a potential crash situation. Research showed a 38% overall reduction in rear-end crashes for vehicles fitted with AEB compared with a comparison sample of similar vehicles without *(112)*. Further development of these and other technologies and implementation by vehicle manufacturers would reduce fatal and serious road traffic injuries.

2.2.5 Raising awareness about the dangers of speeding

Stand-alone public campaigns

Research and evaluation studies present mixed findings about links between extensive public education and the risks associated with speeding, and subsequent changes in driver speed behaviour. The general conclusion is that mass media road safety campaigns (TV, newspaper) can change knowledge and attitudes but there is limited evidence that they change behaviour in the absence of accompanying enforcement *(113).*

Public campaigns supporting enforcement initiatives

The objectives of speed management campaigns may sometimes be to gain greater public support for measures that will have an impact on individual road user behaviour, such as legislation, stronger penalties, more enforcement or road/ traffic engineering changes. In other words, the aim is to create a demand for speed management. This will make it easier for governments to act by reducing some of the community resistance that they might otherwise encounter.

It is important to realize that while conveying dramatically the devastating harm of a speed-related road crash usually does not change individual driver behaviour, it can serve as a call to action, or a way to draw attention to an important injury threat in the community. Using advertising to influence people emotionally can assist in persuading them that there is an important problem to address. When the community is convinced that the issue of speeding is an important one to understand, they will then be prepared to learn more about it and support actions to reduce the problem.

The link between small increments in speed and increased risk of fatal crash involvement can be conveyed to the public over time using mechanisms that are in accord with local customs and supported in a variety of ways to achieve broad awareness of the message and its seriousness. The community needs to understand why speed compliance is being sought, what the benefits are and why it is necessary for them to modify their behaviour.

It may be best to start public information campaigns about speed with less controversial issues such as increased crash severity caused by excessive speed. Another less-disputed topic that the community is often interested to know about is differential stopping distances required under different speeds, weather and road surface conditions.

There is also a case for using publicity to inform the public in advance of increased levels of enforcement in order to avoid adverse reactions against the police. This is particularly the case where laws are changing – for example if a new, lower, speed limit is to be introduced.

School-based education on speeding

While studies show the education on road safety in schools does improve knowledge *(114)*, there is no evidence that this knowledge changes the safety level of on-road behaviour *(115).* There even is a risk that increased knowledge increases confidence and risk-taking. Even if there were benefits from school-based training, it would require immense resources (funding and skilled trainers) to produce any significant safety benefit in terms of crash reduction *(116).*

Given the lack of evidence for positive safety outcomes through school-based education and training, it is recommended that better approaches to improving road safety outcomes for school-aged children should be used, including investment in road infrastructure traffic calming measures around schools. This is also reflected in the WHO's *Ten strategies for keeping children safe on the road* – none of the 10 is education *(117).*

Driver skills training

Driver skills training is proven repeatedly to be ineffective, or even harmful, for road safety. The Cochrane Library's review of post-licence driver training evaluations concluded that there is no evidence that these trainings are effective in preventing road traffic injuries or crashes *(118).* Although this result might seem counterintuitive, the simplest way to understand this is that any benefits that might arise through training are greatly outweighed by the overconfidence imparted to those involved in these courses.

2.3 Summary

There are many proven or promising interventions for managing speeds. Interventions that have been found effective include:

- Establishing speed limits appropriate to road users based on Safe System principles, such as the implementation of 30 km/h zones in urban areas with regular pedestrian and/or cyclist activity.
- Building or modifying roads to include features that influence speed, such as gateway treatments at entrances to towns and villages, raised pedestrian crossings, refuge islands, medians or roundabouts.
- Enforcing speed limits using manual and/or automated speed enforcement technologies supported by public campaigns.
- Using in-vehicle technologies such as speed limiters or intelligent speed adaptation.

Often a mixture of interventions is required, mainly depending on the types and mix of road users, to make speed management successful across the road network.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Module 3
Implementing the interventions

3.1 Cycle of improvement

Improving the road safety situation in a country requires continued effort of planning, executing and evaluating programmes. It is not a one-off undertaking, implying that the policy planning stages used in specifying actions required are mainly for illustrating a continuous cycle. There are opportunities as well as unexpected challenges that need to be managed as this cycle moves on in each country. Implementing a continuous cycle of road safety improvement begins with an assessment of the existing system followed by the development, execution, evaluation and refinement of a national or a local plan of action. A plan of action will not yield improvements unless it is translated into practical solutions in countries. In addition to identifying and prioritizing actions that should be taken, there are key ingredients that need to be considered and made available or developed: human and financial resources, sharing responsibility among different agencies and political commitment *(2).*

3.2 Pathways to change

Applying the Safe System approach to road safety results in a complex set of interacting interventions, which make them quite difficult or sometimes even unethical to implement and evaluate using traditional research methods such as a randomized controlled trial. For this reason, some researchers have proposed that "understanding the public health intervention's underlying theory of change and its related uncertainties may improve the evaluation of complex health interventions" *(119).*

A theory of change is therefore basically the pathway that will be followed to achieve the objective of a programme. It "explains how activities are understood to produce a series of results that contribute to achieving the final intended impacts. It can be developed for any level of intervention implementation – an event, a project, a program, a policy, a strategy or an organization" *(120)* or the evaluation of such interventions or set of interventions (impact evaluation). It encourages "systems thinking" through the understanding of complex social change processes, different perspectives, assumptions and the contexts needed to optimize success.

A theory of change is a systematic approach to understanding the pathway to change in order to reach a long-term goal. It should always begin with a good situational assessment in order to understand the causes, risk factors, opportunities and challenges in the local situation where an intervention is to be implemented. It should then be guided by a participatory approach – bringing together multiple key stakeholders, through a workshop for example, to discuss the proposed approaches or interventions that need to be implemented to optimize impact.

Although developing a theory of change is an iterative process, and there are many ways it can be developed, it should include the following basic steps *(121):*

1. Identify the long-term outcomes
2. Develop a pathway of change
3. Operationalize outcomes
4. Develop interventions
5. Articulate assumptions
6. Monitor and evaluate the process.

As a final output of stakeholder discussions, a visual map of the change being explored should be developed to show the relationships between proposed actions/interventions and outcomes and how these interact in order to achieve the goal.

The benefits of developing a realistic and implementable theory of change are articulated in Box 5. In general, this process challenges the status quo and gets stakeholders to "think outside the box" so that mistakes are not made when interventions are implemented. It also forces stakeholders to think about resources and how these will be best utilized to bring about the required change. Finally, the process develops a shared understanding of the actions to be taken and expected outcomes on one hand and accountability on the other.

Box 5 How a theory of change would benefit speed management interventions

It will provide:

- A clear and testable hypothesis about how change will occur that not only allows you to be **accountable for results**, but also makes your results **more credible** because they were predicted to occur in a certain way.
- A **visual representation** of the change you want to see in your community and how you expect it to come about.
- A **blueprint for evaluation** with measurable indicators of success identified.
- An **agreement among stakeholders** about what defines success and what it takes to get there.
- A powerful **communication tool** to capture the complexity of your initiative.

Source: (122).

The following section outlines some of the steps needed in order to design, implement and evaluate effective speed management in a country based on theory of change principles.

3.3 How to assess the situation

3.3.1 What we need to know

First, it is necessary to build up knowledge of the situation to be addressed through a speed management intervention. Therefore, gathering information on the types and mix of road users and their behaviour, the road environment, laws and their enforcement, and the inherent risks associated with speed is necessary.

Types of all road users, road user needs and their vulnerability

Many countries classify their roads in a road hierarchy based on their primary function. Ideally, speeds of motor vehicles using each road will be appropriate to the types and mix of road users, the type and quality of the road, and the surrounding environment. But this is often not the case, for example in LMICs, where highways plough through towns and villages with high volumes of vulnerable road users which are not adequately protected.

Reducing risk through speed management interventions requires a good understanding of the needs of all road users and their vulnerability. For example, a major arterial road carrying through traffic between cities may be able to safely accommodate maximum speeds of 70 km/h – if adequate provisions at intersections and for vulnerable road users exist. Whereas roads through shopping and residential areas as well as towns and villages with high pedestrian activity may need to have a maximum limit of 30 km/h.

If the current default speed limits are higher than those shown in Table 1 (e.g. the speed limit is 60 km/h for urban areas) there is an urgent need to change this – even without much further assessment.

When determining whether speed limits are at the right level or even speed management interventions are needed, it is especially important to take into account the presence of pedestrians, cyclists and other road users (such as motorcyclists) who are more vulnerable to injury in the event of a crash. In residential areas where children may be playing close to the road, for example, the speed limit should be set at an even lower level. If motorized four-wheeled vehicles cannot be separated from two-wheeled road users (or three-wheeled vehicles), again, the maximum speed should reflect the risk to the more vulnerable road users.

A study of the road and its environment, including the behaviour of the people close to the road, should be undertaken to enable a full assessment of speed-related injury risks. For example, is there residential or commercial development in rural areas along arterial roads? Are people walking along the side of the road?

Further, it needs to be assessed whether there are any land-use plans which could lead to a road changing in function over time, e.g. the mix of road users, the amount and speed of traffic, and the safety risk. It is then necessary to re-evaluate the safety provisions for pedestrians and other vulnerable road users. This study should have a particular focus on those road users more likely to be injured because of a lack of protection – pedestrians are as important to plan for as drivers. Changing the traffic environment may require lower speed limits and additional infrastructure improvements, such as giving vulnerable road users priority at crossings or separating them from fast-moving vehicles.

Road traffic crash and speed data

Good road safety data are important in assessing the situation. This means data that are appropriate, accurate, complete and reliable. It is a fact that in many countries such high-quality data are not yet available. Even so, in many instances it is obvious that speeds are excessive and speed limits are inappropriate.

The lack of such data should not be used as an excuse for inaction or ignoring the problem of speed-related serious casualties. Some country-level injury data, no matter how rudimentary, together with some simple measurement of free-flow speeds, can be used as a starting point for better managing speed.

At an even more basic level, if there are vulnerable road users being seriously injured by vehicles (regardless of whether data are available or not) there is the need for something to change. Data are preferable but not a necessary prerequisite.

The useful set of data depend on the actual speed management intervention to be assessed (i.e. whether it is engineering, an enforcement, a vehicle technology or an education/public campaign intervention), but might include:

- numbers of fatal crashes where speed was a contributing factor;
- number and type of road users killed as a result of speeding;
- the age and sex of all involved in speed crashes;
- type of road, traffic volume and speed limit of roads where speed crashes have occurred;
- mean free-flow travel speeds;
- the proportions of drivers and riders at, below or above the speed limit;
- speed variance (by what amounts and in what proportions are road users above, near to or below the speed limit);
- other measures of speed distribution, such as the 85th percentile speed (the speed below which 85% of vehicles travel);
- public opinion about speed compliance;
- attitudes towards police enforcement activity;
- public opinion about appropriateness of current speed limits and penalties.

While introducing speed management measures that have the support of the general public is preferable, it is often necessary to pursue measures that will be highly effective but, initially at least, unpopular. Accurate data on speed-related serious casualties and free-flow speeds will help provide evidence about the potential scope for serious casualty reductions thus helping convince both policy-makers and the general public.

Methods for collecting data vary and the breadth of data obtained will depend on their source. Hospital data on crashes and injuries, for instance, will only take account of part of the problem because they only include cases that are brought to hospital. Similarly, police data on crashes will only record cases the police investigate.

However, either of these two sources provides a good starting point. Ideally, the information obtained by trauma rescue, medical facilities, police, press and road authority investigators will be integrated to give a fuller picture of circumstances and outcomes of speed-related crashes.

Some crashes will have been identified by police as having speed as a major contributing factor, but the police in many countries do not provide such information on crash causes. In most crash situations, especially with mixed traffic, analysing to what extent speed contributed to the crash requires careful study.

Box 6 Speed variation analysis: a case study for Thailand's roads

Between 2015 and 2019 a total of 867 km of national roads in Thailand and 258 km of streets in Bangkok were assessed under the Bloomberg Philanthropies Initiative for Global Road Safety (BIGRS). The importance of speed in influencing road user risk was highlighted in two case studies on different road types – the Outer Ring Road and Hathai Rat Road in Bangkok – to demonstrate the effects of different speeds on the International Road Assessment Programme (iRAP) star ratings. These ratings objectively quantify the likelihood of a crash, and its severity, whereby a person's risk of injury is highest on a 1-star road, and lowest on a 5-star road. The study shows that enforcing a reduction of the speed limit by 10 km/h could prevent one in three fatal and serious injuries on both those roads.

Source: (123).

Speed risk profile and vulnerable road users

The crash risk varies for different types of road user. Vulnerable road users are defined as those exposed directly to vehicle impacts (pedestrians, cyclists, users of PTWs) as opposed to those protected within a vehicle (drivers, passengers). Pedestrians, cyclists and those using PTWs are much more vulnerable to injury than those using larger motor vehicles.

An examination of the risks of exposing vulnerable road users to heavier motorized traffic warrants particular attention. This examination should consider whether enough has been done to manage the speed of motorized vehicles so that collision and injury risks are minimized. It is essential that the risks faced by vulnerable road users on the network are well understood, in order to develop targeted risk reduction interventions.

In addition to understanding speed crash and injury data, it might be useful to conduct further research about local behaviour patterns and cultural settings to determine which people are most at risk of having a speed-related crash. Knowing more about the circumstances in which people drive or ride at dangerous speeds might help in selecting the appropriate speed management intervention.

3.2.2 How to measure the problem

Collecting data on speed-related road traffic crashes

Usually, it is the role of traffic police to investigate road crashes. In the case of serious crashes, specially trained investigators or crash reconstruction specialists may be able to find more clues about road environment, vehicle-related and behavioural factors that might have contributed to the crash or crash severity. While most high-income countries have teams of crash experts, many lower income countries rely on traffic police conducting such investigations – often with limited training and experience.

Investigators can determine if speed was involved in a road crash by observations, interviews of witnesses, measurement and analysis of changed road-environment characteristics including skid marks. As far as possible, an estimation of impact speed and travel speed in the moments just prior to the crash should be made. Tachometers, if they are fitted to vehicles, will record these with greater accuracy.

More advanced (and expensive) technologies use traffic monitoring cameras and software algorithms to determine speeds from real-time traffic data. A growing research field is real-time traffic monitoring using mobile phone data or GPS data and estimating traffic speeds using these data sources. Due to the high market penetration of mobile phones in most countries, very detailed spatial data at lower costs than with traditional data collection techniques would be available. Data from cellular phones open new and important developments in transportation engineering but several steps are still needed to achieve significant confidence in the use of these data, not only in terms of data reliability but also regarding privacy and security issues. The tracking of people or goods transported raises many privacy issues regarding the protection of personal data from a number of perspectives.

In practice, extensive information on crash data is often not available in LMICs because data may not be complete. Issues of underreporting in police records (for example, compared with hospital-based data) also exist, even in those countries with a good road safety record. Other sources of data might be nongovernmental organizations (NGOs), universities and other research organizations. Insurance companies may also have such information since police crash reports are often required as part of any claim.

To analyse these data the following questions should be asked:

- What is the scale of the problem of speed-related crashes as identified in police records in terms of the number of crashes and the number of fatalities (and serious injuries)?
- What proportion of overall road traffic crashes does this comprise?
- What do the crash data indicate about the appropriateness of speed limits?
- Who are those most likely to be involved as drivers or riders in speed-related crashes?
- Where are the locations where pedestrian and other vulnerable road user crashes form a high proportion of total speed-related crash numbers?
- What are the characteristics of drivers involved in serious or fatal speed-related pedestrian crashes?

Measuring speed

Assessing free-flow speeds on a representative sample of arterial and local roads in urban and rural areas will be an important activity to enable an assessment of the opportunities for various speed management interventions to reduce serious injuries.

Free-flow speeds are measurements of the speed of travel of vehicles that are not affected by other vehicles. Surveys are usually carried out using a radar or laser detector (or “speed gun”), selecting those vehicles that have a substantial headway and are not impeded by other vehicles or other factors. It is usual to set a minimum headway between vehicles in the traffic flow of 3 seconds to measure free speed, but a time gap of at least 4 seconds is preferable.

Speed surveys can be conducted with fixed speed measuring equipment, or with observational surveys involving researchers discretely standing by the roadside with hand-held speed measuring devices. They can also be done by observing the types of drivers who are exceeding limits (male, female, young, old). Such observational speed surveys should be sufficiently large to identify any significant differences between men and women, motorcycle riders and vehicle drivers, speeds in cities and smaller towns, urban roads and highways, and different regions of the country.

Regardless of the speed measurement method used, speed survey results highly depend on the way the survey is conducted. When planning a speed survey, the guidance in Box 7 may be used.

Box 7 Guide for conducting a speed survey

- Select appropriate location for the specific purpose of the study considering that the location is safe for the operator and away from areas that might influence speeds.
- Define data that need to be collected besides free-flow speeds (e.g. type of vehicle, environmental conditions, posted speed limit) and choose appropriate data collection tool.
- Select appropriate speed measuring device (e.g. speed gun) for the specific purpose of the study.
- Train operators on safely carrying out the onsite measurements including correct use of the measuring devices.
- Choose sample size considering:
  - the different types of vehicles using the roads (motorcycles, cars, lorries);
  - the traffic volume and variables such as time of day, day of week, holidays and weather conditions (e.g. 200 vehicles of each type over a minimum of 2 hours).

  The recommended minimum sample size is 100 free-flow vehicles. Only if a study is being conducted on a very low-volume roadway, then it is acceptable to collect speeds for 2 hours, regardless of how many vehicles are observed. On a low-volume road the peak hours of the morning (07:00 to 09:00) and the afternoon (16:00 to 18:00) are time periods when the study should be conducted in order to increase the likelihood of observing a minimum of 100 vehicles. On roads with higher traffic volumes, however, the morning and afternoon peak periods are times when speed studies should not be conducted since the speeds observed while the traffic volumes are at or near capacity are unlikely to be an accurate reflection of free-flow speeds.
- When measuring free-flow speeds select those vehicles that have a substantial headway and are not impeded by other vehicles or other factors (minimum headway of 3–4 seconds is recommended).
- Guarantee minimum influence of the observer and/or equipment on the drivers and their speed (hide observer and recording equipment, if possible).
- Collect and evaluate the data.

Speed surveys should be repeated on a regular basis to show trends in vehicle speeds and monitor the impact of speed management interventions on driver behaviour. In this case the same location as well as the same recording equipment and, preferably, the same equipment operator should be used. It is important that speed surveys are conducted under similar conditions each time, as any variation in collection procedures may result in differences in the speeds recorded. Environmental conditions have to be considered as well, as drivers typically do not travel at a normal speed if the road is wet or snow covered.

The measurement of speeds should be collated and analysed to find out the mean speed of traffic flow over a period of some hours. The 85th percentile speed should also be calculated from the free speed distributions. As shown in Section 2.2.1 it is not good practice to set speed limits based on the 85th percentile, but it is an excellent way of identifying when speed limits and road design don't match, and the design of a road is inappropriate for the posted speed limit. It should be noted that speed survey results are highly dependent on the way the survey is conducted.

If free-flow speeds are in excess of the posted speed limit, this will indicate an opportunity to reduce speeds to the speed limit by carefully targeted enforcement and engineering interventions appropriate to the location.

If the free-flow travel speeds are below the speed limit and there are still substantial crash risk problems along a length of road, or at a particular site, it should be clear that travel speeds need to be reduced through even lower speed limits and evidence-based engineering and enforcement interventions as presented in Module 2.

Measuring why people speed

Relying on quantitative data collected during a speed survey to tackle speeding does often not paint the whole picture. It should be complemented by qualitative research, e.g. based on interviews or group discussions, that involve collecting and analysing non-numerical data to better understand the reasons drivers choose to comply with or exceed speed limits. Qualitative studies are effective in gaining a more thorough understanding of issues by allowing opportunities for elaboration beyond that available from quantitative methods *(124).*

Box 8 Prevalence, knowledge, attitude and practice of speeding in two districts in Kenya: Thika and Naivasha

Compared with other conditions, road crashes had the second highest increase in disability-adjusted life years between 1990 and 2010. Vehicle speeds were measured at various times during the day and different days of the week on six roads in the two districts of Thika and Naivasha in Kenya. The speed measurements showed an overall high proportion of vehicles speeding above posted limits in both districts, with an average of 46.8% in Thika and 40.2% in Naivasha. To get a better understanding of why drivers speed, they were interviewed at motorcycle bays, petrol stations and rest areas. While the majority of respondents agreed that speeding is a cause of road traffic crashes in both Thika (70.3%) and Naivasha (68.7%), knowledge of speed limits at the locations was found to be limited.

Source: (125).

3.3 Opportunities and challenges in implementing interventions for managing speed

There are several challenges and opportunities to utilize to advance speed management interventions and actions. Examples of opportunities and challenges in implementing speed management interventions are briefly discussed below.

3.3.1 Pilot projects

Challenge

Often decision-makers or politicians at national or regional level are reluctant to implement new speed management interventions such as an engineering measure or an enforcement method as they want to be sure that the new intervention will work in their jurisdiction before choosing to invest in a full-scale implementation. They want to manage the risk of a new idea and identify any deficiencies before substantial resources are committed.

Opportunity

Pilot projects are often helpful to introduce interventions in a country, a region or a city. It is often better to start small by selecting a pilot location to show whether an intervention is effective and to test, evaluate and optimize new ideas, always having in mind the overall goal and the "bigger picture". To have better acceptance, speed interventions should start where the strategic impact of a speed reduction is high. In this context, school areas are often ideal, as these areas have some of the most vulnerable road users and it is very hard for local stakeholders as well as the general public not to support protection of school children by limiting speeds.

Box 9 Building on lessons learned and community: Walk This Way programme leads the path for safer school zones in Ho Chi Minh City, Viet Nam

In 2017, Ho Chi Minh City commenced construction of the bus rapid transit (BRT). While the BRT corridor offers excellent public transportation options, it presented challenges for pedestrian safety that were answered with the Walk This Way (WTW) programme, implemented by the AIP Foundation. A baseline study among 37 pilot schools consisted of a road safety environment assessment with the iRAP Star Rating for Schools (SR4S) app, rating the risks and safety of roads from 1-star (least safe) to 5-star (safest). Before the intervention, 60% of pilot school sites were 1 or 2 stars. Road modifications were then made by replicating a successful safe school zone model previously piloted in the city.

In 2022, WTW was proven to have measurably increased student safety using a systemic approach: school zone modifications implementation, with awareness and education. Modifications have been implemented in 11 schools, including installing pavements, yellow warning lights, refuge islands, school zone and pedestrian crossing signs, and slow down markings.

Post-modification results showed that 10 schools among 11 are ranked at least 3 stars or above with SR4S. In parallel, advocacy with the local government permitted funding for school modifications at 10 additional schools, meaning a total of 21 schools have now been modified, creating a safer walking environment for children and communities in Viet Nam.

Before (left) and after (right) pictures of installing refuge island at a project school in Ho Chi Min City

Source: (126).

3.3.2 Community involvement and participation

Challenge

There seems to be a widespread perception among decision-makers and politicians that local communities do not want speeds lowered, but more and more community demands for lower speeds are emerging in many parts of the world *(127).* One example is the "20's Plenty for Us" campaign in the United Kingdom of Great Britain and Northern Ireland with over 600 local groups campaigning to make roads in cities, towns and villages safer. Following campaigning by the NGO Amend *(128)*, a long-term partner of the FIA Foundation and the Zambia Road Safety Trust, the Zambian Government introduced lower speed limits around Zambian schools and areas with high pedestrian flow.

Opportunity

Speed management interventions will be successful if they are supported by local stakeholders, community decision-makers and the communities themselves. Thus, advocating for speed limit change as well as seeking support for speed-related interventions, will require engaging the appropriate stakeholders.

Once evidence is produced that speed and speeding are problematic, support from politicians for lowering the speed limit must be obtained and the affected communities and road users should be involved so that the impacts of speed changes are understood by the public and expectations can be considered. This can be done via citizen engagement or other methods of participation by events in the local area during the development as well as the implementation of speed management interventions.

If speed management should be introduced it is worthwhile to involve road engineers, traffic police, emergency services and, where necessary, public transport providers as well as communication experts at an early stage to discuss the most cost-effective and feasible interventions in engineering, enforcement and public campaigns *(129).*

In some cases, speed limit changes will be easier to accept by the relevant stakeholders if they are phased in over time, i.e. if a reduction from 50 km/h to 30 km/h is the ultimate goal this could be phased in gradually by lowering the speed to 40 km/h, evaluating the effects and finally changing to 30 km/h.

Source: Amend.

There is increasing public demand for safe and comfortable speeds. Lower speed limits are safer for people and better for the environment. This is even more true for urban environments. That is why citizens' groups in many countries around the world are campaigning to set urban speed limits at 30 km/h; some as part of wider campaigns to improve the quality of life in urban areas.

Box 10 Road users' speed awareness

A survey conducted by the European Survey Research Association (ESRA), with a total of 35 000 respondents across 32 countries, showed that the majority of respondents were aware of speeding being one main cause of a road crashes and thought speeding to be an unacceptable behaviour. Less than 20% of the respondents found it acceptable to drive faster than the speed limit. For built-up areas this number decreased to less than 10%. In addition, up to 90% of the respondents suggested that traffic rules on speeding should be stricter.

Source: (129).

3.3.3 Embedding interventions in speed management action plans and strategies

Challenge

In many countries speed management interventions are singular, stand-alone activities that are not embedded into a broader framework. These are often selected as a reaction to a high number of crashes on a road using the trial-and-error principle. A planned, systematic and results-focused approach to increase road safety by managing speed is often missing. Still, the countries with the safest road networks in the world have many common characteristics in speed management. They have adopted a systematic approach to speed management interventions and targeted safety outcomes *(130).*

Opportunity

Two powerful instruments to implement speed management are the speed management strategy and the speed management action plan. These two instruments have different purposes, contents and target audiences and so should not be confused.

A **speed management strategy** (also called a speed management programme) is a long-term framework for implementing safe speeds for the whole road network in a country. It is based on the Safe System approach and covers the main focus areas as well as the goals and objectives of speed management. A speed management strategy is usually set at a national level in line with the national road safety programme and any other high-level documents that cover road safety issues on a national level, such as the national transport strategy.

It is agreed at a high political level and issued by the responsible department/ministry. To succeed, many different organizations, e.g. ministry of transport (road safety agency), ministry of public works (road authority), ministry of the interior (police), ministry of health (emergency services) as well as road safety organizations or other NGOs are required to be involved in developing the strategy and supporting its implementation.

The **speed management action plan** is typically derived from the speed management strategy and defines the concrete actions for managing speeds including the timeline for implementation, e.g. in the fields of engineering, enforcement or public campaigns, with the aim of managing speed and reducing speed-related fatalities and serious injury crashes on parts of the road network. It is usually issued by the responsible road authority or road operator, e.g. by a local administration (such as a region or city) or a public or private entity (such as a freeway operator/concessionaire). The action plan delineates specific activities to be pursued and steps for their implementation, such as a change in local speed limits for designated roads or the implementation of concrete speed management interventions where speeding is a problem. Furthermore, the action plan includes information for engineers, enforcement agencies and other partner organizations to identify and treat high-risk locations and assigns responsibilities to each.

It is important to develop a comprehensive speed management strategy at a national level to lay the ground for speed management action plans at the level of the road authority or road operator, such as a region or a city, and to define the legal, financial and organizational framework for consistent and safe speed limits for all roads. Depending on country size and administration, a strategy could also be developed on a regional or even major city level, but a national strategy is always preferable. Where a robust national speed management strategy exists, individual regions or cities can be encouraged to adhere to this approach so that when road users travel from one area to another, they experience a coherent speed management system. However, an existing national speed management system should not stand in the way if local authorities wish to improve road safety by introducing lower local speed limits. Indeed, it is often the case that cities can bring about much quicker change than is possible at a national level.

In the absence of a national speed management strategy, regions or cities should not wait, but choose to develop their own strategies based on the principles outlined in this guide (see Box 11). However, the ultimate objective should be for national uniformity that follows good practice approaches to managing speeds.

Box 11 Managing speed in Bogotá, Colombia

In 2016, vulnerable road users accounted for 96% of the 585 fatalities that happened in the city of Bogotá. 72% of all these fatalities occurred on arterial roads. In response to these data, Bogotá set an ambitious goal to reduce traffic fatalities by 35% in the period 2017 to 2026. To help reach this goal, the city implemented a speed management programme in 2019, which was designed to promote more sustainable mobility choices, improve the road environment, and ensure the safety of all road users. The programme focuses on the needs of people instead of vehicles with the aim of transforming the city and transport options to protect pedestrians, cyclists and drivers alike. A strong focus of the programme is on traffic calming by introducing low-speed zones and supporting these with adequate infrastructure improvements as well as speed enforcement. The aim of the programme is not only to influence road safety, but to make people healthier and more active, while reducing air pollution. The Bogotá speed management programme was delivered through BIGRS with technical guidance from the WRI Ross Centre and has been awarded a Prince Michael International Road Safety Award for its innovation.

Source: (131).

3.4 How to evaluate progress and utilize results for improvement

Monitoring and evaluation of any speed management intervention is vital to determine whether it works, to adapt it if necessary, and to provide evidence for continuing support of speed management measures – at the level of policy-makers, key stakeholders and the general public. Evaluation will not only provide feedback on the effectiveness but will also help to determine whether a speed management intervention is appropriate, whether there are any problems with its implementation and support, and whether there are any ongoing concerns that need to be resolved as the intervention is implemented.

It is often the case that plans for evaluation are only considered late in the implementation phase, or even after the changes have been made. This means that a proper comparison study cannot be undertaken, as data from before the change is made (without the intervention) are no longer available. This demonstrates the importance of carefully planning for evaluation early in the design process.

An evaluation of the impact on crash history should not be conducted until at least 1 year of post-installation data are available, and a minimum of 3 years of crash data are desirable to provide a larger sample size. The recommended timeframe for a speed evaluation after a major engineering change (e.g. a new speed limit or road design element) is also 1 year. Waiting a full year will allow motorists to get acclimatized to the new treatment and environment and will allow it to be encountered in all types of weather conditions.

In reality, besides a long-term evaluation, it is often important to collect data soon after the implementation of an action to make sure the immediate benefits are as expected (and that an action did not make the situation worse). Put another way, the site should be closely monitored from the beginning, while a longer term assessment as part of an evaluation should be conducted as well.

The criteria in Box 12 can be used when evaluating a speed management intervention.

Box 12 Criteria for evaluating speed management interventions

- Start evaluation process *before* the implementation of the speed management intervention.
- Determine the aim of the evaluation and develop an evaluation framework.
- Clearly define the target population, place, time and performance indicators.
- Develop and test procedures for data collection, ensuring consistency in measurement.
- Collect and analyse data – before implementation of the speed management intervention and at predetermined intervals after implementation.
- Write and disseminate an evaluation report.
- Use evaluation results to feed back into planning new interventions and to promote interventions.

3.4.1 Planning the evaluation

It is important that the evaluation is built into the speed management intervention from the outset, not simply "bolted on" at the end. The process should also be developed to provide much more than a simple "yes/no" or "good/bad" conclusion; and it is vital to be clear about the aims and objectives of the evaluation. Therefore, it is essential that the evaluation framework is developed and implemented alongside the intervention. Baseline data need to be collected before the intervention is put in place so that changes can be measured.

The evaluation will assess the extent to which the objectives of the intervention have been met and may have more than one aim. There are many possible indicators that can be measured for a speed management intervention, so at the outset it is essential to clarify the aim(s) of the evaluation – in other words, what questions does the evaluation need to answer? The breadth of an evaluation will always be limited by the resources available, but a well-designed, simple evaluation can be as useful as a more complex and costly one.

3.4.2 Choosing the performance indicators

To succeed in implementing a successful speed management intervention it is necessary to carefully monitor its effects. In this context, performance indicators are a measure of how successful a speed management intervention has been. They should relate directly to the objectives of the intervention. Choice of performance indicators will be determined by the aims of the evaluation, the study type used, the resources available and, to a certain extent, the requirements of the funding agency. For instance, government funding agencies may require certain information to ensure support for increased enforcement or for further rollout of an intervention.

International best practice shows that there are some important key dimensions and criteria for choosing performance indicators, which can be summarized as follows:

- relevance, i.e. related to an important aspect of speed management (impact, results, causes etc.);
- measurable in a reliable way;
- measured systematically, allowing monitoring over time;
- useful for setting targets; and
- useful for comparison and benchmarking.

A large number of performance indicators exist, but not all of them are equally important. The importance of a performance indicator can be assessed by the strength of its relationship with speed crash occurrence, its contribution to speed crash reduction and its connection to a speed management strategy or speed management action plan.

It is advisable to start out with a small set of well-chosen indicators that are not too difficult to collect – more can be added rather easily later in the process – if necessary.

The performance indicators could be changes in observed speeds, in the number of crashes, or reactions from the public and stakeholders. Monitoring is needed in order to rectify problems as quickly as possible, as well as ensuring policy-makers and key stakeholders are kept fully informed of progress, challenges, difficulties and solutions. The performance can also be measured in terms of economic efficiency.

3.4.3 Choosing the evaluation methods

The methods used for evaluation will vary. Both qualitative and quantitative methods can be used within the design of an evaluation. Qualitative methods may be employed for formative and process evaluations, e.g. focus groups, short-answer or open-ended questionnaires. Quantitative methods such as surveys may also be employed for process evaluations.

Impact and outcome evaluations may be carried out using a variety of quantitative methods. Using an experimental or quasi-experimental design to demonstrate a change (or not) is the most powerful tool for detecting changes in outcome. The methods used will depend on the aim and the budget for the evaluation. There is an extensive and well-defined hierarchy of experimental designs for examining the effectiveness of interventions. These range from fully randomized control trials (which can provide high-level evidence for the effectiveness of an intervention) to, for example, uncontrolled "before-after" studies which can only provide weak indicative evidence of effectiveness.

3.4.4 Dissemination and feedback

Once an evaluation is complete, it is important to provide feedback to the policy-makers and key stakeholders as well as the general public, even if results were not very good. Dissemination of the results in this way will help to garner further support for speed management if it is successful, and help others gain support for the introduction of similar interventions.

Communicating results

While a speed management intervention may have succeeded in achieving its objectives, it is still helpful to examine and discuss what worked well and why.

If the intervention has not been successful, it is important to share this with others so that weaknesses or relevant issues are considered in similar interventions, including whether or not to introduce such interventions in the first place. Implications of the evaluation findings should be discussed, and it should be considered whether they demonstrate any tangible benefits, problems to be rectified or elements to be abandoned. Moreover, the evaluation could discover unexpected side-effects of the interventions – both positive and negative. These should be considered in the further development of interventions.

Dissemination may also involve presenting the results at public meetings or publishing reports and papers in (scientific) literature. The results of the evaluation should be fed back into the planning cycle and the appropriate modifications made before the intervention is expanded further.

Sharing lessons about success factors with key stakeholders will help to ensure that any benefits obtained at the beginning are maintained. Longer term funding requirements and adequate speed management resources are more likely to be secured if performance is measured and reported.

Giving recognition to individuals and agencies and celebrating success

When successful outcomes have been identified, it is recommended that both formal and informal activities be arranged with staff from participating agencies to celebrate success. In road safety projects the major benefit that staff receive from participation in a successful project is personal satisfaction. However, positive endorsement by senior management of the value of their work is a critical component for maintaining staff morale and showing all participants that their work is acknowledged and acclaimed. Equally, one agency showing its appreciation of the good inputs by another can go a long way towards building strong, long-lasting partnerships.

3.5 Summary

Improving speed management in a country requires continuous effort of planning, implementation and evaluation. In many countries speed management interventions are currently selected as a reaction to a high number of crashes on a road using a trial-and-error principle and are often singular, stand-alone activities not embedded within a broader framework. A planned, systematic and results-focused approach to increase road safety by managing speed is required.

Complete and reliable data are important for planning, implementing and evaluating speed management interventions. In many LMICs such high-quality data are not yet available, but it is still obvious that speeds are excessive and speed limits are inappropriate. Thus, the lack of data should not be used as an excuse for ignoring the problem of speed-related serious casualties. Some country-level injury data, no matter how rudimentary, together with some simple measurement of free-flow speeds, can be used as a starting point for better managing speed. At an even more basic level, if there are vulnerable road users being seriously injured by vehicles (regardless of whether data are available or not) there is the need for lowering speeds. In this case, data are preferable but not a necessary prerequisite.

Monitoring and evaluation of any speed management intervention is vital to determine whether it works, to adapt it if necessary, and to provide evidence for continuing support of speed management to policy-makers, key stakeholders and the general public.

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