Speed management in New Zealand: What works and what does not work

Soames Job

Global Road Safety Solutions Pty Ltd

Acknowledgements

This report was written by Soames Job with expert input and data supplied by Section 9(2)(a) and Section 9(2)(a) Waka Kotahi NZ Transport Agency. Peer review was provided by Section 9(2)(a and Section 9(2)(a)

Funding: This work was supported by Waka Kotahi and Auckland Transport. The funders sought an evidence-based commentary on the role of speed in fatal and serious injury crashes, with a particular focus on New Zealand and considering the evidence relating to the many attitudes and beliefs held by members of the community. The funders have not revised the author's findings, allowing independence of analysis and conclusions.

Global Road Safety Solutions Pty Ltd
Published February 2024
ISBN 978-1-99-106875-0 (online)

Contents

Executive summary

Purpose of this report

This report provides evidence to promote road safety and build understanding of road safety issues in relation to speed and speeding for New Zealand. The report does this by highlighting the general applicability to New Zealand of most evidence on speed and speeding based on much that is common to all countries: the universal laws of physics and the features of human vulnerability to physical force and error.

The report draws on practical evidence from around the world and New Zealand to explain the risks of speed and speeding as they apply in New Zealand. It identifies evidence-based actions to save lives and avoid debilitating injuries; provides evidence to help understand and counter misinformation and the psychological errors we make in judging road use risk and speed; informs engagement with the media, stakeholders and communities; and supports decision makers to make evidence-based decisions. The report is a resource for information, understanding and evidence-based solutions.

Evidence-based solutions save lives and have positive economic impacts

The evidence-based solutions identified will save many, many lives and reduce injuries and disabilities. To achieve this, we must change some of our current psychological tendencies as well as our apparently intuitive perspectives on speed and safety, and we must resist the misleading promotion of speed as safe and good for the economy. These messages are often well meant but are misinformed and sometimes driven by vested interests.

We can take heart from the clear scientific evidence (sometimes contrary to common views) that better management of speeds will deliver many less visible benefits as well as safety: reduced greenhouse gas emissions, reduced health harm and health system costs from air and noise pollution, more liveable cities, and improved social equity. The evidence shows the real net economic improvements to be achieved are huge, in addition to the deaths, injuries, disabilities, pain, grief and suffering avoided with lower speeds.

We all (as road safety decision makers and politicians, journalists and commentators, implementers of safety interventions, road system operators and suppliers, and road users) have a role to play is delivering this opportunity for huge improvement for New Zealanders. We can advance road safety by understanding from the evidence in this report and advocating for the following:

- Speed and speeding are major contributors to crash occurrence and crash severity through multiple mechanisms.
- An extensive body of scientific evidence clearly shows that speeding and speed have substantial roles in crash deaths and serious injuries.
- The evidence about speed and speeding exists for and applies in New Zealand. A tragic pattern shows that increasing speeds causes increases in crashes, deaths and suffering, but also shows the opportunity – decreasing speeds reduces crash deaths and suffering.

- The human cost of crashes caused by speed and speeding is personal, often tragic, but also community-wide, profound and avoidable.
- As well as reducing deaths and serious injuries on the roads, improved management of speed will deliver additional benefits that far outweigh the (often over-estimated) dis-benefits.
- We need to understand and address how people's psychological make up means we often don't believe the evidence.
- There are sound proven ways to manage speed and speeding and, thus, to save many lives and reduce injuries each year in New Zealand.

Evidence on speed and speeding

Speed is the "toxin" in crashes. Speed contributes directly to the occurrence of crashes and their severity through the many mechanisms described in this report. Evidence from hundreds of scientific studies and analyses combines to show that reductions in speed generate dramatic reductions in serious crashes, yielding powerful cost-effective opportunities to save lives, avoid injuries, and generate many other social and economic benefits.

Evidence demonstrates the critical role of speed in serious crash occurrence

The real-world research takes various forms, including studies of average speed and serious crash risk, studies of crash impact speed and probability of death, and evaluations of the safety benefits of many interventions that reduce speeds. Across all these approaches the evidence aligns to demonstrate the critical role of speed in serious crash occurrence.

First, for research on average speed and serious crash risk, syntheses combine evidence from many countries and show that each 1 percent decrease in average speed yields about a 4 percent decrease in fatal crashes and around a 3 percent decrease in serious injury crashes.

Second, studies of impact speed show that small changes in impact speed result in large changes in chance of survival. For example, a 2019 study combining research data from multiple countries showed that each 1 km increase in impact speed produced an 11 percent increase in the likelihood of a pedestrian death and a 7 percent increase of serious injury.

Third, evaluations of numerous safety interventions that reduce speeds (including lower speed limits, safety cameras, vehicle technology to reduce speeds, and traffic calming such as gateway treatments, speed humps and raised safety platforms) show powerful crash avoiding, injury-reducing and life-saving outcomes.

Focus on travel time costs of reducing speed without consideration of savings is profoundly misleading

The evidence shows the focus on the travel time costs of reducing speed without consideration of the many savings (reduced crash costs, fuel costs and health costs from air and noise pollution) has been profoundly misleading. Economically ideal speeds are consistently found to be below prevailing speed limits, even without including the benefits of lower speeds for greenhouse gas emissions. Economic analyses show net improvements to economies from lower speeds and show that for speed-reducing actions the total costs of the intervention are more than returned in crash cost savings alone.

Low-level speeding contributes more to serious crashes than extreme speeding

Finally, the evidence also shows that low-level speeding contributes more to serious crashes than extreme speeding because low-level speeding is so common. This is the case even though each case of extreme speeding has a much higher serious crash risk than each case of low-level speeding.

Speed management, including enforcement, must maintain a focus on eradicating low-level speeding as well as high-level speeding.

Speed and speeding in New Zealand

International evidence can be expected to apply in New Zealand

Based on the laws of physics and shared limitations of humanity, the above evidence can be expected to apply in New Zealand. Many studies show directly that it does apply. Examples are presented in this report, including the evidence that various road safety actions that reduce speeds also reduce serious crashes in New Zealand, including gateway treatments, covert safety cameras and reduced speed limits. New Zealand also has the experience that increasing speed limits increases serious crashes.

Around 60 percent of all fatal crashes involve speeding

Evidence-based corrections for the difficulty of identifying speeding in serious crashes (as acknowledged by New Zealand Police as well as police in many other countries) show that around 60 percent of all fatal crashes in New Zealand involve speeding. Avoiding these fatal crashes would have saved around 1920 deaths in the decade 2011 to 2020. In addition, because many speed limits in New Zealand are higher than Safe System levels, unsafe speeds also contribute to crashes even in the absence of speeding.

Economically ideal speeds on highways are below prevailing speed limits

Finally, analyses of the economically ideal speeds on highways in New Zealand consistently show that ideal speeds for the economy are below New Zealand's prevailing speed limits. Including the significant savings that would occur for greenhouse gas emissions, which were not considered in this study, will further reduce the economically ideal speeds.

Actions that work

Actions proven to reduce speeds, and thus to reduce deaths, injuries and crashes, are:

- lower speed limits
- speed enforcement, including safety cameras, especially covert cameras
- general deterrence (created through many actions in addition to enforcement, including effective and unavoidable penalties and public promotion of enforcement)
- graduated licensing systems in which speed is addressed within the constraints placed on novice drivers
- many road engineering measures to reduce speeds such as speed humps, speed cushions, raised platform crossings and raised intersections, lane narrowing, chicanes, gateway treatments and roundabouts
- vehicle technologies such as intelligent speed adaptation, continuous speed monitoring and speed limiting.

Evaluations also show that car-handling skills-based driver training and school-based driver training not only fail to improve safety but may even increase crash rates. The training increases driver over-confidence and thus risk-taking, and enables people to obtain their licences at an age before important brain areas, and thus impulse control, are sufficiently developed.

Actions applicable in New Zealand

Much of the above evidence has been directly tested and shown to apply in New Zealand, including gateway treatments, lower rural and urban speed limits, and safety cameras, especially covert cameras.

Some evidence, such as of particular social campaigns or messages from other countries, will apply only to the extent that parallel social attitudes and beliefs exist in New Zealand and the country in which the messaging succeeded.

Furthermore, some evaluations of on-road changes (such as lower speed limits and the addition of covert safety cameras) in New Zealand provide both the extent of change in average speeds and the extent of change in serious crashes. These studies reveal reductions in deaths and injuries that, for the measured changes in speeds, were larger than those predicted from the global research.

Thus, if New Zealand differs from other countries in relation to the importance of speed and the value of speed-reducing actions, it is that speed is even more important for safety in New Zealand than elsewhere. Possible explanations of this include New Zealand's challenging mountainous typography and many curved roads with unforgiving roadsides such that a speeding run-off-road crash that would be survivable in another country may be less likely to be survivable in New Zealand.

Conclusion – lower travel speeds will deliver an array of benefits

In summary, the practical evidence shows that lower travel speeds in New Zealand will deliver an array of benefits such as:

- major reductions in crash deaths and injuries
- reduced health harm from air and noise pollution
- more liveable cities with greater opportunities for active transport
- improved social equity
- reduced greenhouse gas emissions
- an improved economy.

This report provides evidence to support strategy, policy and implementation.

1 Introduction

An expansive body of scientific evidence exists on road safety, but many people are unaware of it.

1.1 Practically applied evidence can save lives and reduce injuries

Research, data and evidence on road safety can be practically applied to save lives and reduce injuries from road crashes. Large systems allow data from experiences and events to be collected from many millions of hours of real-world driving. Careful analyses of massive data sets and rigorous evaluations **prove** what works to reduce crashes and deaths and what does not. On the other hand, people's personal experiences and those of their friends are not enough to accurately identify the risk factors they face on the road.

Over the last 80 years, the approach to identifying road safety problems and solutions has become increasingly informed by scientific evidence rather than reliance on the feeling that "this should work" informed only by personal experience. Personal experience is important, but it is scientific evidence that informs a true understanding of road safety and how to improve it.

The large body of scientific evidence about road safety, especially for New Zealand, is the basis of this report.

1.2 Deeper issue – humans are prone to bias when judging risk

Approximately 80 percent of New Zealanders aged over 25 have a full driver licence and drive a car or truck or ride a motorcycle. Most people judge risk from personal experience, their observations of others, media coverage of road safety and crashes, conversations with friends, seeing the occasional crash, and, sometimes, data collected and analysed by researchers.

However, people's psychological make-up means they usually consider their experiences and the information they get from around them in ways that are (consciously and unconsciously) biased to outcomes that appear to suit them. This causes many people to misjudge such things as risk and can lead to inaccurate, although seemingly sensible, conclusions. This report describes these psychological biases and the evidence for them occurring and influencing road safety.

1.3 Purpose of this report

This report can be used to promote road safety and build understanding about road safety issues, especially in relation to speed and speeding.[1] It can be used to inform engagement

[1] **Speed** refers simply to the occurrence of movement measures as distance per time, such as kilometres per hour (km/h). Thus, analyses of the role of speed in crashes relate to changes in risk with changes in speed independent of the speed limit. **Speeding** refers to driving (including riding a motorcycle) above the speed limit (including particular driver or vehicle limits) or driving at an inappropriate speed for the conditions. Here, we focus speeding primarily on driving above the speed limit. New Zealand Police notes that the other meaning of speeding is rarely applied, but that other (more serious) charges may be applied in various circumstances.

with the media, stakeholders and communities and support decision makers to make evidence-based decisions.

This report can also be used to address issues and misinformation often raised in opposition to the management of speed, speed limits and speed enforcement. It draws on both international and New Zealand research and evidence.

Road safety can be improved if road users (whether drivers, passengers, or people who walk, cycle and scoot), road safety decision makers, the media and commentators, and implementers of safety interventions have an evidence-based understanding of the road safety impacts of speed and speeding.

Although this report focuses on the numbers, each death and serious injury reflects a human tragedy. The deaths, permanent disabilities, losses, grief and suffering the numbers reflect are avoidable.

Waka Kotahi has a role in accurately and directly informing the community about the impacts of speed and speeding and increasing the evidence base used in public dialogue.

1.3.1 Key messages

Communications to communities and other stakeholders should reinforce the following messages, which are supported by evidence:

- Speed and speeding are major contributors to serious crash outcomes through multiple mechanisms.
- The evidence is clear that speeding and speed have substantial roles in crash deaths and serious injuries.
- The evidence about speed and speeding exists for and applies in New Zealand.
- The human cost of crashes caused by speed and speeding is personal, often tragic, but also community-wide, profound and avoidable.
- There are sound proven ways to manage speed and speeding and, thus, to save many lives and reduce injuries each year in New Zealand.
- As well as reducing deaths and serious injuries on the roads, improved management of speed will deliver additional benefits that far outweigh the (often over-estimated) dis-benefits.
- We need to understand and address how people's psychological make-up means we often don't believe the evidence about speed and safety.

1.3.2 How this report uses the evidence

This report uses the scientific evidence to:

- explain how the belief arose that "speed is good"
- show how speed is important in both crashes occurring and the severity of crashes
- demonstrate the roles of speeding and speed in serious crashes in New Zealand
- show the real, often hidden, costs of speeding and speed in New Zealand
- identify what we can do to greatly reduce the costs of speeding, speed and risks to us all
- consider how personal perspectives, experiences and psychological make-up mean people underestimate the risks of speeding and the importance of speeding and speed in crashes
- indicate optimum speeds that support safety, travel time, emissions and economic benefits for New Zealand
- show the value of road safety changes for broader issues of public health, the environment and climate change.

2 Speed and safety – the evidence

The science of road safety includes a great deal of evidence on speed and its effects on how crashes occur and how serious they are. This evidence comes from many sources, all of which show how important speed (and, thus, speeding) is in serious crashes (internationally and in New Zealand).

The evidence is presented in two broad areas:

- the role of speed in crashes and deaths and serious injuries (discussed in 2.1)
- the effects of managing speed on the economy and other critical public health and global policy issues (discussed in 2.2).

2.1 Role of speed in crashes and deaths and serious injuries

This section explains:

- how speed is fundamental to crash risk and severity, but drivers tend to underestimate its importance (2.1.1)
- the risk of speed for crash occurrence and crash severity (2.1.2)
- why speeding is so important to safety in New Zealand (2.1.3)
- how lower speed limits improve road safety, even though some drivers do not obey the limit (2.1.4).

2.1.1 Speed is fundamental to crash risk and severity, but drivers tend to underestimate its importance

Speed is fundamental to the risk of a crash as well as its severity due to the basic laws of physics. This does not mean speed is the only safety issue – many factors contribute to crash deaths and trauma. However, the evidence demonstrates that speed is one of the most critical factors.

The energy (which must be absorbed, causing the damage) in a crash is determined by the mass (or weight) of the vehicle involved and its speed. Energy is half mass (m) times speed (v) squared (energy = ½m v^2). Therefore, doubling the mass doubles the energy, but doubling the speed does far more than double the energy – it increases the energy exponentially.[2] Speed is the most important single factor in the formula. It affects not only crash severity, but also crash occurrence, because it affects how long the vehicle takes to stop, how easily the vehicle can be manoeuvred, and many other factors (described in this section).

The influence of speed is not intuitive. For example, a car that hits a wall (or tree or other vehicle) travelling at 27 metres per second or around 97km/h (so less than a 100km/h speed limit) exerts a force on the wall equivalent to well over 100 times the car's weight.[3]

---

[2] AZ Jones (2020) The physics of a car collision. ThoughtCo. www.thoughtco.com/what-is-the-physics-of-a-car-collision-2698920 (retrieved February 2022).

[3] T Banas (2020) How to calculate crash forces. Sciencing. https://sciencing.com/calculate-crash-forces-6038611.html (retrieved November 2021).

Drivers generally believe speed has a linear (rather than exponential) relationship with crash risk, and drivers generally underestimate the role of impact speed on their safety[4] as well as generally underestimating braking distances.[5] Perceived risk is an important predictor of drivers' speed preferences,[6] yet drivers commonly judge risk through incorrect cues and do not identify various real risks in the road context.[7]

Despite underestimating the importance of speed, drivers do support more enforcement actions for speeding. Surveys of drivers in New Zealand show majority support for enforcement of low-level speeding and a preference for lower, rather than higher, enforcement thresholds.[8]

Speed contributes to serious crashes in many ways. Speed increases both the risk of a crash as well as its severity. Speed does this through more mechanisms than are generally understood.[9]

Factors by which speed contributes to crash occurrence

Speed contributes to crash occurrence in nine main ways:

1. As speed increases so does the distance the vehicle travels in the time the driver takes to see a problem ahead, judge what to do and react (for example, brake to a stop), because the vehicle is travelling faster for that available time. The vehicle is closer to any problem situation identified even before the driver has judged the need to stop and moved their foot to the brake pedal.
2. Once the brakes are applied, the vehicle takes longer to stop from higher travel speeds.
3. The area of vision shrinks with increasing speed: the driver is less likely to see a hazard in a busy road environment when travelling at a higher speed than at a lower speed simply because the driver has less time to scan the environment on approach, so is more likely to miss hazards.

[4] R Elvik (2010) A restatement of the case for speed limits. *Transport policy* 17(3): 196–204. https://doi.org/10.1016/j.tranpol.2009.12.006

[5] O Svenson (2009) Driving speed changes and subjective estimates of time savings, accident risks and braking. *Applied cognitive psychology* 23(4): 543–560. https://doi.org/10.1002/acp.1471

[6] LM Ahie, SG Charlton & NJ Starkey (2015) The role of preference in speed choice. *Transportation research part F: Traffic psychology and behaviour* 30, 66–73. https://doi.org/10.1016/j.trf.2015.02.007; SG Charlton & NJ Starkey (2017) Driving on urban roads: How we come to expect the "correct" speed. *Accident analysis & prevention* 108: 251–260. https://doi.org/10.1016/j.aap.2017.09.010

[7] SG Charlton, NJ Starkey, JA Perrone & RB Isler (2014) What's the risk? A comparison of actual and perceived driving risk. *Transportation research part f: Traffic psychology and behaviour* 25(part A): 50–64. https://doi.org/10.1016/j.trf.2014.05.003; S Turner, J Khoo & J England (2014) How drivers judge the safety of the road. In *Proceedings of the 2014 Australasian road safety research, policing & education conference*. Melbourne, Australia. http://acrs.org.au/files/arsrpe/full-paper_2117.pdf

[8] For a summary of these surveys, see New Zealand Police (2020) *Speed evidence review*. Wellington: National Road Policing Centre.

[9] RF Job & C Brodie (2022) Understanding the role of speeding and speed in serious crash trauma: A case study of New Zealand. *Journal of road safety* 33(1): 5–25. https://doi.org/10.33492/JRS-D-21-00069

4. Drivers are less inclined to stop and give way when they are travelling at higher speeds due to increased braking and then the acceleration afterwards required to return to their original speed. Research shows a linear relationship between driver approach speed and failing to yield to pedestrians at an unsignalised pedestrian crossing: at 32km/h,[10] 75 percent of drivers yield to pedestrians, but with an increase in speed of just 16km/h, only 40 percent of drivers yield.[11]
5. At night, even moderate speed in a moderately lit urban environment can mean the vehicle is travelling at a speed that results in combined judgement, reaction time and stopping distance that make it impossible to stop within the distance illuminated by the headlights. A crash with a pedestrian or hazard on the road may be unavoidable by the time the risk is visible unless speeds are lower.[12]
6. At a higher speed, the driver is less able to manoeuvre and stay in control of the vehicle to get around a problem and avoid a crash than at a lower speed.
7. At a higher speed, the vehicle is less able to negotiate a curve or corner than at a lower speed without the driver losing control and running off the road or crossing to the wrong side of the road, risking a head-on crash. This is not a rare form of head-on crash on rural roads, with international studies of head-on crashes showing curves are associated with more head-on crashes than straight sections of road[13] and head-on crashes are mostly **not** associated with overtaking (which is involved in less than 8 percent of head-on crashes even on rural roads), with these crashes more commonly caused by driving too fast for the conditions.[14] The figure is similar for New Zealand with only 7 percent of head-on fatal and serious injury crashes involving overtaking.[15]
8. Based on the topography of the road, higher speeds reduce the time from when a risk becomes visible to the driver to when evasive action is required. For example, the speed limit may be low because of curves limiting vision for intersections or junctions just beyond the curve. Therefore, the speed limit is set to allow enough time for entering or crossing vehicles (or pedestrians) to do so safely (that is, in the time they have before a vehicle that is just out of view behind the curve would reach them) and enough time for a vehicle travelling along the road with the curve to see, judge and stop. However, a speeding vehicle can reach the intersection too quickly, causing a crash. The same logic applies to other road features such as crests of hills that limit vision ahead.

---

[10] We have converted research findings in miles per hour (mph) to kilometres per hour (km/h) throughout this paper. In the research, these numbers were 20mph and a 10mph increase.

[11] T Bertulis & DM Dulaski (2014) Driver approach speed and its impact on driver yielding to pedestrian behaviour at unsignalized crosswalks. *Transportation research record* 2464(1): 46–51.

[12] For example, see RH Grzebieta (2019) Safe speed limits, Trauma Week 2019 symposium *Pedestrians: Staying safe*, Royal Australasian College Surgeons, 13 February, Melbourne, Australia. www.surgeons.org/-/media/Project/RACS/surgeons-org/files/trauma-verification/17-r-grzebieta-safe-speed-limits.pdf?rev=be72114dc4ef45689dc3ffa5ede40052&hash=3994BB422E7973A805FBA4C7C061D479

[13] M Hosseinpour, AS Yahaya & AF Sadullah (2014) Exploring the effects of roadway characteristics on the frequency and severity of head-on crashes: Case studies from Malaysian Federal Roads. *Accident analysis & prevention* 62: 209–222.

[14] P Gårder (2006) Segment characteristics and severity of head-on crashes on two-lane rural highways in Maine. *Accident analysis & prevention* 38(4): 652–661.

[15] Waka Kotahi NZ Transport Agency (2011) *High-risk rural roads guide*. Wellington: Waka Kotahi NZ Transport Agency. www.nzta.govt.nz/resources/high-risk-rural-roads-guide/

9. Even if an approaching vehicle is in view, other road users may reasonably expect it to take a certain time to reach them at the prevailing speed limit allowing them time to cross, yet a speeding vehicle may reach them sooner. This is especially true for older pedestrians who tend to (mis)judge a safe crossing gap by the distance to the approaching vehicle more than the speed of the vehicle.[16]

Factors by which speed contributes to crash severity

Speed contributes to crash severity in four main ways:

1. The higher the speed, the higher the energy, so the greater the forces in a crash. Higher speeds deliver exponentially more energy into the crash than lower speeds.[17] For example, when impact speed increases from 30km/h to 50km/h (a 67 percent increase), the energy increases 178 percent.
2. Safety features such as crash barriers are designed, located and built to provide protection up to the speed limit,[18] but may become ineffective if hit at speeds over the limit. Thus, as speed increases, road safety features such as crash barriers, median strips and impact attenuators[19] that are designed to manage crash forces or prevent the vehicle from being in a more severe crash (for example, from going over a cliff or into oncoming traffic) are less effective. It is no simple matter to build all barriers, median strips and so on to withstand high speeds: the cost of doing so may reduce the funds available for other road safety work or installation may not be possible within the space available on many roads.
3. As speed increases, active vehicle safety features such as autonomous braking are less able to stop the vehicle in time to avoid a crash or to reduce speed to safer levels of impact by the time the impact occurs.
4. As speed increases, the passive protective features of vehicles are increasingly likely to fail in a crash: the integrity of the vehicle body may fail, leaving little survival room and crushing the occupants, and restraint systems (that is, airbags and seat belts) may be unable to minimise higher levels of force sufficiently to avoid severe injury or death.

---

[16] RFS Job, J Haynes, T Prabhakar, SHV Lee & J Quach (1998) Pedestrians at traffic light controlled intersections: Crossing behaviour in the elderly and non-elderly. In K Smith, BG Aitken & RH Grzebieta (eds), *Proceedings of the Conference on Pedestrian Safety* (pp 3–11). Canberra: Australian College of Road Safety & Federal Office of Road Safety.

[17] IIHS (2021) *Speed*. Insurance Institute for Highway Safety. www.iihs.org/topics/speed

[18] Waka Kotahi NZ Transport Agency (2021) Appendix A: Permanent road safety hardware & devices. Wellington: Waka Kotahi NZ Transport Agency. www.nzta.govt.nz/assets/resources/road-safety-barrier-systems/docs/m23-road-safety-barrier-systems-appendix-a.pdf

[19] Impact attenuators (such as crash cushions, and barrier end treatments) are designed to absorb the colliding vehicle's kinetic energy to reduce crash severity.

Summary – consequences of a change in travelling speed

The consequences of several of the above factors are highlighted in an Austroads report and summarised in figure 1.[20]

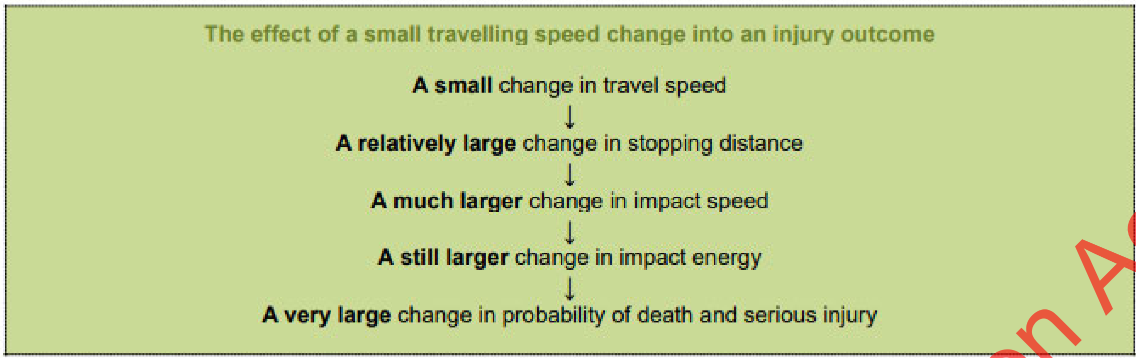

Figure 1 – Consequences for injury of a small change in travel speed. Source: Austroads (2018).

2.1.2 Types of evidence that provide the strongest proof of the importance of speed in crash risk

With all of the above factors adding to risk as speed increases, it is hardly surprising that the scientific evidence shows speed to have a profound role in road crashes, especially in serious crashes. There are many hundreds of scientific studies of the effects of speed on road safety, and many syntheses and analyses that combine results from many studies (combined analyses are often called meta-analyses). Combined analyses select research studies for their scientific thoroughness and combine the data from those studies to produce the most representative real-world evidence.

Three types of evidence provide the strongest proof of the importance of speed in crash risk: detailed analyses of crash impact speeds, scientific studies of the effects of changing the average speed of travel, and evaluations of different speed-reducing interventions. These are described next.

Detailed analyses of crash impact speeds

The first type of evidence is from detailed analyses of crash impact speeds[21] and consequences in real-world crashes. Many studies and several combined analyses of the probability of death for different impact speeds have been undertaken. These all show a dramatic effect of impact speed on severity. For example, the most recent combined analysis for pedestrian crashes found that **each 1km increase in impact speed produced an 11 percent increase in the likelihood of a pedestrian death and a 7 percent increase of serious injury**.[22]

[20] Austroads (2018) *Towards safe system infrastructure: A compendium of current knowledge* (research report AP-R560-18). Sydney: Austroads.

[21] **Impact speed** refers to the speed of the vehicle (relative to the person or object struck) at the instant of collision.

[22] Q Hussain, H Feng, R Grzebieta, T Brijs & J Olivier (2019) The relationship between impact speed and the probability of pedestrian fatality during a vehicle-pedestrian crash: A systematic review and meta-analysis. *Accident analysis & prevention* 129: 241–249.

Broad relationships have been observed in these studies, which indicate that the likelihood of death for different impact speeds and crash types increases exponentially above speeds that are relatively low in relation to New Zealand's default speed limits. The common crash types analysed are typically pedestrian crashes, crashes into rigid objects, side-impact crashes and head-on crashes.[23, 24] The most recent analyses (from 2016 and 2019) have similar findings and indicate that the speeds of impact at which more than 10 percent of pedestrians will die are those above 30km/h.[25] Other studies have shown that the speeds at which more than 10 percent of pedestrians will be seriously injured are even lower than 30km/h, from around 20km/h.[26]

Scientific studies of the effects of changing the average speed of travel

The second type of evidence comes from many scientific studies of the effects of changing the average speed of travel (not impact speeds) on the number of deaths, injuries and crashes that occur. Combined analyses of the best scientific studies allow more reliable identification of the speed–safety relationships across a large range of speeds and countries.

Figure 2 shows the relationship between changes in speed and fatal, serious injury and all injury crashes, based on combined analyses of international studies.[27] More recent re-analyses validate these fundamental influences of speed on safety.[28, 29, 30, 31] Changes in speed have even greater impacts on higher severity crash outcomes with very small changes in speed having dramatic impacts on average fatal occurrence: **each 1 percent decrease in speed yields about a 4 percent decrease in fatal crashes**.

[23] WHO (2008) *Speed management: A road safety manual for decision makers.* Geneva, Switzerland: World Health Organization & Global Road Safety Partnership.

[24] OECD (2006) *Speed management* (report of the Transport Research Centre). Paris: OECD and European Conference of Ministers of Transport. http://documents1.worldbank.org/curated/en/298381607502750479/pdf/Road-Crash-Trauma-Climate-Change-Pollution-and-the-Total-Costs-of-Speed-Six-graphs-that-tell-the-story.pdf

[25] Q Hussain, H Feng, R Grzebieta, T Brijs & J Olivier (2019) The relationship between impact speed and the probability of pedestrian fatality during a vehicle-pedestrian crash: A systematic review and meta-analysis. *Accident analysis & prevention* 129: 241–249.

[26] C Jurewicz, A Sobhani, J Woolley, J Dutschke & B Corben (2016) Exploration of vehicle impact speed: Injury severity relationships for application in safer road design. *Transportation research procedia* 14: 4247–4256.

[27] G Nilsson (2004) *Traffic safety dimension and the Power Model to describe the effect of speed on Safety*. Sweden: Lund Institute of Technology.

[28] R Elvik, A Høye, T Vaa & M Sørensen (eds) (2009) *The handbook of road safety measures*. Bingley, UK: Emerald Group.

[29] R Elvik (2010) A restatement of the case for speed limits. *Transport policy* 17(3): 196–204. https://doi.org/10.1016/j.tranpol.2009.12.006

[30] R Elvik (2013) A re-parameterisation of the power model of the relationship between the speed of traffic and the number of accidents and accident victims. *Accident analysis & prevention* 50: 854–860.

[31] R Elvik, A Vadeby, T Hels & I van Shagen (2019) Updated estimates of the relationship between speed and road safety at the aggregate and individual levels. *Accident analysis & prevention* 123: 114–122.

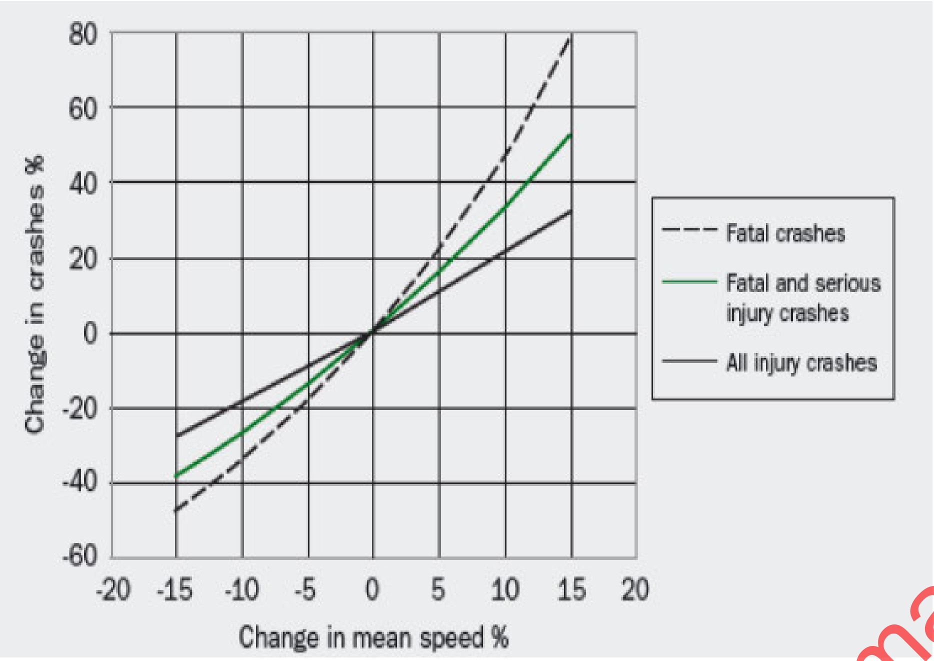

Figure 2 – Relationship between changes in speed, fatal, fatal and serious injury, and all injury crashes. Source: Nilsson (2004).

These speed–fatality risk relationships have led to internationally accepted Safe System survivable speed thresholds, which are described in section 3 (Safe System and speed), in particular table 2 (target Safe System speed by road type).

There are two reasons why the graph for impact speed with pedestrians indicates an even more powerful effect of speed than the graph for average speed and fatal crashes:

- Average speeds are not the same as crash impact speeds because the driver may (or may not) manage to slow down before the crash occurs, so more factors are involved (such as inattention or impairment) to complicate the relationships with crash risk.
- While differences or changes in average speeds are a good guide to crash risk (for the same road and usage conditions), these averages are made up of various speeds that can influence crash risk differently.

Evaluations of different speed-reducing interventions

The third type of evidence comes from evaluations of different speed-reducing interventions. These evaluations show the importance of speed by illustrating that the many different ways to reduce speeds (safety cameras, road engineering such as speed humps or gateway treatments,[32] and vehicle-based technologies such as speed limiting or intelligent speed adaptation) all deliver impressive reductions in serious crashes. Individual studies and scientific reviews of the results show powerful benefits.[33, 34, 35]

Studies of this type have also been undertaken in New Zealand, and they too show the importance of speed. Four New Zealand examples are as follows.

- Example 1: An evaluation of gateway treatments designed to slow traffic entering urban areas found a 23% reduction in serious outcome crashes due to the gateways.[36]
- Example 2: An evaluation of the impact of adding covert (not visibly marked) mobile safety cameras to existing enforcement measures found an area-wide 1.6 percent net reduction in speed produced a net 19 percent reduction in casualties (injuries and deaths). At camera enforcement locations, a 3.2 percent net reduction in speed resulted in a 29 percent reduction in casualties.[37]
- Example 3: Traffic-activated variable speed limit signs that reduced the speed limit at 10 intersections were implemented. Traffic on side roads joining main roads was electronically detected on approach, and the variable speed limit signs on the main road were activated to reduce the speed limit to 70km/h. An evaluation found this intervention reduced speeds by around 7–9km/h on average with a dramatic reduction in crash trauma: net fatal and serious injury crashes reduced by 79 percent and total crashes by 51 percent compared with crashes at untreated control locations.[38]
- Example 4: Many changes in speed limits have also occurred, which present natural experiments in the importance of speed limits. A detailed evaluation of two substantial changes considered the changes in speed as well as changes in deaths and injuries. This evaluation also controlled for other changes in safety policy that applied across all roads

[32] **Gateway treatments** are signs combined with other measures (such as physical or painted lane narrowing, raised platforms or rumble strips) to create a highly visible threshold (or "gateway") between high and low speed environments.

[33] B Turner, S Job & S Mitra (2021) *Guide for road safety interventions: Evidence of what works and what does not work.* Washington, DC: World Bank. www.roadsafetyfacility.org/publications/guide-road-safety-interventions-evidence-what-works-and-what-does-not-work

[34] C Wilson, C Willis, JK Hendrikz, R Le Brocque & N Bellamy (2010) Speed cameras for the prevention of road traffic injuries and deaths. *Cochrane database of systematic reviews* (11): CD004607. https://doi.org/10.1002/14651858.CD004607.pub4

[35] UNECE (2021) UN vehicle regulation will increase road safety thanks to "Black-box" collecting information on crashes (press release, 15 October). United Nations Economic Commission for Europe. https://unece.org/media/press/361071

[36] T Makwasha & B Turner (2013) Evaluating the use of rural-urban gateway treatments in New Zealand. *Journal of the Australasian College of Road Safety* 24(4): 14–20.

[37] MD Keall, LJ Povey & WJ Frith (2001) The relative effectiveness of a hidden versus a visible speed camera programme. *Accident analysis & prevention* 33*:* 277–284. www.sciencedirect.com/science/journal/00014575

[38] H Mackie, C Brodie, R Scott, L Hirsch, F Tate, M Russell & K Holst (2017) The signs they are a-changin': Development and evaluation of New Zealand's rural intersection active warning system. *Journal of the Australasian College of Road Safety* 28(3): 11–21.

in New Zealand, by using urban areas where speed limits were not changed as the control group.[39] The evaluation found the following:[40]

- The large national increase in speed limits in 1985 from 80km/h to 100km/h was accompanied by a notable increase in fatalities and injuries on rural roads compared with urban roads.
- The broad reduction in the rural speed limit (from 55mph (88km/h) and in some cases 60mph (97km/h) to 50mph (80km/h)) to save fuel in response to an oil crisis in 1973 was accompanied by a notable reduction in fatalities and injuries on rural roads compared with urban roads.

Because examples 2 and 3 (as well as 4, although it is older) included measures of changes in speed as well as changes in serious crashes, they allow us to assess the power of speed reductions in New Zealand. These examples all found reductions in deaths and injuries that, for the measured changes in speeds, were larger than predicted from the global research. Thus, if New Zealand differs from other countries in relation to the importance of speed, it is that speed is even more important for safety in New Zealand than elsewhere.

Two possible explanations exist for the greater sensitivity to speed in New Zealand. First, New Zealand has a slightly older vehicle fleet than other countries in which most research is conducted.[41] Second, New Zealand has challenging typography with many narrow, curved roads with unforgiving roadsides that may make crashes more likely to be severe, so a speeding crash that would be survivable in another country is not survivable in New Zealand.

2.1.3 Why speeding is so important to safety in New Zealand

New Zealand's crash data identify speeding as a factor in only about 30 percent of crashes, which we know to be an underestimate. Even at 30 percent, a huge cost is incurred, with many hundreds of New Zealanders killed and many more seriously injured each decade.

New Zealand Police agrees that 30 percent is likely an underestimate because in many crashes police cannot determine whether speeding was involved. This determination is extremely difficult. Imagine arriving at the scene of a pedestrian fatality, where the driver is the only person who knows what happened. That driver may not admit they were speeding and may blame the pedestrian by claiming they rushed out and the driver did not have time to stop. Unless there are skid marks or witnesses, determining whether the crash involved speeding is difficult. The same is true for single vehicle run-off road crashes on rural roads and many other crashes.

---

[39] This is an important control and quite likely means the resulting estimate of the impacts of speed changes on serious crashes is conservative, because some associated policies would have benefited urban safety more than rural safety such as car-free days, which were also introduced to manage the oil crisis (but regarded as largely unsuccessful and abandoned less than a year later). See J Polkinghorne (2014) New Zealand and the 1970s oil shocks: More than just "carless days". Greater Auckland (3 January). www.greaterauckland.org.nz/2014/01/03/new-zealand-and-the-1970s-oil-shocks/

[40] G Koorey & WB Frith (2017) Changing rural speed limits: Learning from the past. IPENZ Transportation Group Conference, Hamilton, 29–31 March.

[41] RF Job & C Brodie (2022) Understanding the role of speeding and speed in serious crash trauma: A case study of New Zealand. *Journal of road safety* 33(1): 5–25. https://doi.org/10.33492/JRS-D-21-00069

Fortunately, there is a scientific way to adjust for the likely number of missing speeding-involved fatal crashes. Overseas studies have compared police estimates of speeding involvement with better evidence to determine the real involvement of speeding. This better evidence comes from in-depth crash investigations, crash reconstructions and modern vehicle event recorder systems (the equivalent of a flight recorder "black box"). If these "correction" factors are applied to New Zealand data, speeding is more likely to be involved in around 60 percent of fatal crashes in New Zealand,[42] which means that for the decade 2011 to 2020 around 1920 people died in speeding-related crashes in New Zealand.

2.1.4 Lower speed limits improve road safety even if not all drivers obey them

Lowering speed limits saves lives and reduces injuries. While some drivers speed, most New Zealand drivers generally try to adhere to speed limits. On-road speed surveys in New Zealand show most speeds are at or below the speed limit[43] and evaluations of speed limit reductions in New Zealand show that speeds and serious crashes are reduced (see details below).

Even drivers who speed tend to be influenced by limits, in particular those who sometimes drive several kilometres per hour above the limit. Even just a few kilometres per hour above the limit is speeding and adds to serious crash risk. But lowering speed limits lowers the speeds of this type of speeder as well. (The evidence on the effects of speed management on this type of speeding is considered in 4.4.)

The evidence for the safety benefits of lowering speed limits is irrefutable: if drivers slow down, large safety benefits are delivered. Evaluations show strong safety improvements in Australia, for example.[44, 45, 46, 47] As an example of the importance of speed limits, in the US an increase of 8km/h (5mph) in the maximum state speed limit led to 33,000 more deaths in crashes during 1995 to 2013,[48] and this would be many thousands more since 2013.

The evidence is also strong in New Zealand, as three examples (covering many locations) show. First, before and after evaluations of speed limit reductions in Auckland from 50km/h to 40km/h or 30km/h and from 100km/h to 80km/h both showed significant reductions in deaths.[49]

---

[42] RF Job & C Brodie (2022) Understanding the role of speeding and speed in serious crash trauma: A case study of New Zealand. *Journal of road safety* 33(1): 5–25. https://doi.org/10.33492/JRS-D-21-00069

[43] Ministry of Transport (2015) *Speed Survey Results 2015*. Wellington: Ministry of Transport www.transport.govt.nz/assets/Uploads/Report/Speed-survey-results-2015.pdf

[44] Y Bhatnagar, D Saffron, M De Roos & A Graham (2010) Changes to speed limits and crash outcome: Great Western Highway case study. In *Proceedings of the Australasian road safety research, policing and education conference* (vol 14). Monash University.

[45] CM Kloeden, JE Woolley & AJ McLean (2007) A follow-up evaluation of the 50km/h default urban speed limit in South Australia. In *Proceedings of the Road Safety Research, Education and Policing conference*, Melbourne, Australia, 17–19 October.

[46] J Mackenzie, T Hutchinson & C Kloeden (2015) Reduction of speed limit from 110 km/h to 100 km/h on certain roads in South Australia: A follow up evaluation (CASR report 115). Centre for Automotive Research, University of Adelaide.

[47] J Sliogeris (1992) *110 kilometre per hour speed limit: Evaluation of road safety effects*. Victoria, Australia: VicRoads.

[48] CM Farmer (2017) Relationship of traffic fatality rates to maximum state speed limits. *Traffic injury prevention* 18(4): 375–380.

[49] Abley (2022) *Safe Speeds phase 1: 24 month interim evaluation*. Auckland: Abley. https://at.govt.nz/media/1990901/aukland-transport-report-24-month-safe-speeds-tranche-1-monitoring.pdf

Second, an evaluation of the changes in fatal and injury crashes at three locations where speed limits were reduced compared these locations with control locations where speed limits remained the same. This evaluation found clear and significant reductions in travel speeds and in serious crashes at the sections with reduced speed limits compared with the control sections.[50]

Third, the evaluation described above of traffic-activated reduced speed limits at intersections in New Zealand resulted in reduced speeds, 79 percent fewer deaths and 51 percent fewer crashes.[51]

2.2 Effects of managing speed on the economy and other critical public health and global policy issues

This section identifies:

- lower speeds typically improve the economy (2.2.1)
- time lost through lower speed driving is overestimated (2.2.2)
- lower speed limits can help with fuel efficiency and reduce air pollution (2.2.3)
- lower speeds can help with congestion (2.2.4)
- why, if speed is so important to road safety, Germany's road safety record is good despite some unlimited speeds on its federal motorway system (2.2.5).

2.2.1 Lower speeds typically improve the economy

New Zealanders do not sacrifice human life for economic gain in other spheres, yet we set speed limits that mean a momentary lapse of focus or a misjudgement can be paid for with death or serious injury.[52]

Even if we were to accept that road deaths associated with faster speeds is a cost for economic gain, there is no evidence such a gain exists. Higher speeds cause many hidden costs, yet commentaries on speed tend to focus on travel time as the sole economic factor. Lower speeds save many costs and the sole focus on travel time is profoundly misleading. The hidden savings of lower speed include reducing the high economic cost of crashes and trauma (on top of grief, pain and suffering), reducing vehicle maintenance costs, reducing fuel use, and reducing the following three significant harmful effects on health.

First, lower speeds generate less road noise, and noise (especially road noise) is directly linked to a large array of life and health effects: reduced life quality, more stress, less effective sleep, impaired learning in children, hypertension, cardiovascular disease, diabetes

---

[50] F Tate (2022) *The impact of change in speed limit at three sites* (project 5-C4024.00). New Zealand: WSP.

[51] H Mackie, C Brodie, R Scott, L Hirsch, F Tate, M Russell & K Holst (2017) The signs they are a-changin': Development and evaluation of New Zealand's rural intersection active warning system. *Journal of the Australasian College of Road Safety* 28(3): 11–21. The authors conclude that these safety gains are larger than expected based on the speed reductions. This may indicate some other mechanism of improvement on top of the speed reductions, although there is no evidence for this. The large reductions may also reflect a heightened importance of speed reductions at intersections.

[52] People make mistakes, so we should calibrate the speed limit to the risk of the road to stop unnecessary deaths and serious injuries.

and death.[53] A 2022 study found that children exposed to more environmental noise had a smaller brain cortex than other children.[54]

Second, higher speeds produce more air pollution, which causes many harmful effects on health, including decreased lung function, cardiovascular disease, increased use of health care services and death.[55]

The harmful health effects, including death, of noise and air pollution are documented and recognised by the World Health Organization.[56]

Third, higher speeds create a barrier to people using active transport in cities, contributing to the obesity and cardiovascular disease epidemics through reduced walking and increased pollution from more vehicle motors. All these effects generate huge costs for New Zealand (noting that some are not readily separated from other costs for analysis).

Finally, higher speeds generate more greenhouse gas emissions, contributing to climate change. For New Zealand, domestic transport is the largest single source of greenhouse gas emissions, contributing 48 percent of total carbon dioxide (CO_2) emissions and even more of nitrous emissions. Energy production contributes only 16 percent of greenhouse gas emissions in New Zealand. New Zealand has committed to reducing greenhouse gas emissions by 50 percent by 2030. This cannot be achieved without greatly reducing emissions from domestic transport, and the timeframe is not sufficient to achieve this by changing the vehicle fleet.

Studies reveal that economically ideal speeds are lower than prevailing speed limits and still sacrifice human life for economic gains.[57]

---

[53] For example: W Babisch (2006) Transportation noise and cardiovascular risk: Updated review and synthesis of epidemiological studies indicate that the evidence has increased. *Noise and health* 8(30): 1; T Bodin, M Albin, J Ardö, E Stroh, PO Östergren & J Björk (2009) Road traffic noise and hypertension: Results from a cross-sectional public health survey in southern Sweden. *Environmental health* 8(1): 1–10; C Clark, H Sbihi, L Tamburic, M Brauer, LD Frank, & HW Davies (2017) Association of long-term exposure to transportation noise and traffic-related air pollution with the incidence of diabetes: A prospective cohort study. *Environmental health perspectives* 125(8): 087025; MM Haines, SA Stansfeld, RFS Job, B Berglund & J Head, J (2001) A follow-up study of the effects of chronic aircraft noise exposure on child stress responses and cognition. *International journal of epidemiology* 30: 839–845; MM Haines, SA Stansfeld, RFS Job, B Berglund, & J Head (2001) Chronic aircraft noise exposure, stress responses mental health and cognitive performance in school children. *Psychological medicine* 31: 265–277; RFS Job (1988) Community response to noise: A review of factors influencing the relationship between noise exposure and reaction. *Journal of the Acoustical Society of America* 83: 991–1001; RFS Job (1996) The influence of subjective reactions to noise on health effects of the noise. *Environment international* 22: 93–104; M Klatte, K Bergström & T Lachmann (2013) Does noise affect learning? A short review on noise effects on cognitive performance in children. *Frontiers in psychology* 4: 578; T Münzel, M Sørensen & A Daiber (2021) Transportation noise pollution and cardiovascular disease. *Nature reviews cardiology* 18(9): 619–636; S Ohlwein, F Hennig, S Lucht, C Matthiessen, N Pundt, S Moebus, K-H Jöckel & B Hoffmann (2019) Indoor and outdoor road traffic noise and incident diabetes mellitus: Results from a longitudinal German cohort study. *Environmental epidemiology* 3(1).

[54] KR Simon, EC Merz, X He & KG Noble (2022) Environmental noise, brain structure, and language development in children. *Brain and Language* 229*:* 105–112. https://doi.org/10.1016/j.bandl.2022.105112

[55] JO Anderson, JG Thundiyil & A Stolbach (2012) Clearing the air: A review of the effects of particulate matter air pollution on human health. *Journal of medical toxicology* 8(2): 166–175; CA Pope III, N Coleman, ZA Pond, & RT Burnett (2020) Fine particulate air pollution and human mortality: 25+ years of cohort studies. *Environmental research* 183: 108924.

[56] WHO (2011) *Burden of disease from environmental noise: Quantification of healthy life years lost in Europe*. Geneva, Switzerland: World Health Organization. Regional Office for Europe; MP Neira (2019) Air pollution and human health: A comment from the World Health Organization. *Annals of global health* 85(1).

[57] MD Hosseinlou, SA Kheyrabadi & A Zolfaghari (2015) Determining optimal speed limits in traffic networks. *International Association of Traffic and Safety Sciences* 39(1): 36–41; M Cameron (2003) *Potential benefits and costs of speed changes on rural roads* (report CR216). Victoria, Australia: Monash University Accident Research Centre; M Cameron (2012) Optimum speeds on rural roads based on “willingness to pay” values of road trauma. *Journal of the Australasian College of Road Safety* 23(3): 67–74.

Study of economically optimum speeds for New Zealand: Analyses of the costs and benefits of different speeds have been undertaken for New Zealand for various types of rural state highway.[58] Analyses estimate the economically optimum cruise speed, considering costs and benefits of various speeds. Costs or benefits include crash frequencies and costs; travel time costs, including costs for the freight industry; vehicle operating costs and air pollution costs. As shown in table 1, the economically optimum cruise speed for heavy vehicles on rural state highways is 70km/h, except on motorway-standard roads, where it is 80km/h. For light vehicles on motorways, the economically optimum cruise speed is 105km/h, and on all other roads studied varies from 70km/h to 85km/h.

Table 1 – Economically optimum cruise speeds for non-urban roads in New Zealand

Road category	Light vehicles (cars & light commercial vehicles) (km/h)	Heavy vehicles (medium & heavy commercial vehicles) (km/h)
1. Motorways/expressways (divided four-lane) roads	105	80
2. High-volume national strategic roads	85	70
3. Straight national & regional strategic roads	80	70
4. Winding national & regional strategic roads	75	70
5. Straight regional connectors & distributors	80	70
6. Winding regional connectors & distributors	70	70

Source: Cameron (2022).

These calculations are likely to overestimate economically optimum cruise speeds. Some emissions (considered from the perspective of air pollution) were valued at only 1 percent of their urban cost because of their low impact in rural areas. Thus, pollution costs were regarded as minimal. This work was commissioned and written in 2012, when climate change was not a global or New Zealand focus, so the report does not consider or even mention climate change. However, with the substantially increased focus on climate change and awareness of its costs combined with the deep appreciation of the large (the largest) contribution of domestic transport to greenhouse gases by New Zealand, this is a significant omission of costs of higher speeds. If these costs were included, economically optimum cruise speeds would be lower (to an extent that requires analysis to determine). Similarly, higher fuel prices may also reduce economically optimum cruise speeds. Therefore, the speeds in table 1 are overestimated for current conditions.

[58] M Cameron (2022) *Economic analysis of optimum speeds on rural state highways in New Zealand*. Wellington: Waka Kotahi NZ Transport Agency.

2.2.2 Time lost through lower speed driving is overestimated

It is easy to overestimate the effects of lower speed limits on travel time. For example, if I travel for 10km on 60km/h speed limit roads and these change to 50km/h limits, I might estimate the extra time by simply calculating the difference in time travelling continuously at 50km/h and travelling continuously at 60km/h, which would be 2 minutes. However, for most such journeys this is unrealistic. In reality, during the journey we will slow and stop for lights or stop signs, slow down to give way, be slowed by other cars and trucks often in lines of traffic stopped or slowed at intersections, slow down for turns at intersections, give way to pedestrians at crossings and so on. Thus, we will spend quite a bit of our time travelling at speeds below 50km/h regardless of the speed limit, so for all that time, the speed limit will make no difference to our travel time. The practical change in travel time for most such journeys is small.[59]

For the effects of lower speeds on congestion, see 2.2.4.

2.2.3 Lower speed limits can help with fuel efficiency and reduce air pollution

Ideal speeds for fuel consumption in cars are determined in rigorously smooth and steady speed driving conditions – not real-world conditions. These "ideal" speeds may give some guide to the best speed for fuel consumption on long, flat, even roads with no other traffic causing slowing and accelerating. However, in cities with stop–start and slow-then-accelerate traffic, ideal speeds are very different. Often the difference between a 50km/h and a 30km/h limit is only the speed to which the car accelerates before quite soon afterwards slowing or stopping for the next intersection, line of traffic or pedestrian crossing. Accelerating up to 50km/h instead of 30km/h before slowing or stopping again saves little, if any, time, but costs fuel and wear and tear on brakes, as well as producing more noise and air pollution. Thus, lowering urban speed limits from 50km/h to 30km/h reduced emissions by 25%,[60] and analyses show that many lives would be saved through reduced air pollution if urban speeds are lowered to 32km/h (20mph) in addition to savings of crash deaths and serious injuries.[61]

2.2.4 Lower speeds can help with congestion

Many people assume a decrease in the speed limit will worsen traffic congestion.[62] The reality is quite different: it either has little impact or it reduces the extent of congestion. To

---

[59] C Jurewicz (2010) *Impact of lower speed limits for road safety on network operations* (No. AP-T143/10). Melbourne: Austroads.

[60] M Madireddy, B De Coensel, A Can, B Degraeuwe, B Beusen, I De Vlieger & D Botteldooren (2011). Assessment of the impact of speed limit reduction and traffic signal coordination on vehicle emissions using an integrated approach. *Transportation research part D: transport and environment* 16(7): 504–508.

[61] SJ Jones & H Brunt (2017) Twenty miles per hour speed limits: A sustainable solution to public health problems in Wales. *Journal of Epidemiology and Community Health* 71(7), 699–706.

[62] This is acknowledged in the media sometimes with helpful information to counter this view; for example, in *The Guardian* – A Jha (2005) How do speed cameras cause traffic jams? *The Guardian* (17 March). www.theguardian.com/science/2005/mar/17/thisweeksciencequestions2 – and in *The Conversation* – R Llewellyn (2018) Increasing the speed limit won't get traffic moving faster. *The Conversation* (6 October). https://theconversation.com/increasing-the-speed-limit-wont-get-traffic-moving-faster-104365

see what happens, we consider two situations: the speed limit is above the speed of the traffic (that is, there may be congestion) and the speed limit is equal to the traffic speed.

If the speed limit is higher than the traffic speed, lowering it makes no material difference to congestion

If the speed of the traffic is below the old and the new (reduced) speed limit (likely caused by congestion), then lowering the speed limit makes no material difference to travel speed. For example, if the traffic speed in a congested area is 25km/h, then changing the speed limit from 50km/h to 30km/h will not reduce the congestion nor will it make the congestion worse.

The question then becomes, what is the point of lowering the speed limit? There are two reasons. First, in congestion, drivers may accelerate up to the speed limit before stopping at the next point of congestion or joining a slow-moving line of traffic. No or very little time is saved, but the higher the maximum speed, the greater acceleration and the more braking required, which all add to crash risk and severity, as well as noise pollution, air pollution and greenhouse gas emissions. Second, further benefits of lower maximum speeds arise from better management of speed at the times of day when the roads are not congested.

If the speed limit is the same as the traffic speed, either more vehicles will get through a congestion point if speeds are lower or there will be very little effect

If the speed limit is at or below the traffic speed (which means the area is not particularly congested), then the complex relationship between speed and vehicle throughput becomes relevant for changes in speed. At low levels, as speeds increase, the traffic flow initially improves slightly but with further increases in speed, the reverse effect occurs – the traffic flow through a specific location (such as an intersection) reduces.

The reason for this is as follows. Advice on driving gaps says at 30km/h a vehicle should leave 2 seconds to the car in front, at 40–50km/h 3 seconds, and at higher speeds 4 seconds. This means that at an intersection with traffic travelling at 30km/h one vehicle gets through the intersection every 2 seconds, at 50km/h one vehicle gets through every 3 seconds, and at higher speeds one vehicle gets through every 4 seconds. Therefore, more vehicles get through this congestion point if speeds are lower. This matters, because for trips in urban areas, the primary generators of congestion are intersections, traffic queues, and braking for cornering and turning.[63]

The evidence supports the above commentary. Figure 3 shows the relationship between speed and traffic flow. It shows that, in the range of the speed limit changes New Zealand is undertaking (reduction to 30km/h or higher), there are quite small reductions in traffic flow with lower speeds or traffic flow is improved with lower speeds.

[63] J Archer, N Fotheringham, M Symmons & B Corben (2008) *The impact of lowered speed limits in urban and metropolitan areas* (report 276). Monash University Accident Research Centre. www.monash.edu.au/miri/research/reports/muarc276.pdf

The relationship between speed and traffic flow means decreasing speeds does not necessarily increase congestion and can improve congestion.[64]

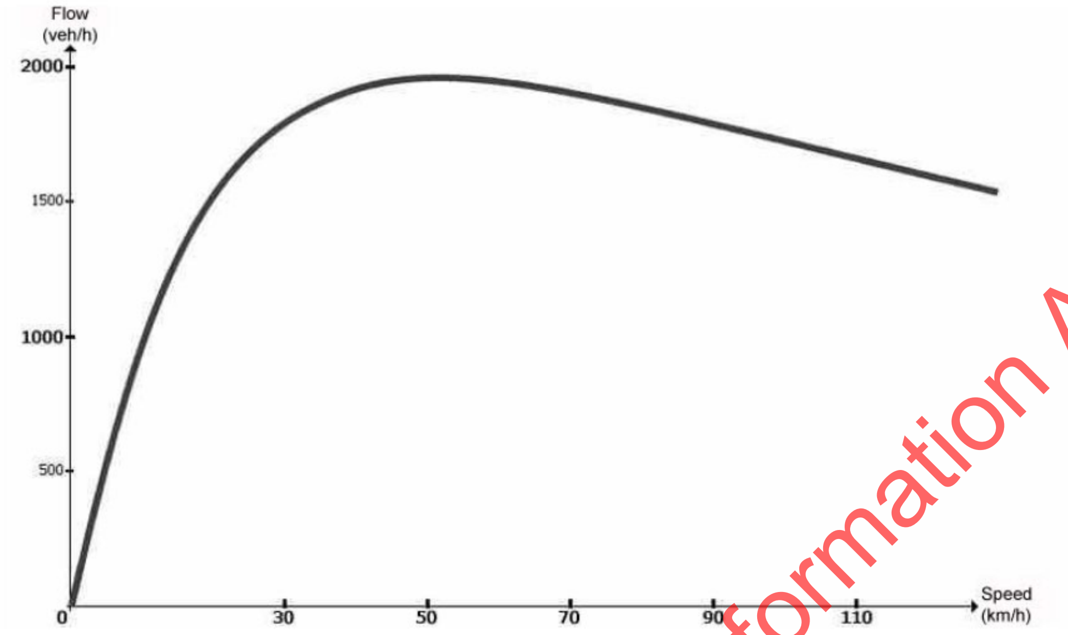

Figure 3 – Curve relating speed and traffic flow. Source: OECD (2006).

2.2.5 Case study: Speed management on German motorways

Germany is often seen as an example of road safety success without managing speed. This is misleading. Germany uses many speed management techniques, including speed limits, on its motorways, although it is famous for having no speed limit.

The federal motorway system in Germany is called the *Bundesautobahn. Autobahnen* (motorways) are built to very high safety standards. Although at one time all of Germany's motorways famously had no speed limit, speed management is now a vital part of Germany's road safety approach and a key reason for Germany's road safety improvements. German authorities reacted to the number of serious crashes and deaths occurring on its motorways by putting speed limits on almost half of them. In addition, Germany has over 4600 speed cameras, a low enforcement tolerance with 3km/h over the speed limit being a punishable offence, and 50km/h maximum urban speed limits[65] with 30km/h limits in many city centres and residential areas.[66]

---

[64] OECD (2006) *Speed management* (report of the Transport Research Centre) Paris: OECD and European Conference of Ministers of Transport. http://documents1.worldbank.org/curated/en/298381607502750479/pdf/Road-Crash-Trauma-Climate-Change-Pollution-and-the-Total-Costs-of-Speed-Six-graphs-that-tell-the-story.pdf

[65] WHO (2018) *Global status report on road safety*. Geneva, Switzerland: World Health Organization.

[66] ETSC (2015) Germany unblocks 30km/h zones. European Transport Safety Council (17 April). https://etsc.eu/germany-unblocks-30kmh-zones/#:~:text=Germany's percent20Federal percent20Transport percent20Minister percent20Alexander,to percent20implement percent2030km percent2Fh percent20zones.

However, the country is still significantly behind the road safety records of the best-performing countries in Europe (Sweden, The Netherlands and Norway) that have speed limits on all of their streets and roads, including motorways. Due to extreme speeds, despite being the best engineered roads in Europe, Germany's motorways are less safe than those of similar countries in Europe, with the motorways of the UK, Switzerland, Denmark, The Netherlands, Ireland and France all having better safety records.[67]

[67] ETSC (2008) *German Autobahn: The speed limit debate* (speed factsheet 01-08). Brussels: European transport Safety Council. https://etsc.eu/wp-content/uploads/Speed_Fact_Sheet_1.pdf

3 Safe System and speed

New Zealand adopted Safe System principles in its Safer Journeys national road safety strategy[68] and further refined the approach and added targets under the Road to Zero national strategy.[69] Fatalities occur, not just because of driver error, but because the system is unforgiving (for example, speed limits too high for the prevailing environment or possible crash types).

A Safe System approach recognises that people make mistakes. It reduces the price paid for a mistake, so crashes don't result in death or serious injury. Mistakes are inevitable – deaths and serious injuries from road crashes are not.

3.1 Safe System principles

A Safe System recognises that people, speeds, vehicles and road infrastructure must interact in a way that ensures everyone's safety. People should not, and do not need to, die or be seriously injured for the sake of mobility.

Therefore, a Safe System:[70]

- accepts that people make mistakes and protects road users from a mistake resulting in death or serious injury
- manages speeds, roads and vehicles to limit crash forces to levels that are survivable for the human body
- motivates governments and people who design and maintain roads, manufacture vehicles, and administer safety programmes to accept and address shared responsibility for safety and to stop blaming road users for system inadequacies
- adheres to the underlying premise that the transport system should not compromise safety for the sake of factors such as cost or faster travel times.

Safe System principles guide interventions towards an ultimate goal of eliminating road crash deaths and injuries. They also emphasise the many elements of the system that must be improved rather than continuing the (broadly failing) focus of the last 80 years of just improving road users. As the current national road safety strategy, Road to Zero, notes:[71]

> We must also turn our attention to fixing a transport system that fails to protect people – by improving our road network, tackling unsafe speeds and lifting the safety of our vehicle fleet.

[68] New Zealand Government (2010) *Safer Journeys: New Zealand's road safety strategy 2010–2020.* Wellington: Ministry of Transport.

[69] New Zealand Government (2019) *Road to Zero: New Zealand's road safety strategy 2020–2030.* Wellington: New Zealand Government. www.transport.govt.nz//assets/Uploads/Report/Road-to-Zero-strategy_final.pdf

[70] This description is based on WHO & United Nations Regional Commissions (2021) *Global plan: Decade of action for road safety 2021–2030.* Geneva, Switzerland: World Health Organization. But it also adopts the position on shared responsibility recently advanced as more internally consistent with the safety system. See RFS Job, J Truong & C Sakashita (2022) The ultimate safe system: Redefining the Safe System approach for road safety. *Sustainability* 14(5): 2978. https://doi.org/10.3390/su14052978

[71] New Zealand Government (2019) *Road to Zero: New Zealand's road safety strategy 2020–2030.* Wellington: New Zealand Government, p 15. www.transport.govt.nz//assets/Uploads/Report/Road-to-Zero-strategy_final.pdf

To be consistent with the principles, a Safe System must accommodate human error rather rely on errors not occurring. Only on this basis can the system deliver on the vision of zero deaths and serious injuries in road crashes. Thus, the ultimate Safe System is a system "in which road users cannot be killed or seriously injured regardless of their behaviour or the behaviour of other road users".[72] However, in the absence of such a system, improving road user behaviour continues to save many lives and injuries.

3.2 Safe System speeds – 20–30km/h for the safety of vulnerable road users

The speed–fatality risk relationships for average speed and impact speed (described in 2.1.2) have led to internationally accepted Safe System speeds. These speeds are supported in many global guidance documents for road safety, including those by the World Health Organization,[73] International Red Cross,[74] United Nations,[75] International Transport Forum of the OECD[76] and Global Road Safety Facility of the World Bank.[77] Most recently, the Academic Expert Group for the third global ministerial conference on road safety also explicitly recommended Safe System speed limits, especially the adoption of 30km/h for the safety of vulnerable road users,[78] and the World Bank assessed 30km/h zones for pedestrians as a "highly effective" intervention.[79]

Safe System speeds from the International Transport Forum are in table 2.[80] These speeds are based on the evidence described earlier on death and injury risk related to travel speed and impact speed, but they are a compromise to the need for mobility, so are higher than the speeds required to achieve zero deaths and serious injuries. First, these speeds are set at

---

[72] RFS Job, J Truong & C Sakashita (2022) The ultimate Safe System: Redefining the Safe System approach for road safety. *Sustainability* 14(5): 2978. https://doi.org/10.3390/su14052978

[73] GRSP & WHO (2008) *Speed management: A road safety manual for decision makers and practitioners*. Geneva, Switzerland: World Health Organization & Global Road Safety Partnership.

[74] GRSP & WHO (2008) *Speed management: A road safety manual for decision makers and practitioners*. Geneva, Switzerland: World Health Organization & Global Road Safety Partnership; GRSF (World Bank) & GRSP (International Red Cross & Red Crescent Society) (2020) *Guide for determining readiness for speed cameras and other automated enforcement.* Geneva, Switzerland: Global Road Safety Facility & Global Road Safety Partnership.

[75] WHO & United Nations Regional Commissions (2021) *Global plan: Decade of action for road safety 2021–2030.* Geneva, Switzerland: World Health Organization.

[76] ITF (2022) *The Safe System approach in action.* Paris, France: International Transport Forum, OECD; OECD. (2006) *Speed management* (report of the Transport Research Centre). Paris, France: OECD and European Conference of Ministers of Transport. http://documents1.worldbank.org/curated/en/298381607502750479/pdf/Road-Crash-Trauma-Climate-Change-Pollution-and-the-Total-Costs-of-Speed-Six-graphs-that-tell-the-story.pdf

[77] B Turner, S Job & S Mitra (2021) *Guide for road safety interventions: Evidence of what works and what does not work*. Washington, DC: World Bank. www.roadsafetyfacility.org/publications/guide-road-safety-interventions-evidence-what-works-and-what-does-not-work; RFS Job & LW Mbugua (2020) *Road crash trauma, climate change, pollution and the total costs of speed: Six graphs that tell the story* (GRSF note 2020.1). Washington, DC: Global Road Safety Facility, World Bank. http://documents1.worldbank.org/curated/en/298381607502750479/pdf/Road-Crash-Trauma-Climate-Change-Pollution-and-the-Total-Costs-of-Speed-Six-graphs-that-tell-the-story.pdf

[78] C Tingvall & the Academic Expert Group (2021) *Saving lives beyond* 2020*: The next steps* (recommendations of the Academic Expert Group for the third global ministerial conference on road safety). Stockholm: Swedish Transport Administration.

[79] B Turner, S Job & S Mitra (2021) *Guide for road safety interventions: Evidence of what works and what does not work.* Washington, DC: World Bank. www.roadsafetyfacility.org/publications/guide-road-safety-interventions-evidence-what-works-and-what-does-not-work

[80] ITF (2016) *Zero road deaths and serious injuries: Leading a paradigm shift to a safe system.* Paris: International Transport Forum, OECD. http://dx.doi.org/10.1787/9789282108055-en

the level at which the evidence indicates that 10 percent of people involved in the relevant crash will die (see figure 2, p 20). Second, they consider only death and not protection from serious injury, which can occur at lower speeds.

Analysis in 2016 considered fatal and serious injuries combined and indicated Safe System speeds of 20km/h for pedestrian protection and 30km/h for head-on and side impact crashes.[81]

Table 2 – Target Safe System speed by road type

Road and section types combined with road users	Target Safe System speed (km/h)
Roads and sections used by cars and vulnerable users	30
Intersections with possible side-on conflicts between vehicles	50
Roads with possible frontal conflicts between vehicles	70
Roads with no possible frontal or side-on conflicts between vehicles and no vulnerable road users	≥ 100

Source: ITF (2016).

The survivable speed will change over time with new evidence and, in the longer term, better vehicle technologies and road and roadside improvements that protect all road users. The speeds in table 2 are in anticipation of future improvements in other aspects of safety.

Box 1 explains the value of speed management compared with engineering solutions for New Zealand.

[81] C Jurewicz, A Sobhani, J Woolley, J Dutschke, & B Corben (2016) Exploration of vehicle impact speed–injury severity relationships for application in safer road design. *Transportation research procedia* 14: 4247–4256.

Box 1: Benefits of different Safe System interventions, including speed management

When developing Safe System intervention strategies, it is important to understand the risks, the distribution of those risks across the road network, and the appropriateness, depth, spread, effectiveness and responsiveness of the various interventions available. This allows for the solutions that will be the most effective at saving lives and avoiding serious injuries to be identified and implemented.

In most countries, around half of all serious road trauma occurs on the busiest and highest risk 10 percent of the network, and New Zealand is no different. The Safety Investment Programme of Waka Kotahi targets these highest-risk locations with infrastructure improvements or speed management or both. It is vital that trauma across the entire network is reduced and, ultimately, eliminated. This can be achieved by using the full suite of Safe System interventions.

Analysis undertaken for Waka Kotahi indicates that one-third of all deaths and serious injuries on the roads occur on less than 3 percent of the network (about 2500km of New Zealand's 95,000km of road). These are the highest-volume, highest-risk roads and intersections where transformational infrastructure investment (such as roundabouts and median barriers) will make the biggest difference. This investment will be supported by effective speed management as necessary. Transformational infrastructure upgrades are relatively expensive and take time to design and construct, so it may be necessary to better manage speeds in the interim.

It is not practical or affordable, and would take considerable time, to upgrade infrastructure to the same extent on the remaining 92,000km of roads. This leaves 97 percent of the network unimproved, where the remaining two-thirds of deaths and serious injuries occur.

The analysis also shows that speed management interventions such as safer speeds and enforcement, cost about 5 percent of the cost of transformational infrastructure improvements to achieve similar death and serious injury reductions. Speed management reduces trauma on a per kilometre basis but at a lower rate than infrastructure improvements. But improved speed management, can be delivered across many more kilometres of the network. Far more speed management interventions can be implemented each year, so more lives can be saved sooner.

Speed management can be considerably more efficient than infrastructure improvements, particularly if targeted at medium- to high-risk roads, and supported with lower-cost infrastructure improvements where appropriate. A further 40 percent of all deaths and serious injuries occur on about 10 percent (10,000km) of the network considered medium to high risk.

Speed management alone may be appropriate across wider, lower-risk parts of the network where random crashes resulting in deaths and serious injuries can and do occur at any time.

Infrastructure and speed management investment alone is still not enough to deliver Vision Zero. Safer vehicles and safe road use are also required to address all risks across the entire network.

Source: Section 9(2)(a) *, Colin Brodie Consulting Ltd (formerly Lead Advisor, Road Safety, Waka Kotahi).*

To save lives and serious injuries, speed limits must increasingly consider Safe System speeds – speeds that are based on scientifically robust findings about human behaviour and human tolerance of physical force. It is no longer acceptable to set speed limits based on the speed 85 percent of drivers choose to travel at. In New Zealand, this approach and the increase in speeds, particularly from 80km/h to 100km/h in 1985, have left a legacy of speeds limits that are unsafe for the conditions, so produce high death and injury rates.[82] The International Transport Forum's 2016 Safe System report identified New Zealand and Australian rural speed limits as examples of unsafe speed limits, particularly with topographical challenges compounding the lack of safety in New Zealand, and compared New Zealand and Australia speed limits with the lower 70km/h or 80km/h limits in countries with much better road safety performance.[83]

An example of inadequate speed limit setting in rural settings is where high speeds are allowed on narrow, low-standard roads with an unstable gravel shoulder as the only recovery space between the vehicle and endless lines of roadside trees, utility poles, drainage channels and myriad other hazards. In countries such as The Netherlands and Sweden, the default speed limit in these rural environments is 70km/h or 80km/h. In New Zealand and Australia, the default rural speed limit is 100km/h regardless of road and roadside conditions. When a vehicle leaves the roadway at this speed, the impact forces with unforgiving roadside objects are well in excess of a person's biomechanical tolerances.[84]

---

[82] G Koorey & WB Frith (2017) Changing rural speed limits: Learning from the past. IPENZ Transportation Group Conference, Hamilton, 29–31 March.

[83] ITF (2016) *Zero road deaths and serious injuries: Leading a paradigm shift to a safe system.* Paris: International Transport Forum, OECD. http://dx.doi.org/10.1787/9789282108055-en

[84] ITF (2016) *Zero road deaths and serious injuries: Leading a paradigm shift to a safe system.* Paris: International Transport Forum, OECD, p 109. http://dx.doi.org/10.1787/9789282108055-en

4 Promotion of speed and psychological mistakes we all make – the evidence

Everyone uses the roads, but people are not deeply informed about road safety because it has developed into a strongly scientific and technical discipline. Many in the community base their views on personal experience not scientific evidence. People often mistrust and disbelieve the evidence (which amount to many people's experiences turned into numbers) that does not align with their individual experiences.

This mistrust and disbelief are common to many aspects of risk judgement and is not a simple matter to change. This section explores common views that are inconsistent with the evidence and how people arrive at these views.

This section covers:

- how people came to believe speed is safe and good for them (4.1)
- the continuing risk of high speeds despite driving skills and safety improvements (4.2)
- reducing speed is critical for road safety – it's not a ploy to raise revenue from enforcement (4.3)
- the importance of targeting people who speed by small amounts (4.4)
- advice to the road safety community (4.5)
- why people think that because they speed without having a serious crash, the evidence about speed and speeding must be wrong (4.6)
- speed management is not the only way to reduce speed and speeding -- it's one tool in the toolbox (4.7)
- why evidence from other countries often applies in New Zealand (4.8)
- most road deaths and serious injuries are of local people (4.9).

4.1 How people came to believe speed is safe and good for them

Many believe higher speed road travel is good for the economy,[85] so good for people, saving time with almost no other cost, and that travelling at speed is fun. It can seem inconsistent that road safety practitioners want to reduce travel speeds to keep people safe – after all, each of us is still here despite travelling at (or above) existing speed limits, with the many who are killed through speeding not around to tell their story. There seems to be no reason to slow people's journeys. How did society come to this inaccurate view about speed? The answer lies with the development and promotion of the motor vehicle and the motor racing industry and the unrealistic depiction of speed in movies, television, games and online.

[85] This mistake is even the basis of policy by politicians (for example, R Llewellyn (2018) Increasing the speed limit won't get traffic moving faster. *The Conversation* (6 October). https://theconversation.com/increasing-the-speed-limit-wont-get-traffic-moving-faster-104365

4.1.1 Impact of the motor racing industry

Before cars and motorcycles achieved high speeds, travel was at the speed of a trotting or, albeit rarely, galloping horse. Horses typically trot at around 13km/h.[86] The car industry stepped in to change this: falsely promoting the value and safety of speed and escalating motor racing events to promote the glamor of high speed and the value of driving skill in keeping us safe.

A master stroke of public messaging was the phrase, "The nut behind the wheel", which appeared in poems and other printed and promotional materials from the 1920s on. The nut behind the wheel, the problem causing crashes, was the driver, and the message was couched in engineering terms to emphasise that the problem was not the car or its speed but the person driving. This has been combined with massive commitment to and promotion of motor racing through Formula 1, stock cars, rally driving and motorcycle racing. There is a lot to learn from motor racing that has real value for road safety. However, as explained below, road safety is not about driving skill or safety at speed, even though racing and rally drivers and navigators have a great deal of skill.

The motor racing industry does aim to protect its drivers and others involved as well as to promote the sport, and it has done so largely effectively although the level of safety the sport has achieved is often overestimated (as described below).

The industry contributes significantly to road safety through the UK FIA Foundation,[87] which funds road safety programmes and runs the major motor racing programmes, including Formula 1 Grand Prix. The United Nations Special Envoy for Road Safety appointed in 2015 was also the FIA president.

However, many car manufacturers continue to actively promote speed as fun, sexy and desirable in their car advertising. In New Zealand, examples abound, including connecting cars with motor racing such as the Toyota advertisement, "Finding New Zealand's next world champion", which depicts high-risk driving at a speed excessive for the conditions (a utility is shown fully airborne on a dirt road),[88] or a promotional description of a car that emphasises performance, sports technologies, power and connection with the racetrack:[89]

> The all-new Ford Fiesta ST is the most responsive, engaging and fun-to-drive Fiesta ST ever, featuring a range of sports technologies that enhance power and performance, cornering and agility, and versatility for scenarios from the school run to race track.

In addition, the views people hold about risk in road use are strongly supported by the deeper systematic psychological mistakes people make when judging risk, as described in 4.6.

---

[86] Deep Hollow Ranch (2021) How fast can a horse run? (Top & average speed). www.deephollowranch.com/horse-speed

[87] www.fiafoundation.org

[88] Driven (2020) Watch: What's the best car ad? *Driven* (27 November). www.driven.co.nz/news/watch-what-s-the-best-car-ad/

[89] Ford (2019) The Ford Fiesta ST: Latest reviews. (23 October). www.faganford.co.nz/news/details/303/the-ford-fiesta-st-latest-reviews

4.1.2 Depiction of speed in movies, television, games and online

Another major influencer of our perceptions of speed and risk comes from the thousands of occasions in which speed is depicted in movies, television, games and online. At some level, people know these depictions are not realistic; it's part of the fun of getting into the story's adventure with the character by accepting the premise of the story and the action involved. If people don't do this, thinking the story unreal or absurd, the magic of entertainment is lost. In addition, sometimes the story and action do seem real and possible. Thus, we are shown and "accept" the following misleading ideas:

- It is possible with skill to travel at high speed without crashing. The popularity of such depictions is evident in the many *Fast & Furious* movies, the central role of the sports car (or motorcycle) in the James Bond series, and the pervasiveness of car chase scenes in police shows and crime thrillers.
- More skilled drivers are less likely to crash than less skilled drivers: In most car chases the good guys win – their superior skill often allows them to not crash while the bad guys crash.
- Macho heroes and aspirational characters like to and can drive fast, often performing dramatic, extreme-risk stunts safely and impressing people.
- Heroes survive crashes even at high speeds and even when not wearing a seatbelt. Not only do they survive, but they can be uninjured, out of the car in a split second, and chasing down the bad guys on foot.

4.1.3 Consequences of the message that travelling at high speed can be done safely

Overall, through entertainment and advertising, people are bombarded with messages about the safety of high speed and the role of skill in making high-speed driving safe. Is it any wonder that the messages about speeding from road safety experts, with much less airtime, do not have the same level of influence?

The above, sometimes inadvertent and sometimes deliberate, activities have given three important wrong impressions.

First, they appear to prove the value of car-handling skills in road safety, which we accept as self-evident.

Second, they make travelling at high speed seem fun and possible to do safely.

Third, they have shifted our thinking away from speed being responsible for fatal and serious crashes to humans being responsible. This is so, even though speed delivers energy into the crashes into hard objects or other cars, pedestrians, cyclists or motorcyclists, making them fatal or severe crashes.

The importance of these mistaken impressions is supported by evidence, which shows that people exposed to more media and images that encourage speeding are more likely to speed.[90] People inevitably make mistakes. Speed compounds mistakes and adds to the severity of consequences.

The evidence for each of the three mistaken impressions is discussed next (in 4.2 to 4.4), because of the profound influence they have had on road safety.

4.2 Continuing risk of high speeds despite driving skills and safety improvements

4.2.1 Increasing driver skill increases driver confidence, increasing risk taking

A study showed that, on public roads, more skilled drivers have more crashes. The crash records (on public roads) of racing and rally drivers were compared with the average for all drivers. Racing and rally drivers were found to have more crashes than average drivers.[91] This finding surprises many of us (because of our mistaken belief in car-handling skills as critical to safety), yet it is consistent with the extensive body of scientific evidence on the limited value of car-handling skills for road safety (discussed in 5.2).

As background to understanding the above evidence, it is helpful to understand that risk-taking by road users is a motivation problem. Whether people take risks when driving is influenced by whether they think they can "get away with it" (that is, not crash, be fined or lose their licence) and the perceived value ("risk utility") of taking the risk.[92] (This is also a broad human characteristic in risk taking generally.[93]) Supporting this finding are New Zealand studies that show driver perceptions of risk and their reasons for driving (motivation) are important predictors of their speed preferences.[94] Increasing driver skill has the effect of increasing the driver's confidence in being able to travel faster without crashing, so commonly increases risk taking (see 5.2). Therefore, more skilled drivers take more risks.

---

[90] KB Stefanidis, V Truelove, M Nicolls & J Freeman (2022) Perceptions matter: Speeding behaviour varies as a function of increasing perceived exposure to content encouraging the behaviour. *Traffic injury prevention* 1–6.

[91] WA Tillman & GE Hobbs (1949) The accident-prone automobile driver. *American journal of psychiatry* 106: 321–331. A more recent formal study could not be found, although crashes by famous Formula 1 race car drivers reported in the media suggest the problem continues. These include a crash by Lewis Hamilton while still an active F1 driver (D Johnson (2015) Lewis Hamilton: Heavy partying is to blame for my Monte Carlo car crash. *The Telegraph* (12 November). www.telegraph.co.uk/sport/motorsport/formulaone/lewishamilton/11992509/Lewis-Hamilton-Heavy-partying-is-to-blame-for-my-Monte-Carlo-car-crash.html) and fatal crashes by other drivers after leaving Formula 1 driving (A Henry (2006) Ferrari icon Clay Regazzoni dies in car crash aged 67. *The Guardian* (16 December). www.theguardian.com/sport/2006/dec/16/formulaone.gdnsport3; R Horton (1999) Reflections on another age: Mike Hawthorn remembered. *Atlas Formula 1 journal*. http://atlasf1.autosport.com/99/jan27/horton.html). Other research confirms that expert police drivers show as much over-confidence in their own driving, comparing themselves with other experts, as do normal drivers, comparing themselves with other normal drivers: AE Waylen, MS Horswill, JL Alexander & FP McKenna (2004) Do expert drivers have a reduced illusion of superiority? *Transportation research part F: Traffic psychology and behaviour* 7(4–5): 323–331.

[92] T Prabhakar, SHV Lee & RFS Job (1996) Risk taking, optimism bias and risk utility in young drivers. In L St John (ed), *Proceedings of the road safety research and enforcement conference* (pp 61–68). Sydney, NSW: Roads & Traffic Authority of NSW.

[93] ND Weinstein (1988) The precaution adoption process. *Health psychology* 7(4): 355–386.

[94] LM Ahie, SG Charlton & NJ Starkey (2015) The role of preference in speed choice. *Transportation research part F: Traffic psychology and behaviour* 30: 66–73. https://doi.org/10.1016/j.trf.2015.02.007; SG Charlton & NJ Starkey (2017) Driving on urban roads: How we come to expect the "correct" speed. *Accident analysis & prevention* 108: 251–260. https://doi.org/10.1016/j.aap.2017.09.010

This does not mean that drivers should have no skills – basic skills are needed to drive safely. However, the facts show that high levels of skill make safety worse. While we can all think of scenarios in which more skill might help us avoid a crash, the evidence from large numbers of cases tells us that these scenarios are not as common or important to overall road safety as the extra confidence and risk-taking that is created by the higher levels of skill.

4.2.2 Continuing risk of high speeds despite improved safety features

If skill is not what is saving racing drivers, what is? For the short distances driven overall in motor racing, there are a lot of high-risk crashes, including fatal and serious injury crashes. In addition, some crashes from which drivers can walk away in Formula 1 car racing would be fatal on an average road in an average car.[95]

The racing industry has done an extraordinary job in creating safety in a high-risk sport. One important lesson is how much can be achieved by managing the safety aspects of the system. In Formula 1 Grand Prix car racing, these system features are as follows:

- Cars: Formula 1 has steadily improved vehicle engineering to protect racing car drivers.
- Protective clothing: Drivers wear particularly effective protective clothing and helmets and, since 2019, must also wear a neck brace.
- Vulnerable road users: School children are never and pedestrians are rarely crossing the race track. Where pedestrians have been on the track, such as marshals or drivers after a crash, some deaths have occurred. There are also no cyclists and no mixing of motorcycles and cars.
- Speed management: Pedestrians are in pit areas, so low speeds are required and enforced. Even then, pedestrians have been injured in crashes in pit areas.
- Managing the risk of secondary crashes: When an incident occurs in the race, a safety car is deployed to slow speeds.
- Exposure management: Races are allowed to last a maximum of 3 hours or drivers are changed, and races may be shortened due to bad weather conditions. Only one person is in each vehicle.
- Traffic management: There are no trucks, buses, train crossings and two-way traffic.
- Race track sides: The track is very different from a standard road: there are no 90 degree angle roads entering at intersections and there are wide clear zones or effective cushions and crash barriers.
- Driver error management: Drivers are not impaired by alcohol or fatigued by many hours of driving (races are limited to a maximum of 3 hours) or age and failing eyesight.[96]

[95] For many examples from 2020 seasons, see the video compilation of crashes: Formula 1 (2021) The 10 most dramatic crashes of the 2020 F1 season. *YouTube.* www.youtube.com/watch?v=ZGd9A2IhQeU

[96] Even in high-speed rally car racing on public roads, many of the normal risks are eliminated: the car may have added structural protection, drivers and navigators wear helmets as well as great seatbelts, and traffic and other road users are managed (school children are not crossing the road, other traffic is not entering from side roads, and there are no cyclists, motorcyclists, trucks and oncoming traffic).

The lesson we should learn from the racing industry is the power of the system to protect people – through traffic management, pedestrian protection through speed control or prevented access, complete negation of head-on traffic, more protection in vehicle engineering, and the value of safe roadsides. However, even all this (as well as the highly skilled drivers in Formula 1) is not enough to save drivers from the extraordinary risks of very high speeds and close quarter driving.

Continuous improvement in road, roadside and vehicle technologies for safety Formula 1 can be expected to gradually and eventually lead to zero deaths over many decades of racing.

4.3 Reducing speed is critical for road safety – it's not a ploy to raise revenue from enforcement

The evidence briefly presented earlier shows that speed, and thus speed management, is critical to road safety. The most credible road safety organisations agree that the evidence overwhelmingly proves speed plays a major role in road safety and managing speed powerfully improves road safety. These organisations include the:

- International Red Cross and Red Crescent Society, including its road safety arm, the Global Road Safety Partnership
- International Road Association (also known as the Permanent International Association of Road Congresses)
- International Transport Forum of the OECD
- United Nations
- World Bank, including its road safety arm, the Global Road Safety Facility
- World Health Organization.

In 2021, the Academic Expert Group for the third global ministerial conference on road safety also supported strong speed management and a zero-tolerance approach to speeding,[97] and the International Transport Forum reported on the critical role of the Safe System (which New Zealand has adopted) for improving road safety and the fundamental role of speed management in delivering a Safe System.[98]

Enforcement using safety cameras (or speed cameras) does collect revenue for the Crown, but more importantly these cameras save lives and prevent injuries. Scientific evaluations across many countries support this. The extent of the safety benefits depends on many factors, such as the size of the penalty, number of cameras, swiftness and unavoidability of the penalty, and features of the processes for evaluating safety camera effects.[99]

[97] C Tingvall & the Academic Expert Group (2021) *Saving lives beyond* 2020*: The next steps* (recommendations of the Academic Expert Group for the third global ministerial conference on road safety). Stockholm: Swedish Transport Administration.

[98] ITF (2022) *The Safe System approach in action.* Paris, France: International Transport Forum, OECD.

[99] RFS Job (2022) Evaluations of speed camera interventions can deliver a wide range of outcomes: Causes and policy implications. *Sustainability* 14(3): 1765. https://doi.org/10.3390/su14031765

A 2010 systematic review of the evidence from scientific studies using the best methodologies concluded that, although more research is needed to establish the exact level of benefit for various camera programmes, "the consistency of reported reductions in speed and crash outcomes across all studies show that speed cameras are a worthwhile intervention for reducing the number of road traffic injuries and deaths".[100] Many more evaluations since then continue to show the safety benefits of fixed and mobile speed cameras.[101] In 2021, a World Bank assessment of evidence on safety interventions rated speed cameras as "highly effective".[102]

Speed cameras have delivered powerful reductions in serious crashes in New Zealand as well as showing the clear additional safety value of including covert mobile camera enforcement. The addition of covert mobile cameras to existing camera enforcement reduced speeding broadly and produced a 19 percent reduction in casualties (injuries and deaths) across the target road network. At enforcement locations, the effects were larger: a 3.2 percent net reduction in speed, resulting in a 29 percent reduction in casualties (compared with untreated locations).[103] This New Zealand study (the only one of its type) not only shows the importance of safety cameras but also the importance of a mix of visible and covert camera enforcement.

4.4 Importance of also targeting people who speed by small amounts

Low-level speeding adds significantly to serious crash (fatal or injury) risk. For example, at 40km/h in a 30km/h zone, the risk of a serious crash is elevated by over 80 percent compared with the risk at the speed limit.[104]

Per driver, extreme speeding does create much more risk of a serious crash than low-level speeding. Extreme speeding "appears" to be the main contributor for three reasons.

First, extreme speeding crashes are more likely to be reported in the news because the cause is (apparently) clear and the results are horrible and more dramatic for photos and television coverage. Low-level speeding in even serious crashes often goes undetected, so is not likely to be reported in the news.

Second, people notice extreme speeding and generally disapprove of it, branding the driver as dangerous or stupid and someone who should be caught and stopped from driving.

---

[100] C Wilson, C Willis, JK Hendrikz, R Le Brocque & N Bellamy (2010) Speed cameras for the prevention of road traffic injuries and deaths. *Cochrane database of systematic reviews* (11): CD004607. https://doi.org/10.1002/14651858.CD004607.pub4

[101] L Carnis & E Blais (2013) An assessment of the safety effects of the French speed camera program. *Accident analysis & prevention* 51: 301–309; E De Pauw, S Daniels, T Brijs, E Hermans & G Wets (2014) An evaluation of the traffic safety effect of fixed speed cameras. *Safety science* 62: 168–174; A Høye (2015) Safety effects of fixed speed cameras: An empirical Bayes evaluation. *Accident analysis & prevention* 82: 263–269; P Tankasem, T Satiennam, W Satiennam & P Klungboonkrong (2019) Automated speed control on urban arterial road: An experience from Khon Kaen City, Thailand. *Transportation research interdisciplinary perspectives* 1: 100032.

[102] B Turner, S Job & S Mitra (2021) *Guide for road safety interventions: Evidence of what works and what does not work*. Washington, DC: World Bank. www.roadsafetyfacility.org/publications/guide-road-safety-interventions-evidence-what-works-and-what-does-not-work

[103] MD Keall, LJ Povey & WJ Frith (2001) The relative effectiveness of a hidden versus a visible speed camera programme. *Accident analysis & prevention* 33*:* 277–284. www.sciencedirect.com/science/journal/00014575

[104] Calculated by applying the classic Nilsson curve of risk: G Nilsson (2004) *Traffic safety dimension and the Power Model to describe the effect of speed on safety.* Sweden: Lund Institute of Technology.

However, people often do not detect low-level speeding. Thus, we actively brand extreme speeding as the main problem and the news seems to support this.

Finally, a focus on extreme speeding rather than low-level speeding has been contributed to by many road safety messages (see 4.5 for details).

It is not viable to assess the role of low-level compared with high-level speeding by analysing crash data because speeding is often missed as a factor and low-level speeding is more likely to be missed.[105] However, the science in road safety provides an objective picture. Low-level speeding contributes more to speeding deaths and injuries than does extreme speeding because low-level speeding is so much more common, as demonstrated in New Zealand speed surveys, which measure the speed of each vehicle in many locations.[106]

Thus, concentrating on extreme speeding will address only a small but visible proportion of the deadly speeding problem. The uncomfortable truth is that the speeding problem is caused by many of us, and to address it we all need to actively aim to drive at or below the speed limit all the time. The evidence shows that low-level speeding is contributing greatly to speeding-related deaths and injuries. Thus, it is appropriate to deter all speeding to save lives.

Speeding is significantly reduced by enforcement[107] (including in New Zealand[108]) and speeds are lowered by reducing speed limits. Enforcement and lower limits are both proven to save lives and reduce trauma. Some speeding, including extreme speeding, will continue, indicating a need for more action.

Extreme speeding is more visible than low-level speeding, and when a crash occurs with extreme speeding it is more likely to be covered in the media because the consequences are more visually dramatic. However, we do have enough scientific evidence to determine the effects of enforcement on extreme speeding and on lower-level speeding, through detailed records of exact speeds before and after the addition of speed cameras. Such analyses indicate that speed cameras reduce extreme speeding even more than they reduce low-level speeding.[109] An evaluation of the benefits of adding covert mobile camera enforcement in New Zealand found a similar pattern – extreme speeding was reduced more than the average speed.[110]

---

[105] RF Job & C Brodie (2022) Understanding the role of speeding and speed in serious crash trauma: A case study of New Zealand. *Journal of road safety* 33(1): 5–25. https://doi.org/10.33492/JRS-D-21-00069

[106] Ministry of Transport (2015) *Speed Survey Results 2015*. Wellington: Ministry of Transport www.transport.govt.nz/assets/Uploads/Report/Speed-survey-results-2015.pdf

[107] R Elvik (2012) Speed limits, enforcement, and health consequences. *Annual review of public health* 33(1): 225–238. https://doi.org/10.1146/annurev-publhealth-031811-124634

[108] LJ Povey, WJ Frith, & MD Keall (2003) *An investigation of the relationship between speed enforcement, vehicle speeds and injury crashes in New Zealand.* Wellington: Land Transport Safety Authority. www.transportationgroup.nz/papers/2003/01_Povey_Keall_Frith.pdf

[109] R Elvik (2019) A comprehensive and unified framework for analysing the effects on injuries of measures influencing speed. *Accident analysis & prevention* 125: 63–69.

[110] MD Keall, LJ Povey & WJ Frith (2001) The relative effectiveness of a hidden versus a visible speed camera programme. *Accident analysis & prevention* 33*:* 277–284. www.sciencedirect.com/science/journal/00014575

4.5 Advice to the road safety community

On the issues of low-level speeding and extreme speeding, many road safety messages are misleading the community and media. The road safety community has helped to create the misperception of the importance of extreme speeding and the acceptability of low-level speeding. The approach must change to better reflect the scientific evidence.

Road safety advocates, including police, tend to identify extreme behaviours to justify road safety actions (for example, using extreme speeding to justify speed enforcement). A case of a driver speeding at 100km/h in a 50km/h zone is likely to be noted to the media, but the case of a driver caught at 60km/h in a 50km/h zone is not. The extreme speeder is considered more newsworthy and a more acceptable target for community derision.

The systematic over-emphasis of extreme speeding causes many problems. It:

- encourages a misperception that extreme speeding is the speeding problem and moderate speeding is not much of a safety issue
- normalises moderate speeding, making it seem acceptable, so a driver who speeds at 55km/h in a 50km/h zone may feel safe and normal in doing this, compared with their negative feelings about a driver doing 100km/h in a 50km/h zone that they heard about on the news
- increases the demand to focus enforcement on extreme speeders and let moderate speeders (who kill more people) go unpunished.

There is no doubt that on a per occasion basis extreme speeding is more dangerous than moderate speeding. However, low-level speeding is killing and injuring more people in New Zealand than is extreme speeding, because low-level speeding is so common. A focus on extreme speeding may be politically acceptable, but leaves moderate speeding relatively untouched. All speeding must be discouraged to deliver better safety outcomes for the community. Thus, when justifying speed enforcement measures, the message should reduce the normalisation of low-level speeding:

> Our speed enforcement this week shows that most drivers are doing the right thing – most drivers were not speeding, for which we are thankful. Unfortunately, we still caught [number] drivers travelling above the speed limit. Speeding is dangerous and will be penalised.

4.6 Why people think because they speed without having a serious crash, the evidence about speed and speeding must be wrong

Humans are not good at judging the risk for events based on personal experience, which is the way most people judge the risk of having a serious crash, unless they have scientific evidence.

When judging personal risk, humans have a set of deep psychological biases that affect our judgement. These self-serving biases have been proven in scientific studies. One bias is over-confidence in abilities and behaviours: most people believe they are better drivers than the average. Large surveys in Australia revealed the majority of drivers thought they were better than average, some thought they were around average and only 2 percent thought they were worse than average.[111] The same bias is found in other countries in which it has been tested.[112] People cannot mostly be better than average with so few people below average. Somehow the population has to average out as, well, average.

In addition to over-confidence, humans over-estimate their ability to control outcomes ("illusion of control") and have an optimism bias about their future (expecting to have better future lives than average for their peers with more good things and fewer bad things happening to them).[113] People's optimism about their future is sometimes referred to as the "illusion of invulnerability" when it is about the risk of a bad thing happening such as causing a serious road crash.

Studies show New Zealanders share these same biases:[114] over-confidence about driving abilities and optimism bias about crash risk.[115]

Part of the problem creating these mistakes is that as individuals we only have data from one individual (ourselves) compared with the power we can reach by combining data over the crash experiences of many millions of drivers, as done in scientific studies. Even if we drive long distances each year for many years, we would need to live for millions of years to have enough personal experiences to judge the effects of speeding. For this reason, the scientific evidence is a better guide to reality than our personal experiences.

Despite this, people tend to judge risk in terms of "if it hasn't happened to me yet, it won't happen in the future" and "I haven't had a fatal crash yet, so I never will". Because no one has two fatal crashes in a lifetime, this apparent claim of safety would have applied to everyone involved in a fatal crash until the second it happened. Things that have never happened before do happen, and people can't rely on personal experience to understand the risk of speed.

---

[111] RFS Job (1990) The application of learning theory to driving confidence: The effect of age and the impact of random breath testing. *Accident analysis & prevention* 22: 97–107.

[112] O Svenson (1981) Are we all less risky and more skillful than our fellow drivers? *Acta Psychologica* 47(2): 143–148. www.sciencedirect.com/journal/acta-psychologica/vol/47/issue/2; BA Jonah (1986) Accident risk and risk-taking behaviour among young drivers. *Accident analysis & prevention* 18: 255–271.

[113] FJ Chua & RFS Job (1999) Event-specific versus unitary causal accounts of optimism bias. *Journal of behavioural medicine* 22: 457–491; ND Weinstein (1984) Why it won't happen to me: Perceptions of risk factors and susceptibility. *Health psychology* 3(5): 431–457; ND Weinstein (1980) Unrealistic optimism about future life events. *Journal of personality and social psychology* 39(5): 806–820.

[114] D Walton & K Smith (2009) Survival confidence of New Zealanders in outdoor and post-earthquake situations. *Australian journal of emergency management* 24(3): 38–43; HG Seaward & S Kemp (2000) Optimism bias and student debt. *New Zealand journal of psychology* 29(1): 17–19.

[115] D Walton & J Bathurst (1998) An exploration of the perceptions of the average driver's speed compared to perceived driver safety and driving skill. *Accident analysis & prevention* 30(6): 821–830; N Harre & CG Sibley (2007) Explicit and implicit self-enhancement biases in drivers and their relationship to driving violations and crash-risk optimism. *Accident analysis & prevention* 39(6): 1155–1161.

4.7 Speed management is one tool in the toolbox

Managing speed is not the only way to improve safety. Road safety is being improved in New Zealand in many ways, including through promotion, enforcement, vehicle safety regulation and maintenance, and road safety design engineering improvements, as well as emergency response and post-crash care.

Waka Kotahi and other agencies at various levels are working to improve road infrastructure with barriers, safer designs for curves, safer designs for intersections, bicycle lanes and safer pedestrian facilities. These works take time and significant resources.

The path to achieving a safe road system must include speed management because speed is the most powerful contributor to crash forces. It is also the most cost-effective way to save lives – more lives can be saved through speed management than with infrastructure for the same budget.

4.8 Evidence from other countries often applies in New Zealand

New Zealand is unique in many ways. It has a particular combination of features and challenges in relation to road safety, so a clear case exists for not simply assuming that all actions that work overseas will work here. This is especially the case when considering the right messages to encourage attitudinal change, which rely on an understanding of a population's social values and beliefs. Thus, distinctiveness, local attitudes, beliefs and the nature of the road transport system (which is influenced by New Zealand's challenging typography) must be considered when applying some aspects of speed management.

On the other hand, evidence from various countries has regularly been applied successfully in New Zealand, including the successes of safety cameras, lower speed limits and speed-managing infrastructure.[116] In addition, New Zealand studies confirm the vital role of speed and speeding in serious crashes as well as life and injury saving successes in managing speed.[117]

In terms of road safety, New Zealand has more in common with many countries than it has differences. This is especially true for many elements of speed and severe crash risk. Most importantly, the role of speed in road safety in New Zealand, universal laws of physics, universal vulnerability of the human body to force, and similarity of human reaction times

---

[116] B Turner, S Job & S Mitra. (2021) *Guide for road safety interventions: Evidence of what works and what does not work*. Washington, DC: World Bank. www.roadsafetyfacility.org/publications/guide-road-safety-interventions-evidence-what-works-and-what-does-not-work; C Wilson, C Willis, JK Hendrikz, R Le Brocque & N Bellamy (2010) Speed cameras for the prevention of road traffic injuries and deaths. *Cochrane database of systematic reviews* (11): CD004607. https://doi.org/10.1002/14651858.CD004607.pub4; A Delaney, H Ward, M Cameron & AF Williams (2005) Controversies and speed cameras: Lessons learnt internationally. *Journal of public health policy* 26(4): 404–415.

[117] Accident Rehabilitation & Compensation Insurance Corporation & LTSA (2000) *Down with speed: A review of the literature and the impact of speed on New Zealanders*. Wellington: Land Transport Safety Authority; MD Keall, LJ Povey & WJ Frith (2001) The relative effectiveness of a hidden versus a visible speed camera programme. *Accident analysis & prevention* 33: 277–284. www.sciencedirect.com/science/journal/00014575; T Makwasha & B Turner (2013) Evaluating the use of rural-urban gateway treatments in New Zealand. *Journal of the Australasian College of Road Safety* 24(4): 14–20; RF Job & C Brodie (2022) Understanding the role of speeding and speed in serious crash trauma: A case study of New Zealand. *Journal of road safety* 33(1): 5–25. https://doi.org/10.33492/JRS-D-21-00069

across countries mean the effects of speed on crash risk and crash severity apply the same way across countries.[118] Universally, in the absence of other changes, higher speeds increase both crash risk and severity, and interventions that reduce speeds also reduce fatal and serious injury crashes. For this reason, research findings on the effects of speed are transferable from one country to another, with an appreciation of some differences in consequence.

The safety rating of cars is one important difference. Newer cars and cars with more-effective passive safety features (such as effective seatbelt tensioning, an effective and full set of airbags, the best structural integrity around occupants with crumple zones elsewhere to absorb impact energy, and more forgiving car fronts for pedestrians) have higher New Car Assessment Programme (NCAP) safety star ratings and can be more effective in protecting occupants from severe injuries than poor safety-rated cars.[119]

Vehicle fleet age is relevant for New Zealand, because the average age of the fleet is older than in many of the high-income countries in which relevant research has been conducted (14.4 years in New Zealand compared with 11.6 years in the US, 10.1 years in Australia and 7.4 years in Europe).[120] Thus, if anything, severe injuries may occur at slightly lower speeds in New Zealand than in other countries due to vehicles affording slightly less protection on average.

4.9 Most road deaths and serious injuries are of local people

Almost all (around 97 percent) fatal and serious injury crashes in New Zealand involve New Zealand drivers. In the remaining 3 percent, foreign drivers were involved but not necessarily at fault (see table 3). It is mostly locals (not visitors) who die on local roads.

Table 3 – Foreign drivers involved in fatal and serious injury crashes

Year	Drivers with an overseas licence	All drivers	Proportion of all drivers (%)
2017	151	4,212	3.6
2018	122	3,800	3.2
2019	90	3,871	2.3

Source: Data from Waka Kotahi road safety outcomes reports.

[118] B Turner, S Job & S Mitra. (2021) *Guide for road safety interventions: Evidence of what works and what does not work.* Washington, DC: World Bank. www.roadsafetyfacility.org/publications/guide-road-safety-interventions-evidence-what-works-and-what-does-not-work

[119] M Van Ratingen, A Williams, A Lie, A Seeck, P Castaing, R Kolke, G Adriaenssens & A Miller. (2016) The European new car assessment programme: A historical review. *Chinese journal of traumatology* 19(2): 63–69.

[120] Te Manatū Waka Ministry of Transport (2020) *Vehicle age*. Wellington: Te Manatū Waka Ministry of Transport. www.transport.govt.nz/statistics-and-insights/fleet-statistics/sheet/vehicle-age

5 Recap – actions that work and actions that do not

This section summarises the actions proven to work and not work to reduce deaths and serious injuries from speed. In road safety, it is critical we choose actions demonstrated to work so we do not waste time and resources on ineffective actions. Interventions based on "gut instinct" rather than evidence may be popular, but they will not achieve desired results.

The six actions demonstrated to reduce deaths and serious injuries, especially in relation to speed, and the three that do not are described in 5.1 and 5.2, respectively.

5.1 Actions proven to reduce deaths and serious injuries

Six actions are proven to reduce deaths and serious injuries, especially in relation to speed:

- **Lower speed limits** – evaluations in New Zealand support international findings (see 2.1.4 and 4.6).
- **Speed enforcement, including safety (speed) cameras**, with more safety gains from covert cameras being added to visible cameras – evaluations in New Zealand support international findings (see 2.1.2, 4.3 and 4.6).
- **General deterrence** (through many actions that improve it such as effective unavoidable penalties and promotion of enforcement) is a powerful motivator of behaviours and can be improved by maximising the chances that speeding behaviour is detected and effectively punished.[121]
- **Graduated licensing systems** where speed is addressed within the constraints placed on novice drivers.[122] In New South Wales, Australia, the introduction of a penalty for provisional drivers of licence loss, instead of just a fine and demerit points, led to a 34 percent reduction in speeding-related deaths involving these provisional drivers.[123]

[121] B Turner, S Job & S Mitra (2021) *Guide for road safety interventions: Evidence of what works and what does not work.* Washington, DC: World Bank. www.roadsafetyfacility.org/publications/guide-road-safety-interventions-evidence-what-works-and-what-does-not-work; R Homel (1988) *Policing and punishing the drinking driver: A study of general and specific deterrence.* New York: Springer-Verlag.

[122] AF Williams, BC Tefft & JG Grabowski (2012) Graduated driver licensing research, 2010–present. *Journal of safety research* 43(3): 195–203; JT Shope (2007) Graduated driver licensing: Review of evaluation results since 2002. *Journal of safety research* 38(2): 165–175.

[123] C Sakashita & RFS Job (2015) Employing refined licensing conditions to reduce the serious crashes of young drivers. *Journal of local and global health science* 43.

- Many **road engineering measures** reduce speeds and reduce serious crashes such as speed humps, speed cushions, raised platform crossings and raised intersections, lane narrowing, chicanes, gateway treatments and roundabouts.[124]
- **Vehicle technologies** such as intelligent speed adaptation[125] (especially as more than just a warning to the driver), continuous speed monitoring and speed limiting.[126]

5.2 Actions not proven to reduce deaths and serious injuries

It is vital we do not divert precious road safety resources into ineffective actions (even if they are popular and accepted by the public) such as:

- car-handling skill-based driver training (see 5.2.1)
- education, including school-based education and driver training (see 5.2.2)
- awareness raising that simply uses crash risk and severity as a deterrent (see 5.2.3).

5.2.1 Car handling skill-based driver training

Direct evidence exists that car-handling skill-based training does not improve road safety (and often increases crash rates) and that such training increases driver over-confidence (thus, risk taking).[127] This does not mean all forms of driver training do not work (discussed further below).

The highly credible Cochrane Library has published methodologically rigorous reviews of the evidence, which show no safety benefits from post-licence driver training. For example, a review of post-licence driver training concludes:[128]

---

[124] RFS Job & LW Mbugua (2020) *Road crash trauma, climate change, pollution and the total costs of speed: Six graphs that tell the story* (GRSF note 2020.1). Washington, DC: Global Road Safety Facility, World Bank. http://documents1.worldbank.org/curated/en/298381607502750479/pdf/Road-Crash-Trauma-Climate-Change-Pollution-and-the-Total-Costs-of-Speed-Six-graphs-that-tell-the-story.pdf; T Makwasha & B Turner. (2013) Evaluating the use of rural-urban gateway treatments in New Zealand. *Journal of the Australasian College of Road Safety* 24(4): 14–20; J Huang, P Liu, X Zhang, J Wan, & Z Li (2011) Evaluating the speed reduction effectiveness of speed bump on local streets. *11th International Conference of Chinese Transportation Professionals* 2348–2357. http://ascelibrary.org/doi/abs/10.1061/41186(421)234

[125] **Vehicle intelligent speed adaptation** involves advanced vehicle technology systems to determine the speed limits applicable for the vehicle in its current location to assist drivers to stick to the speed limit. Technology using a global navigation satellite system such as GPS is linked to a speed zone database and thus allows the vehicle (or the mobile phone) to "know" its location and the speed limit on that road.

[126] OMJ Carsten, M Fowkes, F Lai, K Chorlton, S Jamson, FN Tate & R Simpkin. (2008) *Intelligent speed adaptation: Final report to Department for Transport.* University of Leeds and MIRA Ltd.

[127] For a brief review, see B Turner, S Job & S Mitra (2021) *Guide for road safety interventions: Evidence of what works and what does not work*. Washington, DC: World Bank. www.roadsafetyfacility.org/publications/guide-road-safety-interventions-evidence-what-works-and-what-does-not-work; A Katila, E Keskinen, M Hatakka & S Laapotti (2004) Does increased confidence among novice drivers imply a decrease in safety? The effects of skid training on slippery road accidents. *Accident analysis & prevention* 36(4): 543–550. www.sciencedirect.com/science/journal/00014575; NP Gregersen (1996) Young drivers' overestimation of their own skill: An experiment on the relation between training strategy and skill. *Accident analysis & prevention* 28(2): 243–250; B Jones (1995) The effectiveness of skid-car training for teenage novice drivers in Oregon. *The Chronicle of American Driver & Traffic Safety Education Association* 43(1): 1–8.

[128] K Ker, IG Roberts, T Collier, FR Beyer, F Bunn & C Frost. Post-licence driver education for the prevention of road traffic crashes. *Cochrane database of systematic reviews* (3): CD003734. DOI: 10.1002/14651858.CD003734

> This systematic review provides no evidence that post-licence driver education [training] is effective in preventing road traffic injuries or crashes. … Because of the large number of participants included in the meta-analysis (close to 300,000 for some outcomes) we can exclude, with reasonable precision, the possibility of even modest benefits.

A 2003 review of the evidence states:[129]

> No one form of education [training] … was found to be substantially more effective than another, nor was a significant difference found between advanced driver education and remedial driver education.

Reviews in 1995 and 2009 demonstrate increased crash rates following vehicle-handling skills-based training such as skid training.[130]

The same pattern of no road safety benefits from skills-based training for car drivers also applies for motorcycle riders – benefits are absent in a systematic review of the evidence[131] and in a well-controlled evaluation of post-licence rider training.[132]

This does not mean all forms of driver training do not work. Evidence indicates that many hours of supervised on-road driver experience reduces the subsequent crash rates of novice drivers.[133] It is not clear why this works. We can only speculate about why this works where other forms of driver training fail. It may be that the many hours of on-road supervised practice teaches drivers to better anticipate traffic and hazards or that the supervisor teaches safe non–risk-taking habits such as driving within the speed limit and wearing a seatbelt.

5.2.2 Education (including school-based education and driver training)

Education (including school-based education and driver training) is not a solution to road safety. Education has only small effects on road safety at best, and even these effects, if they occur at all, will take most of the rest of this century to permeate the population, based on New Zealand's average life expectancy of around 82 years. There may be value in some aspects of school-based road safety education (for example, training children how and where to cross the road safely), but evaluations are poor and effects often weak or non-existent.[134]

---

[129] K Ker, IG Roberts, T Collier, FR Beyer, F Bunn & C Frost (2003) Post-licence driver education for the prevention of road traffic crashes. *Cochrane database of systematic reviews* (3): CD003734. DOI: 10.1002/14651858.CD003734.

[130] B Jones (1995) The effectiveness of skid-car training for teenage novice drivers in Oregon. *The Chronicle of American Driver & Traffic Safety Education Association* 43(1): 1–8; R Elvik, A Høye, T Vaa & M Sørensen (eds) (2009) *The handbook of road safety measures*. Bingley, UK: Emerald Group.

[131] K Kardamanidis, A Martiniuk, RQ Ivers, MR Stevenson & K Thistlethwaite (2010) Motorcycle rider training for the prevention of road traffic crashes. *The Cochrane Library*. www.cochrane.org/CD005240/INJ_motorcycle-rider-training-for-preventing-road-traffic-crashes

[132] RQ Ivers, C Sakashita, T Senserrick, J Elkington, S Lo, S Boufous & L de Rome (2016) Does an on-road motorcycle coaching program reduce crashes in novice riders? A randomised control trial. *Accident analysis & prevention* 86: 40–46.

[133] NP Gregersen, A Nyberg & HY Berg. (2003) Accident involvement among learner drivers: An analysis of the consequences of supervised practice. *Accident analysis & prevention* 35(5): 725–730.

[134] R Elvik, A Høye, T Vaa & M Sørensen (eds) (2009). *The handbook of road safety measures*. Bingley, UK: Emerald Group.

An evaluation of school-based bicycle safety education found an increase in crashes with the education.[135]

A 2020 review of high school driver education (training) concluded: "The net result of high school driver education is increased numbers of crashes."[136] A comprehensive review of the evidence on school-based driver training by the Cochrane Library concluded:[137]

> The results show that driver education [in schools] leads to early licensing. They provide no evidence that driver education reduces road crash involvement, and suggest that it may lead to a modest but potentially important increase in the proportion of teenagers involved in traffic crashes.

This result may seem unusual given the changes we can create in many other areas of behaviour through education and training. Three factors appear to create this result.

First, education creates knowledge, but the human behaviours involved in most serious crashes are not knowledge problems – people do not speed because they do not know there is a law against it – speeding is a motivation problem. Not drink-driving and not wearing a seat-belt are also not issues of skill – they too are motivation issues. Therefore, education is the wrong tool for this particular job.

Second, as identified earlier, training creates over-confidence and thus more risk-taking.

Third, as the Cochrane Library review identified, school-based driver training has the added disadvantage of starting people driving at a younger age. This matters, because young drivers have more crashes because they are young not just because they are inexperienced. Drivers who start driving at a later age are safer, even though they have the same level of experience at the start of driving as do younger drivers. Age matters because of relatively recently discovered brain development phases. The frontal cortex of the human brain does not fully develop until between ages 19 and 25.[138] The frontal cortex is critical in the processes of inhibiting the urge to do something (like driving fast or attempting to take a corner too fast to impress friends). Therefore, the lack of development of this part of the brain weakens its ability to control such urges in younger drivers. Socially, we may not find it reasonable to delay driving until this part of the brain is fully developed in everyone, but delaying solo driving improves road safety and facilitating earlier solo driving harms safety.

---

[135] JB Carlin, P Taylor & T Nolan (1998) School based bicycle safety education and bicycle injuries in children: A case-control study. *Injury prevention* 4(1): 22–27.

[136] B O'Neill (2020) Driver education: How effective? *International journal of injury control and safety promotion* 27(1): 61–68.

[137] Roberts IG, Kwan I. (2001). School-based driver education for the prevention of traffic crashes. *Cochrane database of systematic reviews* (3), p 2.

[138] BJ Casey, RM Jones & TA Hare (2008) The adolescent brain. *Annals of the New York Academy of Sciences* 1124: 111–126. doi: 10.1196/annals.1440.010; SB Johnson & VC Jones (2011) Adolescent development and risk of injury: Using developmental science to improve interventions *Injury prevention* 17(1): 50–54.

5.2.3 Awareness raising that uses crash risk or severity as a deterrent

Awareness raising that simply uses crash risk or severity as a deterrent is a weak intervention. Awareness raising is easy to measure and easy to achieve through advertising, so is often misleadingly offered as the evidence of success. The valuable objective of road safety promotions is a change to safer behaviour, measured in observations of behaviour or in crash outcomes. We should not assume on the basis of theory that raising awareness of crash risk will achieve this – evidence for this in road safety is poor to non-existent.

As background to why this action fails to deliver road safety gains, see the discussion about over-confidence and personal illusions of invulnerability (4.6). Over-confidence leads a person to accept that others have a serious crash risk, but they do not because of "superior driving" and "invulnerability".

By following the evidence carefully, we can identify forms of awareness raising that do reduce serious crashes. For example, promotion of improved or more extensive enforcement or stronger penalties can reduce serious crashes – as has occurred with the promotion of mobile safety cameras before their introduction, upcoming random breath testing or mandatory seat belt laws.[139] There is a natural tendency to attribute these benefits to the enforcement (which is essential for sustained benefits) but the benefits of such programmes when advertised in advance often occurs before it is possible for the enforcement itself to create the benefits.[140] This works because over-confidence in driving ability does not mean the safety camera will not catch the speeding driver, so the risk of the penalty applies to "me" even if I believe I am a great driver.

[139] DC Herbert (1980) *Road safety in the seventies: Lessons for the eighties* (Traffic Accident Research Unit report 4/80). New South Wales: Department of Motor Transport; NSW Centre for Road Safety, RTA (2010) *Do you see what I see: Re-introduction of mobile speed cameras.* Sydney: Roads & Traffic Authority & Government of NSW.

[140] RFS Job (1988) Effective and ineffective use of fear in health promotion campaigns. *American journal of public health* 78: 163–167; DC Herbert (1980) *Road safety in the seventies: Lessons for the eighties* (Traffic Accident Research Unit report 4/80). New South Wales: Department of Motor Transport.

6 Conclusion

This report has presented practical scientific evidence from around the world and from New Zealand. That evidence leads compellingly to the following conclusions:

- Speed and speeding are major contributors to both crash occurrence and crash severity through many identified mechanisms, demonstrating that speeding and speed have substantial roles in crash deaths and serious injuries
- The evidence regarding speed and speeding exists for and applies in New Zealand. If New Zealand differs from the global evidence it is that speed is even more critical in serious crashes in New Zealand, possibly because of New Zealand's topography leading to many curved road sections and unforgiving roadsides, which result in crashes at speed being less survivable.
- As well as reducing deaths and serious injuries on the roads, improved management of speed will deliver additional benefits that far outweigh the (often over-estimated) dis-benefits.
- We need to understand and address how people's psychological make-up and interpretation of experience means we often don't believe the evidence.

The evidence in this report shows that reducing both urban and non-urban travel speeds in New Zealand will:

- deliver large reductions in crash deaths and injuries each year
- reduce health harm from air pollution and noise pollution
- create more liveable cities with greater opportunities for active transport
- improve social equity
- reduce greenhouse gas emissions
- improve New Zealand's economy.

The report also presents a variety of actions that can deliver the needed reductions in travel speed and the evidence for their success, as well as noting a few actions we might expect to work that the evidence shows do not work and may even do harm.

This report explains the effects of speed and speeding not only on road safety, but also on many health and social issues, helps us understand why we often resist the evidence based on our psychological biases and misjudgement of risk, and offers the evidence for and value of lower speeds. All this is presented for road safety implementers and decision makers at all levels, for road users (whether drivers, passengers, or people who walk, cycle and scoot), and for the media and commentators to understand, accept, support and deliver lower travel speeds for New Zealand.

References

Abley (2022) *Safe Speeds phase 1: 24 month interim evaluation*. Auckland: Abley. https://at.govt.nz/media/1990901/aukland-transport-report-24-month-safe-speeds-tranche-1-monitoring.pdf

Accident Rehabilitation & Compensation Insurance Corporation & LTSA (2000). *Down with speed: A review of the literature and the impact of speed on New Zealanders*. Wellington: Land Transport Safety Authority.

Ahie, LM, Charlton, SG, & Starkey, NJ (2015) The role of preference in speed choice. *Transportation research Part F: Traffic psychology and behaviour* 30: 66–73. https://doi.org/10.1016/j.trf.2015.02.007

Anderson, JO, Thundiyil, JG, & Stolbach, A (2012). Clearing the air: A review of the effects of particulate matter air pollution on human health. *Journal of medical toxicology* 8(2): 166–175.

Archer, J, Fotheringham, N, Symmons, M, & Corben, B (2008) *The impact of lowered speed limits in urban and metropolitan areas* (report 276) Monash University Accident Research Centre. www.monash.edu.au/miri/research/reports/muarc276.pdf

Austroads (2018) *Towards Safe System infrastructure: A compendium of current knowledge* (research report AP-R560-18). Sydney: Austroads.

Babisch, W (2006) Transportation noise and cardiovascular risk: updated review and synthesis of epidemiological studies indicate that the evidence has increased. *Noise and health* 8(30): 1.

Banas, T (2020) How to calculate crash forces. Sciencing. https://sciencing.com/calculate-crash-forces-6038611.html (retrieved November 2021).

Bertulis, T, & Dulaski, DM (2014) Driver approach speed and its impact on driver yielding to pedestrian behavior at unsignalized crosswalks. *Transportation research record* 2464(1): 46–51.

Bhatnagar, Y, Saffron, D, De Roos, M, & Graham, A (2010) Changes to speed limits and crash outcome: Great Western Highway case study. In *Proceedings of the Australasian road safety research, policing and education conference* (vol 14). Monash University.

Bodin, T, Albin, M, Ardö, J, Stroh, E, Östergren, PO, & Björk, J (2009) Road traffic noise and hypertension: Results from a cross-sectional public health survey in southern Sweden. *Environmental Health* 8(1): 1–10.

Cameron, M (2003) *Potential benefits and costs of speed changes on rural roads* (report CR216). Victoria, Australia: Monash University Accident Research Centre.

Cameron, M (2012) Optimum speeds on rural roads based on “willingness to pay” values of road trauma. *Journal of the Australasian College of Road Safety* 23(3): 67–74.

Cameron, M (2022) Economic Analysis of Optimum Speeds on Rural State Highways in New Zealand. Wellington: Waka Kotahi NZ Transport Agency

Carlin, JB, Taylor, P, & Nolan, T (1998) School based bicycle safety education and bicycle injuries in children: a case-control study. *Injury prevention* 4(1): 22–27.

Carnis, L, & Blais, E (2013) An assessment of the safety effects of the French speed camera program. *Accident analysis & prevention* 51: 301–309.

Carsten, OMJ, Fowkes, M, Lai, F, Chorlton, K, Jamson, S, Tate, FN, Simpkin, R (2008) Intelligent speed adaptation: Final report to Department for Transport. University of Leeds and MIRA Ltd.

Casey, BJ, Jones, RM, & Hare, TA (2008) The adolescent brain. Annals *of the New York Academy of Sciences* 1124: 111–126. doi: 10.1196/annals.1440.010.

Charlton, SG, & Starkey, NJ (2017) Driving on urban roads: How we come to expect the “correct” speed. *Accident analysis & prevention* 108: 251–260. https://doi.org/10.1016/j.aap.2017.09.010

Charlton, SG, Starkey, NJ, Perrone, JA, & Isler, RB (2014) What’s the risk? A comparison of actual and perceived driving risk. *Transportation research part F: Traffic psychology and behaviour* 25 (part A): 50–64. https://doi.org/10.1016/j.trf.2014.05.003

Chua, FJ, & Job, RFS (1999) Event-specific versus unitary causal accounts of optimism bias. *Journal of behavioural medicine* 22: 457–491.

Clark, C, Sbihi, H, Tamburic, L, Brauer, M, Frank, LD, & Davies, HW (2017) Association of long-term exposure to transportation noise and traffic-related air pollution with the incidence of diabetes: A prospective cohort study. *Environmental health perspectives* 125(8): 087025.

De Pauw, E, Daniels, S, Brijs, T, Hermans, E, & Wets, G (2014) An evaluation of the traffic safety effect of fixed speed cameras. *Safety science* 62: 168–174.

Deep Hollow Ranch (2021) How fast can a horse run? (Top & average speed). www.deephollowranch.com/horse-speed

Delaney, A, Ward, H, Cameron, M, & Williams, AF (2005) Controversies and speed cameras: Lessons learnt internationally. *Journal of public health policy* 26(4): 404–415.

Driven (2020) Watch: What’s the best car ad? *Driven* (27 November). www.driven.co.nz/news/watch-what-s-the-best-car-ad/

Elvik, R (2010) A restatement of the case for speed limits. *Transport policy* 17(3): 196–204. https://doi.org/10.1016/j.tranpol.2009.12.006

Elvik, R (2012) Speed limits, enforcement, and health consequences. *Annual review of public health* 33(1): 225–238. https://doi.org/10.1146/annurev-publhealth-031811-124634

Elvik, R (2013) A re-parameterisation of the power model of the relationship between the speed of traffic and the number of accidents and accident victims. *Accident analysis & prevention* 50: 854–860.

Elvik, R (2019) A comprehensive and unified framework for analysing the effects on injuries of measures influencing speed. *Accident Analysis & Prevention* 125: 63–69.

Elvik, R, Høye, A, Vaa, T, & Sørensen, M (eds) (2009) *The handbook of road safety measures*. Bingley, UK: Emerald Group.

Elvik, R, Vadeby, A, Hels, T, & van Shagen, I (2019) Updated estimates of the relationship between speed and road safety at the aggregate and individual levels *Accident Analysis & Prevention* 123: 114–122.

ETSC (2008) German Autobahn: The Speed Limit Debate. European Transport Safety Council Speed Factsheet 01-08.

ETSC (2015) Germany unblocks 30km/h zones. European Transport Safety Council (17 April) https://etsc.eu/germany-unblocks-30kmh-zones/#:~:text=Germany's percent20Federal percent20Transport percent20Minister percent20Alexander,to percent20implement percent2030km percent2Fh percent20zones

Farmer, CM (2017) Relationship of traffic fatality rates to maximum state speed limits. *Traffic injury prevention* 18(4): 375–380.

FIA Foundation, www.fiafoundation.org

Ford (2019) The Ford Fiesta ST: Latest reviews. (23 October). www.faganford.co.nz/news/details/303/the-ford-fiesta-st-latest-reviews

Gårder, P (2006) Segment characteristics and severity of head-on crashes on two-lane rural highways in Maine. *Accident Analysis & Prevention* 38(4): 652–661.

Formula 1 (2021) The 10 most dramatic crashes of the 2020 F1 season (video). *YouTube.* www.youtube.com/watch?v=ZGd9A2IhQeU

Gregersen, NP (1996) Young drivers' overestimation of their own skill-an experiment on the relation between training strategy and skill. *Accident Analysis & Prevention* 28(2): 243–250.

Gregersen, NP, Nyberg, A, & Berg, HY (2003) Accident involvement among learner drivers: An analysis of the consequences of supervised practice. *Accident Analysis & Prevention* 35(5): 725–730.

GRSF (World Bank) & GRSP (International Red Cross & Red Crescent Society) (2020). *Guide for determining readiness for speed cameras and other automated enforcement.* Geneva, Switzerland: Global Road Safety Facility & Global Road Safety Partnership

GRSP & WHO (2008) *Speed management: A road safety manual for decision makers and practitioners*. Geneva, Switzerland: World Health Organization & Global Road Safety Partnership.

Grzebieta, RH (2019) Safe speed limits, Trauma Week 2019 symposium, *Pedestrians: Staying safe*, Royal Australasian College Surgeons, 13 February, Melbourne, Australia. www.surgeons.org/-/media/Project/RACS/surgeons-org/files/trauma-verification/17-r-grzebieta-safe-speed-limits.pdf?rev=be72114dc4ef45689dc3ffa5ede40052&hash=3994BB422E7973A805FBA4C7C061D479

Haines, MM, Stansfeld, SA, Job, RFS, Berglund, B, & Head, J (2001) A follow-up study of the effects of chronic aircraft noise exposure on child stress responses and cognition. *International Journal of Epidemiology* 30: 839–845.

Haines, MM, Stansfeld, SA, Job, RFS, Berglund, B, & Head, J (2001) Chronic aircraft noise exposure, stress responses mental health and cognitive performance in school children. *Psychological medicine* 31: 265–277.

Harre, N, & Sibley, CG (2007) Explicit and implicit self-enhancement biases in drivers and their relationship to driving violations and crash-risk optimism. *Accident Analysis & Prevention* 39(6): 1155–1161.

Henry, A (2006) Ferrari icon Clay Regazzoni dies in car crash aged 67. *The Guardian* (16 December). www.theguardian.com/sport/2006/dec/16/formulaone.gdnsport3

Herbert, DC (1980) *Road safety in the seventies: Lessons for the eighties* (Traffic Accident Research Unit report 4/80). New South Wales: Department of Motor Transport.

Homel R (1988) *Policing and punishing the drinking driver: A study of general and specific deterrence.* New York: Springer-Verlag.

Horton, R (1999) Reflections on another age: Mike Hawthorn remembered. *Atlas Formula 1 journal*. http://atlasf1.autosport.com/99/jan27/horton.html

Hosseinlou, MD, Kheyrabadi, SA, Zolfaghari, A (2015) Determining optimal speed limits in traffic networks. *International Association of Traffic and Safety Sciences* 39(1): 36–41.

Hosseinpour, M, Yahaya, AS, & Sadullah, AF (2014) Exploring the effects of roadway characteristics on the frequency and severity of head-on crashes: Case studies from Malaysian Federal Roads. *Accident Analysis & Prevention* 62: 209–222.

Høye, A (2015) Safety effects of fixed speed cameras: An empirical Bayes evaluation. *Accident Analysis & Prevention* 82: 263–269.

Huang, J, Liu, P, Zhang, X, Wan, J, & Li, Z (2011) Evaluating the speed reduction effectiveness of speed bump on local Streets. *11th International Conference of Chinese Transportation Professionals* 2348–2357. http://ascelibrary.org/doi/abs/10.1061/41186(421)234

Hussain, Q, Feng, H, Grzebieta, R, Brijs, T, & Olivier, J (2019) The relationship between impact speed and the probability of pedestrian fatality during a vehicle-pedestrian crash: A systematic review and meta-analysis. *Accident Analysis & Prevention* 129: 241–249.

Understand inequality (no date) *Inequality: A New Zealand conversation.* www.inequality.org.nz/understand/

IIHS (2021) *Speed*. Insurance Institute for Highway Safety. www.iihs.org/topics/speed

ITF (2016) Zero road deaths and serious injuries: Leading a paradigm shift to a safe system. Paris: International Transport Forum, OECD. http://dx.doi.org/10.1787/9789282108055-en

ITF (2022) *The Safe System approach in action.* Paris, France: International Transport Forum, OECD.

Ivers, RQ, Sakashita, C, Senserrick, T, Elkington, J, Lo, S, Boufous, S, & de Rome, L (2016) Does an on-road motorcycle coaching program reduce crashes in novice riders? A randomised control trial. *Accident Analysis & Prevention* 86: 40–46.

Jha, A (2005) How do speed cameras cause traffic jams? The Guardian (17 March). www.theguardian.com/science/2005/mar/17/thisweekssciencequestions2

Job, RFS (1988) Community response to noise: A review of factors influencing the relationship between noise exposure and reaction. *Journal of the Acoustical Society of America* 83: 991–1001.

Job, RFS (1988) Effective and ineffective use of fear in health promotion campaigns. *American journal of public health* 78: 163–167.

Job, RFS (1990) The application of learning theory to driving confidence: The effect of age and the impact of random breath testing. *Accident analysis & prevention* 22: 97–107.

Job, RFS (1996) The influence of subjective reactions to noise on health effects of the noise. *Environment international* 22: 93–104.

Job, RFS (2022) Evaluations of speed camera interventions can deliver a wide range of outcomes: Causes and policy implications. *Sustainability* 14(3): 1765. https://doi.org/10.3390/su14031765

Job, RF, & Brodie, C (2022) Understanding the role of speeding and speed in serious crash trauma: A case study of New Zealand. *Journal of road safety* 33(1): 5–25. https://doi.org/10.33492/JRS-D-21-00069

Job, RFS, Haynes, J, Prabhakar, T, Lee, SHV, & Quach, J (1998) Pedestrians at traffic light controlled intersections: Crossing behaviour in the elderly and non-elderly. In K Smith, BG Aitken, & RH Grzebieta (eds), *Proceedings of the conference on pedestrian safety* (pp 3–11). Canberra: Australian College of Road Safety & Federal Office of Road Safety.

Job, RFS, & Mbugua, LW (2020) *Road crash trauma, climate change, pollution and the total costs of speed: Six graphs that tell the story* (GRSF note 2020.1). Washington, DC: Global Road Safety Facility, World Bank. http://documents1.worldbank.org/curated/en/298381607502750479/pdf/Road-Crash-Trauma-Climate-Change-Pollution-and-the-Total-Costs-of-Speed-Six-graphs-that-tell-the-story.pdf

Job RFS, Truong, J, & Sakashita, C (2022) The ultimate safe system: Redefining the Safe System approach for road safety. *Sustainability* 14(5): 2978. https://doi.org/10.3390/su14052978

Johnson, D (2015) Lewis Hamilton: Heavy partying is to blame for my Monte Carlo car crash. *The Telegraph* (12 November). www.telegraph.co.uk/sport/motorsport/formulaone/lewishamilton/11992509/Lewis-Hamilton-Heavy-partying-is-to-blame-for-my-Monte-Carlo-car-crash.html

Johnson, SB, and Jones, VC (2011) Adolescent development and risk of injury: Using developmental science to improve interventions. *Injury Prevention* 17(1): 50–54.

Jonah, BA (1986) Accident risk and risk-taking behaviour among young drivers. *Accident Analysis & Prevention* 18: 255–271.

Jones, AZ (2020) The physics of a car collision. ThoughtCo. www.thoughtco.com/what-is-the-physics-of-a-car-collision-2698920 (retrieved February 2022).

Jones, B (1995) The effectiveness of skid-car training for teenage novice drivers in Oregon. *The Chronicle of American Driver & Traffic Safety Education Association* 43(1): 1–8.

Jones, SJ, & Brunt, H (2017) Twenty miles per hour speed limits: A sustainable solution to public health problems in Wales. *Journal of Epidemiology and Community Health* 71(7), 699–706.

Jurewicz, C. (2010). *Impact of lower speed limits for road safety on network operations* (No. AP-T143/10). Melbourne: Austroads.

Jurewicz, C, Sobhani, A, Woolley, J. Dutschke, J, & Corben, B. (2016) Exploration of vehicle impact speed: Injury severity relationships for application in safer road design. *Transportation Research Procedia* 14: 4247–4256.

Kardamanidis, K, Martiniuk, A, Ivers, RQ, Stevenson, MR, & Thistlethwaite, K (2010) Motorcycle rider training for the prevention of road traffic crashes. *The Cochrane Library*. www.cochrane.org/CD005240/INJ_motorcycle-rider-training-for-preventing-road-traffic-crashes

Katila, A, Keskinen, E, Hatakka, M, & Laapotti, S (2004) Does increased confidence among novice drivers imply a decrease in safety? The effects of skid training on slippery road accidents. *Accident Analysis & Prevention* 36(4): 543–550.

Keall, MD, Povey, LJ, & Frith, WJ. (2001) The relative effectiveness of a hidden versus a visible speed camera programme. *Accident analysis & prevention* 33: 277–284. www.sciencedirect.com/science/journal/00014575

Ker, K, Roberts, IG, Collier, T, Beyer, FR, Bunn, F, & Frost, C (2003) Post-licence driver education for the prevention of road traffic crashes. *Cochrane database of systematic reviews* (3): CD003734. DOI: 10.1002/14651858.CD003734

Klatte, M, Bergström, K, & Lachmann, T (2013) Does noise affect learning? A short review on noise effects on cognitive performance in children. *Frontiers in psychology* 4: 578.

Kloeden, CN, Woolley, JE, & McLean, AJ (2007) *A follow-up evaluation of the 50km/h default urban speed limit in South Australia*. Proceedings of the Road Safety Research, Education and Policing Conference, Melbourne, Australia, 17–19 October.

Koorey, G, & Frith, WB (2017) Changing rural speed limits: Learning from the past. IPENZ Transportation Group Conference, Hamilton, 29–31 March.

Llewellyn, R (2018) Increasing the speed limit won't get traffic moving faster. *The Conversation* (6 October). https://theconversation.com/increasing-the-speed-limit-wont-get-traffic-moving-faster-104365

Mackenzie, J, Hutchinson, T, & Kloeden, C (2015) Reduction of speed limit from 110 km/h to 100 km/h on certain roads in South Australia: A follow up evaluation (CASR report 115). Centre for Automotive Research, University of Adelaide.

Mackie, H, Brodie, C, Scott, R, Hirsch, L, Tate, F, Russell, M, & Holst, K (2017) The signs they are a-changin': Development and evaluation of New Zealand's rural intersection active warning system. *Journal of the Australasian College of Road Safety* 28(3): 11–21.

Madireddy, M, De Coensel, B, Can, A, Degraeuwe, B, Beusen, B, De Vlieger, I, & Botteldooren, D (2011). Assessment of the impact of speed limit reduction and traffic signal coordination on vehicle emissions using an integrated approach. *Transportation research part D: transport and environment* 16(7): 504–508.

Makwasha, T, & Turner, B (2013) Evaluating the use of rural-urban gateway treatments in New Zealand. *Journal of the Australasian College of Road Safety* 24(4): 14–20.

Ministry of Transport (2015) *Speed Survey Results 2015*. Wellington: Ministry of Transport www.transport.govt.nz/assets/Uploads/Report/Speed-survey-results-2015.pdf

Münzel, T, Sørensen, M, & Daiber, A. (2021) Transportation noise pollution and cardiovascular disease. *Nature reviews cardiology* 18(9): 619–636.

Neira, MP (2019) Air pollution and human health: A comment from the World Health Organization. *Annals of global health* 85(1).

New Zealand Government (2010) *Safer Journeys. New Zealand's Road Safety Strategy 2010–2020*. Wellington: Ministry of Transport.

New Zealand Government (2019) *Road to Zero: New Zealand's Road Safety Strategy 2020–2030*. Wellington: New Zealand Government. www.transport.govt.nz//assets/Uploads/Report/Road-to-Zero-strategy_final.pdf

New Zealand Police (2020) *Speed evidence review*. Wellington: National Road Policing Centre.

Nilsson, G (2004) *Traffic safety dimension and the Power Model to describe the effect of speed on safety.* Sweden: Lund Institute of Technology.

NSW Centre for Road Safety, RTA (2010) *Do you see what I see: Re-introduction of mobile speed cameras.* Sydney: Roads & Traffic Authority and Government of New South Wales.

O'Neill, B (2020) Driver education: How effective? *International journal of injury control and safety promotion* 27(1): 61–68.

OECD (2006) *Speed management* (report of the Transport Research Centre). Paris: OECD & European Conference of Ministers of Transport. http://documents1.worldbank.org/curated/en/298381607502750479/pdf/Road-Crash-Trauma-Climate-Change-Pollution-and-the-Total-Costs-of-Speed-Six-graphs-that-tell-the-story.pdf

Ohlwein, S, Hennig, F, Lucht, S, Matthiessen, C, Pundt, N, Moebus, S, Jöckel, K-H, & Hoffmann, B. (2019) Indoor and outdoor road traffic noise and incident diabetes mellitus: Results from a longitudinal German cohort study. *Environmental epidemiology* 3(1). DOI: 10.1097/EE9.0000000000000037

Polkinghorne, J (2014) New Zealand and the 1970s oil shocks: More than just "carless days". Greater Auckland (3 January). www.greaterauckland.org.nz/2014/01/03/new-zealand-and-the-1970s-oil-shocks/

Pope III, CA, Coleman, N, Pond, ZA, & Burnett, RT (2020) Fine particulate air pollution and human mortality: 25+ years of cohort studies. *Environmental research* 183: 108924.

Povey, LJ, Frith, WJ, & Keall, MD (2003) An investigation of the relationship between speed enforcement, vehicle speeds and injury crashes in New Zealand. Wellington: Land Transport Safety Authority. www.transportationgroup.nz/papers/2003/01_Povey_Keall_Frith.pdf

Prabhakar, T, Lee, SHV, & Job, RFS (1996) Risk taking, optimism bias and risk utility in young drivers. In L St John (ed), *Proceedings of the Road Safety Research and Enforcement Conference* (pp 61–68). Sydney, NSW: Roads & Traffic Authority of NSW.

Roberts, IG, Kwan, I (2001) School-based driver education for the prevention of traffic crashes. *Cochrane database of systematic reviews* (3).

Sakashita, C, & Job, RFS (2015) Employing refined licensing conditions to reduce the serious crashes of young drivers. *Journal of local and global health science* 43.

Seaward, HG, & Kemp, S (2000) Optimism bias and student debt. *New Zealand journal of psychology* 29(1): 17–19.

Shope, JT (2007) Graduated driver licensing: Review of evaluation results since 2002. *Journal of safety research* 38(2): 165–175.

Simon, KR, Merz, EC, He, X, Noble, KG (2022) Environmental noise, brain structure, and language development in children. *Brain and language* 229: 105–112. https://doi.org/10.1016/j.bandl.2022.105112

Sliogeris, J (1992) *110 kilometre per hour speed limit: Evaluation of road safety effects*. Victoria, Australia: VicRoads.

Stefanidis, KB, Truelove, V, Nicolls, M, & Freeman, J (2022) Perceptions matter: Speeding behavior varies as a function of increasing perceived exposure to content encouraging the behavior. *Traffic injury prevention* 1–6.

Svenson, O (1981) Are we all less risky and more skilful than our fellow drivers? *Acta psychologica* 47(2): 143–148.

Svenson, O (2009) Driving speed changes and subjective estimates of time savings, accident risks and braking. *Applied cognitive psychology* 23(4): 543–560. https://doi.org/10.1002/acp.1471

Tankasem, P, Satiennam, T, Satiennam, W, & Klungboonkrong, P (2019) Automated speed control on urban arterial road: An experience from Khon Kaen City, Thailand. *Transportation research interdisciplinary perspectives* 1: 100032.

Tate, F (2022) *The impact of change in speed limit at three sites* (project 5-C4024.00). New Zealand: WSP.

Te Manatū Waka Ministry of Transport (2020) *Vehicle age*. Wellington: Te Manatū Waka Ministry of Transport . www.transport.govt.nz/statistics-and-insights/fleet-statistics/sheet/vehicle-age

Tillman, WA, & Hobbs, GE (1949) The accident-prone automobile driver. *American journal of psychiatry* 106: 321–331.

Tingvall, C, & Academic Expert Group (2021) *Saving lives beyond 2020: The next steps* (recommendations of the Academic Expert Group for the third global ministerial conference on road safety). Stockholm, Sweden: Swedish Transport Administration.

Turner, B, Job, S, & Mitra, S (2021) *Guide for road safety interventions: Evidence of what works and what does not work.* Washington, DC: World Bank. www.roadsafetyfacility.org/publications/guide-road-safety-interventions-evidence-what-works-and-what-does-not-work

Turner, S, Khoo, J, & England, J (2014) How drivers judge the safety of the road. In *Proceedings of the 2014 Australasian Road Safety Research, Policing & Education Conference*. Melbourne, Australia. http://acrs.org.au/files/arsrpe/full-paper_2117.pdf

UNECE (2021) UN vehicle regulation will increase road safety thanks to “black-box” collecting information on crashes (press release, 15 October). United Nations Economic Commission for Europe. https://unece.org/media/press/361071

Van Ratingen, M, Williams, A, Lie, A, Seeck, A, Castaing, P, Kolke, R, Adriaenssens, G, & Miller, A (2016) The European New Car Assessment Programme: A historical review. *Chinese journal of traumatology* 19(2): 63–69.

Waka Kotahi NZ Transport Agency (2011) *High-risk rural roads guide*. Wellington: Waka Kotahi NZ Transport Agency. www.nzta.govt.nz/resources/high-risk-rural-roads-guide/

Waka Kotahi NZ Transport Agency (2021) Appendix A: permanent road safety hardware & devices. Wellington: Waka Kotahi NZ Transport Agency. www.nzta.govt.nz/assets/resources/road-safety-barrier-systems/docs/m23-road-safety-barrier-systems-appendix-a.pdf

Walton, D, & Bathurst, J (1998) An exploration of the perceptions of the average driver's speed compared to perceived driver safety and driving skill. *Accident Analysis & Prevention* 30(6): 821–830.

Walton, D, & Smith, K (2009) Survival confidence of New Zealanders in outdoor and post-earthquake situations. *Australian journal of emergency management* 24(3): 38–43.

Waylen, AE, Horswill, MS, Alexander, JL, & McKenna, FP (2004) Do expert drivers have a reduced illusion of superiority? *Transportation research part F: Traffic psychology and behaviour* 7(4–5): 323–331.

Weinstein, ND (1980) Unrealistic optimism about future life events. *Journal of personality and social psychology* 39(5): 806–820.

Weinstein, ND (1984) Why it won't happen to me: Perceptions of risk factors and susceptibility. *Health psychology* 3(5): 431–457.

Weinstein, ND (1988) The precaution adoption process. *Health psychology* 7(4): 355–386.

Williams, AF, Tefft, BC, & Grabowski, JG (2012) Graduated driver licensing research, 2010–present. *Journal of safety research* 43(3): 195–203.

Wilson, C, Willis, C, Hendrikz, JK, Le Brocque, R, & Bellamy, N. (2010) Speed cameras for the prevention of road traffic injuries and deaths. *Cochrane database of systematic reviews* (11): CD004607. https://doi.org/10.1002/14651858.CD004607.pub4

WHO (2008) *Speed management: A road safety manual for decision makers.* Geneva, Switzerland: World Health Organization & Global Road Safety Partnership.

WHO (2011) *Burden of disease from environmental noise: Quantification of healthy life years lost in Europe.* Geneva, Switzerland: World Health Organization, Regional Office for Europe.

WHO (2018) *Global status report on road safety*. Geneva, Switzerland: World Health Organization.

WHO & United Nations Regional Commissions (2021) *Global plan: Decade of action for road safety 2021–2030*. Geneva, Switzerland: World Health Organization.