

ROAD SAFETY IMPLICATIONS OF EXCESSIVE AND INAPPROPRIATE VEHICLE SPEED

Original version

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1 A BRIEF STATEMENT OF THE ISSUE

The association between speed and crash risk is clear, with speed being a major contributor to road trauma world-wide. Despite many efforts to manage the speed at which people travel on the road, speed is a continuing problem and one of the 'last frontiers' in road safety. The purpose of this paper is to explain in detail the associations between speed and crash and injury risk, including quantification of the relationship, and to discuss ways in which travel speed can be reduced within the 'Safe System' approach.

The primary reference for this paper remains Patterson et al. (2000).

2 AN ASSESSMENT OF THE ROAD SAFETY PROBLEM

2.1 Definitions of excessive and inappropriate speed

The distinction between 'excessive (illegal) speeding' and 'inappropriate speeding' may be summarised thus: '....a speed limit declares [only] higher speeds to be illegal, and it remains for each driver to decide what speed, within the limit, is appropriate' (ETSC 1995).

'Excessive speed' refers to instances when vehicles travel in excess of the legally-declared speed limit. There are a number of levels of 'excessive speed':

1. speeding in excess of the posted speed limit but within 10 km/h
2. speeding in excess of 10-25 km/h over the posted speed limit
3. speeding in excess of 25 km/h or more over the posted speed limit.

While level (3) speeding is intrinsically more risky, there are few drivers/riders who travel at such speeds. In contrast, level (1) speeding is much more common, though intrinsically less risky than other levels.

'Inappropriate speed' refers to instances when vehicles travel at speeds which are unsuitable for the road and traffic conditions prevailing at the time. Here, drivers and riders may drive at or less than the posted speed limit, but with elevated risk for the circumstances (e.g. in areas of high pedestrian activity with a posted speed limit of 60 km/h).

2.2 Mechanisms underlying the speed/crash relationship

The faster one travels on a road, the more likely one is to crash. This is because, the higher the travel speed:

- the more likely that the driver will lose control of the vehicle, therefore increasing the chance of running off the road or into an oncoming vehicle, e.g. by exceeding the critical speed on a curve
- the more likely that the driver will miss important hazard cues
- the greater the distance that the driver will travel before applying the brakes in response to a hazard
- the greater the distance that the vehicle will travel, once the brakes are applied
- the greater the chance that other road users will misjudge the vehicle's speed (because the speeding driver becomes more unpredictable) and thus precipitate a crash.

The severity of injuries resulting from a crash is also directly related to the pre-crash speed of the vehicle. Higher travel speeds invariably mean higher impact speeds and therefore more severe injuries for those involved. Further, when a vehicle crashes, it undergoes a rapid change of speed. The occupants, however, keep moving at the pre-crash speed until stopped, either by being thrown from the vehicle and hitting an external object, by hitting the vehicle interior, or by being restrained by a safety belt or airbag. All else being equal, the higher the pre-crash speed, the greater the rate at which the human body must absorb the energy released in the crash and the greater the severity of the resulting injury. Even small increases in speed can result in dramatic increases in the forces experienced by crash victims.

2.3 Speeding as a factor in road trauma

Speed is a major public safety and health issue. For example, in New Zealand in 2002, 126 deaths and 2,339 injuries were attributed to speeding, based on police judgements - representing 31% of all fatalities and 17% of all serious injuries (Frith, Strachan & Patterson 2005). Similar proportions are reported in Australia and elsewhere (ETSC 1995; Fildes & Lee 1993; NHTSA 1998). These levels are likely to understate the full impact of speed on crashes and injury severity: indeed, it may be argued that speed is involved in all casualty crashes – crashes and injuries only occur because the speed is too high to avoid a crash and to prevent injuries.

If the average speed on New Zealand's rural roads was reduced by just 4 km/h, the number of all deaths would decrease by about 15% and the total number injured by about 8% – meaning that about 45 deaths and 480 reported injuries would be saved. The difference between the fatal and serious injury proportions reflects the greater impact of any speed reduction on the most severe injuries ((Frith, Strachan & Patterson 2005). Applying the same scenario to the Australian situation, each year around 255 deaths and 1760 serious injuries (hospitalisations) would be saved.

Fildes, Langford and Szwed (2006) estimated crash benefits associated with speed limit setting in a given Australian jurisdiction, based on Nilsson's (1984) formula. Table 2.1 shows the estimated crash changes associated with speed limits using two scenarios: Scenario 1 representing a minimal reduction in some urban speed limits; Scenario 2 representing further reductions in some urban and rural speed limits.

Table 2.1: Estimated casualty crash changes associated with changes in speed limits in a given jurisdiction, Scenarios 1 and 2

Road type	Current speed limit km/h	Proposed speed limit: Scenario 1 km/h	Proposed speed limit: Scenario 2 km/h	Scenario 1: change in casualty crashes	Scenario 2: change in casualty crashes
Urban residential	50	40	30	-23%	-44%
Urban arterial	50-90	50	50	-9%	-9%
Urban freeway	100	100	100	0%	0%
Rural freeway	110	110	110	0%	0%
Rural arterial	110	80	70	-21%	-30%
Rural sealed minor	50-60	80	70	+125%	+96%
Rural unsealed minor	110	80	70	-23%	-34%
Total savings				-9%	-14%

3 A REVIEW OF THE RESEARCH

3.1 The relationship between speed and crash and injury risk

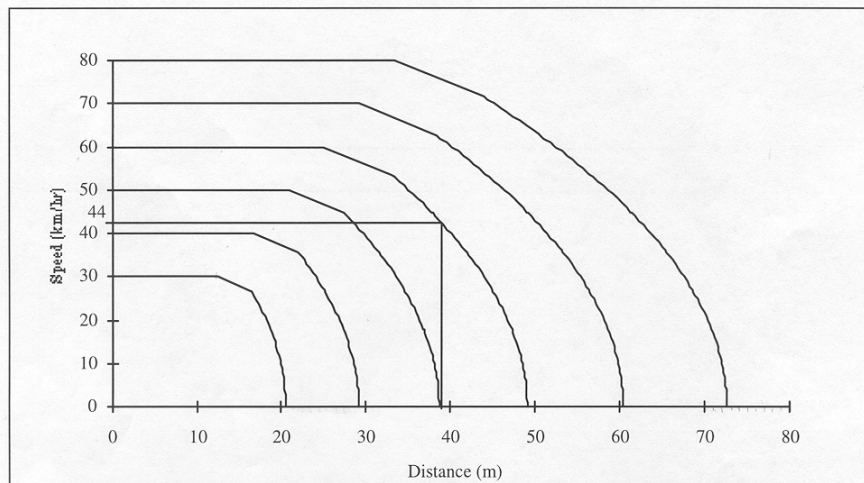
Early work in the 1960s – and especially Solomon’s U-shaped curve (Solomon 1964) -suggested that crash risk increased for vehicles travelling slower than average speed, as well as for vehicles travelling faster. However this conclusion has been increasingly questioned (for example: Baruya 1998; Taylor, Lynam & Baruya 2000). Many crashes involving slow speed were probably attributable not to speed variation but to road and traffic characteristics, including congested traffic, narrow roads or roads with a high density of intersections and vehicles that were stopping or slowing to turn or just entering the road.

In addition, crashes at low speeds invariably result in less serious injuries than crashes at higher speed. Indeed, subsequent work investigated the issue of slow travel and crash risk and failed to find many vehicles travelling at lower speeds involved in serious injury crashes, or to establish high crash and injury risk associated with slow travel. Most research now provides clear evidence of the relationship between higher vehicle speeds (not lower vehicle speeds) and crash involvement (Baruya 1998; Bowie & Walz 1993, 1994; Fildes et al. 1991; Taylor et al. 2000).

The relationship between travel speed and injury severity is even more strongly demonstrated by the research (Elvik, Christensen & Amundsen 2004; Kloeden et al. 1997; Nilsson 1984, 2004). The probability of injury, and the severity of injuries that occur in a crash increases, not linearly, but exponentially with vehicle speed – by a factor of four for fatalities, three for serious injuries, and two for casualty crashes. Even small increases in travel and impact speed results in a great increase in the forces experienced by vehicle occupants and other road users.

The central factor in the relationship between speed and both crash frequency and crash severity, is stopping distance. There are two components to stopping distance – the distance travelled by the vehicle during the reaction time of the driver, and the distance travelled once the brakes are applied. For example, (assuming normal reaction times and typical road/vehicle braking capabilities) a vehicle travelling at 30 km/h could come to a halt in 15 m, whereas a vehicle travelling at 40 km/h would come to a halt in approximately 22 m. At 15 m, this vehicle would still be travelling at approximately 37 km/h. Figure 3.1 illustrates the increased stopping distance required with increased speed.

Figure 3.1: Speed versus distance for emergency braking from time=0 (McLean et al. 1994)



3.2 The relationship between speed limits and crash and injury risk

Speed limits are considered to be the most powerful road feature that determine the speed at which drivers and riders choose to travel and therefore play a pivotal role in determining overall crash and injury risk. Many studies world-wide have examined the effect of raising or lowering speed limits in both rural and urban environments and consistently show that crash incidence and injury severity decline whenever speed limits have been reduced (Finch et al. 1994; Frith & Toomath 1982; Haworth et al. 2001; Newstead & Mullan 1996; Nilsson 1990; Diamantopoulou & Corben 2001; Sliogeris 1992). Conversely, studies consistently show that the number of crashes and injury severity increase when speed limits are raised, especially on freeways (Cameron 2004; Johnston 2004; Newstead & Mullan 1996; Newstead & Narayan 2001; NHTSA 1989; Parker 1997; Patterson et al. 2002; Richter et al. 2004; Sliogeris 1992; TRB 1998).

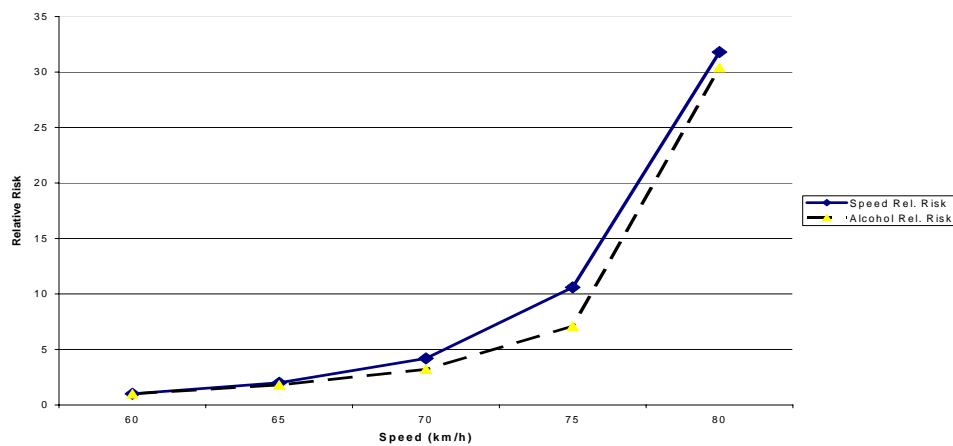
All Australasian jurisdictions have now introduced 50 km/h urban default speed limits and there is consistent evidence that this initiative has significantly reduced road trauma (e.g. Haworth et al. 2001). There is also good evidence of the benefits of speed zones lower than 50 km/h. Yeates (2001) argued that pedestrians are only likely to be relatively safe in areas with traffic speeds of 30 to 40 km/h subject to traffic volumes. At these speeds, most potential collision situations can be recognised and avoided. If a collision does occur, damage and injury should be light to severe, but rarely fatal. Many others world-wide support the introduction of lower speed limits in areas where vehicles and vulnerable road users mix (Breen 2002; ETSC 1995; Wramborg 2005).

3.3 Comparing speed and alcohol risks

The role of speed in causing injury and death on the roads may be compared to the role played by alcohol. Most people understand that a driver affected by alcohol is more likely to be involved in an injury crash than a driver not affected by alcohol. Similarly, a driver travelling at an excess or inappropriate speed is more likely to be involved in an injury crash than a driver travelling at the legal or appropriate speed limit.

Research reported from Australia showed that in a 60 km/h zone, there was an exponential increase in risk of casualty crash involvement with increasing travel speed above 60 km/h, such that the risk approximately doubled with each 5 km/h increase. As shown in Figure 3.2 the consequent risk curve for speeding closely resembles that of drink driving.

Figure 3.2: Relative risks of casualty crash involvement (Kloeden et al. 1997)



A major difference between alcohol and speed in terms of crash risk is the length of time that the increased risk exists. An alcohol-affected driver will present a higher crash risk over a sustained period of time, generally for the entire journey, until the alcohol has been processed. By contrast, a speeding driver increases the crash risk only when speeding and can maintain a relatively low level of risk at other times during the journey.

4 POLITICAL, SOCIAL AND OTHER FACTORS ASSOCIATED WITH THE ISSUE

There are three overarching issues addressed in this section. First, there is speed choice. Related to this is the lack of awareness of the risks associated with excessive and inappropriate speed and the need to promote speed as a key road safety issue to the general public and to promote appropriate speed enforcement strategies. The second issue relates to the methods used by system designers in setting speed limits and the gap between the attitudes and knowledge of system designers and users of the system (what drivers/riders understand of what is expected of them). Australia's adoption of the 'Safe System' concept, derived from the Swedish 'Vision Zero' and Dutch 'Sustainable Safety' approaches, requires that both these issues be better managed. Thirdly, there is the issue of public acceptance of changes in speed limits and the concerns commonly raised by communities when lowered travel speeds are mooted.

4.1 Speed choice

All drivers choose a speed at which to travel and this choice potentially imposes risks that can affect both the probability and severity of crashes. The evidence points to a number of factors that influence speed choice, including the road environment (speed limits, physical cues of the road environment, and traffic conditions), likelihood of police enforcement, knowledge of the risks of speeding and personal characteristics.

4.2 Driving behaviour

Most drivers drive without crashing and this reinforces the attitude that speeding is not risky, resulting in an under-estimation of the association between speeding and probability of serious injury or death in a crash (Elliott 2001). Oxley & Corben (2001) noted that speeding, except at extreme levels, is not regarded by drivers as a particularly dangerous activity. Other research suggests that most drivers over-estimate the speed of other drivers and want to drive at similar speeds (Åberg et al. 1997; Radalj & Kidd 2000; Walton & Bathurst 1998), over-estimate their ability to control their vehicle in an emergency (McKenna, Stanier & Lewis 1991; Walton & McKeown 2001); over-estimate what is an appropriate or safe speed, and drive at a speed within a perceived tolerance of margin where enforcement will not occur (Blincoe et al. 2006; Corbett & Simon 1999).

4.3 Vehicle features

Modern vehicle design has created less noise, less vibration, less tilting when taking corners and more comfort. These design features tend to insulate drivers from the perception of speeding and thereby contribute to speeding behaviour. Silcock et al. (1999) found that many drivers linked choice of speed to in-vehicle safety features such as frontal and side-impact airbags and many drivers were more confident in driving faster when these features were present in vehicles.

This attitude is justified to some extent. Swedish data suggest that in a vehicle that affords good crash protection to its occupants, it is possible to experience a frontal crash with another vehicle at 70 km/h without long-term injuries. However, for impacts with poles or trees when only 20-25% of the frontal structure is directly contacted, any speed above 30 km/h would result in serious injury to the car occupants. For side impact crashes, a car can only offer occupant protection at speeds under 50 km/h (Swedish Road Administration, personal communication).

4.4 The road environment

Road characteristics greatly influence what seems to be an appropriate speed to a driver/rider: for example, roadside development tends to slow traffic down, so drivers will travel faster on open rural roads and slower on built-up urban roads. However many roads may give incorrect messages to drivers and riders: while appearing safe for high-speed travel, they may contain vulnerable road users, concealed tight curves etc.

In addition, road features play a vital role in determining the severity of injuries in the event of a crash. The following features can increase the risk of serious injury: presence of roadside hazards such as trees and poles, intersections and their design, alignment of roads and their design speeds, and road surface conditions.

4.5 Speed limits and enforcement

Australia's 'Safe System' concept acknowledges the vital role of speed in determining system safety.

The primary reason for setting speed limits is to balance travel time and crash risk for specific roadway sections. The posted speed limit aims, therefore to inform drivers of maximum driving speeds that the authorities consider reasonable and safe. System designers expect road users to treat speed limits as a maximum value not to be exceeded - with one important criterion for setting speed limits being the 85th percentile driving speed (which is based on the perception that speed limits need to be 'credible'). However, allowing drivers to set what they believe to be acceptable travel speeds, is arguably unsafe: as indicated in the previous section, drivers are poor at choosing a safe speed and often have little appreciation of what is safe and unsafe on the road. Relying on driver choice of speed means that speed limits will always be compared with travel speeds that are most likely excessive for the inherent safety of the road.

On the other hand, drivers seem to expect that driving at the speed limit will be appropriate for most of the time and therefore frequently choose the speed limit as their target travel speed) – or worse, as the lower end of a speed continuum that has as its upper margin, an estimated speed that will be tolerated by police before enforcement action is taken. There are a number of reports that show that: driving faster than the speed limit is considered acceptable behaviour by many drivers; travelling up to 10 km/h over the speed limit is not considered ‘speeding’; ‘moderate’ speeding is not a crime, nor is it unsafe; the culture of speed is so embedded that exceeding the posted speed limit is perceived as normal; and, there is widespread belief that it is acceptable to break speed limits, particularly on motorways and freeways (Blincoe et al. 2006; LTSA 2001; Oxley & Corben 2001; Rothengatter 1991; van Schagen, Wegman & Roszbach 2004).

While enforcement efforts encourage higher levels of compliance, public attitude towards enforcement appears to be somewhat negative. A 2002 survey conducted in Victoria, which investigated public perception of that State’s enforcement initiatives, found that 71% of the sample population believed that speeding fines were issued mostly for revenue raising purposes and only 24% thought that speed cameras improved road safety (Smith & Senserrick 2004).

In summary, to be effective, speed limits should: be consistent with the design speed of the road; recognise how drivers set about varying their speeds to ensure their safety; and, be backed up by appropriate enforcement.

4.6 Public response to lowered speed limits

Jurisdictions invariably approach the issue of reducing speed limits with caution, largely because of inevitable claims from some motorists and motoring associations relating to compromised mobility, increased travel time, increased traffic congestion and increased vehicle operating costs. Each of these issues have been considered in more detail in another Hand book paper (see the earlier paper ‘Road Safety Benefits of 50 Km/H Urban Speed Limits’). In short, surveys of public opinion consistently suggest that a substantial majority of Australians simultaneously endorse a cynical view of government motives in regard to speed enforcement and fines and also recognise the links between speed, enforcement and safety. Reduced speed limits often represent the reverse of the NIMBY (Not In My Back Yard) response: many respondents want speed reductions in their own neighbourhood for reasons of safety and amenity (including noise reduction) but wish to maintain the capacity to travel through other neighbourhoods at higher speeds. Increasingly however the findings from surveys suggest a growing support for lowered limits across the total road network and not just in respondents’ own neighbourhoods.

5 CONCLUSIONS

Excessive and inappropriate speed has a twofold effect on safety – it increases the risk of involvement in an injury crash and it affects the severity of the consequences of a crash. It is essential for road safety that drivers travel at speeds which are not excessive in terms of well-set speed limits nor inappropriate in relation to local conditions. Road design (environment and appropriate criteria for speed limit setting), public education and enforcement all have a role in achieving these outcomes.

The approaches to safety management require that all forms of speeding are comprehensively addressed. Illegal or excessive speeding needs to and can be addressed through enforcement. Inappropriate speeding is more difficult to address and may require a strategy that incorporates education, publicity and promotion of the critical nature of speed in terms of crash and injury risk, and a change in the ‘speed culture’.

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