

Consequence Deniers). These research findings guided communications, resulting in greater compliance with speed limit over time.

Tracking of campaign effects have shown that message effects of specific campaign executions appear to diminish quickly, necessitating continuous re-invigoration of messages and approaches to the problem. Memorable and impactful messages that provide cut-through are necessary to overcome perceived dryness and relevance of the issue. Tracking research also suggest that emotive messages, rather than rational, appear more salient.

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Road Safety Case Studies

Speed Limits: Getting the limit right – the first step in effective Speed Management

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Key Findings

- This paper illustrates and challenges some of the orthodoxy surrounding the setting of speed limits using a case study:
 - Focus on the safe speed limit without compromising on the assumption it may be unacceptable to drivers.
 - The correct safe speed limit is essential to deliver further speed management initiatives.
 - The 85th percentile method for setting speed limits does not deliver a safe speed limit.
 - Proposes that there may be an ideal range when reducing a speed limit.

Abstract

The safety benefits of reducing speed limits and managing travelling speeds is well proven. However, practitioners involved in reviewing and setting speed limits continue to include practices that are based on assumptions. This paper uses a case study to apply established road safety models while challenging established practices that limit the potential for safety benefits. The next step is to better understand, through research, the range of effects on driver behaviour when speed limits are reduced and to develop physical devices suitable to safely moderate travelling speeds on higher-speed roads.

Key Words

Speed limits, speed limit increments, driver compliance, speed calming, speed management on high-speed roads

Introduction

It is still often stated that drivers will choose to travel at a speed they feel most comfortable, regardless of the posted speed limit. However, research suggests this simplistic statement underestimates the factors that influence driver behaviour. Research in developed countries has demonstrated that the speed limit affects speeding behaviour (Nilsson 2004, Elvik 2009). It could also be argued that this is in an environment with high-profile police enforcement.

Experience in the Middle East suggests that, like the developed nations, speed limits are regularly exceeded (Al Ghamdi 2006) but that they too can have an influence on driver behaviour. The results of a recently evaluated case study demonstrate that posted speed limits affect driver behaviour and that, based on reduced travelling speed, a positive road safety benefit can be expected.

Furthermore, while setting a safe speed limit is an important first step to maximising road safety, the benefit would be greater if additional speed management measures were introduced. The temptation to compromise when setting a speed limit based on anticipated driver preference is to compromise on the potential safety benefit.

Case study

Following a number of complaints from members-of-the-public and Police it was decided to reduce the speed limit on a 40 km length of desert road from 120 km/h to 80 km/h. The road is a major collector road connecting the capital city to an important regional centre. It is a two lane undivided road with a high percentage of heavy vehicles.

The road is largely straight with mostly unencumbered clear zones. However, there is a history of vehicles rolling over in the clear zones due largely to speed and the softer surface (sand). There are a number of intersections along the road

with basic T-junction layouts and some channellisation for deceleration and acceleration. It is noted that these junction types allow for vehicles to turn across high speed oncoming traffic, which can be an unsafe manoeuvre. The road was in fair condition throughout the evaluation, with extensive heavy patching in places.

Intervention: speed limit reduction

The decision to reduce the speed limit to 80 km/h was based on sound Safe System principles (Marsh and de Roos 2016) and the likelihood for a vehicle occupant to survive a head-on crash at an impact speed of 70 km/h or less (RTA 2011). Due to budget constraints and noting that the road is scheduled to be upgraded to a dual lane road in the near future it was possible to install speed limit signs only. No additional works were undertaken to support the reduced speed limit and no additional speed enforcement was undertaken.

The speed limit was reduced in December 2015 and 7 day 24 hour speed surveys were undertaken before and after the speed limit change to monitor the effect on driver behaviour. The before speed survey results suggest that while vehicles were not travelling at 120 km/h they were still travelling in excess of 110 km/h, which should be considered unacceptable for an undivided road (with potential for head-on crashes and right-against crashes at junctions). The speed survey results obtained after the speed limit change show that 85th percentile vehicle speeds reduced by 8 to 17 km/h (Table 1) and mean speeds by 6 to 8 km/h (Table 2).

Fatal and injury crash reductions

Unfortunately, reliable crash data is not available to directly measure the effect of the reduced speed limit on road related trauma. However, by using the Power Model it is possible

Table 1. Before and After 85th percentile speed results

85th percentile	Before	After	Difference	% change
Westbound	112.7 km/h	104.6 km/h	-8.1 km/h	-7.2%
Eastbound	110.9 km/h	93.5 km/h	-17.4 km/h	-15.7%
Both Directions	111.8 km/h	99.1 km/h	-12.7 km/h	-11.4%

Table 2. Before and After mean speed results

Mean	Before	After	Difference	% change
Westbound	90.6 km/h	84.6 km/h	-6.0 km/h	-6.6%
Eastbound	85.5 km/h	77.5 km/h	-8.0 km/h	-9.4%
Both Directions	88.4 km/h	81.1 km/h	-7.3 km/h	-8.3%

to predict the road safety benefits and casualty savings as a result of the reduced speed limit. The model was originally developed by Nilsson (2004), later validated by Elvik (2005 and 2009) and subsequently tested by numerous case studies including Bhatnagar (2010). The Model enables a simulation of the relationship between measured speeds and level of trauma and, by inference, the effect of changing the speed limit.

The Power Model predicts that a 1% reduction in mean speeds results in: a 2% reduction in all injury crashes, a 3% reduction in fatal and serious injury crashes; and a 4% reduction in fatal crashes. When applying the same principles to this road, which experienced an 8.3% reduction in mean speed (two-way), it is anticipated that there will be a 16.6% reduction in injury crashes, 24.9% reduction in serious injury crashes and 33.2% reduction in fatal crashes.

Impact on driver behaviour

In this case, the original speed limit of 120 km/h was too high. Allowing (or endorsing) opposing vehicles that are travelling at 120 km/h to pass each other on a road while separated only by a thin white line is unacceptable and serious head-on crashes will be inevitable. Based on Safe System principles and associated survivability curves (Marsh and de Roos 2016, RTA 2011) the speed limit should be no more than 80 km/h.

It is interesting to note that when considering the before speed survey results the majority of drivers also felt uncomfortable traveling at 120 km/h, with 85 percent not exceeding 112 km/h. The after speed survey results indicate that drivers felt more comfortable travelling at about 100 km/h.

The results suggest that:

- a. Setting the speed limit too high acts as a target value that drivers will attempt to drive to;
- b. The old style 85th percentile method for setting speed limits would have suggested a speed limit of 100 km/h which would have been too fast for these road conditions (Al Ghamdi 2006, Austroads 2008).

In time this road will be upgraded to a dual lane road designed and constructed to high engineering standards. When the potential for head-on crashes is eliminated by the introduction of median barriers the speed limit will be further reviewed and increased to 100 or 120 km/h depending on the junction treatments (either at-grade or grade separated).

Further initiatives

While the reduction in traveling speed will deliver pleasing road safety benefits there is more that could be done to make this a safe road. The road is through an open desert environment with three junctions and large sweeping curves (with radius greater than 800m). The two most obvious remedial safety measures that could be applied here are enforcement and engineering.

Enforcement

There is little opportunity for high-profile face-to-face police speed enforcement on this remote desert road which thus relies on unattended or automated enforcement. Fixed speed cameras operate best as blackspot type treatments (ARRB 2005). However, it is not possible to identify specific blackspots due to lack of crash data. Anecdotally, serious crashes occur anywhere along the road with some increased risk at the junctions due to turning vehicles.

The optimum speed enforcement method in this environment is point-to-point (or average speed) speed cameras. It has been shown that point-to-point speed cameras can: 1) reduce serious casualties by up to 65% (Soole et al 2013); 2) improve compliance with speed limits by an average of 5 km/h; 3) reduce the percentage of vehicles exceeding the speed limit by, on average, 72% (de Pauw et al (2014).

Engineering

Experience on similar rural desert roads (Marsh and de Roos 2016) suggests that large rural roundabouts can be used to reduce travelling speed and change the angle of potential impacts to survivable levels. Should there be concerns about the speed of vehicles on approach to the large rural roundabouts it is possible to install carefully designed vertical deflection devices to slow vehicles. Vertical deflection devices (or speed humps/tables) can be designed with a lower profile or longer approach ramp to allow vehicles to pass over at a speed of approximately 70 km/h to match the safe approach speed to the roundabout.

While not common practice in Australia, the installation of physical speed management devices is common elsewhere. There is scope to further research and develop standards for speed calming devices in higher-speed rural road environments, noting the objective is to reduce speeds to a range of 60 to 80 km/h rather than 20 to 40 km/h as would be the case in a low-speed urban environment.

Setting the speed limit at the correct level, so as to reflect the level of safety (or risk) of the road, is critical if supporting measures such as enforcement or engineering are to be used effectively.

Local conditions

Local conditions may partially explain why the reduction in travelling speed was so large. It is common for rapidly developing Middle East nations to have large expatriate populations of poorly educated workers who are entirely dependent on their income to support an extended family in their home country. As the greatest penalty for these workers is to lose their job and be sent home, they are, on the whole, law abiding. It is possible that drivers under these conditions will be more likely to comply with the speed limit.

While further research is required to test this hypothesis and to quantify the impact, this effect illustrates that a strong incentive to abide by the law creates an environment of increased compliance. Notwithstanding, the results suggest

that reduced speed limits can be used to great effect in developing nations.

Traditional speed zoning guidelines and practice

Traditional speed zoning has developed as a traffic engineering practice rather than a road safety discipline and adopts accepted practices such as:

- a. *Avoid speed limits that are too low.* If speed limits are set at levels substantially less than what is suggested as appropriate by the road environment, say 50 km/h on a wide and level rural road, the speed limit can be perceived as an error and drivers will largely ignore it.

The problem with this approach is that often safe speed limits are discounted as being unrealistic or too difficult to manage. In Australian jurisdictions it is often argued that 80 km/h on rural undivided roads is too low (notwithstanding that 50 mph used to be the rural default speed limit in NSW). However, the experience outlined in this case study suggests that 80 km/h on a rural undivided road can be effective. This is similar to the experience of Scandinavian countries which have a practice of setting lower speed limits on undivided rural roads and higher speed limits when a median barrier is installed.

- b. *Substantial increments.* While speed zoning guidelines generally allow for speed limits to be changed in increments of 10 km/h, it is typically accepted as good speed zoning practice to change speed limits in increments of at least 20 km/h so that drivers perceive it as a substantial difference (and to reduce the number of changes of speed limit along a route) (NSW Centre for Road Safety 2011).

In contrast to point (a) above, if a speed limit is reduced by only a small amount, i.e. by just 10 km/h, it could be perceived as a minor change not requiring much attention: but if it is reduced by 20 km/h then clearly it is a more serious matter.

It can then be hypothesised that there is an ideal range when reducing a speed limit. More research would be required to quantify the effect but it appears there is a ‘sweet spot’ when reducing speed limits that maximises driver acceptance and as a result delivers increasing levels of compliance. For example, on an undivided rural road reducing the speed limit by between 20 km/h and 40 km/h may have the greatest impact on driver perceptions and show greater levels of compliance.

Conclusions

The case study results show that reducing the speed limit has had a positive effect; (1) Vehicle speeds have reduced and (2) even if not all vehicles comply with the speed limit there is an overall improvement in road safety.

In addition, this experience suggests that:

- a. The speed limit should be chosen on sound road safety principles;
- b. Compromising and setting speed limits based on what is assumed to be acceptable to the driver will limit the potential road safety benefits;
- c. A safe speed limit is critical for implementing additional speed management initiatives;
- d. Further research is required to develop physical speed calming devices suitable for higher-speed rural road environments;
- e. There may be an ideal range (or sweet spot) when reducing the speed limit. Research could be conducted to identify ideal ranges when reducing the speed limit as well as the ideal increment when changing the speed limit.

Experience suggests that there is a need for further research to quantify the true effects of changing speed limits. As a result, speed zoning guidelines and practices may need to be revised to reflect these results and to maximise road safety outcomes.

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Commentary on Road Safety

Posted Speed Limits: When is the maximum posted limit not the recommended?

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Key Findings

- Excessive speed continues to be a causal factor in road trauma.
- Country road users are three times more likely to be killed than city drivers.
- Speed reduction on country roads in lieu of road treatment options is essential to reducing trauma.
- The posted speed limit may not be suitable for the road and prevailing conditions.

Towards Zero and Enhancing Community Safety

Towards Zero 2016//2020 Victoria's Road Safety Strategy sets a long term vision of zero deaths and serious injuries on our roads and a target of less than 200 deaths by 2020. Research tells us that country road users are three times more likely to be killed and 40 % more likely to be seriously injured than drivers in metropolitan Melbourne (Victoria Police, 2014). That 3 out of 4 country fatalities involve older model cars speaks volumes about modern-day "safer cars". Accordingly, our aim is to reduce road trauma and create safer roads by working closely with our road safety partners and the community to embed the Safe Systems approach; Safer roads, Safer speeds, Safer road users and Safer vehicles.

In 2013, Victoria achieved a record low Lives Lost of 243. This is in direct contrast to 1970 when 1061 lives were lost. The introduction of the mandatory wearing of seat belts, random alcohol / drug testing, fixed / mobile safety cameras and reduced speed limits in built up areas, central Melbourne, shopping strips and school zones combined with improved road infrastructure and vehicle safety have contributed to road trauma reductions.

In 2012, Victoria Police piloted and subsequently implemented the Speed Tolerance Enforcement Program

(STEP). STEP aims to shift community attitudes and beliefs around speeding; to have the community see the posted speed limit as essentially the limit, thereby enhancing compliance and removing the concept of de-facto speed limits. During the initial pilot, low level speed enforcement increased by 144% and overall speed enforcement by 27%, equating to an additional 4442 motorists being penalised for speeding (Victoria Police 2016).

The Adaptive Challenge

Notwithstanding progress in reducing road trauma, the recurrence of speed, impairment, and road conditions continue to be causal factors in road trauma. In 2016, there were 291 fatalities. Frustratingly, 150 of these fatalities occurred in rural locations, representing an increase of 9% compared to 2015. More than half of these were single vehicle crashes. The majority involved loss of control prior to running off the road. 72% of rural crashes occurred in 100 kph speed zones or higher (Victoria Police, 2017).

The design of our major highways and freeways prevent head on crashes through engineering such as a solid divide or concrete bollards or wire rope barriers in the event of a run off road situation. There are no trees to hit and any