The Impact of Lowered Speed Limits in Urban Areas

Jeffery Archer, Nicola Fotheringham, Mark Symmons and Bruce Corben
Monash University Accident Research Centre

1. Introduction

The increasing and sometimes conflicting goals of the transport system such as overall performance and efficiency, mobility, safety and environmental sustainability, have become increasingly difficult to achieve without major investments in the road infrastructure. New and affordable ways of reducing levels of road trauma that have a minimal impact on mobility are keenly sought by the Australian Government, federal and state road authorities and by society at large. This particular literature study addresses a number of the issues surrounding a lowering of speed limits in urban areas; a relatively low-cost measure that is likely to have a positive impact on safety but also a negative impact of some magnitude on mobilty.

The relationship between vehicle speed and accident outcome severity is well established. A major study conducted by the OECD and the ECMT in 1996 concluded that speeding is the number one road safety problem in most countries around the world, and that reductions in average speeds of approximately 5 per cent would yield a reduction in fatalities by as much as 20 per cent (OECD/ECMT , 2006). Research also indicates that even modest speed reductions can prevent the occurrence of collisions and significantly reduce the outcomes of those crashes that do occur; particularly those that involve vulnerable road-users who are more predominant in the urban environment (e.g. Kloeden, et al. 1997, 2001; Elvik, 2002; Gårder, 2004; Racioppi et al. 2004).

In addition to safety, there are other potential benefits to be gained by speed limit reductions in urban areas. Those suggested in the literature include an increase in traffic flow and consequent reduction in congestion and delays, particularly where the roads are functioning at near capacity. Further, reductions in speed bring about a reduction in vehicle operating costs with less wear and greater energy (fuel) efficiency, and less pollution and noise (see e.g. Carlsson, 1997; Kallberg and Toivanen, 1998; Cameron, 2000; Elvik and Vaa, 2004).

2. Literature Review

The literature review focused specifically on speed limit reduction and the impact this has on mobility and general traffic system performance. In particular, more information was sought on the relationship between speed and travel time. The search included national and international literature in areas related to engineering, psychology and traffic safety.

Speed Management

While the most elementary method of managing travel speed is by imposing speed limits. In order to be effective speed limits must be compatible with the design speed of the road. Research has shown that the design speed tends to have a greater effect on a driver's choice of speed than the actual speed limit (Varhelyi, 1996). On the basis of studies in many different countries, Elvik and Vaa (2004) suggest that speed limits are most often set in accordance with three main principles: adapting the speed limit to actual speed levels; varying the speed limit to the standard and design of the road; and, choosing a speed limit that minimises the total costs to society (e.g. accident costs, travel time costs, vehicle operating costs, road maintenance costs, and environmental costs). In practice, a combination of several of these principles is used.

Generally, a driver expects a good level of mobility in the traffic system such that it takes as little time as possible to get from A to B, but also a reasonable level of safety. Unfortunately, most drivers temnd to trade safety against travel time for themselves and other road-users. In the decisions regarding a suitable travel speed, drivers weigh-up factors including road geometry, the maount of traffic, accident rates, car performance, levels of enforcement and own driving skills (Elvik and Vaa, 2004). However, posted speed limits are perhaps the most significant factor in determining a drivers choice of speed. Research suggests that younger and inexperienced drivers tend to overestimate their own skills and underestimate potential hazards. It is a fair assumption that if posted speed signs did not exist, many drivers would adopt unsuitably high speeds. Speed enforcement is probably the most common mediator between speed limit and speed choice. There is ample evidence that drivers respond to perceived enforcement by adjusting their behaviour, most notably by reducing their speed (see e.g. Shinar and McKnight 1985).

Another approach to speed control is through road design. Traffic safety strategies aimed at reducing speeds in the urban environment have often been based on a combination of different physical measures such as: speed-humps, chicanes, raised intersections, rumble strips, etc.. While there is a great deal of research suggesting the success of such traffic calming measures, many of the measures are not suitable for urban arterial streets, particularly where these serve commuter and commercial traffic and carry emergency vehicles (see e.g. Fildes and Lee, 1993; Elvik and Vaa, 2004). A further problem is related to the migration of traffic to less suited neighbouring streets.

Operational measures can also be effectively used to slow traffic. In some neighbourhoods, multi-way stop or yield signs, traffic signals, turn prohibitions, and one-way streets can be used effectively to manage speed. Because such measures require driver compliance, some operational measures are less effective than other physical measures in reducing driving speeds. Taylor (1997, 2000) suggests that if traffic signalling systems are correctly timed and coordinated with posted speed limits, they can be a highly effective means for controlling travel speeds, particularly on urban collector and arterial roads, provided the speeds are mandatory and not recommended (Elvik and Vaa, 2004). New infrastructure based technologies such as variable message signs are often used to inform drivers of adverse road and/or weather conditions, or other factors that require an increase in awareness and a reduction in speed. Variable speed limits are also used to offer drivers guidance on appropriate maximum (or minimum) speed limits on the basis of real-time monitoring of prevailing traffic and roadway conditions using dynamic information displays (Parker and Tsuchiyama, 1985).

A more direct means of reducing speed is through the introduction of speed limiting or intelligent speed adaptation (ISA) devices within the vehicle. Speed limiters are often used to control the maximum speed of heavy vehicles (on open roads) and are common in Australia and most European countries. ISA devices have the ability to warn drivers or physically limit the speed of a vehicle in accordance with speed limits on all classes of roads. Many studies have been conducted to examine the effectiveness and acceptability of ISA systems (Carsten, Tate and Liu, 2006). In Australia, ISA has been trialled as one of several Intelligent Transportation Systems (ITS) believed to enhance safety in the TAC SafeCar project (Regan et al. 2006).

Driver attitudes also have an important role in relation to speed compliance. The Australian Transport and Safety Bureau's (ATSB) report on community attitudes to road safety for 2004 showed that there is a general and increasing awareness of the dangers of driving at increased speeds, with 96 per cent of respondents agreeing that a crash at 70 km/h will be more severe than one at 60 km/h, (Pennay, 2005). Additionally, 73 per cent of respondents agreed that if speed was increased by 10 km/h they would be more likely to be involved in a crash, (55% in 1995, and 70 per cent in 2003). Furthermore, 83 per cent of respondents believed that speed limits were generally set at reasonable levels. Somewhat inconsistent with these more positive views regarding speed, was the proportion of respondents who believed that it was "*okay to speed as long as you're driving safely*" which remained constant at approximately 32 per cent.

The Relationship between Travel Time, Speed Limits, Speeding Behaviour and Safety

A general and often misleading assumption made by drivers is that increasing their speed will, to a similar degree, reduce overall travel time. In the urban environment, drivers must frequently stop or slow down for different forms of regulatory control at intersections (traffic signals, stop signs or yield signs), pedestrian crossings, rail crossings and reduced speed areas near schools and shopping zones. Speeds are also affected by congestion where preceding vehicles prevent the adoption of a discretionary free-flow speed. Factors such as these cause large amounts of variance in individual speed profiles even during off-peak periods.

In Australia, in the lead up to re-zoning many 60 km/h residential zones to 50 km/h, Cairney and Donald (1996) suggested that any journey time increases due to lowered speed limits would be negligible. Their argument was that the main source of delays on such roads relate to intersections, traffic hold-ups and negotiating corners – all situations generally unaffected by the prevailing speed limit. Reviewing the Unley (South Australia) experience of setting a city-wide 40 km/h speed limit (the Lower Urban Speed Limit, or LUSL project), Dyson, Taylor, Woolley and Zito (2001) noted that travel time declined to only a small degree, and not directly proportional to the reductions in posted speed limits. The authors suggest that smoother traffic flow may have served to minimise the losses in travel time.

In research reported by SMEC and Nairn (1999), the effect of reducing cruising speed on travel time was simulated for Melbourne traffic during morning peak hours. Results indicated that reducing the speed limit on all roads by 10 km/h would, in the short-term, result in an increase in travel time by up to 5 per cent (reducing down to 1 per cent in the long-term due to behavioural adaptation), but also bring about a 13.5 per cent decrease in accidents. With a reduction of 10 km/h for roads other than freeways, travel time was found to increase by only 3 per cent (reducing to 0.6 per cent in the long term), with a 10.3 per cent decrease in accidents.

Taylor (2000) also used a simulation approach to study urban traffic under a number of different scenarios including varying speed limits and different congestion levels. The model was used for examining the potential outcomes of engineering modifications to the actual network. Taylor found that regardless of congestion level and speed limit (40, 50 or 60 km/h), and whether traffic signals were coordinated or un-coordinated, predicted mean travel speeds were always less than the posted speed limit. Further, it was found that increases in the speed limits from 40 to 50 to 60 km/h produced expected increases in average journey speed. Taylor also found reduced delays at lower speed limits, which were believed to be due to the smoother flow of traffic. Furthermore, overall fuel consumption and emissions were found to be higher for the lower speed limits. Of the three speed limits, 60 km/h (with coordinated traffic signals) resulted in the best performance.

In a report prepared for the National Road Transport Commission, Haworth, Ungers, Vulcan and Corben (2001) modelled the travel times costs associated with a national decrease in the general urban speed limit from 60 to 50 km/h. They found that a 50 km/h default urban speed limit on local streets, collector roads and arterial roads would, on the assumption of a 5 km/h reduction in travel speed, result in the prevention of an estimated 3,000 casualty crashes and an increase in average travel time per trip of less than 10 seconds. Further, they found that a 10 km/h reduction in average cruise speed would prevent over 8,000 casualty crashes per year while at the same time increasing average travel time by less than 26 seconds per trip.

A report by the TRB (1998) has found travel time to be more dependent on congestion and roadway design and geometry factors, than on the posted speed limits. During times of congestion, posted speed limits are often believed to have little effect on driving speed, except during the build-up of queues and their later dispersion. It can therefore be argued, that reducing a speed limit by 5 or 10 km/h during peak hours when the level of congestion is high is unlikely to result in any significant safety benefit. Hypothetically at least, reduced speed limits should have their greatest safety impact under medium congestion levels, where traffic is periodically able to travel at or near the speed limit. At such levels, a lower speed limit may actually ***reduce*** overall travel time by allowing a more harmonic traffic rhythm, this is particularly the case on urban arterials and urban motorways where there is likely to be less lane-changing friction, less speed dispersion, and greater headways which result in less shock-waves and fewer accidents (see e.g. Noland and Quddus, 2005).

The insight that travel speed is dependent on factors such as road type, levels of congestion, and driver's personal speed preferences, suggests that the relationship between speed limits and travel time is far more complex than most drivers are willing to admit. Given that average trip distances in metropolitan areas are relatively small (see e.g. Robertson and Ward, 1998), it is interesting to see how much additional time is needed for a 10 kilometer journey when the average speed is reduced by 5 km/h. Figures to this effect are presented in Table 1 below. The data suggests that the effects are of a 5 km/h reduction are greater at increasingly lower speeds.

Table 1. Extra travel time on a journey of 10 km when average speed is reduced by 5 km/h.

Original Speed (km/h)	30	50	70	90	110	130
Reduced Speed (km/h)	25	45	65	85	105	125
Extra Travel Time (mins:secs)	4.00	1:20	0:40	0:23	0:16	0:11

Other research has also shown that maintaining short headways, changing lanes and other aggressive behaviours such as accelerating hard from traffic lights and other stops are often exhibited by drivers in the belief that they will reduce their journey time (RACV, 1990). The differences in travel time between aggressive and non-aggressive drivers in motorway conditions were also compared in a recent experiment conducted by the University of Queensland, (Panwai and Dia, 2006). In this study, aggressive drivers were found to reduce travel time by as little as one minute for a 44 km journey. In addition, the fuel consumption and CO_2 emissions from aggressive driver's vehicles as much as four times that of non-aggressive drivers.

Elvik and Vaa (2004) have reviewed the existing literature in relation to speed limits. The literature concerns either a transition from unrestricted speeds to signed limits, or reducing existing limits. The authors indicate that, across all studies, the total effect of reducing or introducing a speed limit is a reduction in accident frequency by 13 per cent. This level of effect can be assumed where there is an average speed reduction of 11 km/h. Larger percentage reductions are found for fatal accidents when compared to injury accidents; and for injury accidents when compared to property damage only accidents. For higher speeds; a reduction from 115-110 km/h to approximately 97-88 km/h will reduce fatalities by as many as 54 per cent while the reduction in injury accidents is only 6 per cent. For lower speed limits the ratio is approximately 2:1 between fatal accidents and injury accidents.

Weighing-up the Costs and Benefits

Studies and research in Europe and Australia have suggested ways in which the social costs and benefits of increased travel time, decreased road trauma, vehicle operating costs, emissions, noise, etc. resulting from reductions in posted speed limits and their estimated influence on travel speed can be assessed (Kallberg and Toivanen, 1998, Ward et al., 1998; Thoresen, 2000; Cameron, 2000). In most cases, these studies suggest significant overall benefits to society as a result of lowering speed limits. However, when these benefits are weighed against the costs associated with increased travel times the net result is often negative. This has led to a debate regarding the assumptions with economic rationalist approaches and how safety and travel time benefits and costs are estimated. Particular concern lies with the question of how appropriate and meaningful is is to aggregate small increments in travel time, and whether individual's tasks or activities will be noticeably affected by increases of a few seconds (see e.g. Ward, Robertson and Allsop, 1998).

Cameron (2000) and other researchers around the world (see e.g. Elvik and Vaa 2004) have been able to calculate optimal speed limits for various classes of urban roads that have the potential to yield the maximum benefits to society. These speeds are generally slightly less than the posted limits on most classes of urban and rural roads, and in many cases decrease over time due to the increasing costs associated with traffic accidents relative to those for travel time.

3. Conclusions

On the basis of the literature reviewed, it is possible to conclude that lowered speed limits most certainly do have a potential to bring about a large positive impact on safety in the urban environment, and also a relatively minor impact on average journey times (mobility) at the individual level. Aggregating travel-time data appears to be debated for the purposes of cost-benefit analysis. The literature also points to the need to consider other approaches to improve road transport system efficiency, e.g. better use of coordinated or self-optimized signalling and forms of infrastructure ITS, where thse can influence speed behaviour with minimal or positive impact on mobility at relatively low cost.

Reducing speed through speed limits will also bring about a reduction in vehicle operating costs. Savings in fuel consumption are likely to be smaller the further the speed limit is from the optimal level for light vehicles (approximately 60-70 km/h) and are heavily influenced by more variable speed. Generally, savings in fuel consumption are proportionate to savings in gaseous emissions. The literature also suggests that there is a need to encouraging better safety awareness and a change in attitudes toward speeding, and a need to give priority to less prioritized road-users who are more vulnerable to the effects of speed. Speed management is presently a major concern and is recognised in the National Road Safety Stratgey and Action Plans as a means to fulfill the longer term goals for a sustainable and safe road transport system.

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