


Safe speed: promoting safe walking and cycling by reducing traffic speed

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Executive summary

1. Introduction

The provision of supportive environments that encourage people of all ages and capacities to use active transport[1] as part of their daily activities delivers multiple benefits including:

- health benefits of leading an active life (increased physical activity and reduced rates of chronic diseases)
- transport benefits of reduced congestion, car space requirements and costs
- environmental benefits of reduced air, noise, and visual pollution
- energy use reductions through fewer care numbers and lower fossil fuel use and greenhouse gas emissions
- community strengthening through increased social interactions on streets and within neighbourhoods
- improved community safety, as 'peopled' places are safer places.

For all these reasons it is important that efforts are made to increase currently low levels of active transport in the Victorian community.

Pedestrians and cyclists are legitimate road users, but they are frequently overlooked in transportation systems. Currently, a range of socio-environmental, public policy and regulatory factors favour car use and make active travel choices more difficult than car use. However, the recent convergence of problems associated with rapid population growth in urban areas, obesity, inactivity, climate change, oil depletion, traffic congestion and reduced community liveability has triggered a reassessment of the current dominance of car travel in Australia.

Vehicle speed is a major contributing factor in crashes of all types, and is especially hazardous for pedestrians and cyclists. 'Speeding' includes travelling above the speed limit, as well as travelling too fast for the road and traffic conditions, and the mix of road users. Speed limits that are set inappropriately high increase the incidence and severity of pedestrian and cyclist injuries.

The promotion of safe, active transport is usually achieved through the implementation of multi-component strategies that include speed reduction. High levels of safe walking and cycling for transport are incompatible with high vehicle speed as, for many trips or parts of trips, pedestrians and cyclists are required to share the road space with motor vehicles. International experience suggests that speed reduction is not the only change needed to increase safe active transport, but it is a key component.

This report aims to provide an evidence-based answer to the question ***"Does reduced traffic speed increase the prevalence and safety of active travel behaviour?"***

[1] Active transport includes walking, cycling and public transport use, as the latter usually involves an active component (NPHP, 2001).

2. Key questions

This report aims to review the impacts of vehicle speed on (i) active transport participation rates; (ii) perceptions of traffic safety and community liveability; and (iii) pedestrian and cyclist injuries. The review includes international and national research, with a focus on Australian and Victorian data and research where appropriate.

Little rigorous research has been conducted that addresses the main study question; however, multiple sources of 'lower level' evidence are available. A model of the impacts of vehicle speed on active transport is presented which proposes that the relationship between speed and active transport is mediated by perceived and actual risks of injury to pedestrians and cyclists (see Figure 1). It is also proposed that speed impacts on active transport by reducing community liveability. The review examines evidence relevant to these sub-pathways within the overall relationship between speed and active transport.

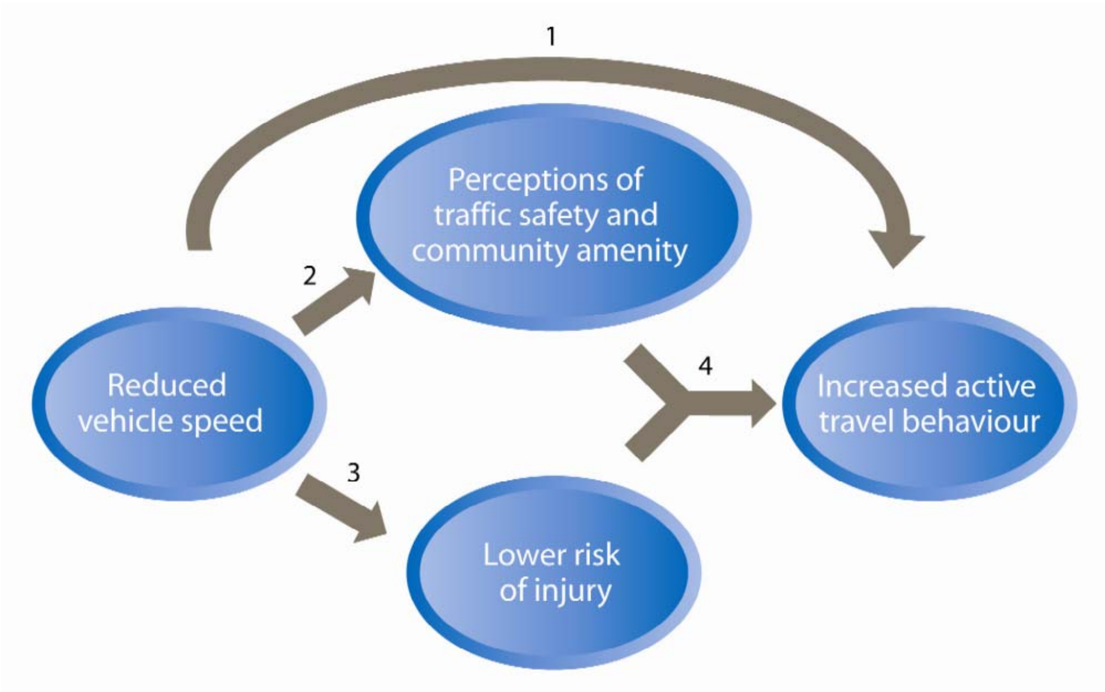

Figure 1: Proposed relationships between vehicle speed and active travel behaviour

3. Key findings

3.1 Vehicle speed and active travel behaviour

Pathway 1 represents the overall relationship between vehicle speed and active transport. Evidence for this relationship comes from four types of studies: (i) pre/post evaluations of speed reduction interventions in cities and municipalities; (ii) cross-country comparative analyses; (iii) cross-sectional analytical studies (non-interventions) of differences in people's transport environments and travel behaviour; and (iv) case studies of speed reduction interventions.

(i) Evaluation of speed reduction interventions in cities and municipalities
Based on limited available research there is some, but not definitive evidence that traffic calming measures, including lowering speed limits (usually to 30 km/h) *contribute* to the promotion of active travel. Variable findings suggest that impacts are likely to vary according to location, the nature and extent of the traffic calming measures, and population demographics.

(ii) Cross-country comparative analyses
In response to environmental concerns and increasing traffic congestion, a number of countries have invested in walking and cycling as an alternative to car use. Countries, cities and municipalities with high rates of active transport incorporate speed reduction as a key element in promoting active transport. Low neighbourhood speed limits (usually 20-30 km/hr) are a common feature of active transport promotion internationally and are considered to have contributed to more and safer walking and cycling for transport (Pucher and Buehler 2008).

(iii) Cross-sectional analytical studies of differences in people's transport environments and travel behaviour
Very few studies have examined traffic speed as a correlate of walking and cycling for transport, with most studies focusing instead on variables associated with urban form. However, there is emerging evidence from recent Australian research (including one longitudinal study) that traffic safety measures including speed reduction may increase walking and cycling among children, adolescents and adults (Carver et al 2008).

(iv) Case studies of speed reduction interventions
A number of examples of speed reduction interventions both internationally and locally indicate that speed reduction in cities and municipalities can be successfully implemented, including within car-oriented countries such as Australia, the USA, Canada and the UK. A small number of these interventions (mainly international) have been evaluated, with positive findings in terms of injury reduction and, less commonly, walking and cycling rates (due to lack of measurement).

In summary, there is good evidence from the four types of studies described above that low neighbourhood speed limits (generally 30 km/h or less) are *associated* with active transport participation in industrialised countries, cities and municipalities. While evidence from each of the four study types separately is not definitive, together they suggest a consistent overall pattern. Evidence of a direct causal relationship is not available due to limited research studies and difficulties disaggregating the effect of reduced speed from multi-component strategies aimed at increasing active transport.

3.2 Vehicle speed and perceived risk of injury and reduced community liveability

Pathway 2 proposes that reduced vehicle speed will improve perceptions of safety and community liveability, which will in turn increase active travel. There is strong and consistent evidence that traffic hazards (including vehicle speed) are a major constraint on active transport in Australia. It is likely that reducing speed will increase active travel by removing one of the key reported barriers to walking and cycling for transport. Few studies have examined the impact of vehicle speed on perceived safety and community liveability, but a small number of intervention studies have found that speed reduction schemes increase perceptions of safety and active travel behaviour.

Examples include an evaluation of speed reduction measures in Denmark which reported increased feelings of security and a reduced 'barrier effect'[2], particularly for elderly pedestrians. Following the implementation of ten speed reduction schemes in Scotland, residents reported increased neighbourly interaction, improved perceptions of pedestrian safety, and improved neighbourhood appearance.

3.3 Vehicle speed and injury to pedestrians and cyclists

Pathway 3 proposes that reduced speed will lower the risk of injury to pedestrians and cyclists, resulting in increased active travel behaviour. There is consistent, strong evidence for the relationship between speed and risk of injury to pedestrians and cyclists. Speed is the single most important contributor to road fatalities; an aggravating factor in all crashes; and contributes to the severity of crash outcomes regardless of the cause (WHO 2008).

Pedestrians and cyclists are at greatest risk of excessive or inappropriate vehicle speed. The human tolerance to injury by a car is exceeded if the vehicle is travelling at more than 30 km/h. While most unprotected road users survive if hit by a car travelling at 30 km/h, the majority are killed if hit by a car travelling at 50 km/h (WHO 2008).

In car-oriented countries such as Australia, transport systems are not designed on the basis of human tolerance, but instead on what are considered safe speeds for motor vehicles. Under these circumstances, driving within the speed limit can represent a hazard to pedestrians and cyclists. When speed limits are set using criteria that place a relatively high value on vehicular mobility compared with safety (as is common in countries such as Australia), this hazard is often not fully acknowledged or acted on. These underlying cultural values and norms are reflected in road safety policies, which, in Australia, result in speed limits considered unacceptably high in many other countries. Accordingly, pedestrians and cyclists can be 'blamed' for injuries that result from collisions with vehicles travelling at a legal but unsafe speed.

In general, German and several other European road systems require higher standards of duty-of-care on the part of drivers for pedestrians and cyclists than does the Australian system. In Australia, a driver is generally not considered to be at fault in a casualty crash if he or she was obeying the road rules. In contrast, in many European and Asian countries a driver must anticipate pedestrian and cyclist errors and take evasive action to avoid a collision. In these countries the onus is on drivers to prove no-fault when in collisions with pedestrians and cyclists.

[2] Roads carrying high volumes of high speed traffic that cut through an area can create physical and psychological barriers to the movement of community members, resulting in reduced social participation.

3.3.1 Pedestrian and cyclist injuries in Victoria

Pedestrians and cyclists experience disproportionately more severe injuries than motor vehicle occupants. In the Melbourne Statistical Division (covering the Melbourne metropolitan area), from 1987 to 2007, pedestrians and cyclists accounted for:

- 14.3% of all casualties
- 20.7% of all serious injuries
- 30.1% of all fatalities (VicRoads 2008)

Despite sustained improvements in road safety in Victoria over several decades, the number of fatalities and injuries among pedestrians and cyclists remains high in many urban areas and for specific segments of the population.

Older pedestrians for instance, are at greater risk of being killed. In contrast, children and adolescents account for a high proportion of bicycle fatalities. Injury severity among cyclists follows a U-shaped age distribution, whereby children and older adults experience relatively more severe injuries. This injury data indicates that unsafe conditions for pedestrians and cyclists, while affecting most people, have a greater impact on members of the community who often rely on walking and/or cycling for their main means of transport– children and older adults.

The *Power model* for the relationship between percentage change in speed and percentage change in crashes shows that decreases in mean vehicle speed result in greater reductions in the more serious injuries (WHO 2008). This relationship has been confirmed in practice, based on findings from the evaluation of speed reduction initiatives in Australia and Victoria.

3.3.2 Impact of reduced speed limits

Evaluations of speed reduction interventions in Australia and Victoria (50 km/h default speed limit, 40/60 km/h school zones, 40 km/h shopping strip zones) show a consistent pattern of reduced overall casualty crashes, with greater reductions in serious crashes involving pedestrians, cyclists and children/adolescents.

Consistent with Australian data, countries that have implemented lower urban speed limits (20-30 km/h) and associated policies (e.g. driver and pedestrian/cyclist education, enforcement of speed limits) have lower pedestrian and cyclist injury rates.

The extent to which reductions in perceived and actual risk of injury lead to increased active transport behaviour is difficult to assess, and very few studies have addressed this topic. However, it appears likely from the limited direct evidence available, together with substantial indirect evidence, that the overall speed/active travel relationship is mediated by perceived and actual injury risks.

In summary, the relationships between vehicle speed, perceived and actual risks of injury, community liveability and active transport behaviour reviewed in this report are complex and, in many cases, under-researched. While acknowledging the limitations of few rigorous studies that directly address the review questions, there is nevertheless, evidence from a diverse range of less-rigorous studies that lower speed limits and reduced vehicle speed are likely to increase both the safety and prevalence of active transport.

4. Implementation issues

Key issues relevant to implementing safe speeds for pedestrians and cyclists in Victoria include the following:

4.1 Area-wide versus site-specific traffic calming

A number of studies indicate that area-wide traffic calming, such as global reduction of traffic speed, is more effective for reducing population-level injury rates than site-specific (pedestrian 'black spot') treatments. This is consistent with studies of the distribution of pedestrian road casualties which show that pedestrian casualties are frequently widely dispersed across road networks, with few pedestrian 'black spots' (Morency and Cloutier 2006; Jacobsen 2006).

4.2 Speed reduction and the Safe System approach to road safety

Victoria's road safety strategy *"Arrive Alive 2008-2017*" is loosely based on the Safe System approach originally developed as part of Sweden's Vision Zero road safety strategy (Swedish Road Administration 2000). The Safe System approach suggests that the protection of human health takes priority in the trade-off between the benefits of mobility and the human and economic costs of death and injury. Road traffic injuries are preventable through reduced traffic speed, and the transport system should adopt speeds that offer mobility without compromising safety (WHO 2008).

Arrive Alive states that the Safe System approach includes *"setting speed limits according to the safety of the road and roadside"*. There is little acknowledgement of safe speeds for pedestrians or cyclists. This is in contrast to the Safe System approach internationally, which stresses the importance of setting speed limits based on human tolerance to injury by a car - which is exceeded if the vehicle is travelling at more than 30 km/h (WHO 2008). The Safe System recommendation in the WHO report *"Speed management: a road safety manual"* is for 30 km/hr speed limits in built-up areas with a mix of pedestrians and cyclists and motor vehicle traffic.

4.3 Barriers to speed reduction: perceived and actual impacts on travel time

The main barriers to speed reduction are perceived and actual increases in vehicle travel time and associated costs. However, there is mounting evidence of a mismatch between perceived and actual travel times, particularly for the majority of relatively short trips[3] undertaken in urban areas. Evidence from studies in several countries indicates that the main (publicly articulated) reasons for opposing reduced speed limits in urban areas; namely, increased travel time and costs, are substantially overstated. Small travel time benefits associated with higher speed limits (an average of 9 seconds/km in one study) come at substantial cost in terms of the health and wellbeing of individuals and communities. While the research

[3] About 50% of trips in Melbourne are under 5km (RMIT, 1999).

evidence is clear, barriers to speed reduction remain in the form of public perceptions, and regulators' reluctance to act on the evidence.

4.4 Additional benefits of lower speed limits

In addition to the benefits associated with reduced casualty collisions and likely increases in active transport, lower vehicle speeds also bring other gains. Lower speeds can reduce fuel use, greenhouse gas emissions, and air and noise pollution (Haworth and Symmons 2001; Fildes et al 2005). In urban environments where vehicles are required to slow or stop for roadway intersections and then accelerate again, lower speeds offer the best fuel economy. A review of the relationship between fuel economy and road safety outcomes concluded that reduced vehicle speed can improve both fuel economy (and therefore greenhouse gas emissions) and road safety (Haworth and Symmons 2001).

Vehicle speed impacts on the emission of pollutants such as carbon dioxide, carbon monoxide, hydrocarbons, nitrogen oxides and particulates. Emissions are lowest for a warm engine travelling at a relatively low and steady speed. Under typical driving conditions, vehicle emissions increase substantially from around 40-50 km/h (Ward et al 1998, cited in Fildes et al 2005).

Motor vehicle noise, the most significant source of noise pollution in urban areas, increases uniformly with increased speed (Kallberg and Toivanen 1997, cited in Fildes et al 2005). It has a negative impact on human health, most noticeably for children as it affects their developing nervous systems (cited in Whitelegg, 1997).

5. Conclusions

The findings from this review indicate that lower traffic speed in urban areas (preferably based on a speed limit of 30 km/h) will improve pedestrian and cyclist safety and community liveability, and is likely to contribute to increased rates of walking and cycling for transport. 'Safe speed' is often conceptualised in terms of vehicle speeds that minimise the risk of injury, but in the light of the multiple benefits of active transport, it may be more appropriate to think of 'safe speed' as that which delivers injury prevention outcomes as well as many additional health and social benefits.

The setting of speed limits in urban areas in Australia is based mainly on achieving a balance between mobility and injury reduction. Traditionally, little consideration has been given to the additional, non-injury benefits of speed reduction. These are multiple and wide-ranging, and are likely to include increased active transport and the associated benefits of active living and reduced motor vehicle use. If these 'externalities' were included in algorithms used for setting speed limits, it is likely that the benefits of speed reduction in urban areas would outweigh the disadvantages in the form of small increases in vehicular travel time and associated costs.

When implemented overseas, speed reduction has achieved high levels of community support; improved safety for all road users; increased rates of active modes of transport; and resulted in negligible increases in car travel times. A growing number of safe speed initiatives in Victoria suggest that similar changes in Australia are not only desirable but also achievable.

Active, liveable cities and communities provide all people from children through to older adults with the right to move about in public spaces. Active living and community engagement is constrained when people retreat into their homes and cars through fear of traffic. Road safety improvements should not be dependent on people remaining indoors or in cars. The focus needs to be on removing traffic danger from people, not people from the hazardous environment we have inadvertently created. Reducing traffic speed is an effective way of righting this balance and encouraging people to engage in active transport modes with ease, resulting in significant improvements in the health and wellbeing of the population and the environment.

Safe speed: promoting safe walking and cycling by reducing traffic speed

1. Introduction

Active transport[4] is a clean, green and healthy way to get around. The provision of supportive environments that encourage people of all ages and capacities to incorporate walking, cycling and public transport use into their daily activities is integral to increasing physical activity levels, social interaction and community engagement.

Pedestrians and cyclists are legitimate road users, but are frequently overlooked in transportation systems. As car travel largely replaced other modes of travel in Australia during the 20th century, transport planning became increasingly car-centric (Davison 2004). The recent convergence of problems associated with rapid population growth in urban areas, obesity, inactivity, climate change, oil depletion, traffic congestion and reduced community liveability has triggered a reassessment of the current dominance of car travel in Australia.

Physical inactivity for example, is one of the key modifiable risk factors for disease and injury in Australia. A 2003 study estimated that physical inactivity is responsible for 6.6% of the total burden of disease and injury in Australia (Begg et al 2007). This results in an estimated direct gross cost to the Australian annual health budget of $1.49 billion (Econtech 2007).

The benefits of active transport span several aspects of individual and community life and well-being. The health benefits of being physically active include increases in life expectancy, physical fitness, energy, mental health, cognitive functioning and social connectedness (Bull et al 2004), as well as independent living for older adults (Bauman 2004). Physically active children perform better academically (Dwyer et al 2001) and adults in the workforce have lower rates of absenteeism and increased job satisfaction (Parks and Steelman 2008). Physically active people are less likely to become overweight or obese, and to develop cardiovascular disease, type 2 diabetes, colon cancer, breast cancer, osteoporosis and depression (Bull et al 2004).

The promotion of 'lifestyle' physical activity such as walking and cycling is more cost-effective than structured exercise programs (Sevick et al 2000), and physical activity through active travel does not show the marked social gradient associated with leisure-time physical activity[5] (Berrigan et al 2006). Not surprisingly, the promotion of moderate intensity physical activity has been described as 'today's best buy in public health' (Morris 1994).

Current cycling participation in Australia (for recreation and commuting) reduces the health costs of sedentary lifestyle diseases by approximately $154 million (Bauman

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[4] Active transport includes walking, cycling and public transport, as the latter usually involves an active component (NPHP, 2001).

[5] People with higher education levels and incomes are more likely to be adequately active, principally due to higher levels of leisure-time physical activity.

et al 2008). Similar economic benefits have been found for walking, with a study of the benefits of walking for people with type 2 diabetes reporting that a 4.8km daily walk reduces medical and social costs by a total of about $1,000 per individual per year (Di Loreto et al 2005).

In addition to the wide-ranging health benefits, the transport benefits of walking and cycling as alternatives to car use include reduced traffic congestion and travel costs, and improved community liveability. The primary cause of congestion in Australia is private motor vehicle use. The Bureau of Transport and Regional Economics (2007) estimated that the cost of avoidable congestion in 2005 in Australia was $9.4 billion. A recent report estimated that even the current relatively low levels of commuter cycling in Australia reduce the cost of congestion by approximately $63.9 million per annum (Bauman et al 2008).

The environmental benefits of active transport include reduced air, noise and visual pollution; energy use; and greenhouse gas emissions (Litman 2004; Dora and Phillips 2000). Motor vehicles are a major source of air and noise pollution in Australian cities (Bureau of Transport and Regional Economics, 2005). Between 900 and 4500 cases of cardiovascular and respiratory disease occurred as a result of motor vehicle related air pollution in 2000, costing between $0.4 billion and $1.2 billion. Air pollution caused by motor vehicles accounted for between 900 and 2000 premature deaths, with an estimated cost of between $1.1 billion and $2.6 billion (Bureau of Transport and Regional Economics, 2005).

Transport accounts for the highest proportion of Australian household greenhouse gas emissions (34%). In comparison, home heating and cooling (11%) and lighting (5%) are responsible for substantially less greenhouse gas emissions (Department of the Environment, Water, Heritage and the Arts 2008). Even at the current low levels of active transport in Australia, cycling to work in Australian capital cities in 2006 accounted for 189,392,000 km of travel (based on 2006 census data), amounting to a greenhouse gas saving of 45,000 tonnes per year (Bauman et al 2008). At a carbon price of $40 per tonne, this equates to $1.8 million per year (Cycling Promotion Fund 2008).

Car reliance and associated excessive motor vehicle traffic contribute to community disruption, noise pollution, social isolation and urban sprawl, and restrict children's independent mobility and opportunities for outdoor play and social interactions (Carver et al 2008a, Carver et al 2008b; Handy et al 2005; Litman 2004a; Litman 2004b; Frumkin et al 2004; Social Inclusion Unit 2003; Dora and Phillips 2000).

> "There are many compelling reasons for affording walking a much higher priority than has occurred over the last half century." (Corben et al 2008, p.1)

Many industrialised, car-oriented countries such as Australia have identified a substantial latent demand for access to more active and sustainable alternatives to car use (Rissel et al in press; Litman 2004b; Goldsmith 1992). Active transport addresses the principal constraint on physical activity; namely, lack of time, by combining exercise and travel time. Nearly all people are pedestrians at some time, and walking is the most popular activity undertaken for exercise, recreation or sport in Victoria (Standing Committee on Recreation and Sport 2008). A high proportion of car trips in Melbourne are for relatively short distances that potentially could be undertaken by walking or cycling (36% of car trips in Melbourne are less than 3km, and 52% are less than 5km) (RMIT 1999). Bicycle ownership in Melbourne is high (0.44 bicycles per capita) (VicRoads 2004), and for the last eight years, Australians have purchased more bicycles than cars (Bauman et al 2008). Cycling is the fourth most popular form of exercise and recreation in Victoria (Standing Committee on Recreation and Sport 2008), and most children and adolescents prefer to walk or cycle to school (Garrard et al 2008a).

Despite these indicators of considerable potential for people to walk and cycle for transport, active transport rates in Australia are very low. Pedestrian and bicycle mode shares of the journey to work in Melbourne in the 2006 population census were 3.60% and 1.34% respectively (Australian Bureau of Statistics 2008). In comparison, rates of active travel in many European and Asian countries are high (see Figure 1). Comparable data for Australia are not known because at the national level, only mode share of journey to work on census day is available. However, best estimates place Australia close to the relatively low active transport levels of Canada and the USA.

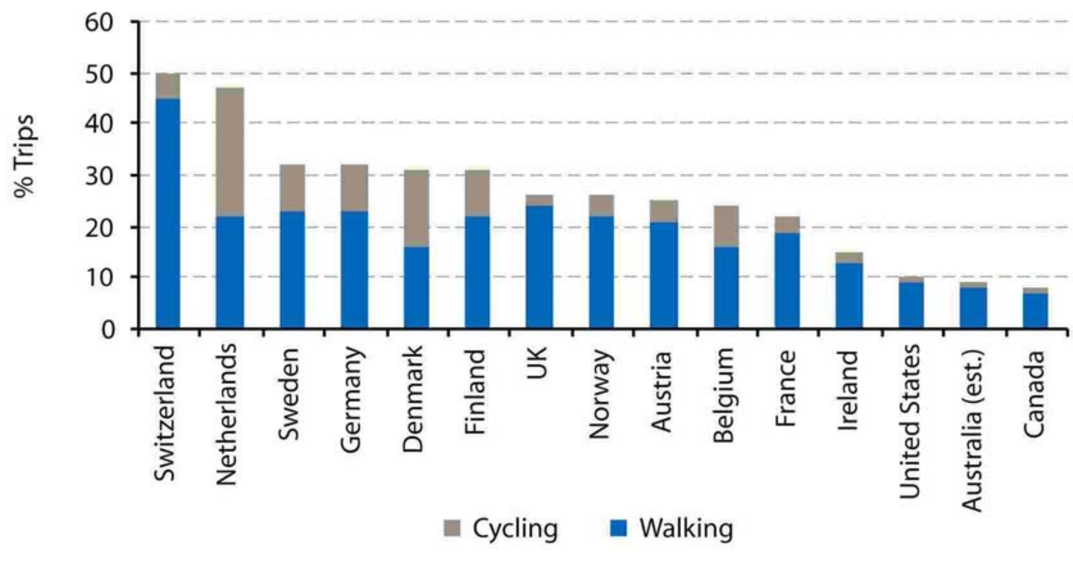

Figure 1: Cycling and walking shares of urban trips in Europe, Canada, and the USA
(Source: adapted from Bassett et al 2008)

This international comparative data points to some important constraints on active travel in Australia. Hazards associated with the road transport environment have been consistently and strongly identified as a principal constraint on walking and cycling in countries such as Australia (Bauman et al 2008; Carver et al 2008a), with vehicle speed a key component of perceived and actual road traffic hazards (Daley et al 2007). Countries such as the Netherlands, Germany, Denmark and Japan, which have achieved relatively high rates of active transport, have implemented transport strategies with a strong focus on a range of speed reduction initiatives (Pucher and

Beuhler 2008). In these countries, increased rates of active transport are associated with lower rates of transport fatalities and injuries for pedestrians, cyclists and other road users (Pucher and Dijkstra 2003; Jacobsen 2003) (see Figure 2). Comparable data is not available for Australia as there are no national data on population all-mode transport trips and trip distances. However, Australian data is likely to lie between the USA and Germany/the Netherlands.

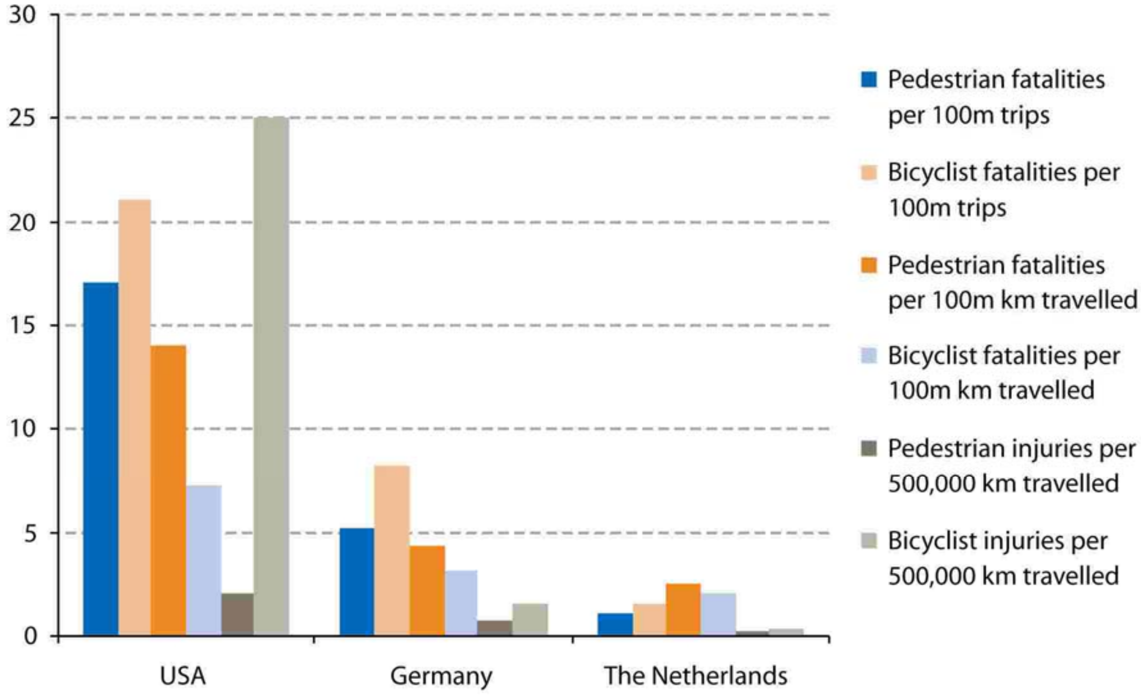

Figure 2: Pedestrian and bicycling fatality rates and nonfatal injury rates in the USA, Germany and the Netherlands, 2000
(Source: Pucher and Dijkstra 2003)

While the impacts of vehicle speed on risk of injury to pedestrians and cyclists are well-documented, relatively little research has been conducted into the impacts of vehicle speed on active travel behaviour. The principal aim of this review is to explore this latter relationship. The study objectives are to review the impacts of vehicle speed on (i) active transport participation rates; (ii) perceptions of traffic safety and community liveability[6]; and (iii) pedestrian and cyclist injuries. The review includes international and national research, with a focus on Australian and Victorian data and research where appropriate.

2. Active transport in Australia

In the latter half of the 20th century, substantial declines in active travel to work, school and other destinations occurred in countries such as Australia and the USA as personal travel became increasingly car based (Mees et al 2008; McDonald 2007).

[6] Community liveability refers to the environmental and social quality of an area as perceived by residents, employees, customers and visitors. This includes safety and health (traffic safety, personal security, public health), local environmental conditions (cleanliness, noise, dust, air quality, water quality), the quality of social interactions (neighbourliness, fairness, respect, community identity and pride), and opportunities for recreation and entertainment (Litman, 2005).

The precise extent of the decline in active transport in Australia is difficult to quantify as comprehensive data are lacking. Journey to work data from the Australian population census captures mode of travel to work on census day (in August), and while it does not include non-work related travel destinations at other times of the year, it is an indicator of travel behaviour. A recent study of travel modes in Australian capital cities based on census data from 1976 to 2006 reported substantial declines in active travel to work in the last three decades (Mees et al 2008). The number of people driving to work in Melbourne increased by 66.4% between 1976 and 2006. 43% of this increase was due to growth in the workforce, with the remaining 57% resulting from a shift away from public transport, walking and cycling. The mode share for car drivers in Melbourne increased from 56% in 1976 to 73% in 2006, while public transport declined from 24% to 14%, walking declined from 6.0% to 3.6%, and cycling increased marginally from a low base (1.0% to 1.3%) (Mees et al 2008).

This data indicates that Australia, together with the USA and Canada, has some of the highest rates of car travel and lowest rates of active travel in the western world (Bassett et al 2008) (see Figure 1).

Similar declines have occurred in active travel to school. Representative, longitudinal data on students' modes of travel to school is not available in Australia, but two state-based surveys indicate substantial declines in walking and cycling to school in Victoria and New South Wales - Australia's two most populous states. Based on household surveys in 1985 (n = 557) and 2001 (n = 926) in Victoria, for children aged 9-13 years, walking to and from school declined by 17.8%, from a mean of 4.4 trips per week in 1985 to 3.6 trips per week in 2001. Cycling to and from school declined by 70.5% from a mean of 1.22 trips per week in 1985 to 0.36 trips per week in 2001 (Salmon et al 2005).

Based on household travel surveys (in the form of 24-hour travel diaries) from the New South Wales Department of Planning in 1971 (n = 4284), 1981 (n = 4936), 1991 (n = 662) and 1999-2003 (n = 816) in the Sydney metropolitan area, the proportion of children aged 5-9 years who walked to school on the day of the survey declined by 55.8% between 1971 (57.7%) and 1999-2003 (25.5%). For children aged 10-14 years, there was a 52.0% reduction (44% to 21.1%). Cycling data was not included in the analysis, but was reported to be low (1-2%) (Hidde et al 2008).

While data from these two states are not directly comparable, both indicate substantial declines in walking and/or cycling to school in the last three decades in Australia.

Reasons for the decline in active transport in Australia include the speed, comfort and convenience of car travel; together with a range of socio-environmental, public policy and regulatory factors that favour car use and make active travel choices more difficult choices (Bauman et al 2008; Frank 2004; Pucher and Dijkstra 2003). This review focuses on the impact of vehicle speed on the use of active transport.

3. Speed and active transport

Public health research on the correlates of walking and cycling for transport has focused largely on individual factors such as motivations, skills, opportunities and social norms; and on environmental factors such as urban form, aesthetics and transport systems (Aytur et al 2008; Aytur et al 2007; Owen et al 2007; Saelens et al 2003). The role of vehicle speed as a factor in active transport behaviour has received relatively little attention, and is not included in many audit tools which are used to assess the 'walkability' and 'bikability' of specific locations. (Moudon and Lee 2003).

Consequently, there are few frameworks or models relating to vehicle speed and active travel behaviour. This review presents evidence for this relationship using the model outlined in Figure 3.

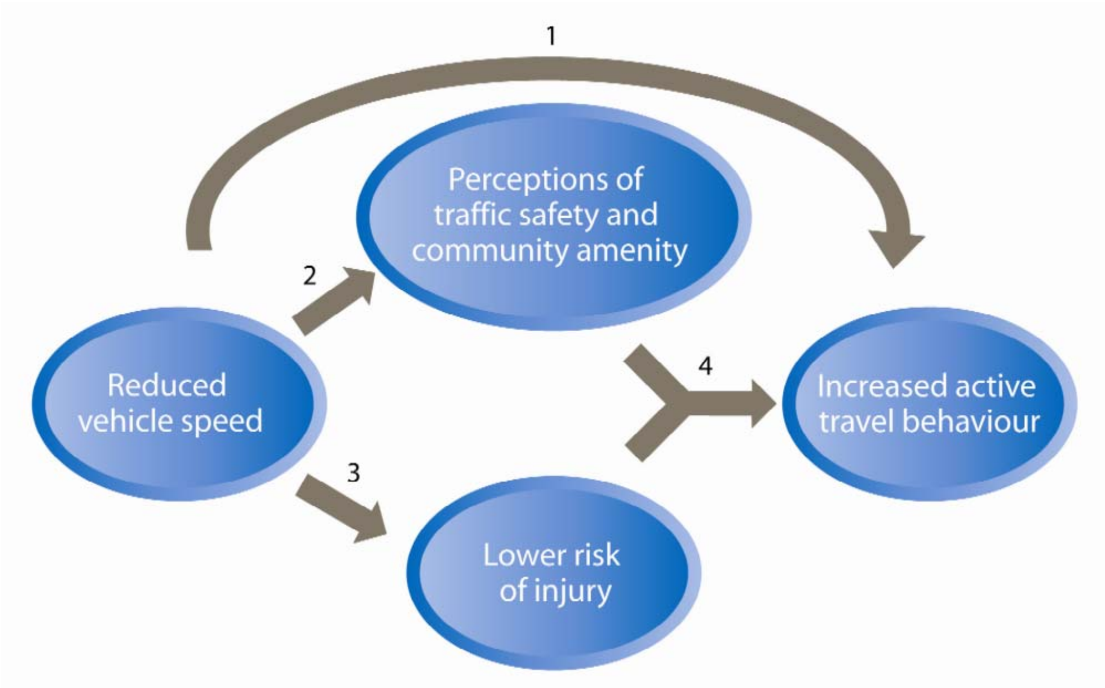

Figure 3: Proposed relationships between vehicle speed and active travel behaviour

This model proposes that reduced vehicle speed leads to overall increases in active travel (1) via reductions in actual and perceived risk of injuries and improved community liveability (2, 3, 4). Other potential pathways linking reduced vehicle speed with increased active travel behaviour are possible, but are not included in this review.

In addition, there are also three potential feedback loops: (i) increased active travel behaviour lowers the risk of injury (the 'safety in numbers' principle); (ii) increased active travel behaviour lowers the perceived risk of injury (through the experience of safe active travel); and (iii) increased active travel behaviour leads to reduced vehicle speed as more pedestrians and cyclists advocate for improved road safety, including reduced vehicle speed. This report reviews evidence for pathways 1-4 only.

This review adopts the WHO definition of 'speeding' as including driving above the speed limit, but also driving within the speed limit but nevertheless too fast for the road conditions or mix of road users (WHO 2008). The review is also based on the well-established relationship between speed limits and vehicle speed, whereby lowering speed limits is an effective means of reducing vehicle speed when accompanied by sustained, visible enforcement of speed limits (WHO 2004).

4. Evidence associated with reduced vehicle speed and active travel

4.1 Pathway 1: vehicle speed and active travel behaviour

The seemingly straightforward question “Does reduced road traffic speed increase active travel behaviour?” is difficult to answer because very few research studies have addressed this question directly. Monitoring the impacts of speed reduction measures usually involves assessing changes in traffic speed, crashes or injuries; and few studies have examined the impact on active travel. Only recently has the impact of speed reduction on travel mode share been included in the evaluation of traffic management interventions (e.g. Portsmouth City Council 2008). In addition, when municipalities attempt to increase active travel mode share they rarely rely on speed reduction alone. Most strategies are multi-faceted, making it difficult to disaggregate the impact of speed reduction.

A recent review conducted by the UK National Institute for Health and Clinical Excellence, with similar objectives to the current study, lamented both the paucity and lack of rigour of relevant research studies. The authors of the evidence-based review of transport interventions for increasing the prevalence and safety of active travel stated that:

> *“While experimental study designs – randomised controlled trials (RCTs) – provide the most robust approach for determining cause and effect between dimensions of transport and physical activity, the feasibility of undertaking such studies is limited in this field*.”
>
> And:
>
> *“It became clear that virtually no papers addressed our review questions specifically. Most papers did not examine physical activity (walking and cycling) as outcomes. The majority of potentially relevant papers used injury and accidents as a primary health outcome.”*
>
> (Killoran et al 2006)

Lack of definitive proof of the effectiveness of interventions should not preclude taking action. In this important but complex public policy domain it is appropriate to base policy and action on the best available evidence. In assessing the link between vehicle speed and active travel, it is therefore necessary to consider evidence from non-experimental sources. These sources include policy analysis and evaluation; time series and geographical analyses; cross-sectional analytical studies; and case studies. Together, they can provide good evidence of likely relationships rather than definitive proof in the scientific sense.

Evidence of the impact of reduced vehicle speed on active travel behaviour from these multiple sources is presented in Sections 4.1.1 to 4.1.4.

4.1.1 Impacts of speed reduction interventions on active travel

The studies reviewed in this section are those in which speed reduction interventions in specific locations are evaluated for their impact on active travel behaviour. Speed reduction schemes are neighbourhood-based transport interventions that are primarily intended to reduce accidents and injuries to pedestrians and cyclists through traffic speed reduction (Morrison et al 2004). They commonly include speed limits of 30 km/hr or less, and a range of treatments including pedestrian crossings, speed cushions, speed humps and chicanes, kerb build-outs, and central refuges.
Rigorous assessment of the impacts of speed reduction interventions has the potential to provide good evidence of their impacts on active travel behaviour, but, as noted above, for a range of reasons, few studies of this type have been conducted.

A small number of studies have been conducted in the UK, including a study of ten traffic calming schemes on both trunk and local roads in Scotland. Post-implementation, residents reported increased neighbourly interaction, improved perceptions of pedestrian safety, improved neighbourhood appearance, reduced crime risk, and increases in walking and cycling (Scottish Office 1999; Department of Transport, Local Government and the Regions, 2001).

Another evaluation of the health effects of a neighbourhood traffic calming scheme in Glasgow, Scotland, reported that the project was associated with increases in walking and willingness to allow children to exercise outside that were attributed to the traffic calming scheme; increased observed pedestrian activity; reductions in local traffic related nuisances; and improvements in physical health. The authors concluded that traffic calming schemes may have wider health benefits than those associated with accident reduction (Morrison et al 2004).

In contrast to the findings described above, evaluation of the impacts of construction of 20 mph (32 km/hr) zones in six towns in northern England, which were enforced using a range of engineering measures, found that overall, the project had no significant effect on local travel patterns (Babtie Group 2001). However, post-implementation, some residents stated that they would be willing to cycle or walk more, and there was an increase in the number of parents who said they were willing to allow their children to play in the streets.

A brief summary report on physical activity and the environment prepared by the UK National Institute for Health and Clinical Excellence reviewed evidence of the impact of traffic calming on physical activity. The review stated that the evidence from five studies tended to suggest that traffic calming can lead to small self-reported and observed increases in walking and cycling (including children’s play) both in the short and in the long term. However, three studies reported either no significant change in self reported and observed levels of walking or cycling, or slight declines in walking and cycling in the short and long term (NICE Public Health Collaborating Centre 2006).

Based on the limited available research outlined in this section, it appears that there is some, but not definitive evidence that speed reduction measures contribute to the promotion of active travel. It is likely that impacts will vary according to location, the nature and extent of the traffic calming measures, and population demographics.

4.1.2 Comparative analyses of countries, regions and municipalities

There are substantial differences between countries in active transport mode shares (see Figure 1). Comparable data for Australia is not known because at the national level, only mode share of journey to work on census day is available. However, best estimates place Australia close to the relatively low active transport levels of Canada and the USA.

Observation of large variations in active travel modes between countries has led to a number of studies aimed at understanding the reasons for these differences. Historically, nearly all industrialised countries experienced substantial declines in walking and cycling for transport with increased motorisation of travel during the 20th century. This trend continued relatively uniformly until the 1970s when a combination of increasingly car-congested cities and towns and growing environmental concerns led some countries to take action to reverse the trend. Chief among these countries was the Netherlands, where the Dutch Ministry of Transport and Public Works implemented the first official national bicycle policy which has resulted in a steady increase in cycling since 1978 (Pucher and Buehler 2008) (see Figure 4). Figure 4 also shows that, as cycling increased, cyclist fatalities decreased due to the implementation of a range of traffic safety measures including speed reduction and other traffic calming measures. The Netherlands has since been joined by Germany, Denmark, Switzerland, Sweden, Austria and other European and affluent Asian countries such as Japan in successfully promoting a mode shift from car travel to active travel (see Figure 1).

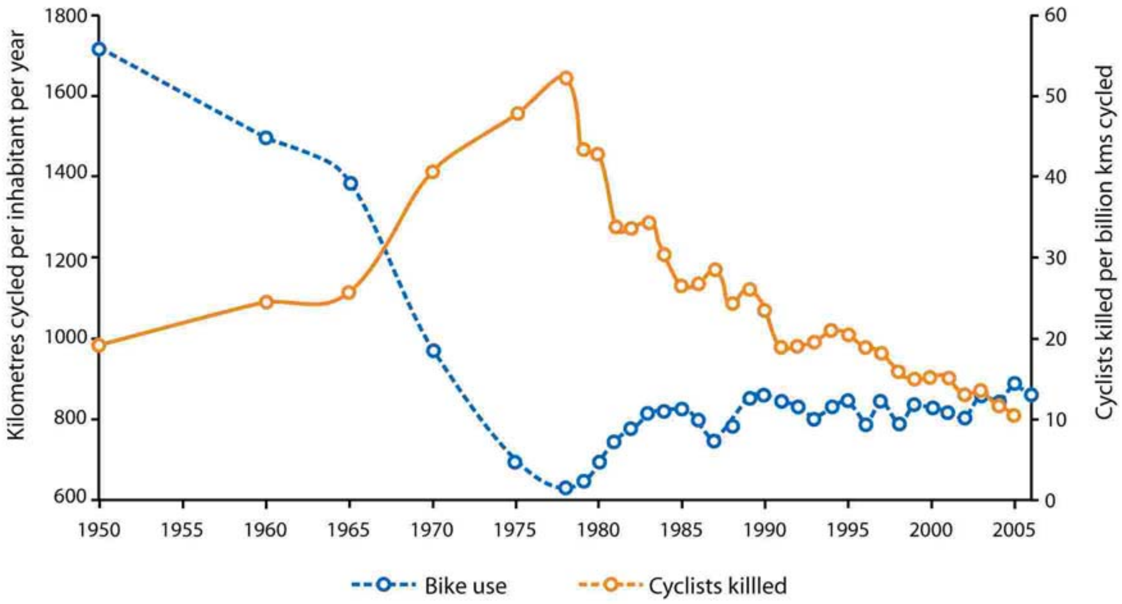

Figure 4: Annual kilometres cycled per inhabitant in the Netherlands and cycling fatality rates, 1950–2005
(Source: Pucher and Buehler 2008)

Vehicle speed reduction is an essential element in achieving high rates of safe, active transport. In a comparative cross-country analysis of "what makes cycling irresistible", Pucher and Buehler (2008) reported that the Netherlands, Denmark and Germany have:

> *"…better facilities for walking and cycling; urban design and spatial planning more sensitive to the needs of cyclists and pedestrians; lower speeds on urban roads; restrictions on motor vehicle use and parking; more rigorous traffic education; and strict enforcement of traffic regulations protecting non-motorists."*

The authors also noted that "since most active trips start at home, traffic calming of neighbourhood streets is crucial to enabling active trips to start off in a safe, pleasant environment" and that traffic calming is usually area-wide rather than in isolated streets. Speed limits in residential areas are generally 30 km/hr or less. In Berlin (Germany), for example, 3,800km of city streets (72%) are traffic calmed with speed limits of 30 km/hr or less (Jacobsen 2006).

The analysis by Pucher and Buehler (2008) concluded that speed limitations in cities with high levels of active transport use include the following:

- Traffic calming of residential neighbourhoods limits cars to speeds of 30 km/hr or less
- 'Home Zones' in many neighbourhoods give cyclists and pedestrians equal rights to road use and limit cars to *walking speed* (about 7 km/hr)
- Car-free zones, one-way streets and artificial dead-ends make car travel through the city centre slow and inconvenient
- Turn restrictions for cars but not for cyclists
- Almost no limited access highways (motorways) in city centres
- Strictly enforced speed limits and traffic rules in cities (such as police cameras at intersections)
- Frequent random speed limit enforcement checks by the police
- Advance stop lines and traffic signal priority for cyclists

Speed limits in Australia are generally well above those in the industrialised world. Table 1 summarises the main speed limits in Europe and Australasia.

Table 1: International and Australasian speed limits
(Source: Fildes et al 2005)

ROAD TYPE	EUROPE (mainly)	AUSTRALASIA (mainly)
School areas	30 km/h	40 km/h
Residential areas	30 km/h	50-60 km/h
Built-up areas	60 km/h	70-80 km/h
Urban roads	60-70 km/h	80 km/h or higher
Rural roads	80-90 km/h	100 km/h
'Motor' roads	100 km/h	100 km/h
Motorways	120 km/h	110 km/h

"A review of international speed limits showed that Australasia has some of the highest speed zones in the world, especially when compared to Europe." (Fildes et al 2005)

Fildes et al (2005) also noted that while speed limits in the U.S. are generally closer to Australasian speeds, US limits in urban areas are generally well below their Australasian equivalents.

Safety, including speed control, has also been shown to be a determinant of active travel rates *within* countries. In an analysis of the impacts of municipal policies on bicycle use in several locations in the Netherlands, Reitveld and Daniel (2004) reported that the safety of cyclists was a determinant of levels of cycling within municipalities.

While successful promotion of active transport in industrialised countries invariably includes speed reduction, it is rarely a stand-alone strategy. It is therefore impossible to disaggregate the impact of lower traffic speed on high rates of active transport in cross-country and regional analyses. Nevertheless, low neighbourhood speed limits (usually 20-30 km/hr) are a common feature of active transport promotion and participation in countries and municipalities that have successfully made the transition to reduced car dependency.

The comparative data described above suggests that, for industrialised countries, there is a negative association between urban speed limits and active travel prevalence. While these associations do not prove causation, they nevertheless provide one source of evidence for consideration, along with additional sources described in this review.

It has been argued that lower, European-style speed limits are inappropriate in Australia because Australian urban environments and road networks differ substantially from those in Europe. In response, Fildes et al (2005) note that while this is the case in some European cities and towns with high population densities and narrow streets, many of the modern suburban road networks in Europe are similar to those in Australia. The achievement of high rates of active transport through strategies including reduced speed limits in cities and municipalities in Australia (e.g. Unley, SA), the US (e.g. Portland), Canada (e.g. Vancouver), and the UK (e.g. York), demonstrate that speed limits and active transport rates are not an inevitable by-product of urban form, but, rather, an outcome of values-based policy decision-making.

4.1.3 Survey-based analytical studies

Studies reviewed in this section are non-interventions that involve analysing naturally occurring differences in people's environments and active travel behaviour. A number of environmental correlates of walking and cycling for transport have been identified consistently in the public health research literature. These include living in neighbourhoods with greater residential density, street connectivity and land use mix (Frank et al 2008). Very few studies have examined road safety correlates of walking for transport, but a recent longitudinal survey-based study involving 356 mothers in Melbourne in 2004 and 2006 found some evidence of an association between mothers' perceptions of the social and physical environments of the local neighbourhood and walking for leisure and transport (Cleland et al 2008).

Two road safety measures were positively associated with increased transport walking from baseline to follow-up (“I am satisfied with the number of pedestrian crossings in my neighbourhood”; and “there are traffic slowing devices in our local streets”) (Cleland et al 2008).

A small number of studies have considered how aspects of the road environment designed to improve road safety or reduce traffic flow and/or speed are related to active transport and other forms of physical activity among youth. A review of the influence of the physical environment on children’s physical activity found that transport infrastructure (number of roads to cross and traffic density/speed) was negatively associated with children's participation in physical activity (Davison and Lawson 2006). Similar findings were reported in a review by Carver et al (2008a).

However, in a study of the associations between objective (GIS-based) measures of the local road environment and physical activity (including active transport) among youth, Carver et al (2008b) found little evidence of a consistent relationship between neighbourhood road environment (e.g. traffic/pedestrian lights, speed humps) and children’s and adolescents’ walking or cycling to neighbourhood destinations. The authors concluded that the road environment influences physical activity among youth in different ways, according to age group, sex and type of physical activity (e.g. active travel, out of school activity). The study did not include a direct measure of vehicle speed.

Within the constraints of having few studies to refer to and methodological limitations, there is some emerging evidence based on cross-sectional analyses that traffic safety measures including vehicle speed reduction may increase walking and cycling among children, adolescents and adults in Australia.

4.1.4 Case studies of speed reduction interventions

International approaches

Internationally a number of initiatives have applied ‘safe speed’ limits aimed at reducing the rate and severity of crashes between vehicles and other road users. Examples of longer running strategies are ‘Vision Zero’ in Sweden and ‘Tempo 30’ in wider Europe. These speed reduction strategies are usually part of larger initiatives generally aimed at reducing death and injury on road systems. There are also regional or city specific examples of speed reduction initiatives such as in Toronto, Canada; Fingal County, Ireland; York, Plymouth and Portsmouth, UK, and others.

‘Vision Zero’ is a long term Swedish initiative that aims to reduce deaths and serious injury on the Swedish road network to zero. ‘Vision Zero’ considers the issue of safety in the road system in an ethical context rather than an economic or engineering one, so that no death or serious injury is acceptable (Swedish Road Administration 2000). ‘Safe speed’ in this program recognises 30 km/h as one strategy to reduce the severity of car/pedestrian collisions but also considers separating different road users where appropriate and encourages the use of safety devices such as helmets for cyclists. 'Vision Zero' applies a 'road hierarchy' that distinguishes between through traffic routes, main streets or urban arterials, residential streets and walking speed streets. It applies speeds based on these categories so that in built-up urban areas a standard 30 km/h speed restriction applies, and in areas where there is high vehicle and other road user interaction, walking speeds can be applied. This has resulted in fewer crashes and less severe road traffic accident outcomes for pedestrians and cyclists.

'Tempo 30' is a more general application of 30 km/h speed limits in Europe based on impact speed and pedestrian fatality and injury data. 'Tempo 30' was initially developed in Germany in the 1980s and involved a road hierarchy system with five categories ranging from Autobahns to pedestrian orientated zones. 'Tempo 30' has become the general term for the application of 30 km/h speed limits across Europe and is supported by the European Federation for Transport and Environment. The 'Tempo 30' concept has been applied in a number of cities and regions across Europe. Different strategies have been used to implement 30 km/h speed restrictions including enforcement and other traffic calming measures.

A small number of evaluations of these initiatives have been reported. The Danish Road Directorate evaluated traffic calming in three pilot towns where vehicle speeds were slowed using a range of measures, and priority was given to pedestrians and cyclists (Herrstedt 1992). The aim was to increase safety, reduce the feeling of insecurity, and improve the local town environment. The comprehensive evaluation included measurement of speeds, accidents, 'barrier effect'[7] for pedestrians and cyclists, delays for cars and side-road drivers, retail trade, noise and air pollution, energy consumption, costs, and users' opinions. Vehicle speeds were reduced significantly in the three pilot towns and feelings of security and traffic safety increased. The town environments were improved and were perceived by citizens to have become more attractive (Herrstedt 1992).

In the town of Baden in Austria, about 75% of the road network is a 30 km/h zone or woonerf[8]. Since the introduction of its integrated transport and safety plan in 1988, there has seen a 60% reduction in road casualties (Lines and Machata, 2000).

In York, UK, on-going investment in bicycle-friendly infrastructure and a policy of restricting motor vehicles and promoting walking and cycling has resulted in substantial reductions in pedestrian and cyclist casualties compared with the national average, as shown in Table 2.

[7] Roads carrying high volumes of high speed traffic that cut through an area can create physical and psychological barriers to the movement of community members, resulting in reduced social participation.
[8] Woonerf is a dutch term for an area where motorists and other road users share the street without boundaries such as lanes and curbs. In a woonerf, people on bikes and on foot have access to the whole street, not just footpaths and bike lanes.

Table 2: Road user casualties: York compared to the rest of the UK, average % change between 1990-1994 and 1981-1985
(Source: WHO 2002)

CASUALTIES	YORK (% CHANGE)	UK (% CHANGE)
Casualties	York (% change)	UK (% change)
All casualties	– 40.0	– 1.5
Pedestrians	– 36.0	– 15.0
Cyclists	– 29.5	– 12.0
Powered two-wheelers	– 65.0	– 54.0
Car passengers	– 16.0	+16.0
Car drivers	+2.5	+41.5

Victorian examples
Victoria's road transport policies have focussed largely on traffic 'flow' and car mobility. There has been no overall push for 30 km/h speed limits as has occurred in Europe, however there are some examples of speed reduction measures. In 2001 a state-wide default speed limit (except where otherwise signed) of 50 km/h was introduced, replacing the previous default limit of 60 km/h. More recently there have been examples of 40 km/h initiatives in specific locations in Melbourne and regional Victoria (notably around schools and in shopping strips).

VicRoads has supported initiatives implementing 40 km/h zones in specific circumstances such as around schools and some local shopping strips. While the introduction of 40 km/h zones around schools has been widely adopted and accepted, their application to shopping strips has been limited to an initial trial of 18 strip shopping centres that were identified based on their poor crash history. A further five sites were added to the initial pilot in mid 2008 (see Section 4.3.5).

There are guidelines available to support the implementation of speed restrictions around shopping strips, and some examples of the program in practice are as follows.

City of Darebin – High Street
A 40 km/h zone along High Street in Preston was implemented to ensure safe passage for all users. The 40 km/h speed limit was introduced as part of the *'High Street Management Plan'* to assist pedestrian movement, along with other measures such as improvements to signal crossing facilities and the introduction of a central median. Variable message signage has been placed along a 2 km section of High Street, Preston from near Regent St in the north to Dundas/Miller Streets in the south. A 40 km/h speed restriction is enforced from 7am to 7pm with the signs flashing "40 km/h". Outside of this time the signals do not flash and the road reverts to 50 km/h.

City of Moreland – Pascoe Vale Road
Along the stretch of Pascoe Vale Road through Glenroy Shopping Centre a 40 km/h speed limit has been implemented during shopping hours, 7 days a week. This is a VicRoads 'Blackspot' initiative aimed at improving the safety of intersections and

high risk stretches of road. Another planned example of illuminated speed signs is a stretch of Lygon Street that runs through East Brunswick Shopping Centre. The signs display 40 km/h speed restrictions and operate during shopping hours, 7 days a week.

City of Yarra – Victoria Street

In the City of Yarra, Victoria Street (from Hoddle to Fairchild Streets) has been added to the list of 40 km/h shopping strips. The City of Yarra also has full-time 40 km/h limits operating throughout North Fitzroy and Clifton Hill as well as in part of Fitzroy. VicRoads has recently approved a proposal to make the area of Richmond bounded by Hoddle, Victoria, Church Streets and Bridge Road a 40 km/h zone.

Examples of other speed reduction measures that reflect one of the strategies used in a number of Tempo 30 projects and Vision Zero – the hierarchy of roads model - is being implemented in the City of Yarra which has recently installed a new shared zone in Lennox Street from Victoria Street to Little Butler Street with a 10 km/h limit. Another shared zone in Yarra is on Mary Street adjacent to the Richmond Primary School where the speed limit is also 10 km/h.

City of Port Phillip

Fitzroy Street from the Esplanade to Lakeside Drive was part of the 40 km/h strip shopping centre trial, and is now operating for 24 hours a day. Ormond Road Elwood is a permanent 40 km/h zone, and implementation is in progress in Carlisle Street. A small grid of streets in Elwood bounded by Brighton Road, and Blessington, Mitford and Byron Streets has a 40 km/h speed limit.

City of Melbourne

The City of Melbourne's transport policy "*Moving people and freight -Transport Strategy 2006-2020***"** includes implementing a 'blanket' 40 km/h speed limit in the CBD (including around the Queen Victoria Markets) and local areas to help reduce pedestrian injuries and improve the walking and cycling environment (City of Melbourne 2006).

There have been few municipality-based, evaluated speed reduction interventions in Victoria, and none have measured changes in active transport or community amenity as outcomes. The impacts of system-wide changes in speed limits (e.g. 50 km/h default speed limit; 40 km/h school zones, 40 km/h shopping strip zones) on road user casualties have been evaluated and are discussed in Section 4.3.5.

In summary, there is good evidence from the four types of studies described in Sections 4.1.1 to 4.1.4 above that low neighbourhood vehicle speeds (generally 30 km/h or less) are associated with active transport participation in industrialised countries, cities and municipalities. While evidence from each of the four study types separately is not definitive, together they suggest a consistent overall pattern. Evidence of a direct causal relationship is not available due to limited research studies and difficulties disaggregating the effect of reduced speed from multi-component strategies aimed at increasing active transport.

Pathway 1 (Figure 3) described above in Sections 4.1.1 to 4.1.4 reviewed evidence from studies of the relationship between vehicle speed and active travel. It is likely that this over-arching relationship between speed and active travel is mediated by perceived pedestrian/cyclist safety and perceptions of community liveability (including the 'barrier' effect) (Pathway 2), and actual risk of injury (Pathway 3). Evidence for Pathway 2 is described in the following section.

4.2 Vehicle speed and perceptions of pedestrian/cyclist safety and community liveability

The model outlined in Figure 3 proposes that vehicle speed influences active travel behaviour via perceived risk of injury; that is, when vehicle speeds are high, people perceive that the risk of injury is high and are less likely to walk or cycle as a result (Pathway 2). Perceptions of traffic safety impact on community amenity as the ability to move about safely and freely in the public domain is a key component of perceived community liveability (Litman 2005). In a New Zealand study of children's perceptions of the space between home and school, Mitchell et al (2007) reported that:

> *"Most [children] desire to travel independently within public space, but are limited in their ability to do so, given the fears and obstacles that prevail within their neighbourhoods. We contend that restricted use of public space diminishes children's agency in inner suburbs."*

Studies in this area fall into two types: (i) surveys of constraints on active travel behaviour; and (ii) studies of the impact of traffic calming on perceptions of the safety of walking and cycling, and on community liveability.

4.2.1 Speed as a constraint on active travel

Numerous studies of self-reported constraints on active transport (including surveys, interviews and focus group discussions) consistently report that traffic hazards (including vehicle speed) are a barrier to walking and cycling for transport in Australia.

In a telephone survey of a random sample of 1880 adult Australians in 2004 by the Australian Associated Motor Insurers, a high proportion of respondents agreed or strongly agreed that "Aggressive drivers put me off cycling or walking" (46% of women and 38% of men) (AAMI 2004, personal communication). Inappropriate or excessive vehicle speed is one element of perceived 'aggressive' driving (Drugs and Crime Prevention Committee 2005).

A number of studies of self-reported constraints on cycling have been conducted in several Australian states. A recent qualitative study explored factors that influence personal decisions to initiate and maintain cycling, or not to cycle in inner Sydney, and identified differences according to current cycling behaviour. Twelve focus group discussions were conducted, comprising 22 non-riders, 23 occasional riders and 25 regular riders (Daley et al 2007).

Safety was a dominant theme among occasional and non-riders, and fear was a significant deterrent to initiating or maintaining regular cycling. Cycling's dangerous image prevented many non-riders from contemplating riding. Riders discussed the impact of vehicle speeds on the riding environment, and the speed differential between bicycles and motor vehicles was a safety concern, including for regular riders. Many participants supported the introduction of lower speed limits, restricted motor vehicle access and other traffic calming measures to make the local environment more amenable to cycling (Daley et al 2007).

A population survey and focus group discussions conducted in Perth in 1999 as part of the *Cycle Instead* campaign reported that the belief that cycling is dangerous was an important factor that influenced the (non-cycling) behaviour of infrequent or non-cyclists (Greig 2001). In Victoria, a survey of 2403 individuals randomly selected from Bicycle Victoria's database of members and contacts, found that concerns about cycling in traffic comprised a major constraint on cycling (Garrard et al 2006).

Review-level evidence indicates that road safety concerns are a major constraint on children's independent mobility (Carver et al 2008a), though two recent Australian studies reported mixed results for associations between parental and young people's perceptions of unsafe road environments and walking and cycling among children and adolescents (Carver et al 2008b; Carver et al 2008c). In a survey of parents of grades 4-6 primary school students in Victoria conducted as part of the evaluation of the Ride2School program, road safety concerns were frequently reported by parents as reasons for driving their children to school (Garrard et al 2008).

Few studies have specifically examined the impact of vehicle speed on community liveability. More commonly, studies refer to more general terms such as 'busy traffic' or the 'barrier effect' of major roads. For example, in a study of the well-being of 11-16 year-olds in Wales, Mullan (2003) reported that those who reported living with busy traffic were "less likely to have positive perceptions of the safety, friendliness, appearance, play facilities and helpfulness of the people in their local area."

The flip-side of research that identifies speed as a barrier to active transport and community liveability is intervention research aimed at assessing if speed reduction improves people's perceptions of safety and other aspects of community liveability. This is discussed in the following section.

4.2.2 Impact of speed reduction on perceptions of the safety of walking and cycling, and related aspects of community liveability

Perceptions of injury risks can influence active travel behaviour independently of actual risks. Injury rates provide a quantitative, objective measure of risk of injury for pedestrians and cyclists, but people's perceptions of, and behavioural responses to risks vary widely. The risk perception and communication literature identifies a number of 'qualitative' aspects of risk perception that help to explain apparent anomalies such as high rates of 'fear of flying' compared with low rates of fear of car travel, even though car travel carries a higher quantitative risk of death or injury than flying (Fischhoff et al 2002).

Risk perceptions can comprise a major barrier to active transport, with cycling in particular often seen as risky in Australia (Daley et al 2007; Garrard et al 2006). If speed reduction improves people's perceptions of safety, this may assist behaviour change independently of changes in actual risk of injury. In fact most people are unlikely to know the actual injury rates for pedestrians and cyclists, let alone the extent to which they decrease as a result of reduced vehicle speed. In this sense, individual and community perceptions of safety may be more important determinants of active travel behaviour than actual risks.

Recognition of the complex ways in which perceived and actual risks influence people's behaviour has important implications for the promotion of safe, active transport. Speed reduction may encourage active travel because the transport environment is *perceived* to be safer, and will therefore have benefits in addition to the benefits of injury reduction (see section 4.3). Changed risk perceptions are therefore relevant outcomes of traffic calming interventions.

A small number of studies have measured the effect of traffic calming on perceptions of the safety of walking and cycling, and on related aspects of community liveability. In the Scottish study described in Section 4.1.1, a range of traffic calming schemes resulted in increased neighbourly interaction, improved perceptions of pedestrian safety, and improved neighbourhood appearance (Scottish Office 1999; Department of Transport, Local Government and the Regions, 2001).

A study in six towns in northern England reported perceived improvements in quality of life after the implementation of 20 mph (32 km/h) zones, including safety for pedestrians and cyclists, benefits for families with children, and greater independent mobility for children (Babtie Group 2001).

Speed reduction interventions in three towns in Denmark led to similar improvements in safety perceptions. Intercept interviews with pedestrians and cyclists showed that feelings of security were improved considerably in the intervention towns. Perceptions of security improved for all age groups, but the greatest improvements were among the elderly. The authors concluded that the barrier effect (of high traffic speed) was reduced in the three pilot towns (Herrstedt 1992).

In summary, traffic hazards (including vehicle speed) are a major constraint on active transport in Australia. Because vehicle speed is consistently reported as an important constraint on active transport, it is likely that reducing speed will increase active travel by removing one of the key reported barriers to walking and cycling for transport. A small number of intervention studies have found that speed reduction measures increase perceptions of safety, active travel behaviour, and related aspects of community liveability.

Actual risks of injury are also likely to influence active travel behaviour, albeit indirectly, through the multiple safety narratives and messages that shape the social norms influencing individual behaviours such as travel mode choices (Rose 1992). Accordingly, reducing pedestrian and cyclist injuries is likely to contribute to increased active transport, as has been achieved in industrialised countries with high rates of active transport (see Figures 1 and 2). The following section reviews evidence of the impact of speed on risk of pedestrian and cyclist road traffic crash injuries (i.e., Pathway 3 in Figure 3).

4.3 Vehicle speed and injury to pedestrians and cyclists

4.3.1 The speed/injury relationship

Speed is the single most important contributor to road fatalities. It is estimated that one-third of crashes resulting in a fatality involve an element of excess speed, but speed is also an aggravating factor in all collisions. Speed contributes to the severity of crash outcomes regardless of other causal factors (WHO 2008). Higher speeds lead to increased risk of a crash and a greater probability of serious injury if one occurs. As speed increases, both the distance travelled during the driver's reaction time to an emergency, and the distance needed to stop increase. For example, a car travelling at 30 km/hr will travel about 13 metres before stopping in an emergency response to a pedestrian stepping onto the road. At a speed of 50 km/hr, the distance more than doubles to about 27.5 metres (WHO 2008).

Because pedestrians and cyclists are not protected by being enclosed within a vehicle, crashes involving pedestrians and cyclists tend to be more severe than those involving motor vehicles alone. As illustrated in Figure 5, human tolerance to injury by a car is exceeded if the vehicle is travelling at more than 30 km/hr.

> While most 'unprotected' road users (pedestrians and cyclists) survive if hit by a car travelling at 30km/hr, the majority are killed if hit by a car travelling at 50km/hr (WHO 2008).

In a study of the risk factors associated with injury severity of non-motorists in traffic crashes, Eluru et al (2008) noted that patterns of injury severity were similar for pedestrians and cyclists. This relationship is the basis for the recommended 20-30 km/hr speed limit in high pedestrian/cyclist traffic areas (WHO 2008), which when implemented, contributes to the low pedestrian and cyclist injury rates shown in Figure 2 for the Netherlands and Germany (compared with the USA, which generally has higher speed limits) (Pucher and Dijkstra 2003).

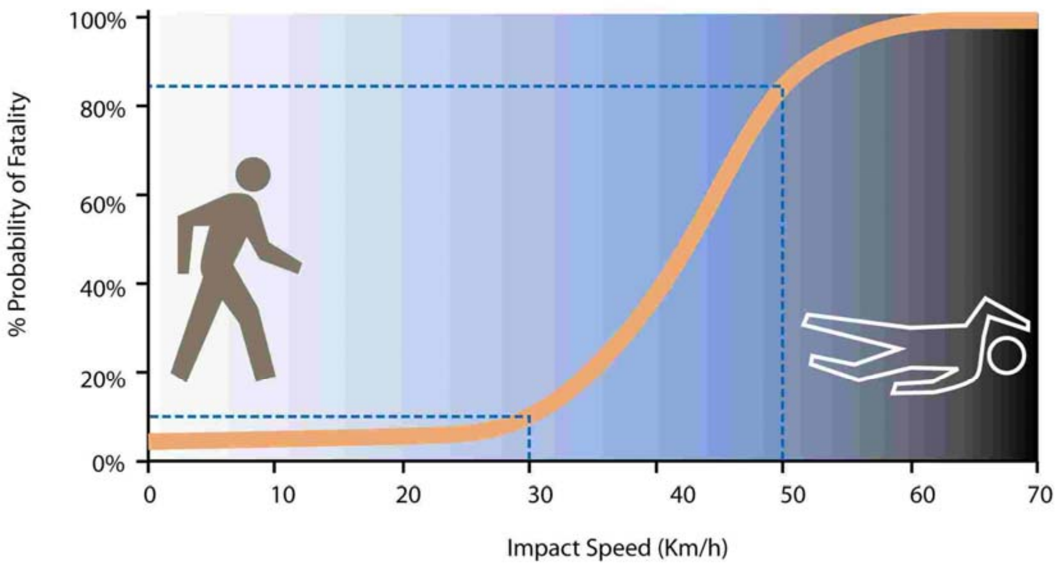

Figure 5: Probability of fatal injury for a pedestrian or cyclist struck by a motor vehicle (Source: WHO 2008)

Speeding can include driving above the speed limit, but also driving within the speed limit but nevertheless too fast for the road conditions or mix of road users. In car-oriented countries such as Australia, transport systems are not designed on the basis of human tolerance, and what is considered a safe speed for motor vehicles is often not safe for pedestrians and cyclists. Under these circumstances, driving within the speed limit can represent a significant hazard to pedestrians and cyclists. When speed limits are set using criteria that place a relatively high value on mobility compared with safety (as is common in countries such as Australia), this hazard is often not acknowledged or acted on. These underlying cultural values and norms are reflected in road safety policies, and reproduced through the narratives of daily life.

A recent media article on pedestrian safety illustrates these underlying value positions. The article entitled "*Sharp rise in deaths of elderly pedestrians*" (Russell 2008, see Appendix B) included the following statements:

> "…drivers were at fault in only four of the incidents in which 39 pedestrians were killed this year"
>
> "…elderly pedestrians and children under 14 …had to be more vigilant when out walking…"
>
> "…elderly people…who failed to heed the road rules…"
>
> "…older people who simply aren't taking the time to walk to a crossing and crossing when it's safe."
>
> "…police, the State Government and VicRoads were trying to educate older people on the dangers of crossing roads…"

Injuries to elderly pedestrians can be prevented through speed reduction. On the other hand, a review of injury prevention strategies stated that "There is little evidence that efforts to change the behavior of elderly pedestrians [e.g. through road safety education] have any long-term effects, and there is no evidence that programs focused on drivers have any benefit." (Rivara et al 1997). A more recent review reported similar findings (Duperrex et al 2002).

Based on the fatality-speed relationship illustrated in Figure 5, many of the pedestrian fatalities reported in the media article referred to above might not have occurred had the speed limit been within the range of human tolerance to being struck by a car. In industrialised countries with high levels of active transport such as Berlin (Germany), neighbourhood speed limits are usually 30 km/hr or less. As noted earlier, 72% of Berlin's city streets are traffic calmed with a speed limit of 30 km/hr or less (Jacobsen 2006). It is inappropriate to 'blame' pedestrians for being injured by a motor vehicle when vehicles are permitted to travel at speeds that are unsafe for pedestrians and cyclists, and that are considered inappropriate in countries with lower pedestrian and cyclist injury rates than Australia.

Not only do attitudes to appropriate vehicle speed vary between car-oriented countries and countries with safer and more balanced transport systems, but so too do attitudes to the responsibilities of road users. In Australia, a driver is generally not considered to be at fault in a casualty crash if he or she was obeying the road rules. In contrast, in many European and Asian countries a driver must anticipate pedestrian and cyclist errors and take evasive action to avoid a collision. For example, the German licence testing manual includes the scenarios depicted in Figure 6.

Figure 6 shows four traffic situations. In every case, the motorist is required by law to yield right of way to the cyclist or pedestrian. The lower right photo shows that motorists must anticipate the child possibly darting out into the street, and must actively avoid endangering children in such situations. The onus is on drivers to prove no-fault when in collisions with pedestrians and cyclists. In general, German and several other European road systems require higher standards of duty-of-care on the part of drivers for pedestrians and cyclists than does the Australian system.

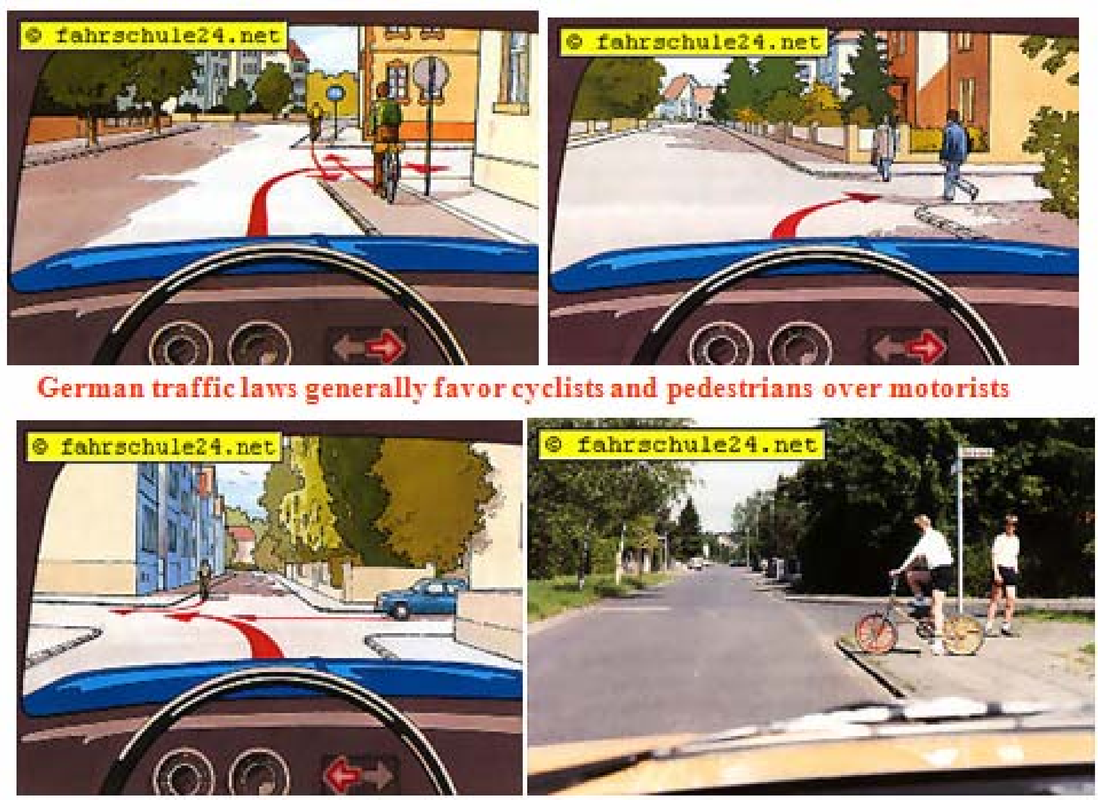

Figure 6: German traffic laws – drivers must yield to, and watch out for pedestrians and cyclists
(Source: Pucher 2006)

The greater vulnerability of pedestrians and cyclists to collision injuries is also reflected in patterns of injury severity, with pedestrians and cyclists experiencing disproportionately more severe injuries than motor vehicle occupants. In the Melbourne Statistical Division (covering the Melbourne metropolitan area), from 1987 to 2007, pedestrians and cyclists accounted for:

- 14.3% of all casualties
- 20.7% of all serious injuries
- 30.1% of all fatalities (VicRoads 2008).

The *Power model* illustrated in Figure 7 shows that decreases in mean vehicle speed result in greater reductions in the more serious injuries (WHO 2008). For example, a 2 km/hr reduction in average vehicle speed from 50 km/hr to 48 km/hr reduces the total number of crash injuries by 7.8%, fatal and serious crashes by 11.5% and fatal crashes by 15.1% (WHO 2008). While this data is for all road users, pedestrians and cyclists benefit most from reduced speeds. A reduction in travel speed of 10 km/h in 60 km/h zones is estimated to halve the number of pedestrian fatalities and prevent a collision completely in about one-quarter of cases (Anderson et al 1997). A small reduction of 5 km/h is predicted to result in 30% less pedestrian fatalities (McLean et al 1994).

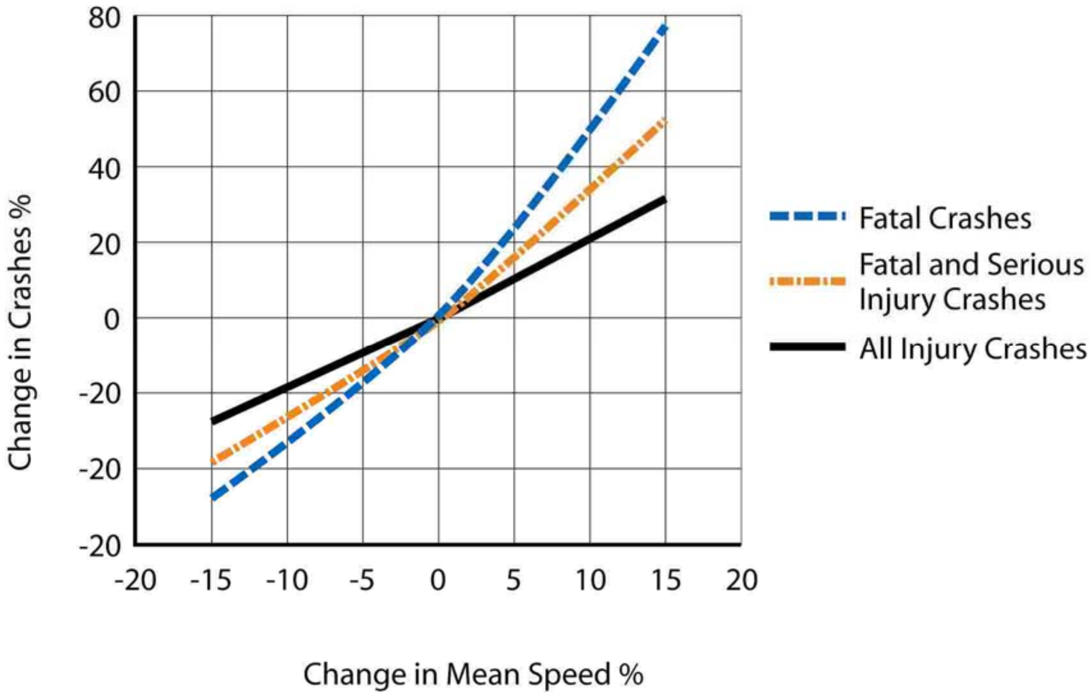

Figure 7: Relationship between percentage change in speed and percentage change in crashes
(Source: WHO 2008)

Patterns of pedestrian and cyclist injuries in Victoria reflect the impact of the current transport environment and highlight the potential for further improvements in the safety of pedestrians and cyclists. The following section provides an overview of pedestrian and cyclist injuries in Victoria.

4.3.2 Pedestrian and cyclist injuries in Victoria

Despite sustained improvements in road safety in Victoria over several decades, the number of fatalities and injuries among pedestrians and cyclists remains high in many urban areas and for specific segments of the population.

In the 10 years from 1997 to 2006, 7561 pedestrians and 3570 cyclists were killed or seriously injured in road traffic crashes in Victoria. Nearly one in six of all persons killed or seriously injured were pedestrians or cyclists (16.3%). In this 10-year time period pedestrian fatalities and serious injuries have decreased; and while cyclist fatalities have decreased, serious injuries among cyclists have increased (Figure 8).

This increase may be partly due to increased participation in cycling in Victoria over this time period (VicRoads 2008).

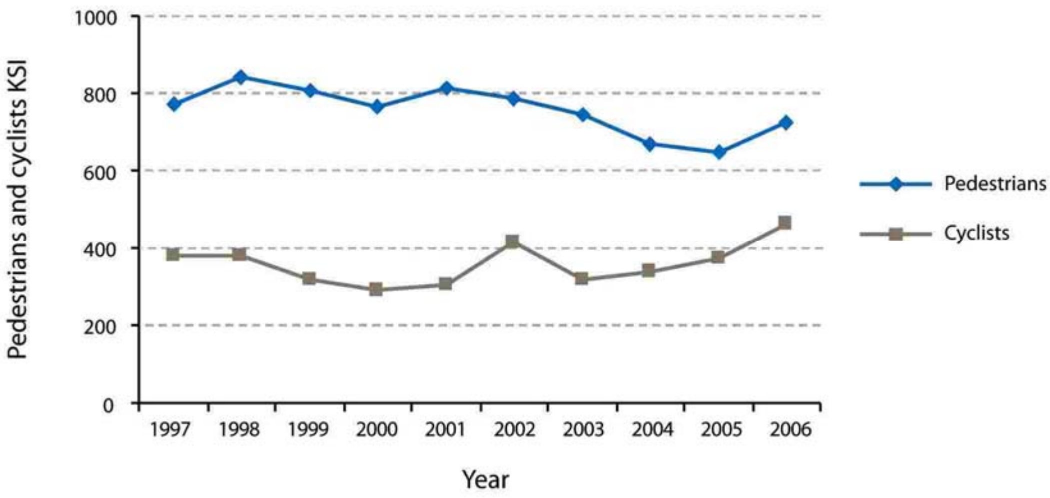

Figure 8: Pedestrians and cyclists seriously injured or killed, Victoria, 1996-2007
(Source: VicRoads 2008)

4.3.3 Distribution of pedestrian and cyclists injuries

The age distribution of pedestrian fatalities shows that older pedestrians are at greater risk of being killed (see Figure 9). In contrast, children and adolescents account for a high proportion of bicycle fatalities. Injury severity among cyclists follows a U-shaped age distribution, whereby children and older adults experience relatively more severe injuries (Figure 10).

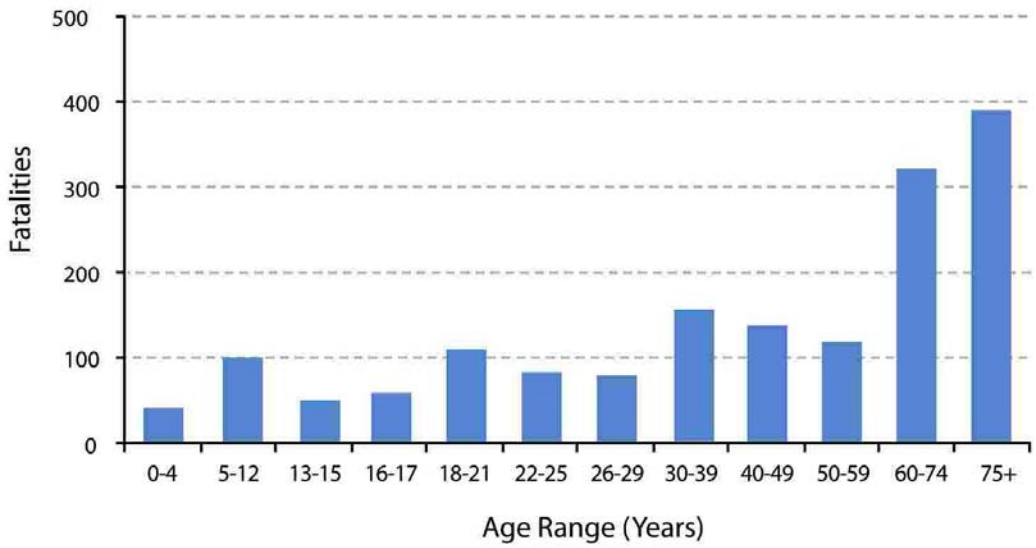

Figure 9: Pedestrian fatalities, 1987-2006, Victoria
(Source: VicRoads 2008)
(Note: Age ranges in the Crash Stats database are not uniform)

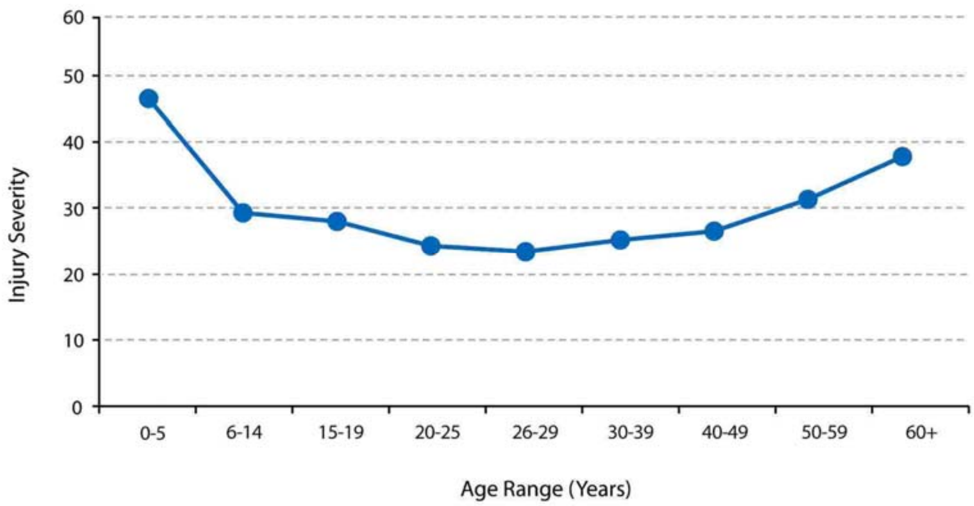

Figure 10: Proportion of cyclists killed or seriously injured by age
(Source: Watson and Cameron 2006)

This injury data indicates that unsafe conditions for pedestrians and cyclists have a greater impact on particular groups in the community – children and older adults. These are also the population groups that are more likely to have fewer transport options because they cannot or chose not to drive a car. Other population groups with limited transport options include disadvantaged communities. Ten percent of Melbourne households do not have a car, and in some disadvantaged suburbs of Melbourne this rises to nearly 30% (Department of Sustainability and Environment nd).

"Specific groups that do not or cannot drive primarily depend on walking for transportation, including children, the elderly and low-income populations. These groups are particularly in need of a safe walking environment to help lower their risk of injury and death." *(*National Cooperative Highway Research Program (NCHRP) (nd).

Regardless of whether people are compelled or choose to use non-motorised means of travel, it is imperative that these transport modes are provided with an environment that is as safe as possible. International comparative data on pedestrian and cyclist casualty rates indicates that there is much room for improvement in Australia (Australian Transport Safety Bureau 2000).

In addition, road transport systems that support safe non-motorised transport options are increasingly recognised as an effective road safety strategy, with international research suggesting that shifts to non-motorised transport result in overall increases in road safety (Litman and Fitzroy, 2005). Figure 11 illustrates the inverse relationship between active transport mode share and total road fatalities per 100 000 population in OECD countries for which national transport data is available for walking and cycling mode share (note that Australian data for walking and cycling trips are estimated as national data are not available). It can be seen that as numbers of people engaging in active transport increase, the number of fatalities drop.

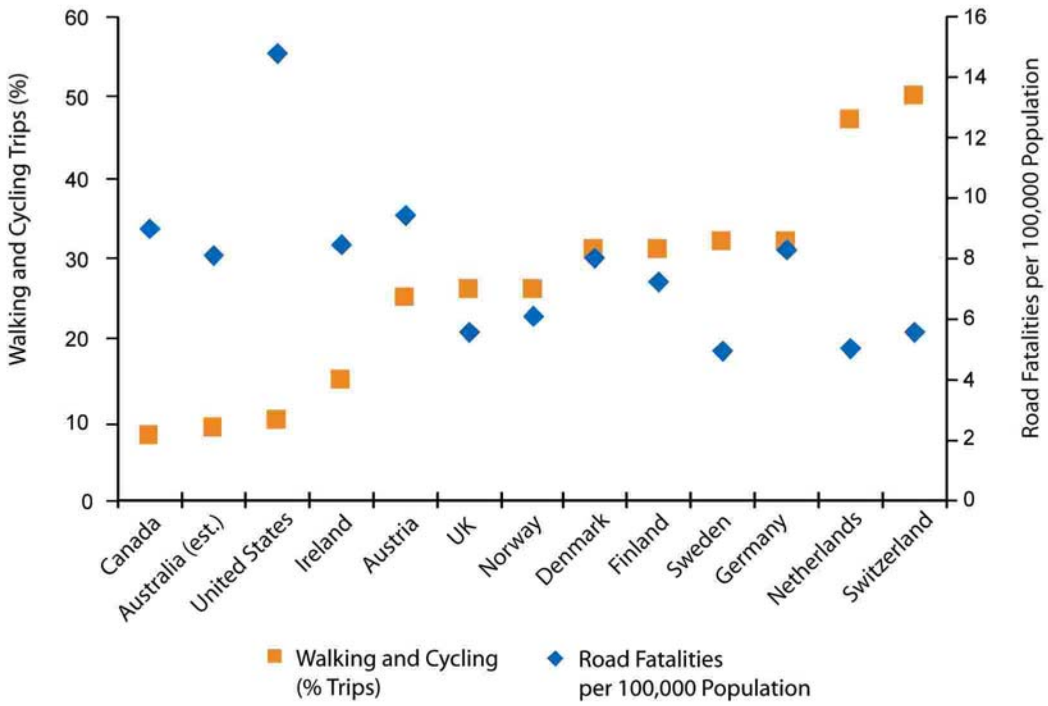

Figure 11: Walking and cycling mode share (% trips) and total road fatalities per 100 000 population, 1995
(Source: Bassett et al 2008; Eyestat 2008)

Based on the relationships between vehicle speed and pedestrian and cyclist injuries described above, reduced speed limits are predicted to result in injury reductions. This evidence is reviewed in the following section.

4.3.5 Impact of reduced speed limits

Three recent reductions in speed limits in Australia and Victoria have been evaluated for their impact on road traffic injuries: the 50 km/hr default speed limit introduced in Victoria in January 2001; the 40/60 km/hr school zones introduced in Victoria in 2003/4; and a trial of 40 km/hr strip shopping centre zones which commenced in Victoria in 2003.

50 km/hr default speed limit in Australia

The introduction of 50 km/h urban speed limits in a number of states has resulted in substantial reductions in the number and severity of urban crashes. In the first 21 months following the introduction of the 50 km/h default speed limit on residential streets in New South Wales, there was an estimated 45% reduction in fatal crashes and 22% reduction in all casualty crashes. For two of the most vulnerable road user groups - pedestrians and older drivers - crash reductions were estimated to be 51% and 50% respectively (Roads and Traffic Authority 2000).

The introduction of the Victorian default 50 km/h urban speed limit was associated with overall reduced casualty crashes of around 12%, with greater reductions in fatal and serious injury crashes involving pedestrians of between 25% and 40% (Hoareau et al 2006).

A comprehensive analysis of the impacts of the introduction of the 50 km/hr default speed limit in South Australia found: reduced speed (mean 3.62 km/hr) and injury crashes; 23.4% reduction in casualty crashes; greatest reduction in fatal crashes (36.6%) (not statistically significant); smaller reductions on roads that remained at 60 km/hr (comparison roads); and estimated savings of $129m over the 3-year period in South Australia (Woolley et al 2007).

40/60 km/hr school zones in Victoria

VicRoads (Crash Stats) data have been collated for pedestrians and cyclists within school zones in Victoria (40 km/hr in less than 80 km/hr zones; 60 km/hr in 80 km/hr zones or greater) for all persons and for school-age children and adolescents (5-18 years).

All persons

The average annual number of casualty crashes for pedestrians and cyclists around schools (250m radius) during school travel hours, decreased from 152 prior to the introduction of the reduced school speed zones (1998-2003) to 127 after their introduction (2004-2007), representing a 16.5% decrease. (VicRoads 2008).

School age children and adolescents

For school-age children and adolescents (5-18 years) cycling and pedestrian injuries decreased from an average of 71 per year pre-2003 to an average of 50 per year post-2003, a decrease of 30% (VicRoads 2008).

These decreases in pedestrian and cyclist injury crashes occurred over a time period during which enrolments in Victorian schools increased by 6.3% (1997-2007). It is also likely that traffic volume increased over this time period, increasing the exposure of children and adolescents to motor vehicle traffic (Bureau of Transport and Regional Economics 2007).

These data indicate that the injury reduction benefits of reduced school zone speed limits occurred for adults as well as school-age children and adolescents, with children and adolescents benefiting the most.

40 km/h strip shopping zones in Victoria

Evaluation of the Strip Shopping Centre Program that commenced in Victoria in 2003 found that the implementation of 40 km/h speed zones in 18 strip shopping centres in Victoria resulted in reduced casualty crashes of all types at treated sites by 8.1%, but the change was not statistically significant. There was also a non-significant reduction of 16.9% in casualty crashes involving pedestrians (Scully et al 2008). Economic assessment of the program showed that the Strip Shopping Centre program would only require a 1% reduction in casualty crashes of all types across all 18 sites to provide positive economic benefits to the community (Scully et al 2008).

International studies

Studies from several countries have reported findings consistent with those described above in Australia. Such is the amount of research on this topic that several systematic reviews of evidence have been conducted, including a 'review of reviews' (Killoran et al 2006). The authors concluded that there is review-level evidence showing that speed limit zones are effective in reducing personal accidents and material damage (Killoran et al 2006).

When the overall body of research evidence on speed and pedestrian and cyclist injuries is taken into account, there is little doubt that reduced speed limits result in lower mean speeds and fewer and less serious injuries for pedestrians and cyclists.

4.4 Perceived and actual safety, and active transport

Based on the evidence reviewed in sections 4.2 and 4.3, reduced vehicle speed contributes to improved perceived and actual safety (pathways 2 and 3 in Figure 3). While it seems likely that perceived and actual safety contributes to increased active transport (pathway 4), very few studies have examined this link directly. More often, both perceptions of safety and active transport behaviour are assessed together, as concurrent outcomes of traffic calming interventions (see section 4.2). Consequently, there is little direct research evidence that improvements in perceived and actual safety lead to increased active travel behaviour.

This relationship was discussed by Reitveld and Daniel (2004) in their study of the determinants of cycling in a range of municipalities in the Netherlands. They commented that *"the extent to which perceived accident risks may have an impact on travel demand is a generally under-researched subject*". They went on to discuss that, in general terms, accident risks have been shown to play a role in travel demand:

> *"It is well known that aviation is quite sensitive to these risks, given the slumps in air travel demand in a situation of crisis. However, for the other modes the effect of accident risks is much less known. Nevertheless, in a complete account of generalised costs, the risk factor should be included (see, e.g., De Borger and Proost, 2002), and it must have an impact on travel demand. It is plausible that accident risks do play a prominent role in non-motorised transport because cyclists and walkers are relatively vulnerable per kilometre travelled, compared with car drivers. Our research indicates that the actual low accident rates experienced by cyclists in a small town do matter in explaining their modal choice."*

Indirect evidence for the relationship between perceived and actual risk of injury and cycling for transport is provided by the analysis of cross-country gender differences in transport cycling. In Australia, transportation cycling rates for women are approximately one-fifth of the male rates (Garrard et al 2006). For example, in the 2006 census, only 21% of the trips to work by bicycle were made by women (ABS 2008). In contrast, countries with high rates of safe active transport have few gender differences in transportation cycling (see Figure 12). These gender differences have been attributed to females being more risk averse than males (Byrnes et al 1999) and therefore more sensitive to adverse traffic conditions and road safety concerns in their transport mode choice (Garrard et al 2006; Garrard et al 2008). Older Australians and children also have low levels of walking and cycling for transport compared with European and Asian countries with high population rates of active transport and more favourable active transport conditions. For example, in Germany 48% of the trips undertaken by individuals aged 75-plus years are walking trips, and in the Netherlands, 24% of trips in this age group are by bicycle and 24% are by walking (Pucher and Dijkstra 2003). There is therefore some indirect evidence that perceived risk of injury constrains active transport behaviour.

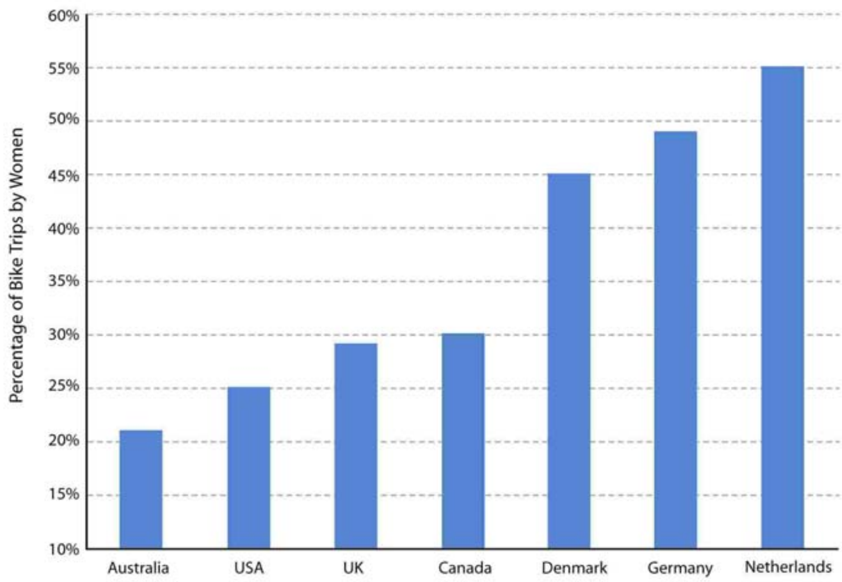

Figure 12: Women's share of total bike trips in Australia, the USA, the UK, Canada, Denmark, Germany and the Netherlands (2000–2005).
(Source: Pucher and Buehler 2008)

Proof of a causal link between perceived and actual risk of injury and active transport behaviour is difficult to obtain, and very few studies have addressed the topic, but it appears likely from the limited evidence available that the overall speed/active travel relationship is mediated by perceived and actual injury risks.

Reducing injury risks and increasing active transport through speed reduction clearly has many benefits. The following section outlines some additional issues related to implementing vehicle speed reduction in the context of promoting safe levels of active transport.

5. Implementation issues

Additional issues relevant to the implementation of speed reduction interventions include: area-wide compared to site-specific traffic calming; Victoria's Safe System road safety policy; perceptual barriers to speed reduction; additional benefits of lower speed limits; and lessons from overseas. These are discussed in the following sections.

5.1 Area-wide versus site-specific traffic calming

There is good evidence that area-wide traffic calming, such as global reduction of traffic speed, is more effective than 'black spot' treatments for reducing population-level pedestrian injury rates (Jacobsen 2006; Morency and Cloutier 2006). This is consistent with studies of the distribution of pedestrian road casualties which show that pedestrian casualties are frequently widely dispersed across road networks, with few pedestrian 'black spots'. For example, in an analysis of the geographic distribution of pedestrian crash sites in Montreal, Canada, Morency and Cloutier (2006) reported that 22 identified black spots (at least eight pedestrian casualties in the 5-year period) represented only 1% of all city intersections with at least one victim and 4% of all injured pedestrians, whereas 5082 victims were injured at more than 3500 different crash sites. They concluded that:

> *"a high-risk preventive strategy cannot substantially reduce the total number of injured or the insecurity that many pedestrians experience when walking. Considering the large number and widespread occurrence of pedestrian crashes in Montreal, prevention strategies should include comprehensive environmental measures such as global reduction of traffic volume and speed".*

These study findings are consistent with a large body of international research that challenges the overall effectiveness of black spot engineering treatments for the prevention of pedestrian injuries (Morency and Cloutier 2006; Jacobsen 2006).

"Considering the large number and widespread occurrence of pedestrian crashes….prevention strategies should include comprehensive environmental measures such as global reduction of traffic volume and speed". (Morency and Cloutier 2006)

5.2 Speed reduction and the Safe System approach to road safety

Victoria's road safety strategy *"Arrive Alive 2008-2017"* is loosely based on the Safe System approach originally developed as part of Sweden's Vision Zero road safety strategy (Swedish Road Administration 2000). The Safe System approach takes as its starting point that the protection of human life and health takes priority in the trade-off between the benefits of mobility and the human and economic costs of death and injury. Road traffic injuries are preventable through reduced traffic speed, and the transport system should adopt speeds that offer mobility without compromising safety (WHO 2008).

Victoria's *Arrive Alive* policy states that the Safe System approach includes *"setting speed limits according to the safety of the road and roadside"*. There is little acknowledgement of safe speeds for pedestrians or cyclists. This is in contrast to the Safe System approach internationally, which stresses the importance of setting speed limits based on human tolerance to injury by a car - which is exceeded if the vehicle is travelling at more than 30 km/h (WHO 2008). The Safe System recommendation in the WHO report *"Speed management: a road safety manual"* is for 30 km/hr speed limits in built-up areas with a mix of unprotected road users and motor vehicle traffic.

The Safe System approach also aims to achieve a road transport system that minimises the risk of death or serious injury by anticipating and allowing for human error. An example of this principle in practice is the German driver licence test requirement that drivers must anticipate errors by pedestrians and cyclists and avoid collisions as a result of possible errors (see Section 4.3.1).

Victoria's road safety strategy also acknowledges that the road transport system must allow for human error. However, the application of this principle in Victoria has been more in relation to driver error than pedestrian or cyclist error. Seat-belts, airbags, and interior and exterior car design modifications such as crumple zones protect motor vehicle occupants from their own and other drivers' mistakes. Pedestrians and cyclists are not protected by being enclosed within a 'safer' vehicle. Accordingly, vehicle speed is one of the few available protections for pedestrians and cyclists who share road space with motor vehicles, and who, like drivers, occasionally make errors.

As discussed in previous sections, pedestrians and cyclists are legitimate road users who should not die because of transport system failings. There are ample examples, described within this report, of countries and municipalities that have adopted balanced transport systems that provide greater protection for pedestrians and cyclists, resulting in fewer injuries and increased active transport. Furthermore, speed reduction to reduce the risk of injury for pedestrians and cyclists, as has been achieved internationally, is consistent with the underlying principles, if not always the practice, of Victoria's Safe System based traffic safety strategy.

"… preventing road death and disabling injury entails a traffic system that is better adapted to the needs, errors and physical vulnerabilities of its users rather than one which expects users to cope with increasingly demanding conditions." (Breen 2002).

5.3 Barriers to speed reduction: perceived and actual impacts on travel time

The main barriers to speed reduction are perceived and actual increases in vehicle travel time and associated costs. However, there is mounting evidence of a mismatch between perceived and actual travel times, particularly for the majority of relatively short trips undertaken in urban areas[9].

In a recent review of research associated with setting speed limits to achieve a balance between injury prevention and mobility, Fildes et al (2005) noted that the cost impact of increased travel times arising from any change in speed limits is often less than perceived by road users:

> *"It is generally considered that the greater the speed at which a driver travels, the faster the driver will arrive at the destination. While this direct relationship is largely true on highways with free flowing traffic, the assumption of shorter travel time for higher speeds is less justified in urban environments. Traffic flow in built up urban areas is more dependent on the number of intersections and type of traffic control used, as well as roadway capacity and congestion (Patterson et al., 2000; TRB, 1998). A considerable share of urban driving may therefore be spent stationary or travelling at very low speeds (Tiovanen & Kallberg, 1998)."*

The authors cautioned that analysis of the cost of travel time increases needs to distinguish between travel in urban and in rural areas. For the relatively short trips that comprise the majority of personal travel, time increments, though often

[9] 50% of trips in Melbourne are under 5 km (McKinley et al 2003)

perceived as significant, are likely to be small. As noted by White (2005), "In urban areas traffic flows depend primarily on intersection capacity, not travel speed between them." Small economic losses associated with lower speeds could be partly offset by other benefits such as reduced fuel consumption, maintenance, insurance and possibly future emissions penalties (TRB, 1998, cited in Fildes et al 2005). In addition, analysis of travel time costs needs to include cost savings from reduced crashes (including traffic congestion caused by collisions), reduced injuries and fatalities (TRB, 1998, cited in Fildes et al 2005) and reduced levels of chronic disease caused by lack of physical activity. These factors are often largely ignored because they are not associated with individual journeys, leading to an over-estimation of the time penalties of travelling at a lower speed (Ward et al 1998, cited in Fildes et al 2005).

"…the assumption of shorter travel time for higher speeds is less justified in urban environments. Traffic flow in built up urban areas is more dependent on the number of intersections and type of traffic control used, as well as roadway capacity and congestion (Patterson et al., 2000; TRB, 1998)." (Fildes et al 2005)

Internationally, evaluation of the Danish 3-town speed reduction program found small increases in travel time associated with the implementation of a range of speed reduction measures, including reduced speed limits (from 60 km/h to 40 or 50 km/h). In the three participating towns the mean observed delays were 7 sec/km, 9 sec/km, and 10 sec/km (Herrstedt 1992). Area-wide speed and traffic management research and experience in the British five towns study showed that the additional travel time, vehicle wear and tear and fuel costs were small, and reduced the overall benefits by about 15% (Breen 2002).

In a recent literature review of the impacts of lowered speed limits in urban and metropolitan areas, Archer et al (2008) concluded that:

> *"A relatively minor impact on average travel time (mobility) will occur at the individual level; at the societal level there are likely to be overall benefits depending on how values are assigned to travel time increases*."

In summary, evidence from a number of studies in several countries indicates that the main (publicly articulated) reasons for opposing reduced speed limits in urban areas; namely, increased travel time and costs, are substantially overstated. Small travel time benefits come at substantial cost in terms of the health and wellbeing of individuals and communities. While the research evidence is clear, barriers to speed reduction remain in the form of public perceptions, and regulators' reluctance to act on the evidence.

5.4 Community attitudes to speed reduction

There are some indications that public support for speed reduction may be increasing. There is a high level of acceptance of the 50 km/h default speed limit in local streets (78%), and the majority of Australians believe that increased vehicle speed leads to more accidents (74%) and more severe accidents (94%) (ATSB 2006).

Municipal level speed reduction strategies have also been implemented with community support. In Unley, South Australia, for example, a 40 km/h speed limit was introduced in 1991. The on-going trial has resulted in significantly lower speeds within the trial area, and has a continuing high level of local support for the lower limit (86%) (Department for Transport, Energy and Infrastructure 1998).

Other studies have shown that community support for reductions in urban speed limits increases following their introduction (RTA 2000). Fildes et al (2005) suggest that community support for reduced speed limits may increase with exposure to the benefits and minimal actual disbenefits such as increased travel time. This conclusion is supported by community attitude surveys showing that support for 50 km/h speed limits was higher among residents of streets with 50 km/h limits than residents living in areas that had not adopted the 50 km/h limits (RTA 2000).

Changes in attitudes to reduced speed limits were also observed in focus groups discussions conducted in Western Australia. After statistics supporting the safety benefits of reduced speed limits were presented to participants, many of those who were originally indifferent to reduced speed limits indicated support for the changes, though there was no evidence that education alone was able to reverse the opinions of those who opposed reductions in speed limits (Haworth et al 2001, cited in Fildes et al 2005).

There is now general recognition in the road safety sector that Australian speed limits are too high and that the travel time and economic costs of reduced speed limits, particularly in urban areas, are small. As part of the study by Fildes et al (2005) into optimising harm reduction and mobility in setting speed limits, a consultation workshop was undertaken with representatives from most Australian jurisdictions. The authors reported that:

> *"From both formal presentations and informal discussions, it was apparent that there was a high level of agreement that speed limits were generally too high, with most jurisdictions reviewing their current practices with a view to lowering posted speeds. While the importance of mobility was recognized, there was also the opinion that lower limits would have little impact on travel time other than for long-distance hauling."*

In Australia, speed limits are determined using a number of engineering criteria including road type, surrounds, geometry and the speed that 85 percent of drivers would choose when travelling along that road section. Increasingly however, these traditional criteria are being seen as a barrier to achieving injury reduction targets in road safety strategies (Fildes et al 2005). Evidence presented in this report indicates that they are also a barrier to achieving additional health and social benefits. The balance between harm reduction and mobility in setting speed limits shifts even further towards harm reduction when harm reduction includes health, environmental and community harms in addition to the harms associated with road traffic injuries. The additional (non-injury) benefits of lower speed limits are described in the following section.

5.5 Health and environmental benefits of lower speed limits

Lower speed limits reduce speed and casualty collisions. While injury prevention has been the main focus of speed reduction, there are many additional health, environmental, social and community benefits that, until recently, have largely been overlooked in the setting of speed limits.

The focus of this report has been on the benefits of reducing speed as a means of increasing active transport and reducing car use. Appendix A describes the health benefits of a shift from inactive to active travel modes, and several reports have reviewed the additional environmental, transport, social, community and economic benefits of increased non-motorised transportation (Litman 2004a; Dora and Phillips 2000). Lower vehicle speeds also have benefits in addition to those associated with reduced car use and increased active transport. These additional benefits are briefly outlined in this section.

Traffic congestion is a rapidly growing problem in large cities like Melbourne, with private car use the main contributing factor. The cost of avoidable congestion[10] in 2005 in Australia has been estimated to be $9.4 billion (Bureau of Transport and Regional Economics 2007). In Melbourne, congestion costs were estimated to be $3.0 billion in 2005 and predicted to rise to $6.1 billion in 2020 (Bureau of Transport and Regional Economics 2007).

Speed reductions can contribute to reduced congestion. A vehicle's road space requirements increase with speed, because drivers must leave a greater distance between their vehicle and other vehicles on the road. Under some traffic conditions lower speeds can reduce traffic congestion by increasing road capacity (Victoria Transport Policy Institute 2008).

Lower vehicle speeds can also reduce fuel use, greenhouse gas emissions, and air and noise pollution (Haworth and Symmons 2001; Fildes et al 2005). In urban environments where vehicles are required to slow or stop for roadway intersections and then accelerate again, lower speeds offer the best fuel economy. Traffic noise is the main (and loudest) source of noise pollution in Melbourne (Environment Protection Authority 2007). Motor vehicle noise pollution increases with increased speed. Tyre-road interactions have a strong relationship with speed and dominate engine noise beyond 20-40 km/h for new cars, although the engine noise is often higher for vehicles during acceleration (Kallberg and Toivanen 1997, cited in Fildes et al 2005).

Vehicle speed impacts on the emission of harmful pollutants such as carbon dioxide, carbon monoxide, hydrocarbons, nitrogen oxides and particulates. The relationship between speed and emissions is U-shaped, with the lowest emissions produced from a warm engine travelling at a relatively low and steady speed. Under typical driving conditions carbon monoxide, nitrogen oxides, and particulates increase substantially from around 40-50 km/h (Ward et al 1998, cited in Fildes et al 2005).

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[10] Avoidable congestion is defined as situations where the benefits to drivers of travel in congested conditions are less that the costs imposed on other members of the community (BTRE 2007)

A review of the relationship between fuel economy and road safety outcomes concluded that reduced vehicle speed can improve both fuel economy (and therefore greenhouse gas emissions) and road safety (Haworth and Symmons 2001).

> "The most energy efficient and least costly mode of transportation is muscle power" (*Making the Case for Active Transportation: Fact sheet 1, Go for Green, 2000, Ottawa, Canada)*

5.6 Lessons from overseas

A number of reviews have highlighted both the importance of speed control and the challenges associated with implementing effective speed reduction initiatives. While the evidence in support of speed reduction is clear, the processes required for successful change management appear not to be so well-recognised. In Australia, despite widespread support for speed reduction, progress has been slow and speed limits remain high by international standards.

The Joint OECD/ECMT Research Centre states that public information and support for speed reduction and enforcement are crucial to successful speed management. Drivers often do not perceive either the full risks of speeding or the multiple benefits of slowing down. Perceptions of the time and cost savings of increased speed in urban areas are inconsistent with quantitative data, and speed enforcement programs are often perceived to be more about revenue raising than traffic safety. Public information campaigns are therefore crucial for explaining and demonstrating the risks and reasons for speed reduction and enforcement, and for gaining public, media and political support for improved speed management (OECD/ECMT 2006).

The WHO report *"Speed management: a road safety manual*" also states that while speed management is an important tool for improving road safety, improving compliance with speed limits and reducing unsafe driving speeds are not easy tasks. Many drivers do not recognize the risks involved and often the perceived benefits of speeding outweigh the perceived problems that can result (WHO 2008).

The WHO (2008) speed management manual is an excellent guide to improving road safety through speed reduction. The manual presents good practice on speed management and offers a framework that can be adapted to local conditions. The manual addresses a wide range of measures including setting and enforcing speed limits, engineering measures designed to reduce speeds, and public education and awareness campaigns. The manual comprises five modules which are summarised in Appendix C.

> "The management of speed remains one of the biggest challenges facing road safety practitioners around the world and calls for a concerted, long-term, multidisciplinary response." (WHO 2008)

6. Conclusions

The multiple health, environmental, economic, transport and community liveability benefits of active travel are now well-established in the research literature. Pedestrians and cyclists are legitimate road users, but their needs for safe, comfortable and efficient mobility are often overlooked in car-oriented transportation systems. Traffic hazards in general, and traffic speed in particular, contribute to a substantial number of pedestrian and cyclist deaths and injuries in Victoria each year. In addition, emerging evidence suggests that adverse traffic conditions are an important constraint on active transport.

Speed is a major contributing factor in crashes of all types, and is especially hazardous for pedestrians and cyclists. 'Speeding' includes travelling above the speed limit, as well as travelling too fast for the road and traffic conditions. Speed limits that are set inappropriately high also increase the incidence and severity of pedestrian and cyclist injuries. Speed limits in urban areas in Australia are high by international standards, and this form of legal 'speeding' may be preventing Australia from achieving the health, environmental and social benefits enjoyed by an increasing number of industrialised countries that have lower speed limits and higher levels of safe, active transport.

The promotion of safe, active transport is usually achieved through the implementation of multi-component strategies that invariably include speed reduction. High levels of safe walking and cycling for transport are incompatible with high vehicle speed as, for many trips or parts of trips, pedestrians and cyclists are required to share the road space with motor vehicles.

Speed reduction is not the only change needed to increase safe active transport, but it is a key component. This report aimed to provide an evidence-based answer to the question "Does reduced traffic speed increase the prevalence and safety of active travel behaviour?" In the absence of rigorous research in the traditional sense (due to a lack of research studies addressing the question), multiple sources of less rigorous evidence suggest an affirmative answer to the study question.

Evidence for the relationship between speed and the incidence and severity of pedestrian and cyclist injuries, in particular, is strong and consistent. Vehicles travelling at lower speeds are less likely to collide with a pedestrian or cyclist, and less likely to cause severe injury. Pedestrians and cyclists struck by a motor vehicle travelling at 50 km/h have about an 85% chance of being killed, while at 30 km/h this drops to 10% (WHO 2008).

While it is widely acknowledged that actual and perceived injury risks influence active transport behaviour, there is limited direct evidence for this relationship because it is an under-researched topic. The few studies that have addressed this issue have confirmed the relationship. There is also consistent, strong evidence for the reverse pathway; that is, traffic hazards, including vehicle speed, are a major barrier to active transport in Australia.

These constraints on walking and cycling for transport are a major factor in what has been described as a high latent demand for active transport in Australia. Journey to work data for Melburnians (a proxy indicator of mode share of transport in Melbourne) indicates low levels of commuter walking and cycling relative to car travel (3.0% walking and 1.1 % cycling in the 2006 census) (ABS 2008).

The setting of speed limits in urban areas in Australia is based mainly on achieving a balance between vehicle mobility and injury reduction. Traditionally, little consideration has been given to the additional, non-injury benefits of speed reduction. These are multiple and wide-ranging, as described in this review, and include increased active transport and the associated benefits of active living and reduced motor vehicle use. The road traffic health impact 'iceberg' illustrated in Figure 13 summarises the relatively small number of well-recognised and quantified health impacts of road traffic. As well as the relatively large number of additional but less well-recognised health impacts, such as the effects of sedentary car dependant lifestyles. (Davis 1992). If these 'externalities' were included in algorithms used for setting speed limits, it is likely that the benefits of speed reduction to 30 km/h in urban areas would outweigh the disadvantages in the form of increased vehicular travel time and associated costs.

Figure 13: Road traffic health impact iceberg
(Adapted from Davis 1992)

Recent assessments of changes in travel time due to speed reduction in urban areas indicate only small increases in travel time and associated costs. Public perceptions are generally inconsistent with this research evidence. This can make the task of obtaining public support for speed reduction difficult, though there is some evidence that education can improve community support for lower speed limits. There is also evidence that community support increases following the implementation of lower speed limits when residents experience the benefits of lower vehicle speeds (Fildes et al 2005).

Achieving public and political support for taking evidence-based action to reduce speed limits is one of the many challenges associated with implementing effective speed reduction initiatives. The recent WHO report *"Speed management: a road safety manual"* provides useful guidelines for planning, implementing and evaluation speed management programs, including gaining community and decision-maker support.

In summary, this review found some evidence for the relationships between vehicle speed and active transport outlined in Figure 3. For the overall relationship between speed and active transport (Pathway 1), multiple study types and data sources provide good, though not definitive evidence that low vehicle speeds contribute to active transport participation. While evidence is limited by the lack of research, the small number of studies that have been conducted indicate that speed reduction may improve perceptions of safety and amenity for pedestrians and cyclists (Pathway 2). There is good evidence that lower vehicle speeds reduce risk of injury for cyclists and pedestrians (Pathway 3). There is limited evidence from a small number of studies that increased perceived and actual safety and community amenity make active transport modes more attractive options, and strong evidence of the reverse relationship (i.e. road traffic risks, including vehicle speed, constrain active travel behaviour) (Pathway 4).

Overall, the findings from this review indicate that lower traffic speed in urban areas (preferably based on a speed limit of 30 km/h) will improve pedestrian and cyclist safety and amenity, and is likely to contribute to increased rates of walking and cycling for transport. 'Safe speed' is often conceptualised in terms of vehicle speeds that minimise the risk of injury, but in the light of the multiple benefits of active transport, it may be more appropriate to think of 'safe speed' as that which delivers injury prevention as well as many additional health and social benefits.

When implemented overseas, speed reduction has achieved high levels of community support; improved safety for all road users; increased rates of active modes of transport; and resulted in negligible increases in car travel times. A growing number of safe speed initiatives in Victoria suggest that similar changes in Australia are not only desirable but also achievable.

Active, liveable cities and communities provide all people from children through to older adults with the right to move about in public spaces. Active living and community engagement is constrained when people retreat into their homes and cars through fear of traffic. Road safety improvements should not be dependent on people remaining indoors or in cars. The focus needs to be on removing traffic danger from people, not people from the hazardous environment we have inadvertently created. Reducing traffic speed is an effective way of righting this balance and encouraging people to engage in active transport modes with ease, resulting in significant improvements in the health and wellbeing of the population and the environment.

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Appendix A
Summary of the health benefits of active transport

1. Investing in better health

Better health is an important goal for individuals and a key priority for government. Investing in the health of Victorians is costly. The Victorian Health and Aged Care budget has almost doubled in the last eight years, increasing from $5.1b in 1999-00 to $9.7b in 2007-08. – the majority of which is spent on acute health services (Department of Human Services 2008). Despite rapidly increasing levels of health care spending, Commonwealth and State governments struggle to meet the health needs of all Australians in a timely and equitable manner.

Prevention of high-prevalence chronic diseases is emerging as a key component of health policy in Australia and Victoria (Department of Premier and Cabinet 2008). A major input into policies aimed at improving population health in Victoria is the Victorian Burden of Disease study (Department of Human Services 2005). This study measures the gap between current health status and an ideal situation in which everyone lives into old age free of disease and disability. It therefore identifies areas in which additional health gains can be made.

Cardiovascular disease is responsible for 29 per cent overall of the years of life lost (YLL) as a result of premature mortality, second only to cancer (34 per cent) (DHS 2005). The risk factors contributing most to the total disability adjusted life years (DALYs) are tobacco smoking, obesity, hypertension, high blood cholesterol and physical inactivity. Much of the death, disability and illness caused by cardiovascular disease is preventable through better diet, not smoking, and engaging in regular exercise (Australian Institute of Health and Welfare 2008). Given the interactions between physical activity and the other four leading risk factors for ill health (tobacco use, obesity, hypertension, and high blood cholesterol), increasing activity levels is one of the most important things we can do to improve our health and wellbeing (Morris 1994).

2. Improving health by promoting physical activity

In addition to its role in the prevention of cardiovascular disease, physical activity has multiple benefits including reduced risk of breast cancer and colon cancer, reduced type 2 diabetes risk, improved mental health, improved cognitive functioning, and reduced risk of osteoporosis and falls in the elderly (WHO 2002). Social health benefits include community engagement, social connectedness, and maintaining functional status and social engagement among older adults (Bauman 2004). Based on these wide-ranging benefits, the promotion of moderate intensity physical activity has been described as today's 'best buy in public health' (Morris 1994).

The recommended levels of physical activity to maintain good health are not onerous - an accumulation of 30 minutes of moderate-intensity physical activity on at least five days a week - but approximately half of Australian adults do not achieve these recommended levels of physical activity (AIHW 2008).

Public awareness of the importance of physical activity for good health is high, but participation is constrained by a number of barriers. Lack of time is consistently reported as a major constraint on achieving adequate levels of physical activity (Trost et al 2002). Incidental activity through active transport provides an opportunity for incorporating physical activity into the routine of everyday living (World Health Organisation 2006; National Public Health Partnership 2001). 'Lifestyle' interventions such as these have been shown to be more cost-effective than structured exercise programs (Sevick et al 2000).

> The main sources of health-enhancing physical activities encompass normal and simple activities such as walking, cycling…' (WHO, 2006, p.4)

3. Health benefits of active transport

Cycling, walking and using public transport for transport enable individuals to achieve recommended levels of physical activity in terms of intensity, duration and frequency. Commuter cycling provides similar improvements in physical performance (VO_2max) as specific training programs (Hendriksen et al 2000) and walking or cycling to work has a favourable effect on body fat markers and body mass gain (Wagner et al 2001). Rail transit riders in New Jersey, USA, are twice as likely to meet physical activity guidelines as the overall New Jersey population (Pucher 2004).

In Australia, the economic benefit of commuter cycling is estimated at $144.3 million per year (including $72.1 million in reduced health costs), based on current (relatively low) levels of bicycle commuting. Substantial increases in these benefits will flow from future growth in cycling participation (Bauman et al 2008).

The health benefits of active transport occur in the absence of, but also in addition to, occupational and leisure-time physical activity. Accordingly, daily walking or cycling to and from work has been associated with decreased risk of coronary heart disease, after controlling for occupational and leisure-time physical activity (Hu et al 2007). Cycling to work was found to reduce all-cause mortality by 40% in a random sample of Danish women (n = 13,375) and men (n = 17,265), after adjusting for leisure-time physical activity (Andersen et al 2000). For adults with diabetes, walking more than two hours a week was associated with 39% lower all-cause mortality and 34% lower CVD mortality (Gregg et al 2003). These health improvements also provide cost savings. In an economic analysis of moderate-intensity physical activity for adults with diabetes, a 3-mile daily walk resulted in cost savings (including health and social costs) of $1,000 per person per year (Di Loreto et al 2005).

Australia has one of the highest rates of obesity in the world, with 62% of Australian men and 45% of Australian women overweight or obese (ABS 2008). Evidence is emerging that car dependency is a contributing factor to increasing obesity rates. In a comparative analysis of walking, cycling, and obesity rates in Europe, North America and Australia, Bassett et al (2008) reported that countries with the highest levels of active transportation generally had the lowest obesity rates. In the US, the number of calories burned per capita per day by walking and cycling, is between one-fifth and one-third of that of a number of European countries (Pucher 2006).

'Time in the car' studies provide supportive evidence of the relationship between sedentary travel and obesity; with Wen et al (2006) reporting an association between driving to work and being overweight or obese.

Students who walk or cycle to school are more likely to meet recommended physical activity guidelines. In a large UK study of students' levels of physical activity and modes of travel to school, teenage girls (a relatively inactive population group) who walked or cycled to school were 6.1 times more likely to meet physical activity guidelines than girls who used sedentary travel modes (Smith et al 2008).

While there are also some health risks associated with cycling, a study in the United Kingdom found that, on balance, the benefits in terms of life expectancy of choosing to cycle were 20 times the injury risks (British Medical Association 1992). Similarly, Roberts et al (1996) concluded that, even under current road and traffic conditions in Australia, the health benefits of cycling outweigh the health costs. There is considerable room for further improvements in these benefit/risk ratios. Cross-country comparisons demonstrate that injury and fatality rates decline as cycling prevalence increases (Jacobsen 2003). The industrialised country with one of the highest bicycle mode share of trips (the Netherlands) has one of the lowest rates of road transport deaths in the world (5.0 road transport deaths per 100,000 population, compared with 7.9 for Australia). Not only did *rates* of cycling fatalities decrease markedly from the 1970s, when the Netherlands started to reverse the decline in active transport, but the marked increase in bicycle trips post-1970 was accompanied by a decrease in the *number* of fatalities (Pucher and Buehler 2008). Cycling in London has increased substantially following the introduction in 2003 of a traffic congestion tax, but the pedal cyclist accident rate per cycle kilometre remains substantially below pre-congestion charging levels (Transport for London 2007).

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Active transport and social inclusion

Active transport contributes to social inclusion because it provides an affordable and convenient form of personal mobility that is accessible to people who do not own or have access to a motor vehicle. Transport costs (principally motor vehicle related) account for a high proportion (16%) of household expenditure on goods and services in Australia – second only to expenditure on food and non-alcoholic beverages (17%), and similar to housing costs (16%) (ABS 2006).

One in 10 households in the Melbourne metropolitan area does not have a motor vehicle, rising to approximately 30 per cent in some disadvantaged western and northern suburbs of Melbourne (Department of Sustainability and Environment nd). Studies in the UK have identified that a high proportion of households without a car experience difficulties visiting family and friends, and accessing employment, shops and health services (Social Exclusion Unit 2003).

Active transport modes incorporate physical activity and comprise modes of transport that lend themselves to participation by a diverse range of population groups. In countries that have developed a culture of active transport and recreation, cycling and walking are inclusive, population-wide activities that include children, seniors, women, ethnically and culturally diverse groups, and disadvantaged population groups (Pucher and Dijkstra 2003; Social Exclusion Unit 2003).

In countries such as Germany, Denmark, the Netherlands and Japan, a high proportion of children cycle to school, women cycle as frequently as men, and, in some cases, the majority of trips taken by seniors (65+ years) are active trips (cycling and walking) (Pucher and Dijkstra 2003). These diverse population groups frequently achieve adequate levels of physical activity 'incidentally', at low cost, without having to find the time and money to participate in organised sports, exercise or fitness programs.

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The provision of supportive environments that encourage people of all ages and capacities to be active in their local communities is integral to increasing physical activity levels, social interaction and community engagement. Motor vehicle traffic, on the other hand, contributes to adverse impacts on health and wellbeing through loss of community amenity and social isolation (Carlos and Phillips 2000). The National Heart Foundation's *Healthy by Design* resource has been developed to assist in the design of more liveable communities that encourage people of all ages and capacities to be active in their neighbourhoods, cities and towns. It recognises that healthy urban planning is about planning for people, and puts the needs of people and communities at the heart of the urban planning process (National Heart Foundation 2004). *Healthy by Design* supports the Victorian Government's Neighbourhood Principles in *Melbourne 2030.*

In addition, social isolation, lack of social support and depression are important risk factors for cardiovascular disease. The increased risk contributed by these psychosocial factors is of similar order to the more conventional CHD risk factors such as smoking, dyslipidaemia and hypertension (Bunker et al 2003).

4. Health benefits of active transport – reduced risks associated with motor vehicle use

Motor vehicles are responsible for a wide range of adverse impacts on human health. A modal shift from car travel to active travel reduces these health risks (Litman 2007).

Worldwide, more than 3000 people per day die from road traffic crashes (WHO 2004). In aviation terms, this is equivalent to approximately seven fully laden jumbo jets crashing every day, killing all on board. Globally there are an estimated 50 million road traffic injuries each year with an economic cost of US$518 billion per year (WHO 2004). Without appropriate action, by 2020, road traffic injuries are predicted to be the third leading contributor to the global burden of disease and injury (WHO 2004).

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In Victoria in 2007, there were 332 road traffic crash fatalities, and 6177 serious injuries in 2005 (most recent available data) (TAC 2008). These casualties result in substantial health, social, and economic costs. Connelly and Supangan (2006) estimated the costs of road traffic crashes in Victoria to be $4.1 billion based on 2003 data. Human costs (including medical, long-term care, loss of earnings and quality of life) were $2.3 billion. The annual cost of road traffic crashes in 2003 in Australia was more than $17 billion per annum, comprising approximately 2.3% of Gross Domestic Product (GPD). Fear of traffic is a key factor constraining active transport in Victoria (Garrard et al 2006), and is one of the main reasons cited by parents for not permitting their children to walk or cycle to school (Timperio et al 2006).

Health risks of motorised transport also include air pollution, which is said to comprise “the invisible road toll”. Fine particles from diesel exhaust contribute to atherosclerosis, with Peters et al (2004) reporting a nearly 3-fold increased risk of heart attack within an hour of exposure to traffic. The Bureau of Transport and Regional Economics estimated that in the year 2000, motor vehicle-related ambient air pollution accounted for between 900 and 4500 morbidity cases—cardio-vascular and respiratory diseases and bronchitis—and between 900 and 2000 premature deaths in Australia. The economic cost of morbidity ranges from $0.4 billion to $1.2 billion, while the economic cost of mortality ranges from $1.1 billion to $2.6 billion (Bureau of Transport and Regional Economics 2005).

Motor vehicle related air pollution also affects children. Deficits in growth in lung function in children show a linear relationship with air pollution (Gauderman et al 2004). A study of proximity to engine exhaust emissions in Great Britain and the link with children dying from cancer/leukaemia found maximum effects at short (0.1–0.5 km) effective ranges, tapering to neutral after 3.0 km. Over 24% of child cancers are attributable to these exposures, with roads exerting the major effect (Knox 2006).

Noise pollution associated with motor vehicle traffic also impacts on the health of Victorians. There is emerging evidence of an association between hypertension, heart disease and high levels of noise. Findings from a preliminary study by the WHO suggest that long-term exposure to traffic noise may account for 3 per cent of deaths from ischaemic heart disease in Europe - typically heart attacks (Coghlan 2007). It is also particularly damaging to children’s developing nervous systems (cited in Whitelegg, 1997).

A social survey to assess the impact of environmental noise on the community was conducted by the Victorian EPA in late 2006. An environmental noise measurement survey was also completed in early 2007, measuring noise levels at 50 sites across the inner, middle and outer suburbs of Melbourne. Transport is the main (and loudest) source of noise pollution in Victoria. Environmental noise impacts on people's lives through annoyance, sleep disturbance, reduced work or school performance, stress and anxiety, reduced enjoyment of home life and other physical health effects. Seventy per cent of people hear traffic noise in their homes and over one million Victorians are annoyed by it. The social survey found that the percentage of people exposed to and annoyed by traffic noise has increased since 1986. The results of the noise measurement survey showed that there are a significant number of locations in metropolitan Melbourne that exceed WHO guidelines for community noise (EPA 2007).

Transport is the main source of noise pollution in Victoria.
Traffic noise is also the loudest noise source.
There are a significant number of locations in metropolitan Melbourne that exceed WHO guidelines for community noise (EPA 2007).

Climate change is arguably one of the biggest challenges facing the world today, with transport emissions comprising a substantial and rapidly increasing component of greenhouse gas emissions. Current (and predicted future) health impacts of climate change include:

- increased heatwave-related deaths;
- increase in malnutrition and consequent disorders, including those relating to child growth and development; and
- increased cardio-respiratory morbidity and mortality associated with ground-level ozone.

(Confalonieri et al 2007)

Transport emissions accounted for 20 per cent of all greenhouse gas emissions in the City of Melbourne in 2005–06 and are predicted to grow by 61 per cent by 2020. Passenger transport (road and rail) accounts for 12 per cent of total emissions (City of Melbourne 2008).

The Fourth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) report *Climate Change 2007*, included the following recommended key mitigation factors for the transport sector:

- modal shifts from road transport to rail and public transport systems;
- non-motorised transport (cycling, walking); and
- land-use and transport planning.

Appendix B
Russell (2008) *"The Age"*, 7th Sept 2008

Sharp rise in deaths of elderly pedestrians

MARK RUSSELL 7/9/08

AN ALARMING rise in the number of elderly pedestrians killed on Victorian roads has prompted warnings from authorities about the dangers of not using designated crossings.

Police believe drivers were at fault in only four of the incidents in which 39 pedestrians were killed this year – a jump of 44% on the number of deaths at this time last year. Almost half of those killed were aged over 70, sparking concerns that many were elderly people trying to stay healthy by walking but who failed to heed the road rules.

Between July 27 and August 22, seven pedestrians aged between 78 and 92 were run over and killed.

"It's not the way our older citizens should be ending their lives," the state's top traffic cop, Assistant Commissioner Ken Lay, told *The Sunday Age*.

"And most of those accidents were in daylight. I guess with older people they sometimes lack spatial awareness; they don't realise cars are as close as they are and they might not be as nimble on their feet, with arthritis or other ailments that slow them down.

"It's a trend that certainly has been growing over the past five to six years . . . As society gets older, there are more and more older people out there doing their exercise and walking to stay healthy, and that probably is one of the reasons for this increase in pedestrian fatalities."

Mr Lay said elderly pedestrians and children under 14 were at greater risk of dying after being struck by a car and had to be more vigilant when out walking. "You traditionally think young people are the ones who are impatient to cross streets, but quite often it's the older people who simply aren't taking the time to walk to a crossing and crossing when it's safe," he said.

Mr Lay said police, the State Government and VicRoads were trying to educate older people on the dangers of crossing roads by holding a series of pedestrian safety programs.

TAC's senior manager road safety, David Healy, urged motorists to slow down in areas of busy pedestrian activity. "Pedestrians are very vulnerable to changes in speed," he said. "We know that if a car travelling at 30 km/h hit a pedestrian, there would be a 20% likelihood of death. This compares to an 80% chance of death if a car hit a pedestrian at 40 km/h."

Pedestrian Council of Australia chairman Harold Scruby said he could not understand why cars in Australia were still allowed to be fitted with bull bars when they had been banned in Europe.

"Everything is focused on motor vehicle safety, and pedestrians are being forgotten," he said.

Mr Scruby said deteriorating eyesight might be a factor in some pedestrian accidents. "As we have an ageing population, this situation can only get worse," he said.

Appendix C
Summary of '*Speed management: a road safety manual*' (WHO 2008)

The technical content of this manual is divided into five modules, briefly described below.

Module 1 addresses the general and specific links between speed and road risk, and the need for interventions that manage speed to reduce the number and severity of traffic crashes. It introduces the *Safe-system* approach to improve road safety and discusses its reliance on achievement of safe travel speeds across road networks.

Module 2 guides the user through the process of assessing a country's current situation with respect to speed limits and speeding. It outlines the data needed for a good diagnosis, and how these data can be used to set realistic targets and priorities for a program.

Module 3 describes the tools available for use in a successful speed management program. It begins by explaining how to classify roads by function before determining how to set speed limits. It covers the range of engineering, enforcement and education tools and practices for speed management, providing advice on the benefits that can be expected from each. The module includes sections on what legislation is desirable, how to improve compliance and establishing appropriate marketing and publicity strategies. Educational interventions are also discussed, as well as the role of employers in speed management.

Module 4 discusses how to develop and run a speed management program. This includes setting up management and consultation arrangements, securing community and political support early on, and choosing from the range of tools described in Module 3. It shows how to decide on the most effective tools for achieving objectives, given the assessment of the problem as advised in Module 2.

Module 5 provides a simple framework for evaluating road safety and speed management programs. The module shows how to use research to guide the development of the speed management program, monitor progress and evaluate outputs, impacts and outcomes. It discusses the process of identifying the aims of the evaluation, considers different types of evaluation, how to select the most appropriate method of evaluation, and choosing the performance indicators. The module also discusses the need to disseminate evaluation results to inform other stakeholders.

Case studies, in the form of boxed text, are included throughout the manual. These examples have been chosen to illustrate processes and outcomes, with experiences from a wide range of countries. Less detailed 'notes' are also included as boxed text to illustrate briefer points of interest. At the end of each module is a summary and references section.

Although aimed specifically at low and middle-income countries, this manual has something to offer all countries working to improve their safety record. It aims to help all road safety practitioners, whether working for government or nongovernmental organizations. The list of users will vary according to the country, but will certainly include:

- policy-makers and decision-makers in parliaments, ministries, local authorities and road authorities
- members of the judiciary
- politicians
- police officers
- highway engineers
- road safety and public health professionals
- transport managers
- manufacturers of vehicles, motorcycles and bicycles
- employers in the public and private sectors
- insurance industry personnel
- school and college teachers
- researchers on road safety
- driving and road safety instructors.

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Images: Courtesy City of Port Phillip