Cost and health benefit of active transport in Queensland

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Executive Summary

Our transport system has become heavily dependent on motorised transport in the post-World War II period. This has led to a number of largely unforeseen consequences in terms of congestion, greenhouse gas emissions, air and noise pollution, and sedentary 'lifestyle diseases' such as obesity.

Creating the conditions in which healthy lifestyles become embedded in our social and physical infrastructure is widely acknowledged as a key method of addressing the sedentary lifestyles that are currently at the core of the rising prevalence in lifestyle diseases such as diabetes.

There is considerable potential to boost population levels of physical activity through the encouragement of active transport (walking and cycling). In order for this potential to be realised, improved understanding of the costs and benefits associated with greater levels of walking and cycling need to be developed.

This report provides a comprehensive analysis of the latest literature evaluating the economic impacts of active transport programs and projects. It provides a critical analysis of the models and tools used to assess the costs and benefits of active transport interventions. It offers recommendations to create robust methods of integrating the latest information in order to better assess active transport proposals from a cost-benefit perspective.

Poor diet and exercise habits could see this generation of children be the first in history to die younger than their parents

Queensland Government, 2008, p.5

Creating a supportive environment can encourage walking

Transport, Health and Public Policy

This section outlines where active transport sits in public policy decision-making and articulates the key reasons it sometimes fall off the policy agenda. The variety of co-benefits of active transport are spread across the health, environment and transport portfolios (see Figure 2) and this has meant walking and cycling have found it difficult to 'find a home', with detrimental impacts in terms of government investment. The benefits of active transport are spread across a range of sectors and there is considerable synergy between the outcomes originating from investment in walking and cycling (see Table 3).

The co-benefits of active transport have begun to receive recognition in government strategies, with walking and cycling explicitly and implicitly recognised as helping to support national and/or state targets in a range of public policy sectors. The following strategies have been summarised for their relevance to active transport in this report (see Section 2.5):

- National Cycling Strategy 2011–2016
- Queensland Cycle Strategy
- Toward Q2
- South East Queensland Regional Plan 2009–2031
- Blueprint for an Active Australia
- Active, Healthy Communities
- An Australian Vision for Active Transport
- Healthy Spaces and Places
- Queensland Chief Health Officer's Report: The Health of Queenslanders 2010

Each of the above strategies highlight the important role walking and cycling can play in meeting the future needs of Queenslanders, whether it be in improved health outcomes, greater transport efficiency, reduced greenhouse gas emissions or community liveability benefits. The level of prominence active transport occupies in the strategies listed above signifies a step change for walking and cycling in both national and state contexts, including Queensland. One of the central themes in the documents identified above is that many of the major gains in population health can be made through reforms outside the health sector.

Evaluation in Public Sector Decision-Making

This component of the report provides an overview and critical analysis of the methods employed to evaluate public policy. It finds that evaluation is usually restricted to individual projects or programs, rather than society- or economy-wide analysis. This section describes the difficulties associated with public sector evaluation, such as the way in which different policies interact with each other, making the effects of individual programs difficult to isolate.

Evaluation of active transport policies and programs can be constrained by:

- the perceived need to continue existing programs
- political commitments that may conflict with a proposed new initiative.

In relation to active transport, the public policy focus has been on transport and environmental consequences—with less attention given to health and social outcomes. Even when health is a focus, short-term imperatives such as hospital waiting lists can be prioritised over longer term, population health outcomes related to prevention.

Transport evaluations have typically failed to take into account the ageing of the population and the changes in driving patterns likely to follow this demographic shift. Currently some 14% of the Australian population are over 65 years (increasing to 25% in 2050) and, as these older age groups cease driving, the demands on our transport system will alter significantly. Transport planning will need to become more responsive to this demographic step change.

Active transport has in some cases been the victim of reductionist public policy. When problems are assigned to individual agencies, with narrowly defined responsibilities, walking and cycling (with their wider range of co-benefits) can often be disadvantaged. For example, transport agencies can rationally expand roads to reduce congestion, even if this degrades walking and cycling conditions (and therefore reduces population levels of physical activity). Similarly, environmental agencies can implement fuel efficiency standards that, by reducing the per-kilometre cost of driving, stimulate more car travel and therefore more congestion and accidents. These agencies run the risk of undervaluing walking and cycling improvements.

By developing a comprehensive method of evaluating public policy decisions, 'win-win' strategies can be identified that provide a solution to one problem that also helps reduce other challenges facing society, such as congestion reduction strategies that also help reduce parking costs, improve mobility options for non-drivers and increase physical activity and health.

	STRATEGY		
Planning Objective	Roadway Expansion	Fuel Efficient Vehicles	Improved Transport Options, Efficient Pricing, Smart Growth
Motor Vehicle Travel Impacts	*Increased*	*Increased*	*Reduced*
Congestion reduction	✓ *	✗	✓
Road and parking cost savings	✗	✗	✓
Consumer cost savings	✓/✗	✓/✗	✓
Reduced traffic accidents	✗	✗	✓
Improved mobility options	✗	✗	✓
Energy conservation	✗	✓	✓
Pollution reduction	✗	✓	✓
Smart growth land use objectives	✗	✗	✓
Physical fitness & health	✗	✗	✓

Comparing Strategies
NB: Some transport improvement strategies only achieve one or two objectives (✓), and by increasing total vehicle travel contradict others (***x***). Strategies that improve alternative modes; apply more efficient road, parking, insurance and fuel pricing; and create more compact, mixed land use help achieve many objectives.
*Whilst roadway expansion reduces congestion initially, similar levels of congestion return due to induced traffic (Newman & Kenworthy, 1999).

The introduction of sustainability into evaluation procedures has helped capture the environmental impacts of initiatives designed to boost levels of walking and cycling. This has largely failed, however, to reflect the social impacts of transport and land use projects.

Discount rates are typically used to discount future benefits when undertaking benefit-cost analysis and this is often at odds with sustainability (which is essentially about valuing the future). Active transport enhances the triple bottom line by delivering measurable outcomes of three kinds:

1. enhancing and sustaining economic prosperity
2. sustaining and protecting the natural and built environment
3. enhancing social outcomes, including access opportunities for people who are currently mobility-poor.

Health benefits from active transport can be accounted for under both the economic and social categories. Every part of this triple bottom line will also be enhanced by the positive health effects that arise from active transport and the regular physical activity it entails.

Transport has significant financial costs to households. On average, some 16% of household expenditure is transport related—comparable to housing or food. It is widely expected that motorised transport costs will continue to rise and this is likely to result in less money available to other sectors of the economy. Active transport offers the opportunity to lower household expenditure on transport, thereby enhancing more employment intensive sectors of the Queensland economy.

The two key requirements for evaluating active transport initiatives are to be able to:

1. Quantify the change in travel activity (increased walking and cycling, reduced driving) that is likely to come about as a result of the initiative. This level of evaluation is dealt with in Section 6.
2. Translate the behaviour change into estimates of those things that are of value to the community, such as improved health, lower transport costs and better environmental outcomes. This level of evaluation is dealt with in Section 6 and 7.

Evaluation Tools and Methodologies

Evaluation tools for active transport are of two main types:

1. generic tools that assist in making indicative estimates of the benefits of active transport without reference to specific programs, projects or spatial contexts
2. specific methodological tools that provide a robust assessment framework comparable to those used for other public sector initiatives. These enable comparison between projects and programs in the public sector.

The following matrix provides a summary, including critical analysis of the best studies and tools used to quantify and monetise the benefits of active transport:

> Benefit-cost analysis, supplemented by some form of goals achievement matrix, is the most appropriate way of evaluating active transport initiatives.

STUDY OR TOOL	DESCRIPTION	ANALYSIS SCOPE	ANALYSIS METHODOLOGY	STRENGTHS	WEAKNESSES
ICLEI Active Transport Quantification Tool (ICLEI, 2007)	Estimates the health, community and environmental benefits of walking or cycling.	Includes user cost savings, reduced mortality and reduced pollution.	User-specified changes in active transport for each of five types: • walking school bus • walk to school • ride to school • walk to work • ride to work	• Available at no cost as an online tool. • Straightforward to use.	• Incomplete for evaluation purposes. • Only considers some benefit categories. Health effects limited to: ◦ mortality, not morbidity ◦ type 2 diabetes and coronary heart disease. • Mixes financial and economic values–limited suitability for benefit-cost analysis.
World Health Organisation: Health Economic Assessment Tool (Cavill et al, 2007)	Evaluates health benefits of cycling	Health benefits	Quantifies monetised value of health benefits from a specific increase in cycling by a specific population.	• Available at no cost as an online tool. • Straightforward to use. • Based on best current information on cycling health impacts.	• Incomplete for evaluation purposes. • Only considers cycling, not walking. • Health effects limited to mortality (does not include morbidity). • Based on European conditions.
Victorian and Australian Greenhouse Office Workplace Travel Planning Benefits Calculator (Ker & Sidebottom, 2004; Sidebottom, 2005)	Provides indicative estimates of the benefits of workplace travel planning (WTP). Designed as a demonstration tool to interest businesses in WTP.	Identifies benefits to employees, employers and the community, including health benefits.	Research-based estimates of travel outcomes of workplace travel planning in user-defined situations coupled with benefit values derived from Australian and international research.	• Straightforward to use. • Allows user to specify situation for analysis.	• Incomplete for evaluation purposes. • Health effects limited to mortality (does not include morbidity). • Walking based on cycling research. • Values and algorithms are locked and cannot be modified or updated by the user.
Evaluating Non-Motorised Transport Benefits and Costs (Litman, 2010)	Identifies various categories of non-motorised transport benefits and costs.	Broad range of benefits and costs.	Comprehensive framework for evaluating non-motorised transport benefits and costs, including safety and health impacts.	• Comprehensive. • Defines various impacts and describes methods for quantifying and monetising them.	Provides limited detail on each impact. Methodologies and estimates are mainly based on other sources.
UK Transport Analysis Guidance (Departemnet for Transport, 2010a)	Provides official guidance for evaluation of walking and cycling schemes.	Broad range of benefits and costs, including externalities and health effects.	Applies conventional benefit-cost analysis framework to the outcomes of walking and cycling initiatives. Incorporates additional factors, including health benefits, absenteeism, environmental benefits and journey ambience.	• Methodology and values integrated with the overall guidance on appraisal of transport initiatives (DfT, 2010b) and consistent with Treasury requirements for project appraisal (DfT, 2010c).	Health effects limited to mortality (does not include morbidity). Does not deal with behaviour change initiatives as such, although the guidance is likely to be transferrable.

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STUDY OR TOOL	DESCRIPTION	ANALYSIS SCOPE	ANALYSIS METHODOLOGY	STRENGTHS	WEAKNESSES
New Zealand Economic Evaluation Manual (Land Transport New Zealand, 2006)	Provides official guidance for evaluation of travel demand management and of walking and cycling schemes.	Broad range of benefits and costs, including externalities and health effects.	Applies conventional benefit-cost analysis framework to the outcomes of travel demand management, walking and cycling initiatives.	• Methodology and values integrated with the overall guidance on appraisal of transport initiatives (LTNZ, 2006). • Provides separate values for walking and cycling.	• Health effects limited to mortality (does not include morbidity). • Does not deal with behaviour change initiatives as such, although the guidance is likely to be transferrable. • Research basis for different walking and cycling values not demonstrated.
Applying Health Impact Assessment To Land Transport Planning (New Zealand Transport Agency, 2009)	Provides guidance for health impact assessment (HIA) in transport planning	Transport planning. Only considers health impacts (no other benefits of non-motorised transport	Describes and reviews the scope and methods used for Health Impact Assesment.	• Discusses best current practices for evaluating health impacts. Recommends comprehensive evaluation of health impacts. Recommends incorporating health impacts into comprehensive benefit/ cost analysis	• Only provides general guidance. Does not include specific monetised values.
The Hidden Health Costs of Transportation (American Public Health Association, 2010)	Estimates the costs of automobile-dependent transport	Includes monetised estimates of obesity, air pollution and accidents	Uses unit costs for obesity, air pollution and crash costs from previously published literature (Fincklestein et al, 2009; Federal Highway Administration, 2000; AAA, 2008).	• Quantifies and monetises three major risks.	• Only provides total costs. Offers little detail or guidance for applying cost values to a particular situation.
Walking, Urban Design, and Health: Toward a Cost-Benefit Analysis Framework (Boarnet, Greenwald and McMillan, 2008)	Provides monetised estimate of physical activity benefits	Develops a framework for valuing the health benefits of urban design improvements that increase walking activity.	Estimates benefits of improving neighbourhood walkability from the 50th percentile to the 75th percentile (lower value) and the 95th percentile (higher value), for a hypothetical 5000-resident neighbourhood.	• Provides quantified values of increased walking.	• Incorporates many assumptions that may not be transferable to other situations. • Only considers certain health benefits.
Cost-Effectiveness of Interventions to Promote Physical Activity (Cobiac, Vos and Barendregt, 2009)	Models the cost impacts and health outcomes of six physical activity interventions in Australia.	Health benefits of specific programs.	Assigns dollar values to various programs that increase disability-adjusted life years (DALYs).	• Provides specific dollar values to specific programs	• Focuses on programs, not transport policy changes. • Uses standard values.
Household TravelSmart evaluations (Ker and James, 2000; Ker, 2004, 2008a; Ker and Ringvall, 2006)	Evaluates benefits and costs of IndiMark™ in Western Australia and Queensland	Broad range of benefits and costs, including externalities and health effects.	Applies conventional benefit-cost analysis framework to the outcomes of travel behaviour change initiatives. Values for benefits derived from international research, except: • congestion (based on BTRE, 2007) • climate change.	• Methodology consistent with national (ATC, 2006) and Queensland (DIP, 2010) transport appraisal guidelines. • Benefit values can be updated and range of values extended on the basis of external evidence. • Allows alternative benefit values to be applied–e.g. where values differ between times and places (such as congestion). • Facilitates sensitivity analysis through application of ranges for any item of cost or benefit. • Methodology and values are transferable to other contexts–e.g. cycling infrastructure (Ker, 2009b) and school active travel (Ker, 2006).	• Benefit values may not be transferrable between situations and places. • Health effects limited to mortality (does not include morbidity).

Summary of the major studies to quantify and monetise the benefits of active transport

The World Health Organisation's health economic assessment tool (HEAT) has been incorporated in the UK Department for Transport appraisal standards and Land Transport New Zealand's economic evaluation tool is widely used to assess the benefit-cost ratio for active transport projects and is generally well accepted by practitioners working in the sector.

Benefit-cost analysis (BCA) is described, in relation to the evaluation of active transport, as a means of comparing the costs and impacts of proposed projects. A limitation of BCA is that it is restricted to measuring those impacts that can reasonably be given a monetary value. In general terms:

- Economic impacts are usually observable as a monetary value and therefore relatively straightforward to include in BCA.
- Environmental impacts often have estimated monetary values, but these have limitations as the observed trade-offs are usually based on imperfect information, especially with regard to long-term issues.
- Social impacts rarely have estimated monetary values.

Social issues, including health, are relatively recent additions to the transport evaluation paradigm and there is subsequently a much smaller body of evidence on which to base benefit-cost evaluations. See Section 4.31 regarding benefits not included in BCA.

The literature review found that almost all attempts at developing BCA tools for active transport are based on mortality and fail to account for morbidity and well-being impacts.

The streets connecting communities to schools are critical in determining the level of education-based active transport

Health Impacts of Active Transport: Summary of Evidence

Active transport has significant population health benefits in both the child and adult population. Chief among them are the numerous health impacts associated with increased physical activity. When increases in active transport are also associated with reduced motor vehicle travel, additional benefits accrue from improved air quality, reduced noise pollution, greenhouse gas abatement and enhanced community liveability (see Table 6).

Good evidence has been found to demonstrate:

- Cycling to school increases aerobic fitness.
- Active transport to school does not replace other forms of physical activity.
- Aerobic fitness increases intelligence quotient, cognitive function and educational attainment.

A considerable proportion of the Queensland population do not participate in sufficient levels of physical activity to protect against sedentary lifestyle disease. Active transport levels in Australia are low compared to the best performing OECD countries. Although some trips are beyond a reasonable walking or cycling distance, a majority of Queensland car trips are less than 5 km, indicating considerable scope for greater levels of physical activity through active transport (see Figures 7–9).

In Queensland, insufficient physical activity is the third largest single determinant on the Burden of Disease scale and 62.7% of males and 50.6% of females are overweight or obese. This is expected to double by 2025. A survey of young people in Queensland in 2006 found that 27% of boys and 42% of girls in Year 1 achieved an adequate number of steps per day. In Year 5, this increases to 40% of boys and 53% of girls.

Public transport is also a significant generator of walking trips. For South East Queensland, whole single-mode walking trips are longer than the walking trip stages made to and from public transport, both in terms of distance and time. However there are more than twice as many walking trip stages to and from public transport as there are single-mode walking trips. This indicates that active transport polices, when integrated closely with the public transport system, are likely to significantly increase population levels of walking for transport.

Active transport has also been found to reach population groups less likely to participate in leisure-time physical activity. While socioeconomically disadvantaged population groups are about twice as likely as less disadvantaged groups to participate in leisure-time physical activity or sports, the reverse relationship is often observed in active transport. Increasing the population prevalence of active transport in Queensland may therefore contribute to reducing health inequalities.

It is now widely acknowledged that the implementation of structured exercise programs and sports participation is unlikely to provide substantial improvements in the high and inequitably distributed health burden associated with low levels of physical activity in Queensland. The emphasis is now on fostering 'active living' by building regular activity into daily life.

> **The health benefits of cycling outweigh the health risks associated with potential injury.**

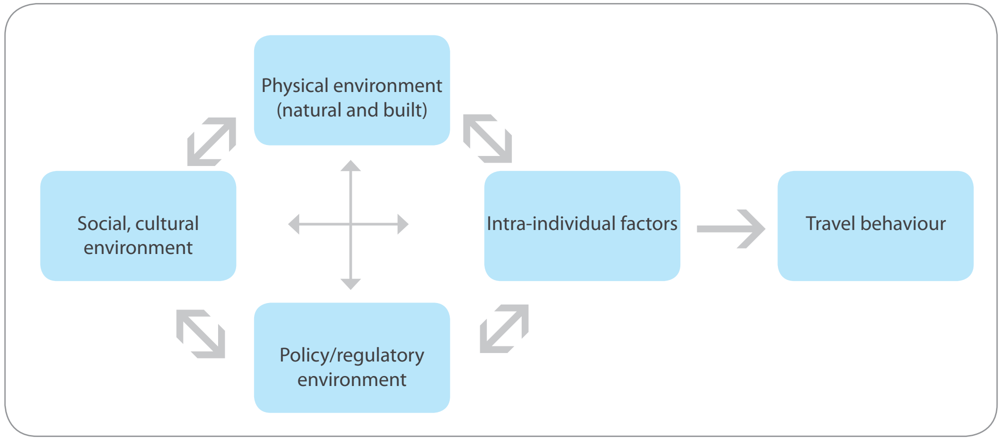
Safety is a key issue related to active transport and whilst absolute levels of risk are low internationally, relative risk, based on traffic exposure, is generally higher for walking and cycling than for car travel. Even in the current traffic environments in the United States and New Zealand, one fatality occurs for approximately 10 million kilometres walked or cycled. In countries with high levels of active transport this figure decreases to one fatality for approximately 100 million kilometres travelled. The considerable variation shown here suggests that much can be done to increase current levels of safety for pedestrians and cyclists. Research also shows the perception of fear is often disproportionate to actual levels of risk and this culminates in a 'fear of cycling' mentality in countries with low levels of cycling (see Figure 18). A number of studies have found the health benefits of cycling outweigh the health risks associated with potential injury.

New research has also discovered particular health benefits associated with exercising while in contact with the outdoor environment. So-called 'green exercise' has been found to improve self-esteem and mood. Whilst these studies have not looked at active transport specifically, walking and cycling for transport almost always occur outdoors and these benefits are therefore likely to hold true for active transport.

Australian studies on the impacts of motor vehicle use have revealed an association between driving to work and obesity, with drivers 13% more likely to be overweight or obese, even after controlling for leisure-time physical activity and other confounders. Similar associations between time spent driving and obesity have been found internationally, including China and the United States.

The Extent of Change in Active Transport: Intervention Types and Evaluation Approaches

A range of interventions aimed at increasing levels of active transport have been evaluated for their effectiveness. The different forms of interventions have been categorised into four domains, as outlined below:



Determinants of travel modes

Individually focused behaviour change programs and active transport infrastructure have been investigated most thoroughly in the literature—with some research addressing both. Few studies have evaluated policy/regulatory interventions and it appears no interventions have been evaluated focusing primarily on social/cultural factors.

Determining what influences active transport is a complex task that requires the analyst to consider a multitude of factors, often whilst faced with a lack of data. At the personal level, the decision to use active transport involves weighing up (often implicitly) the perceived benefits and barriers of both the target behaviour (active transport) and the competing behaviour (driving).

Interventions have been categorised, where appropriate, into the commonly used settings of schools, workplaces and communities. A number of reviews of school-based interventions have been summarised in Table 11. Recent studies critically evaluated include:

- Ride2School program (Victoria)
- Active School Travel Program (Brisbane)
- Auckland School Travel Plans

> Healthy citizens are the greatest asset any country can have.
>
> *Winston Churchill*

To summarise, considerable variation occurs both between these programs and even between individual schools running the same program. Much of this evaluation literature is relatively recent, and there has been little systematic assessment of the reasons for variable program impacts. However, based on limited process/implementation evaluation data to date, the determinants of success are likely to include factors associated with schools, their social, cultural and built environments; program type; and quality of programs implemented. Evaluation designs and methods also impact on evaluation findings.

Community-based interventions have been summarised and are included in Table 12, with workplace interventions contained in Table 13. Interventions to increase active transport in countries such as Australia are relatively recent, and evaluation findings point to considerable variability in program impacts both between programs and within individual settings in multi-site programs. Consequently, it is unlikely that a 'one size fits all' approach will result in substantial and sustained increase in active transport and there is much to learn about what works for whom in which settings. Programmatic interventions also need to be nested within an overall strategy that includes an integrated package of programs and supportive policies. Evidence in areas such as tobacco control, road safety and childhood immunisation indicates that return on investment in comprehensive public health strategies can be substantial for both government and society.

Valuing the Impacts of Change in Active Transport

The benefits associated with active transport have been categorised in the table below and described in further in Section 7.

IMPACT CATEGORY	DESCRIPTION
Direct User Benefits	***Benefits from improved walking and cycling conditions***
Benefits to users	Increased convenience, comfort and safety to walkers and bicyclists.
Option value and emergency response	Increased mobility options, in case they are ever needed, including the ability to evacuate and deliver resources during emergencies.
Improved accessibility	Increased level and types of access to valuable services and activities such as education, employment, healthcare and shopping.
Equity	Improved accessibility for economically, socially or physically disadvantaged people.
More Active Transport	***Benefits from increased walking and cycling activity***
Fitness and health benefits	Improved physical fitness and health as a result of increased walking and cycling activity.
Reduced Vehicle Travel	***Benefits from reduced motor vehicle ownership and use***
Congestion reduction	Reduced traffic congestion from automobile travel on congested roadways.
Reduced barrier effect	Improved non-motorised travel conditions due to reduced traffic speeds and volumes.
Vehicle cost savings	Reduced consumer costs from vehicle ownership and use.
Avoided chauffeuring	Reduced chauffeuring responsibilities due to improved travel options.
Roadway cost savings	Reduced roadway construction, maintenance and operating costs.
Parking cost savings	Reduced parking problems and facility cost savings.
Energy conservation	Increased economic and environmental benefits from reduced energy consumption.
Pollution reductions	Increased economic and environmental benefits from reduced air, noise and water pollution.
Land Use Impacts	***Benefits from more walkable land use development***
Transportation land	Reduced land area required for roads and parking facilities.
Efficient land use development	More efficient land use, such as more compact, mixed, multi-modal development, which increases overall accessibility and reduces sprawl.
Property value increases	Increased local property values due to improved walking and cycling conditions (capitalised value of perceived future user benefits).
Economic Development	***Benefits from increased productivity and employment***
Support for specific industries	Increased support for specific industries, particularly retail and tourism, as a result of improved walking and cycling conditions (e.g. streetscaping, walking and cycling paths etc.).
Increased productivity	Increased productivity and reduced costs to governments and businesses as a result of transport-related savings (i.e. reduced congestion, parking, consumer, healthcare and energy costs).

A summary of potential walking and cycling benefits

The benefits identified in the table vary significantly depending on the particular context in which they occur. For instance, an isolated stretch of bicycle path will provide only modest benefit, but the same stretch integrated into a comprehensive network of active transport infrastructure will give a considerably greater return.

The monetised benefits to health from active transport have been quantified in a number of studies and these have been summarised in Table 17. The value per additional cyclist ranges from £22 to £498 and depends on a number of factors, including the age of the cyclist.

Costs of Active Transport

The benefits of increased active transport described in this report have costs associated with them. These costs come in the form of facility construction costs and additional travel time, although active transport was found to be surprisingly time-competitive with motorised transport over distances less than 5 km in congested, urban areas.

MEASURE	TYPICAL COSTS
On road bike lanes*	$200,000 per kilometre (both sides of street)
Bicycle parking	$300 per bicycle rack (parks two bikes)
Zebra crossing*	$5000 ($10 000 when requiring electrical connection)
Three metre wide shared path*	$600 000 per kilometre
Speed table (bicycle friendly)*	$10 000 per unit

Typical facility costs
****Actual figures will vary considerably depending on local conditions and construction costs***

The cost of bicycle infrastructure is outweighed by its benefits, in terms of health, the environment and congestion reduction

The Economic Basis of Benefit-Cost Analysis

Transport policy and planning decisions have many impacts, including some that affect non-market goods—that is, goods not generally bought and sold in a competitive market, such as personal time, safety, health, and environmental quality. For example, a transport agency may face a decision that requires a trade-off between improved safety and environmental protection and so must make judgments about the value that people would place on these goods. One approach to this type of analysis is to monetise (measure in monetary values) such impacts.

Transport economists have extensive experience monetising non-market goods, including incremental changes in travel time, accident risk and environmental values. Some of the techniques they use are described in Section 9 and include:

- damage costs
- hedonic methods (also called 'revealed preference')
- contingent valuation (also called 'stated preference')
- control or prevention costs
- compensation rates
- travel cost method.

The methodology used to determine the economic value of a particular transport policy or planning decision is illustrated in the table on the following page. This table summarises the various steps to be considered and the information needed to analyse each step in order to evaluate policies and planning decisions that affect active transport activity.

STEPS FROM DECISIONS TO ECONOMIC VALUATION	INFORMATION REQUIREMENTS
Public Policy And Planning Decisions (infrastructure funding and pricing, facility design, facility management, land use development, encouragement programs, etc.) ↓	Types of policy and planning decisions (including innovative and indirect strategies such as pricing reforms and changes in land use development patterns), their design, duration, integration (with other transport and land use policies), level of community support, and responsiveness to user demands.
Change in Travel Conditions (better footpaths, shared paths and bike lanes, higher fees for driving, slower motor vehicle traffic, closer destination, etc.) ↓	Multi-modal evaluation which measures the relative quality of travel by different modes under particular conditions. For example, walking and cycling level-of-service rating which indicate the quality of walking and cycling conditions and how they would be improved by a particular policy or project.
Changes In Travel Activity (less driving, more walking and cycling, more ridesharing, more public transport use, more reliance on local services which reduces average trip distances, etc.) ↓	Multi-modal transport modelling that can accurately predict how specific changes in walking and cycling conditions (including the quality of non-motorised facilities, roadway design, traffic volumes and speeds, transport pricing, and land use patterns) will affect the use of active modes. This should be disaggregated by demographic factors (who would change their travel activity) and trip type (what types of travel would change, such as commuting, errands, recreation, etc.).
Land Use Changes (less land devoted to roads and parking facilities, more compact, mixed, connected development) ↓	Integrated transport and land use modelling that indicates how changes in travel conditions and activity affect development patterns. This should include analysis of demand for more walkable and bikeable locations.
Transport Impacts (changes in traffic congestion, consumer time and money costs, road and parking facility costs, accident rates, emissions, physical activity and health, mobility for non-drivers, etc.) ↓	Quantify various impacts of travel activity changes, including congestion delays, facility costs, user time and financial costs, accidents, emissions, physical activity and health, accessibility and affordability for disadvantaged people, etc. Since public health is particularly important for this project, special attention should be given to health-related impacts. This should be disaggregated by demographic factors (identify who benefits).
Economic Valuation (financial costs to consumers, businesses and governments, monetised value of changes in health and travel time, sum of all monetised values) ↓	Apply various accounting and monetisation techniques to calculate the dollar value of various benefits and costs. Since public health is particularly important for this project this will include monetisation of traffic accidents, vehicle pollution, physical fitness and related health benefits, and (if appropriate) mental health impacts.
Optimisation (determine what policies and planning options are most cost effective)	Create a model that allows various policies and planning options to be tested to determine which provide the greatest net benefits, considering all impacts.

Evaluation Framework

Active Transport Evaluations

The monitoring and evaluation of active transport programs have a mixed record, with household/community social marketing programs like TravelSmart having had the greatest exposure to formal evaluation. This section evaluates a number of individual behaviour change programs taking place at the school, household and workplace setting. In addition, meta-evaluations have been analysed and generally show a consistent pattern of results that demonstrate the positive changes in active travel stemming from behaviour change programs. In general, the programs that have the strongest benefit-cost ratio are those that include a multifaceted approach to active transport promotion.

Adequacy of Active Transport Evaluations

Active transport and travel-behaviour change evaluations, including generic tools developed to support formal and informal evaluation, have supported the validity of benefit-cost analysis as an appropriate evaluation methodology. The returns on investment flowing from active transport initiatives typically outperform conventional motorised transport projects. Socioeconomic benefit-cost analysis, if calibrated to appropriately capture the range of benefits afforded to active transport, is likely to be an effective tool to use in the evaluation of large-scale active transport proposals. The health impacts of active transport are a problematic area of evaluation for three principal reasons:

1. Estimation and quantification of the effects of active transport initiatives on walking and cycling participation can prove difficult.
2. Identification and quantification of the health effects resulting from the changes in active travel are not straightforward.
3. Valuation of the health effects resulting from the changes in active travel, beyond the relatively simplistic valuation of mortality effects is a highly specialised field.

Recommendations for Further Research

In reviewing the current state of knowledge and practice of active transport, with particular reference to the health benefits, it has become clear that there are substantial deficiencies that could be overcome (or at least ameliorated) through further research.

In the area of active transport and health:

1. Better information is needed on the effects of active transport on health of different age groups, especially for children, and the extent to which physical activity (including active transport) in childhood carries over into later life, both in terms of physical activity levels and residual health benefits.
2. Greater understanding is needed of the time period for benefits to become apparent and to achieve their maximum potential. This is likely to vary (a) between the various diseases that are exacerbated by inadequate physical activity and (b) the age group targeted by the active transport intervention.
3. Improved information is needed on the short- and long-term health effects of walking in active transport initiatives, especially for primary school interventions.
4. Australian-specific research is needed to evaluate the incremental change in accident and health risk of specific policies and programs that affect walking and cycling activity, taking into account direct user (walkers and cyclists) risk per kilometre of travel, safety in numbers effect, changes in total travel activity, risk to other road users, and possible risk reduction strategies.

Many of the benefits beyond health are well established in evaluation of transport projects, but emerging areas are less well served:

5. Better information is required on the quality-of-life benefits of active transport, including (a) how to identify, measure and quantify them and (b) how to place a socioeconomic value on them for benefit-cost analysis purposes.
6. In the absence of (b) above, an evaluation framework capable of incorporating non-monetary (either quantitative or qualitative) values should be developed to demonstrate the existence, direction and, where possible, extent of the quality-of-life effects of active transport.
7. More research is required to identify the other social benefits of active transport in schools, including improved learning outcomes and enhanced independence.
8. Better understanding is needed of the durability of the effects of active travel programs, especially those aimed at school children. Life-stage transition, including between primary and high school, have impacts on capabilities, travel needs and opportunities that could diminish or enhance the effects of programs in primary school.

In relation to active transport more generally, in the context of transport planning and sustainability:

9. Standard definitions and questions to include in travel surveys should be established to collect better information on active transport demand and activity. Current practices are fragmented and non-uniform, making it difficult to accurately compare transport patterns across different jurisdictions, or even the same jurisdiction over time.

   Travel surveys should be designed to collect better information on short trips, travel by children, walking and cycling links of motorised trips as well as more detailed user information, such as people's physical ability and health, incomes, vehicle access, and perceptions of walking and cycling conditions.

   Travel survey data should report the amount of time spent travelling by various modes. In addition, travel surveys should be coordinated with public health studies to allow research on the relationships between transport conditions, active transport, emissions, and health outcomes such as road traffic injuries, body weight, diabetes, and cardiovascular diseases. Federal or state governments, or professional organisations should work to establish standard travel survey questions to ensure consistency.

10. Targeted research is required to develop new models and improve existing transport models to better predict how specific policy changes and projects affect active travel activity. This research must include the impact on active transport of improvements to motorised transport infrastructure. Of special importance is the need to investigate latent demand for active transport.

11. Additional research is needed to better understand how changes in active transport affects motorised travel, including substitution rates and leverage effects, and the types of motorised travel reduced, such as urban-peak vehicle travel (which reduces traffic congestion) and driving by young males (which reduces crash risk). It would be helpful to analyse leverage effects using Australian data.

End of trip facilities such as this one at Royal Brisbane Hospital helps make cycling a more attractive commuting option

Contents

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1 Introduction

Active transport refers to walking, cycling and other forms of human-powered mobility. Walking and cycling for transport offer a range of public policy benefits in terms of population health, greenhouse gas emissions, congestion relief and urban liveability. In the last three decades, rates of walking and cycling—particularly among school-aged children—have reduced significantly. Some seven out of 10 Queensland adults "exercise very little or not at all" (Queensland Government, 2008, p. 32). This is considerably more than the national average.

Walking and cycling have untapped potential to reverse this worrying trend towards sedentary lifestyles and chronic disease. However, conventional transport planning tends to undervalue non-motorised transport, in part because these health benefits are not considered in the economic evaluation of transport policies and projects. To address this problem it is important to develop practical tools for more comprehensive evaluation of active transport benefits, including public fitness and health benefits.

Human powered transport holds a wide range of 'co-benefits' that have previously been overlooked

Any evaluations that fail to appreciate the co-benefits of active transport will significantly understate the value to the community of active transport programs and may hinder the widespread adoption of effective active transport programs.

The aim of this project is to develop a comprehensive, accurate and practical framework for evaluating the full benefits and costs of active transport. This includes monetised estimates of health benefits, as well as other economic, social and environmental outcomes, based on existing research and calibrated to the Queensland context.

This is the first of two reports that will be delivered as part of this project. This report reviews:

- evaluation principles and practice
- the process of public policy decision-making
- active transport costs and benefits, including a critique of valuation and modelling methods
- impacts of previous active transport encouragement programs
- monetised costs and benefits of transport modes, with a particular focus on active transport.

Stage Two of the project will be delivered in the second report.

Figure 1 below outlines stages one and two of the project.

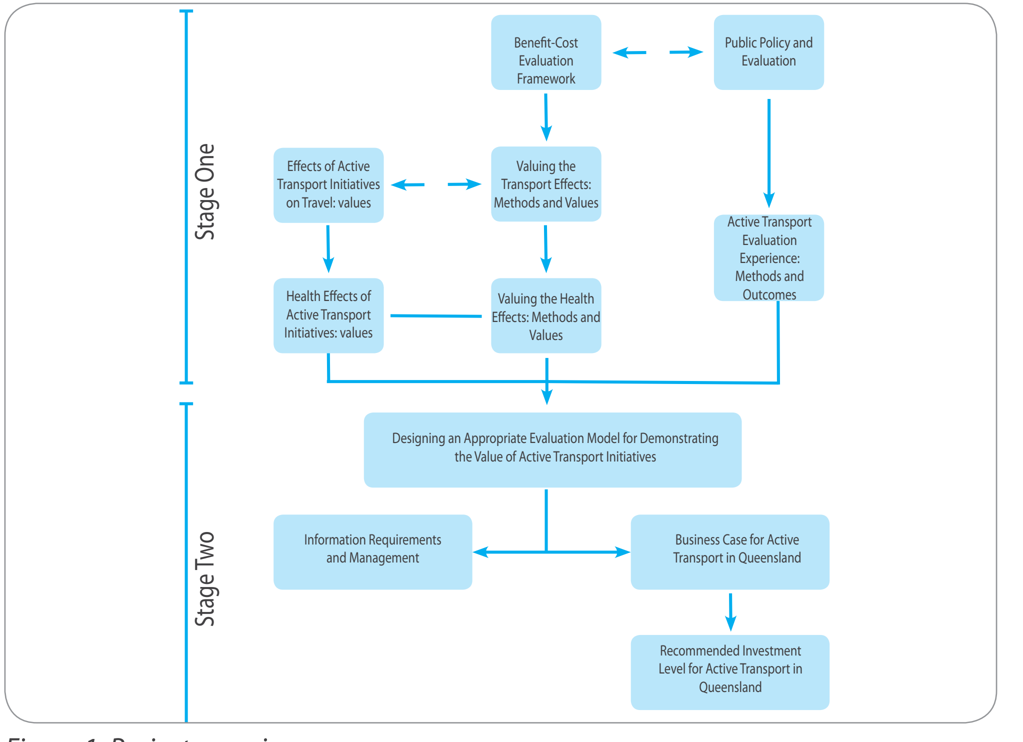


Figure 1: Project overview

This project will provide Queensland Health—and the Queensland Government more broadly—with the information and tools to support public policy decisions that will enable active travel programs to become an effective part of the public policy mix, resulting in more desirable outcomes in a broad range of areas, including health, transport and the environment.

2 Transport, Health and Public Policy

2 Transport, Health and Public Policy

> The multiplicity of agencies involved in strategic transport planning and related land use planning can inhibit the resolution of long-term issues, not only because of different agency objectives but also because resources to tackle the issues can be fragmented. …there appears to be scope for some resolution of roles within the existing organizational structure and for more effective co-operation between the various levels of government.
> (Transport Strategy Committee on Future Perth, 1992)

Sixty years of heavy investment in car-based transport infrastructure have raised our emissions, transport costs and obesity levels

The Queensland transport system, like other Australian states, has developed in a manner heavily dependent on the private automobile (Queensland Government, 2008). This dependence has brought a range of unintended consequences in relation to sedentary lifestyles, climate change, congestion and urban liveability.

> On average Queenslanders travel more kilometres by passenger vehicle than any other state or territory—14,800 kilometres per vehicle in 2006—compared with the national average of 13,900 kilometres. (Queensland Government, 2008, p. 23).

Improving our understanding of the full benefits and costs of different modes of transport can lead to more optimal transport planning and investment decisions. In particular, better understanding of the health benefits of active transport and the external costs[1] of motorised transport, can help identify the best transport policies and planning decisions, taking into account all impacts.

> Against the backdrop of a growing population, the highest ever obesity levels and significant environmental challenges—cycling offers a wealth of benefits.
>
> *Austroads, 2010.*

2.1 Overlooking the Benefits of Active Transport

Conventional transport economic evaluation overlooks many active transport benefits (Table 1). For example, by tradition, transport project evaluation considers travel time and vehicle operation costs (and therefore the benefits of reduced congestion), but ignores parking and vehicle ownership costs. By omitting these latter considerations, the evaluation ignores the savings that result from policies that, by improving travel options, allow households to own fewer motor vehicles. Similarly, conventional transport economic evaluation considers the traffic safety benefits that result if travellers reduce crash rates per kilometre of travel, but tends to ignore the safety benefits that result if travellers reduce total annual vehicle-kilometres, or the fitness and health benefits that result from increased walking and cycling.

[1] Externalities are the impacts not covered by the user, e.g. carbon emissions from transport.

USUALLY CONSIDERED	OFTEN OVERLOOKED
Financial costs to governments	Downstream congestion impacts
Travel speed (congestion delays)	Delay to non-motorised travel (barrier effect)
Vehicle operating costs (fuel, tolls, tyre wear)	Parking costs
Per-kilometre crash rates	Vehicle ownership and kilometre-based depreciation costs.
Per-kilometre emissions	Project construction traffic delays
Project construction environmental impacts	Generated traffic impacts (additional accidents, energy consumption and pollution emissions from induced vehicle travel)
	Indirect environmental impacts
	Strategic land use impacts (e.g., sprawl)
	Transport diversity value
	Equity impacts (e.g. mobility for non-drivers)
	Impacts on physical activity and public health
	Some travellers' preference for alternative modes

Table 1: Consideration of active transport benefits

Conventional transport planning tends to focus on a limited set of impacts. By tradition, many benefits of active transport tend to be overlooked or undervalued.

There are a variety of benefits that result from improved sustainable transport. Some of these benefits result from improved walking and cycling conditions, others result from more active transport activity, and others from more walkable community development, and some from reductions in automobile use, as summarised in Table 2.

IMPROVED ACTIVE TRANSPORT CONDITIONS	INCREASED ACTIVE TRANSPORT	REDUCED AUTOMOBILE TRAVEL	MORE WALKABLE DEVELOPMENT
Improved user convenience and comfort	Improved population-level physical activity	Reduced traffic congestion	More liveable communities
Improved accessibility, particularly for non-drivers	User enjoyment	Road and parking facility cost savings	Improved accessibility, reduced transport costs
Option value	Increased community cohesion (positive interactions among neighbours)	Consumer cost savings	Reduced vehicle ownership
Increased property values		Reduced traffic crashes	Reduced sprawl
		Energy conservation	Habitat preservation
		Reduced air and noise pollution	

Table 2: Walking and cycling benefits

NB: Improving walking and cycling conditions and increased use of these modes can provide many benefits, particularly when they substitute for driving.

This report investigates these benefits. It identifies various categories of benefits, and methods for quantifying and monetising (measuring in monetary units) these impacts. It describes a framework for incorporating these benefits into transport policy and planning analysis.

2.2 Public Policy and Active Transport

Public policy is subject to a wide range of influences from both within government and from the broader community. Concern has been expressed that public sector reforms in many developed countries over the past couple of decades have had too narrow a focus—and this is particularly the case with transport policy (Dora & Phillips, 2000). For instance, a road agency may widen a freeway to relieve congestion without consideration of the negative impact this may have on amenity and time competitiveness for pedestrians and cyclists.

In practice, public policy reforms have often been focused on restructuring to achieve internal efficiencies and greater accountability for outcomes, which has meant that other aspects of public policy have suffered. Curtain (2000, p. 44) concludes:

> Australia needs new mechanisms to not only generate new policy ideas that are a departure from the past. We also need ways to ensure that the new ideas can be further tested and implemented on a large scale where they are judged to be viable.

This describes the issues that policies relating to active transport and voluntary travel-behaviour change have been facing for over a decade. The role of evaluation is crucial to acceptance of these approaches to emerging problems in transport and health and also to the ability to implement effective programs on a scale large enough to have real and substantial benefits for the community.

Decision-making in government, with regard to funding of programs and initiatives, is both centralised and uncoordinated. This is not a contradiction, but a reflection of the fact that budgeting is primarily concerned with inputs and outputs rather than outcomes. Decisions on inputs are centralised in Cabinet and Treasury; decisions on outputs are more often made at departmental level.

Inputs are the resources (mainly finance to purchase resources such as staff and materials) required for an agency to create specified outputs. Inputs are typically allocated to an individual agency, even where these are to be used in joint initiatives with other agencies.

Outputs are the assets or activities that are being funded. Outputs are generally the 'property' of an individual agency. Even with joint projects, the output is likely to be most clearly identified with a single agency that takes the lead role in delivery. Output is usually a poor measure for performance, as it represents the products or services produced rather than the value produced for the community.

Outcomes are what the assets or activities deliver to the community. These outcomes may go well beyond the areas covered by the funded agency or agencies for delivery of outputs. This is particularly the case with active transport, where the output might be a new shared path but the outcomes will be spread across transport, environment and health.

Funding is centralised in that the State Budget is the instrument for determining levels and allocations of funding—in aggregate, for individual agencies and for specified programs.

Funding is uncoordinated in that the initiative for seeking funding most often comes from an agency that is responsible for the outputs, not from those that have a stake in the outcomes.

This is not a new issue (see, for example, Transport Strategy Committee, 1992) but is one that is becoming more urgent as governments and communities become increasingly concerned with sustainability and, at the same time, actions in one area of activity have complex effects on a wide range of sectors. Where once decision-makers were able to focus on the direct impacts of initiatives, they now have to consider impacts, both positive and negative, in areas that are the responsibility of others.

Where once decision-makers were able to focus on the direct impacts of initiatives, they now have to consider impacts, both positive and negative, in areas that are the responsibility of others.

The issues of multiplicity of stakeholders and diversity of outcomes are central to understanding how to approach active transport initiatives in the context of public sector decision-making. Active transport, partly due to its broad range of impacts, has failed to find a dedicated home within one government sector. It has variously been considered the responsibility of the transport, environment and health areas of government, but the outcomes range more broadly into economic and social sustainability, including education (see Figure 2).

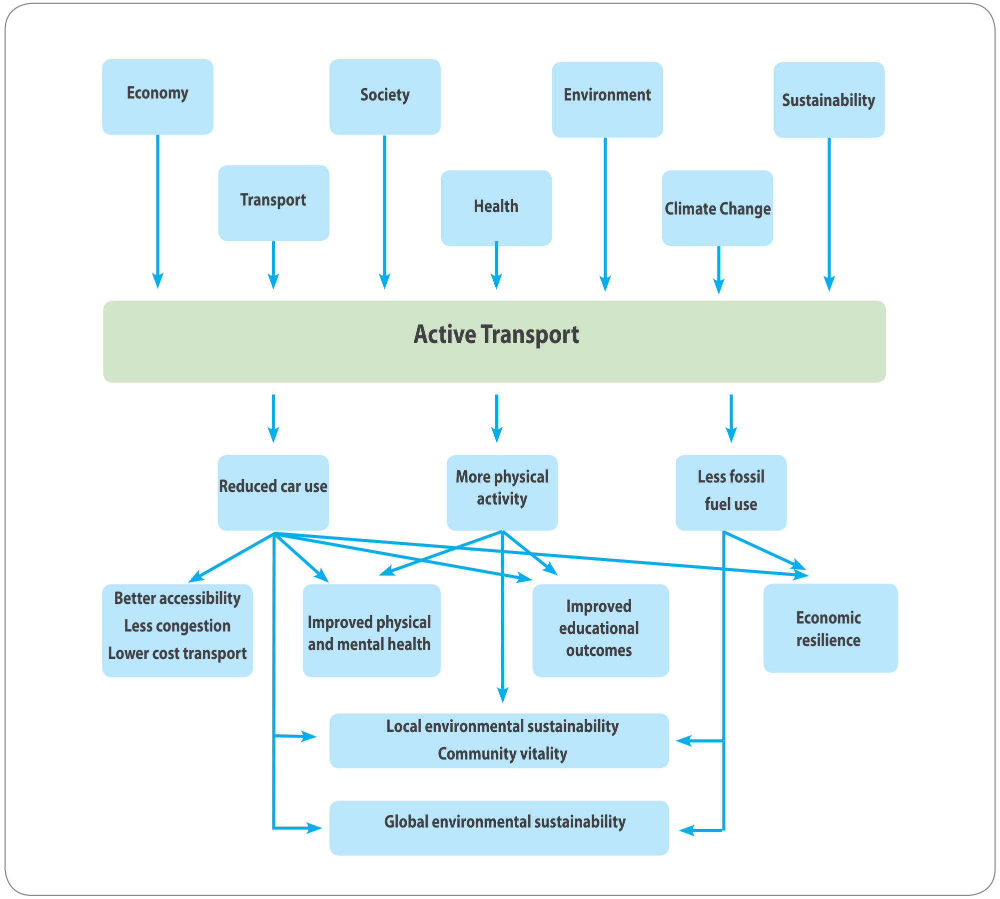


Figure 2: The influences and outcomes of active transport

The indirect outcomes of active transport do not align with decision-making and resourcing as simply as do the outputs, suggesting that a 'whole-of-government' approach to decision-making and resourcing would be desirable. However, as Cavill (2001) demonstrates, there is not only a synergy of interests between transport and health professionals in respect of active transport, there is also a complementarity of capabilities, skills and experience (Table 3). Similar complementarities are likely to be found in respect to other interests and can be built on to improve both the effectiveness and the efficiency of active transport programs.

Globally, cycling is increasingly seen as a smart option for boosting population levels of physical activity

KEY PRIORITIES AND POTENTIAL CONTRIBUTIONS FOR TRANSPORT AND HEALTH PROFESSIONALS IN PROMOTING AND INCREASING RATES OF WALKING	
Transport	*Health*
Reduce car use	Improve health through physical activity
Improve air quality	Reduce rates of respiratory diseases/asthma
Reduce traffic noise	Reduce stress/improve mental health
Reduce congestion	Encourage independent mobility and development (especially in children)
Improve road safety	Reduce mortality and morbidity from crashes
Increase 'liveability' of urban areas	Improve quality of life
Increase equity and access to transport modes	Reduce inequalities in health
Increase sustainability of the transport system	Build social capital and social cohesion

Table 3: Priorities and contributions in transport and health for active transport.
Source: Cavill (2001)

The complex, wide-ranging benefits of increased active transport, such improved liveability, warrant further research

2.3 Decision-Making for Active Transport

2.3.1 Evaluation and Complex Systems

Transport strategies have changed direction very substantially since Goodwin et al (1991) coined the phrase "the new realism", but program delivery and the methodology of evaluation have not kept up. Often this has been because the linkages between new initiatives and outcomes are not defined clearly enough or quantified well enough. In addition, evaluation methodologies often assume that 'more is better'. Traditional evaluation methodologies also have difficulty coping with changes in what we do (activity patterns) and changed in how we get there (travel). Consequently, new initiatives often have great difficulty getting funding (Ker, 2001). Put another way, we commonly set targets for a reduction in the level of reliance on private car travel in cities, but do little or nothing to increase the likelihood of those outcomes being achieved.

In addition to State Transport Policies and Metropolitan Transport Strategies, which embody both the direction and the magnitude of these targets, we have implementation strategies, that tell us—at an almost operational level—what needs to be done. Since many of these initiatives are new, we do not know, a priori, how effective they will be. This poses problems for both the initial evaluation and for post-implementation monitoring. Ironically, lack of experience from which to judge likely effectiveness makes it all the more important to be able to measure actual performance.

It is increasingly recognised that transport systems and cities are complex adaptive systems, not mechanisms with uniquely-definable relationships between actions and outcomes. Complex systems have two key characteristics that make performance measurement difficult:

1. They cannot be controlled, only influenced or disturbed, and therefore the precise outcomes cannot be identified a priori.

2. They are prone to 'emergence' of new characteristics, defined as outcomes that cannot be predicted—let alone quantified—by our current understanding of the system (Chambers & Ker, 1997).

2.3.2 Complex Outcomes of Active Transport

Active Transport is a classic case of outcomes extending far beyond the scope of any single agency responsible for programs and outputs. Most active transport initiatives have been generated out of transport, environmental and, more recently, health concerns and the most obvious direct outputs are also in those areas:

- reduced car use
- less fossil fuel use and associated emissions
- more physical activity.

The direct outputs are the results that are most commonly measured or estimated—partly because they align so simply with originating agencies and partly because they can be measured or observed. However, each of these outputs has multiple outcomes:

Reduced car use leads to:

- better accessibility (social outcome)
- less congestion (economic outcome)
- lower-cost transport (economic and social outcome)
- improved physical health (economic and social outcome)
- improved mental health (economic and social outcome)
- improved educational outcomes (social and economic outcome)
- economic robustness (economic outcome with social consequences)
- local environmental (air quality, noise, water quality) improvements (environmental, economic and social outcome)
- global environmental (climate change) improvements (environmental, economic and social outcome).

Less fossil fuel use leads to:

- economic robustness
- local environmental (air quality, noise, water quality) improvements (environmental, economic and social outcome)
- local community vitality (economic and social outcome)
- global environmental (climate change) improvements (environmental, economic and social outcome).

More physical activity leads to:

- improved physical health (economic and social outcome)
- improved mental health (economic and social outcome)
- improved educational outcomes (social and economic outcome)
- local environmental (air quality, noise, water quality) improvements (environmental, economic and social outcome)
- global environmental (climate change) improvements (environmental, economic and social outcome).

Even those outcomes that can be measured or observed are usually difficult to interpret because of the large number of other factors, beyond the active transport initiative, that can affect them.

Shiel, in a brief commentary on the 'walking school bus', demonstrates the need to take into account the full range of outcomes (not simply health) for an effective evaluation of program value. He concludes:

> The ethical imperative of opportunity cost demands we evaluate the costs and benefits of health promoting interventions. The WSB [walking school bus] example suggests that methodologically health economics has some way to go before it can stand up to the challenge of social interventions. …The alternative is we value only that which has been measured, and this may mean the end of the line for social interventions such as the walking school bus. (Shiel, 2007, p. 334)

It is essential that economic evaluation ensures that all significant costs and benefits are identified—even if they cannot all be measured and valued—lest they be otherwise overlooked. The evaluation framework for active travel in Queensland will be broad-based and inclusive to provide a comprehensive evaluation to support public policy decisions across government.

Giles-Corti et al (2010, p. 125) concluded that:

> As societies confront the economic, social and environmental effects of climate change, population growth, traffic congestion and the burden of chronic disease, there is a unique opportunity to view the benefits of active transportation through a multi-sector lens. …Studying the co-benefits of policy options however is at the nascent stage. …The language of co-benefits is useful as it helps break down policy silos and presents additive (rather than discrete) benefits that could be incorporated in economic analyses to assess cost-effective strategies.

2.3.3 Evaluating New Directions

Demonstrating and evaluating the effectiveness of transport programs depends critically upon being able to determine whether the outcome changed significantly and whether the program or something else caused the change (Higgins & Johnson, 1999). Both of these issues are especially problematic in the context of travel-demand management and strategies to promote non-motorised transport.

Demand management is a relatively new concept in transport and until recently was seen almost entirely in supply-side terms. However, initiatives in Perth and Adelaide have successfully changed people's travel behaviour through 'soft' measures using information, opportunity and incentive aimed at individuals and households—for example, TravelSmart Individualised Marketing (TSIM) in Perth and Travel Blending in Adelaide.

Both TSIM and Travel Blending proceeded through pilot projects which were then evaluated using conventional benefit-cost frameworks. The South Perth pilot of TSIM was constructed according to a rigorous experimental design to ensure that the true effectiveness of the intervention was being measured, uninfluenced by extraneous factors—including publicity. Whilst conventional benefit-cost measures such as benefit-cost ratio and net present value were calculated, the evaluation included clear statements of the component impacts (Ker & James, 2000).

More recently, the evaluation has been enhanced to include specific estimation of a wider range of impacts (Ker, 2002), including:

- health and fitness
- public sector, cross-sectoral financial impacts (mainly in the health sector).

2.4 Underreporting of Active Transport

Conventional planning practices often undercount and undervalue active transport (Burke & Brown, 2007). Conventional travel surveys tend to undercount short trips, non-commute travel, and non-motorised links of automobile and public transport trips (Stopher & Greaves, 2007). For example, a bike-bus-walk trip is often coded simply as a public transport trip, and a commuter who parks at the edge of a city centre and walks several blocks to work, to minimise parking fees, is often classified simply as a car commuter, even if they spend as much time walking as driving. More comprehensive surveys indicate that non-motorised travel is three to six times more common than conventional surveys indicate (Rietveld, 2000). As a result, if official data indicates that only 5% of trips are non-motorised, the actual amount maybe 10-30%.

Although non-motorised travel represents a relatively small portion of travel distance, it represents a much larger share of travel time and trips, which is how users experience and measure travel. For example, a United Kingdom survey indicates that walking represents just 2.8% of total mileage but 18% of travel time and 25% of trips, as shown in Figure 3.

Short walking and cycling trips are often not captured when assessing transport patterns

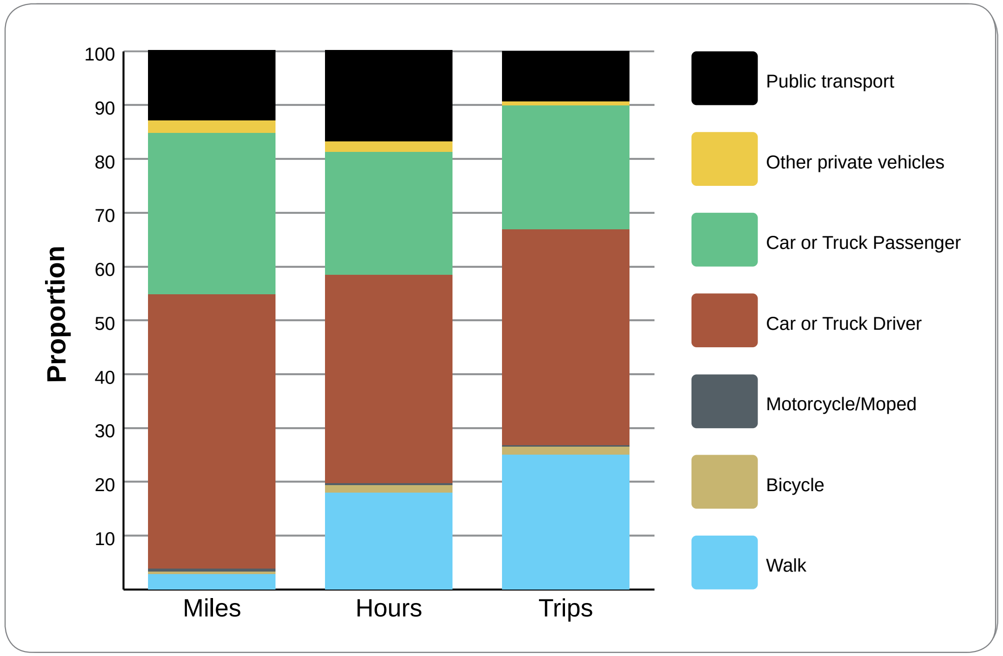


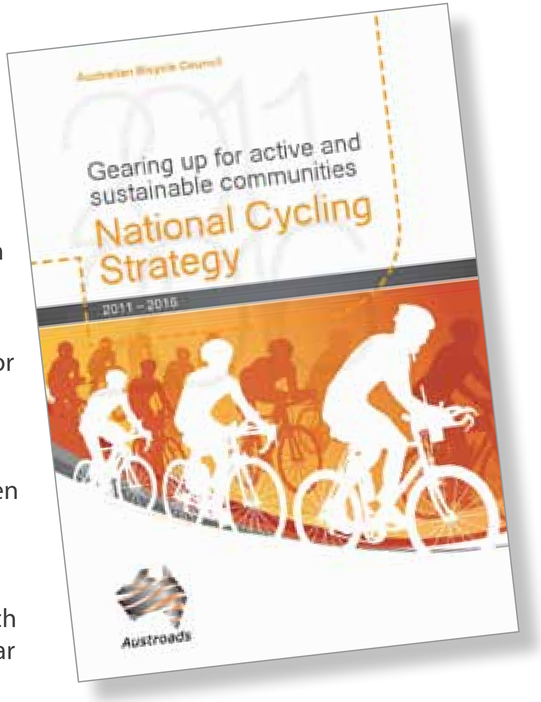
Figure 3: Portion of travel by various Units, 2003
Source: Department for Transport, 2004

Figure 3 shows how the portion of travel by different modes varies significantly depending on the units used for measurement.

2.5 Active Transport and the Queensland Policy Context

2.5.1 National Cycling Strategy 2011 – 2016: Gearing up for active and sustainable communities

The National Cycling Strategy was launched by the Minister for Transport and Infrastructure, Anthony Albanese MP in September 2010 with the aim of doubling the number of people cycling over the next five years.



The stakeholder consultation held as part of the strategy's development identified a concern amongst the sector that the previous strategy acted as a "compendium of existing activity" rather than a "driver of progress" (Austroads, 2010, p. 5).

The strategy identifies that safety is a major concern preventing people from cycling and commits to address these concerns. The strategy acknowledges that, despite cycling's numerous benefits, it has not been supported by high levels of investment, yet it stops short of committing to fill this funding shortfall. Rather, it proposes to establish a "robust and consistent approach to data" (p. 5), in an effort to develop a clear understanding of cycling encouragement impacts. The intention of this approach is to provide the states and territories, as well as local government, with the necessary evidence to invest in cycling.

Priorities and Objectives of the National Cycling Strategy

1. *Cycling promotion*
   Promote cycling as both a viable and safe mode of transport and an enjoyable recreational activity.
2. *Infrastructure and facilities*
   Create a comprehensive network of safe and attractive cycling routes and end-of-trip facilities.
3. *Integrated planning*
   Consider and address cycling needs in all relevant transport and land use planning activities.
4. *Safety*
   Enable people to cycle safely.
5. *Monitoring and evaluation*
   Improve monitoring and evaluation of cycling programs and develop a national decision-making process for investment in cycling.
6. *Guidance and best practice*
   Develop nationally consistent technical guidance for stakeholders to use and share best practice across jurisdictions.

2.5.2 Queensland Cycle Strategy

The Queensland Cycle Strategy provides the strategic direction for increasing cycling participation across the state. The strategy aims to create the conditions in which cycling is "safe and convenient, and where choosing to cycle is respected, supported, and encouraged by all levels of government and the community." (Queensland Government, 2003, Minister's Foreword).

The strategy sets targets to increase cycling by 50% between 2003 and 2011 and by 100% between 2003 and 2021. These targets respect the differences in cycling participation that currently exist around Queensland, and therefore are specific to individual communities. For example, in South East Queensland, the strategy aims for 5% of all trips to be completed by bicycle by 2007 and 8% by 2011.

The overall objectives of the strategy are summarised below:

1. effective coordination and monitoring of strategy implementation
2. integrated policy and practice that facilitates cycling
3. a quality network of bicycle routes
4. improved safety and security for bicycle riders
5. integration of cycling and public transport
6. widespread provision of convenient and secure end-of-trip facilities
7. effective encouragement and promotion of cycling.

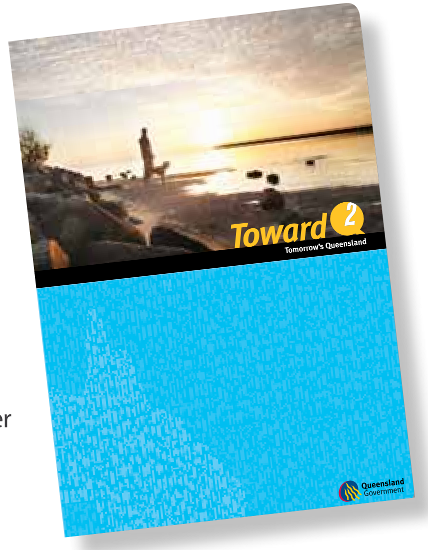
Bike riders need quality facilities like any other transport user.

Queensland Government, 2003, p.8

The strategy highlights the potential to increase the level of cycling participation in Queensland. It notes that some 70% of all trips are less than 5 km and 48% are under 2 km. With regards to education-based active transport, the strategy highlights the benefits associated with increasing the promotion of children riding to school, including the increased likelihood of continued active transport participation during adult years. In terms of specific policies related to education-based cycling, the strategy commits to secure bicycle parking facilities at schools and improved infrastructure to ensure safe routes exist to schools.

Separated active transport infrastructure can be important on high demand routes

2.5.3 Toward Q2



The Queensland Government has established five ambitions for communities in every Queensland region (Queensland Government, 2008), many of which have direct relevance to active transport.

> *Strong: We want to create a diverse economy powered by bright ideas.*

Active transport programs make an effective contribution to ameliorating climate change and congestion, both of which were noted as challenges for this ambition. Q2 acknowledges that high oil prices have raised petrol costs and that has put further pressure on stretched household budgets.

> *Green: We want to protect our lifestyle and environment.*

Active transport programs will support improved attitudes to public transport, which was noted as a challenge for this ambition, but will contribute even more through enhanced attitudes towards walking and cycling. The target for this ambition is to cut the greenhouse gas emissions of Queensland by one-third by 2020 and a 60% reduction by 2050 (consistent with the national target).

> *Smart: We want to deliver world-class education and training.*

Active transport programs increase the level of physical activity of school students, with consequent benefits for learning outcomes.

> *Healthy: We want to make Queenslanders Australia's healthiest people.*

Active transport programs contribute to increasing healthy lifestyle choices. School programs, in particular, have a direct impact on childhood obesity, which is on the rise. Overall, in 2006 21% of Queensland children aged 5–17 years were overweight or obese, including 20% of boys and 23% of girls (Queensland Government, 2008, p. 37).

Diabetes is singled out in Toward Q2 as a major emerging pressure on the Queensland health system and economy. Sedentary lifestyles are highlighted as a major driver of the rise in type 2 diabetes and the graph below illustrates the impact this will have on disability-adjusted life years.

Two of the targets for this ambition of direct relevance to active transport are to reduce obesity levels to one-third of current levels by 2020 and have the shortest public hospital waiting times in Australia.

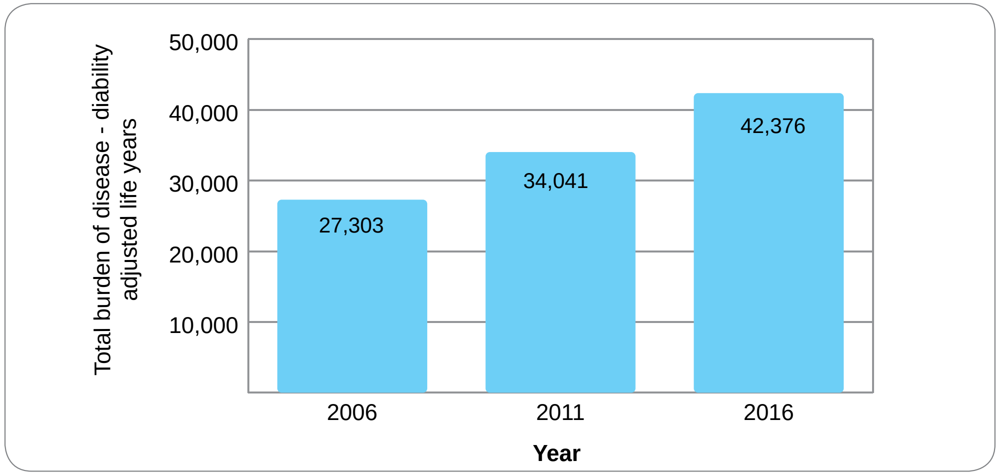


Figure 4: The rising burden of disease due to type 2 diabetes
Source: Toward Q2, 2008; citing Queensland Health and the Australian Institute of Health and Welfare

> *Fair: We want to support a safe and caring community.*

Active transport programs help reduce the cost of transport for families and enhance willingness and ability to access opportunities (e.g. employment, goods and services, recreation) without using a car.

> Poor diet and exercise habits could see this generation of children be the first in history to die younger than their parents.
>
> Queensland Government, 2008, p. 5

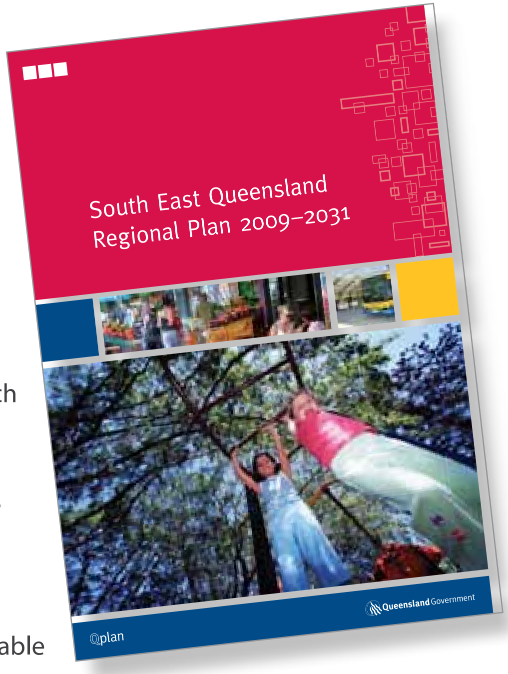
These points outlined above are described as "the areas we must make real and lasting changes in now if we want to shape a better future for ourselves and our children" (Queensland Government, 2008, p. 7). All of these ambitions are addressed, directly or indirectly, by programs to promote active transport, especially in schools.

With regard to the health impacts of active transport, Q2 states: "Poor diet and exercise habits could see this generation of children be the first in history to die younger than their parents." (Queensland Government, 2008, p. 5).

A lack of physical activity is one of the major contributing factors to the prospect of reduced life expectancy outlined in Q2. Active transport creates the opportunity for Queenslanders to integrate sufficient levels of physical activity into their busy lifestyles to protect against the prospect of sedentary lifestyle disease. As Q2 states, "we need to make walking or cycling to work easier than driving the car" (Queensland Government, 2008, p. 33).

2.5.4 South East Queensland Regional Plan 2009–2031

The South East Queensland Regional Plan (SEQRP) is intended to shape South East Queensland over the next two decades. It contains a number of themes conducive to boosting walking and cycling participation.



> To manage growth, the regional plan promotes compact settlement by consolidating growth in existing areas which are close to public transport, to encourage reduced car use and help fight congestion. (Queensland Government, 2009, p. 1)

The SEQRP contains a number of strategic directions. These include the following, which are of direct relevance to sustainable, active transport:

- creating a more sustainable future
- delivering smart growth
- improving regional accessibility
- building a series of strong, identifiable communities
- providing infrastructure and services
- addressing climate change and oil supply vulnerability
- supporting strong and healthy communities.

A number of the strategic directions identified above are clearly supportive of the creation of more pedestrian- and bicycle-friendly environments. Reducing car use and increasing levels of cycling and walking supports a number of the SEQRP's themes, such as reducing the community's impact on the environment, consolidating growth around activity centres, reducing congestion and dependence on oil, and promoting healthy urban environments.

The SEQRP includes the encouragement of cycling through a number of specific policies related to the provision of improved active transport infrastructure and urban development that creates mixed use, higher density environments focused on diverse transport and employment opportunities.

2.5.5 Blueprint for an Active Australia

Blueprint for an Active Australia is a strategy that outlines evidence-based methods of increasing population level physical activity. Active transport is highlighted as a key opportunity to increase levels of physical activity.

The strategy provides a 10-point plan of cost-effective methods of increasing levels of physical activity, many of which are of direct relevance to active transport in Queensland. The 10 key action areas are listed on page 6 of *Blueprint for an Active Australia* and are as follows:

1. Implement a national, integrated and ongoing physical activity mass-media strategy.
2. Regulate to provide a built environment that supports active living.
3. Actively encourage, support and facilitate more walking, cycling and public transport use.
4. Develop and implement a physical activity workforce training strategy.
5. Provide financial incentives (tax and price) for individuals, families and business to make active choices cheaper and easier.
6. Activate healthcare funding systems that support general practitioners (GPs) and other health professionals to prescribe and provide advice about physical activity.
7. Provide programs and opportunities to increase physical activity levels among Aboriginal and Torres Strait Islander peoples.
8. Implement a life-stage approach to physical activity programming, including:
    a. a comprehensive active children and youth program
    b. an active families initiative

   c. an active adults initiative

   d. an active older adults campaign.

9. Provide physical activity programs in key settings where people live, work and are educated, including:

   a. workplaces

   b. local government

   c. schools and childcare facilities.

10. Provide leadership, coordination and infrastructure to support implementation of the above actions:

> Behavioural changes towards a healthier lifestyle need to occur with a minimum amount of effort for the individual; the healthy choice needs to be the easy choice.
>
> *Queensland Government, 2010, p.3*

   a. Establish a Prime Minister's Advisory Council on Physical Activity to oversee development of an implementation strategy for *Blueprint for an Active Australia*.

   b. Identify fiscal measures to ensure dedicated financial resources to fund ongoing implementation.

   c. Fund and support regular monitoring of the Australian population's physical activity levels.

   d. Prioritise funding for physical activity research and program evaluation.

   e. Monitor the impact of a changing environment.

The points identified above are all clearly consistent with measures to increase levels of walking and cycling among the Queensland population. Should these actions be implemented, significant increases in active transport participation could be expected, both in the school-aged population and in the general community.

2.5.6 Active, Healthy Communities

This document, a joint publication between the Queensland Government and the National Heart Foundation, and supported by the Local Government Association of Queensland, is designed to be used as a resource for local government. It aims to increase levels of physical activity and promote healthy eating. It provides practical information and useful ideas that can be implemented by local councils to make healthy choices a realistic, attractive option. Importantly, many of the proposals in the *Active, Healthy Communities* pack can be implemented without needing to increase spending.

Supportive environments for health can range from the physical street environment, such as the presence of bicycle and walking paths, to the political and cultural environment. Social and cultural influences can explain why walking and cycling can be high in one area and low in other, without significant differences in the surrounding built environment.

Active, Healthy Communities focuses on local government due to the major influence it can have on local communities—in terms of street design, local parks and other recreational opportunities as well as the planning of where shops, housing and services are located. Active, Healthy Communities is an excellent guide for local councils wishing to improve the health of their community.

2.5.7 An Australian Vision for Active Transport

This joint report by the Australian Local Government Association, Bus Industry Confederation, Cycling Promotion Fund, National Heart Foundation of Australia, and International Association of Public Transport presents a case for the Australian Government to make a major commitment to active transport (walking, cycling and using public transport) in Australia.

The report calls for a national approach to active transport to achieve improvements in:

- preventive health and physical activity
- sustainable and liveable urban communities
- environment and carbon pollution reduction
- social inclusion
- traffic congestion
- road safety.

The report presents practical and achievable policy options for creating a healthier, more productive, sustainable nation. These are summarised in the form of nine recommendations for increasing active transport in Australia:

1. Develop an integrated national active transport strategy that embraces policy and planning for the major components: walking, cycling and public transport.
   a. Create a national, funded and integrated strategy for active transport.
   b. Establish an independent national active transport authority.
2. Develop clear and realistic targets for active transport and physical activity outcomes.
   a. Provide federal facilitation and reward payments to super-charge change already under way.
   b. Establish a national active transport agreement and partnership to achieve change.
3. Provide local government authorities with substantial, sustained and targeted funding for active transport.
   a. Fund community infrastructure and complementary programs to support active transport.
4. Support the development and widespread application of Healthy Spaces and Places planning principles.
   a. Support implementation of Healthy Spaces and Places guidelines and ensure they are adopted as standard operating procedures at all levels of government and industry.
5. Encourage active domestic tourism by funding major regional projects such as rail trails, cycle routes and hiking tracks.
   a. Develop an overarching strategic vision to end ad-hoc funding for projects.
   b. Renew and expand the National Bike Paths Fund.

6. Promote a safe environment for people who choose to walk, cycle or take public transport and review jurisdictional approaches to the legislative protection of vulnerable road users.
    a. Adopt a nationally consistent approach to lowering speed limits in areas of high pedestrian and cycling use.
    b. Consider wider health and sustainability issues in road rule changes and road safety strategies.
    c. Implement a national road safety campaign on multiple benefits of speed limit changes.
7. Fund social marketing programs to promote the many benefits of walking and cycling for people of all ages.
    a. Promote programs and opportunities in communities, schools and workplaces.
    b. Re-establish walking and cycling as an Australian social norm.
    c. Implement strategies to encourage changes in travel behaviour and increased use of active infrastructure and services.
8. Support cycle training and pedestrian education in schools.
    a. Implement programs that encourage walking and cycling to school.
    b. Identify and develop safe walking and cycling routes.
    c. Establish a national coordinating body for walking and cycling to school within the active transport authority.
9. Provide incentives for employers to encourage employees to walk, cycle or take public transport to work.
    a. Provide incentives such as fare rebates or passes.
    b. Install end-of-trip facilities at workplaces for cyclists.

Each of the above points directly supports greater levels of active transport, including measures particularly targeted at boosting the level of cycling to/from school. There is also a remarkable level of consistency between the strategic direction of this document and those that have been developed by the Queensland and Commonwealth Government (summarised in this report).

Planning for cycling is a major policy objective across a range of state and national strategies

2.5.8 Healthy Spaces and Places

The Planning Institute of Australia, in partnership with the National Heart Foundation and with financial support from the Commonwealth Department of Health and Ageing, has developed the planning resource *Healthy Spaces and Places* to provide a policy framework at the national level to address the role of the built environment and its influence on people's health. The framework assists practitioners and decision-makers to understand the interconnections between planning and health. It has been prepared as a guide for all levels of government, industry, private sector and community groups in their consideration of health and the built environment (Planning Institute of Australia, 2008).

Healthy Spaces and Places showcases existing initiatives and draws on current practices that apply to and are consistent with the proposed framework and principles. In particular, it demonstrates effective policy development and implementation that encourage and require integrated outcomes for wellbeing. *Healthy Spaces and Places* includes the following key design principles to plan for healthy communities:

- *Active transport*: travel modes that involve physical activity, such as walking and cycling, and include the use of public transport that is accessed via walking or cycling.
- *Aesthetics*: the attractiveness of a place or area affects the overall experience and use of a place (e.g. walking, cycling, viewing and talking). An attractive neighbourhood invites people to use and enjoy its public spaces and to feel safe
- *Connectivity*: the directness of links and the number of connections in a path, street or road network, and for Healthy Spaces and Places, the ease with which people can walk and cycle around a neighbourhood and between places.

Medium density development with integrated bicycle parking has been shown to increase bicycle use

- *Environments for all people*: places that are safe and easily accessible for everyone, regardless of age, ability, culture or income, with a suitable range of f acilities and services that are available to all.
- *Mixed density*: residential development that contains a mix of housing types, such as single dwellings and multi-units and development of varying size and height. This promotes a more diverse community and caters to various stages of life.
- *Mixed land use*: complementary uses, such as houses, shops, schools, offices, libraries, open space and cafes, are co-located to promote active transport to and between different activities. People are more likely to walk, cycle or take public transport when they can conveniently undertake multiple activities at one destination.

- *Parks and open space*: land reserved for passive recreation, sport and recreation, preservation of natural environments, green space and/or urban stormwater management.
- *Safety and surveillance*: perceptions of safety influence the nature and extent that people use spaces and places. Design that aims to reduce crime can enhance the physical, mental and social wellbeing of a community.
- *Social inclusion*: refers to a society where all people and communities are given the opportunity to participate fully in political, cultural, civic and economic life.
- *Supporting infrastructure*: facilities that encourage regular and safe physical activity, such as walking (footpaths, lighting, water fountains and signs), cycling (bike paths, bike lockers, signs and showers), public transport (safe shelter, lighting and signs), social interaction (seating, shade, shelter and toilets) and recreation (seating, play equipment and facilities).

2.5.9 Queensland Chief Health Officer's Report *The Health of Queenslanders 2010*

The Third Report of the Chief Health Officer Queensland, The Health of Queenslanders 2010, reported that, in 2010, about half of Queensland adults were sufficiently active, with 54% of people aged 18–75 years reporting levels of physical activity sufficient for health benefit. While 63.1% of 5–15 year-olds participated in organised sport outside school in 2009, just over a third (37.4%) of young people participated in active travel to school.

Drawing on a World Health Organisation estimate that "one-third of physical inactivity levels can be prevented through environmental interventions alone", the report stated that environmental interventions in support of physical activity require:

> ...legislation and regulatory policy development and reform in sectors outside health such as urban planning, architecture, engineering, land development and all tiers of government. The design of urban environments can contribute to the health and wellbeing of communities by supporting active living, physical activity through walking, cycling and using public transport and opportunities for social interaction. The resulting built environment is characterised by infrastructure, land use, urban form and public transport that supports active living, neighbourhood aesthetics, and accessible public open space and destinations linked by public transport (Queensland Health, 2010, p. 117).

The above statement is consistent with many of the key principles of active transport—particularly that physical activity should be built into everyday lives through the design of our neighbourhoods, streets and other land use planning issues that influence transport choice. Indeed, much of the evidence contained in this report suggests that major gains in population health can be made through reforms in areas of public policy outside of the traditional health sector and this is apparent within the themes of the Chief Health Officer's Report.

2.5.10 Sustainable Transport

The Queensland Government has recently established an Office of Sustainable Transport. Its stated definition of a sustainable transport system is one that:

- meets the basic access and equity needs of individuals and societies
- societies can afford to construct, access and maintain
- offers choice, convenience and supports economic activity
- limits pollution and waste and consumption of resources to sustainable levels
- is resilient and capable of being continued with minimal long-term effect on the environment.

The Department of Transport and Main Roads webpage further states: "A sustainable transport system enables Queenslanders to benefit from [activities] while minimising adverse environmental, economic, and social impacts." (Department of Transport and Main Roads, n.d.) However, the discussion of why sustainable transport is important to Queenslanders mentions health only in the context of exposure to air pollution.

The broader aspects of health, as addressed by active transport programs and travel-behaviour change, are important to both the economic (e.g. the cost of health services and lost productivity due to poor health) and social (individual and community well-being) components of sustainability. The broader relationship between health and transport will be comprehensively discussed in Section 5.

3

Evaluation in Public Sector Decision-Making

3 Evaluation in Public Sector Decision-Making

Good public policy requires comprehensive evaluation of all impacts (benefits and costs) to allow decision-makers to understand the full effects of the alternatives they must choose from. More comprehensive evaluation helps identify the options that are most optimal overall, considering all impacts, and helps avoid solutions to one problem that unintentionally exacerbate other problems facing society.

There is an important distinction in public policy and public sector decision-making between policy objectives, which may be enunciated in legislation or in high-level decisions of government, and the strategies and programs to give effect to these objectives. The main emphasis of evaluation (including development of methodology) has usually been on strategies and programs rather than policy, except in the specific case of the use of economy-wide models of budgetary and fiscal policy.

In some cases, policy or legislation aimed at problem solving can be broken down into components that may be commensurate with programs and can be evaluated in the same ways as programs. This can be difficult, however, where:

- Different parts an individual policy interact with each other (in which case the effects of individual programs may not be separable)
- The policies (or legislation) may interact with other policies, creating problems of unclear boundaries (Bussmann, 2010)

Nevertheless, wherever choices have to be made, some form of assessment or evaluation must be undertaken, unless the choice is to be purely random. Sometimes, however, the evaluation is implicit, rather than explicit, in which case the real basis of the choice may be known only to the person making the decision.

Often the evaluation is only partial, on the basis of one or a small number of criteria rather than on the basis of the full range of issues the community would wish to be considered. This may be the case where decisions are made pursuant to public commitments made without full knowledge of the implications or where a particular objective is, at the time, seen as paramount. It is also the case where a decision is made on the basis of a single form of assessment, such as benefit-cost analysis, without consideration of the limitations and exclusions of such a methodology. This raises questions about the extent to which evaluation should be technically or professionally driven and the extent to which there should be a role for stakeholders and the community (see Section 4.2 below).

Often, policy choices are constrained by:

- the perceived need to continue existing programs unless these have been specifically nominated as 'temporary' or 'time-limited'
- political commitments that may conflict with a proposed new initiative or specify another means of achieving the objectives.

In the case of active transport:

- The focus has been on the transport and environmental (especially climate change) consequences, with less attention being paid to health and other social outcomes.
- The health focus has often been on the short-term imperatives of providing healthcare for current health problems (as, for example, measured by hospital waiting lists) to the detriment of the less tangible longer-term reduction of disease achievable through active transport.

Attempts to establish budget processes in which new proposals are considered on equal terms with existing programs (such as 'zero-based budgeting', in which all expenditures have to be justified, not just changes from the previous year) have not been widely successful, largely because of the resources required simply to undertake this form of budgeting on an annual basis[2].

3.1 Evaluation and Public Expenditure

Public sector expenditure proposals are usually subject to well-defined budgetary requirements, including a clear process distinction between capital and recurrent initiatives. However, the definition of capital and recurrent expenditure is more complex and less clear cut than current practice implies.

Governments generally define *capital investments* as those expenditures that create durable physical assets and generate benefits over an extended period of time. Such assets also generate recurrent costs (such as operation and maintenance costs) over time.

Capital investments may or may not generate a direct need for borrowing, but in a pragmatic sense all investments create a net borrowing requirement (an opportunity cost[3]) where the funds could otherwise have been used for another purpose which itself is funded from loans. Even where there is no borrowing, as might be the case with a 'zero-debt' local government, the funds could be returned to their source—there is an opportunity cost for those who provided the funds in the first place.

[2] See, for example, http://www.accountingformanagement.com/zero_based_budgeting.htm

[3] An opportunity cost is the cost related to the next-best choice available to someone who has picked between several mutually exclusive choices. In simple terms, opportunity cost is the cost we pay when we give up something to get something else.

Governments rarely regard the creation of social or human capital in the same terms as the creation of physical capital, yet it also produces benefits over a period of time. It may also require expenditures over a period of time, for example to cover the whole population in a gradual process with yearly stages, but this is conceptually no different from a road program or a school-building program, each of which will consist of a number of individual projects. Most importantly, social capital creates benefits across the triple bottom line, including health.

Adam Smith, often called the 'father of modern economics', regarded human capital as one of the four types of fixed capital—the others being: useful machines and instruments of the trade; buildings as the means of procuring revenue; and improvements of land. Initiatives that enable individuals to achieve desired outcomes (e.g. access to employment, education, recreation or better health) with fewer resources (e.g. cost of driving a car or use of medical services) should properly be regarded as capital.

Recurrent expenditures are defined as those necessary for the operation and maintenance (or consumption, where maintenance does not restore the asset to original condition) of capital assets. Recurrent expenditure does not result in the creation or acquisition of assets.

All this creates a 'no man's land' for initiatives where expenditure creates a continuing stream of benefits but without creating a physical asset and without creating the need for asset maintenance expenditure.

The most effective approach for gaining support and funding is likely to be to evaluate the proposed program as an investment, in terms comparable to those used or required for existing projects and programs, and to demonstrate its value to the community, irrespective of the likely source of funding. This is what most evaluations of voluntary travel-behaviour change have attempted to do, regardless of whether those evaluations are ex-ante (before the event—during the planning stage) or ex-post (after the event—based on the outcomes actually achieved by implementation). This establishes the business case for public expenditure, usually in the form of a community-wide benefit-cost analysis, but sometimes from a single perspective such as public transport (see, for example, Ker, 2003).

3.2 Evaluation and Transport

It is a fundamental principle of transport economics that the demand for transport is a derived demand. In other words, transport and travel are not valued for their own sakes but for what they enable us to achieve (e.g. travelling to work, visiting friends etc.). That being the case, there are circumstances in which we seek to minimise the amount of transport (to achieve given outcomes) as well as occasions when 'more is better' (if the range of outcomes is increased). The common practice of evaluating transport initiatives in purely transport terms (such as vehicle operating costs) does not provide an adequate basis for distinguishing between these circumstances.

Transport is a derived demand – the mobility is valued for what it allows us to achieve (i.e. getting to work, visiting friends), rather than an end in itself

Interestingly, the planning paradigm that is effectively based on universal car access does not apply to more than a bare majority of the population. Up to 45% of people either do not have a driver's licence (this includes children, at least some of whom have reasonable expectations of a degree of independent mobility) or do not have access to a car at any particular time. Add to that the fact that those with access to a car will need to act as chauffeur for the 45% who do not have access to one with increasing frequency and the inconvenience that results from the dominant planning paradigm starts to affect the majority. Moreover, as the Third Intergenerational Report illustrates, some 14% of Australians are currently over 65. In 2050, it is estimated almost one in four will be over 65 (Department of Treasury, 2010). Research on the ageing population shows a significant proportion of people cease driving as they get older and this trend is likely to affect a much larger proportion of the population in the future (Morris, 2007).

Research on the ageing population shows a significant proportion of people cease driving as they get older and this trend is likely to affect a much larger proportion of the population in the future. *Morris, 2007*

3.3 Comprehensive Analysis

Conventional planning tends to be reductionist; problems are assigned to individual agencies with narrowly defined responsibilities (Dora & Racioppi, 2003). For example, transport agencies are responsible for reducing traffic congestion and accidents, environmental agencies are responsible for reducing emissions and protecting wildlife habitat, and public health agencies are responsible for encouraging physical activity and improving mental health. This approach can cause these agencies to implement solutions to their problem that exacerbate other problems, and tend to undervalue strategies that provide modest but multiple benefits. For example, transport agencies can rationally expand roads to reduce congestion, even if this degrades walking and cycling conditions (and therefore discourages physical activity), and environmental agencies can implement fuel efficiency standards that, by reducing the per-kilometre cost of driving, stimulates more vehicle travel and therefore more congestion and accidents, and these agencies are likely to undervalue strategies such as walking and cycling improvements, because they provide only modest congestion and emission reduction benefits.

More comprehensive analysis helps identify 'win-win' strategies—that is, solutions to one problem that help reduce other problems facing society, such as congestion reduction strategies that also help reduce parking costs, improve mobility options for non-drivers, and increase physical activity and health, as illustrated in the table below.

	STRATEGY		
Planning Objective	Roadway Expansion	Fuel Efficient Vehicles	Improved Transport Options, Efficient Pricing, Smart Growth
Motor Vehicle Travel Impacts	*Increased*	*Increased*	*Reduced*
Congestion reduction	✓*	✗	✓
Road and parking cost savings	✗	✗	✓
Consumer cost savings	✓/✗	✓/✗	✓
Reduced traffic accidents	✗	✗	✓
Improved mobility options	✗	✗	✓
Energy conservation	✗	✓	✓
Pollution reduction	✗	✓	✓
Smart growth land use objectives	✗	✗	✓
Physical fitness & health	✗	✗	✓

Table 4: Comparing Strategies

Source: Litman, 2007

NB: Some transport improvement strategies only achieve one or two objectives (✓), and by increasing total vehicle travel contradict others (✗). Strategies that improve alternative modes; apply more efficient road, parking, insurance and fuel pricing; and create more compact, mixed land use help achieve many objectives.

*Whilst roadway expansion reduces congestion initially, similar levels of congestion return due to induced traffic (Newman & Kenworthy, 1999).

Cobiac et al (2009) only consider health benefits when evaluating the cost-effectiveness of programs for encouraging active transport. Of the programs evaluated, some only increase active transport while others (such as the TravelSmart program) also reduce automobile travel and so provide additional benefits, such as congestion reductions, road and parking facility cost savings, and accident and emission reductions. More comprehensive analysis can lead to very different conclusions about what strategies are most cost-effective, and create opportunities for cooperation among interest groups. For example, transport agencies have little reason to support programs that only encourage recreational walking and cycling, but should support programs that encourage walking and cycling as a substitute for driving or that help achieve their objectives in other ways such as reducing congestion and increasing facility costs savings.

The health benefits of active transport are a crucial component of benefit-cost analysis

Mobility Versus *Accessibility* - Implications for Active Transport Evaluation

Mobility refers to physical movement. *Accessibility* refers to people's ability to reach desired services and activities, such as work, school, shops and friends. Accessibility is the ultimate goal of most transport activity, excepting the small portion of travel without destination, such as recreational walking and automobile cruising; even holiday travel generally has a destination such as a resort or campground.

Various factors affect accessibility including vehicle mobility (the ease of automobile travel), transport system diversity (the variety of modes available, including walking, cycling, automobile and public transport), transport system connectivity (the connections between roads, paths and modes), land use accessibility (density and mix), and mobility substitutes such as telecommunications and delivery services.

Current planning tends to be *mobility-based*: it evaluates transport system performance based primarily on motor vehicle travel conditions using indicators such as vehicle traffic speeds, congestion delay, accident rates, parking availability and fuel price. This tends to justify planning decisions that favour automobile travel even if that degrades other forms of access. For example, a destination (such as a worksite, school or shopping centre) designed for convenient automobile access will be located on a major highway, often at the urban fringe, with generous parking supply, although that provides poor access by other modes.

Accessibility-based planning expands the range of solutions that can be applied to transport problems. For example, with mobility-based planning, the only logical solution to traffic congestion is to expand roadways. Accessibility-based planning also considers improvements to alternative modes, pricing reforms, more accessible land use development, and increased use of mobility substitutes such as telecommunications and delivery services.

Put simply, mobility-based planning ignores the benefits provided by travel reduction strategies because it perceives physical travel as an end in itself, rather than recognising that the ultimate goal of most mobility is *accessibility*. Accessibility-based planning recognises that reducing travel is sometimes the most efficient solution to transport problems.

Mobility-based planning tends to place little value on active transport modes, since, according to conventional travel surveys, they represent a relatively small portion (typically 2-5%) of total travel, and because they are slow, efforts to support and encourage active transport purposes are criticised as inefficient and backward, advocated by special interest groups. Mobility-based planning tends to give little consideration to the needs of non-drivers, in part because they are undercounted in conventional travel surveys and there is little information on their unmet travel demands.

Boosting density levels in new develops increases accessibility and reduces pressure on the transport system

Ultimately, decision-making based on conventional evaluation has not always delivered unambiguous benefits in terms of what the community really values (Eckersley, 1997). The social, environmental and health impacts of heavy reliance on the private motor vehicle for access and mobility are becoming more and more evident. Economic benefits are also being visibly eroded by increasing fuel prices and road traffic congestion.

The broader scope of evaluation required to address the triple bottom line has resulted in correspondingly far-ranging guidance for evaluators in many jurisdictions, including Queensland. These place benefit-cost analysis into a more complex decision-making context, one which includes such aspects as:

- Strategic fit
  - ensuring proposals fit with the strategic direction set out in the agency's investment and revenue strategy
  - addressing significant national or regional issues

- Effectiveness
  - evaluating how well do proposals contribute to a particular strategic objective
  - valuing proposals that achieve long-term, integrated and enduring solutions most

- Economic efficiency
  - ensuring proposals use resources efficiently and offer long-lasting benefits
  - assessing the economic efficiency of proposals according to:
    - the benefit-cost ratio (BCR) of proposals that add new or improved infrastructure or services
    - the cost effectiveness of ongoing maintenance, operations and public transport services. (New Zealand Transport Agency, 2010)

Similar guidance, with varying degrees of detail, can be found for Australia (Australian Transport Council, 2006a), the United States (US Office of Management and Budget, 2003) and the United Kingdom (Department for Transport, 2010e, which incorporates UK Treasury requirements on matters such as discount rates for benefit-cost analysis).

The Queensland Government published guidance through the Department of Infrastructure and Planning early in 2010 (Department of Infrastructure and Planning, 2010c). This Project Assurance Framework (PAF) is described in the following terms:

> The Project Assurance Framework (PAF) is the foundation framework for ensuring that project management is undertaken effectively across the Queensland Public Sector, and delivers value for money to the government from its significant investment in project activity.
>
> PAF is a whole-of-government project assessment process that establishes a common approach to assessing projects at critical stages in their lifecycle. Its aim is to maximise the benefits returned to government from project investments. (Department of Infrastructure and Planning, 2010a, p. 2)

Under the PAF, projects have:

- one pre-project stage:
    - strategic assessment of service requirement
- six generic project stages:
    - preliminary evaluation
    - business case development
    - supply-strategy development
    - source supplier/s
    - establish service capability
    - deliver service

At the end of each stage, a decision should be able to be made about the readiness to proceed to the next stage of the project (Department of Infrastructure and Planning, 2010c).

The study of which this report is the first stage largely covers the pre-project stage (strategic assessment of service requirement) and the first two of the project stages (preliminary evaluation and business case development).

3.4 Triple Bottom Line and Sustainability Evaluation

Increasingly, government and community are concerned with the long-term sustainability of our cities and transport systems. Sustainability is most simply represented in terms of the triple bottom line: economic, environmental and social. Benefit-cost analysis (BCA) incorporates the economic and, to some extent, the environmental impacts, but is largely unable to adequately reflect social impacts or other impacts that cannot be quantified. Other assessment methods, such as multi-criteria analysis (MCA) or other (quantitative and qualitative) methods are necessary to fully reflect the value to the present and future community.

Benefit-cost analysis also involves discounting the future, which some argue conflicts with protecting the interests of future generations. Certainly, the rate of any such discounting must be very carefully scrutinised. Initiatives concerned with the long-term future and sustainability are severely disadvantaged by the common Australian practice of requiring the future to be discounted at a rate comparable to the market rate of interest. Queensland, however, does not specify a rate but makes it clear that calculation of the rate for evaluations should be based on values excluding inflation (Department of Infrastructure and Planning, 2010b).

Improved opportunities for active transport will deliver measurable outcomes of three kinds:

1. enhancing and sustaining economic prosperity
2. sustaining and protecting the natural and built urban environments
3. enhancing social outcomes, including the access opportunities for people currently mobility-poor. Health benefits from active transport can be accounted under both the economic and social categories.

Every part of this triple bottom line will also be enhanced by the positive health effects of regular physical activity that comes with use of active transport.

3.4.1 Multiple Bottom Lines

There is nothing new in multiple economic, social and environmental objectives for transport projects. For example, major road projects will often state objectives in respect of:

- transport, such as reducing traffic in congested areas, improving access by other means, reducing traffic on local streets and reducing road trauma
- land use planning, such as minimising planning blight, providing a catalyst for redevelopment and maintaining economic activity
- social, environmental and economic, such as encouraging inner city living, heritage retention, enhancing amenity, improving equity of access and minimising air and noise pollution.

The evaluation response, however, has usually been poor in terms of measuring impacts other than those directly related to transport (such as travel time, travel costs etc.) or, more recently, the physical externalities of transport (such as air pollution, greenhouse gas emissions etc.). Moreover, even where broader impacts are quantified, the evaluator usually attempts to reduce these to a single cardinal or ordinal measure—either in the context of benefit-cost analysis, where all things are reduced to a monetary equivalent, or in the context of multi-criteria analysis, where a range of criteria are weighted to produce a ranking of projects for decision-making purposes.

The real problem with both approaches is that a very large amount of information is lost in the process of measurement and aggregation. Some form of goals achievement matrix is an alternative that is rarely considered by technocrats on the grounds that it is too difficult to interpret and does not give unique and clear results. In the United Kingdom the development of a "new approach to appraisal" (Department of Environment, Transport and Regions, 1998), has now been incorporated into formal guidance on evaluation in transport (Department for Transport, 2010a). This includes the development of an Assessment Summary Table (AST) as the core of the integrated assessment process—this is effectively a goals achievement matrix. Furthermore, this form of disaggregated presentation of impacts has been demonstrated to have a systematic and transparent influence on decision-making (Nellthorp & Mackie, 2000).

In 1998 the National Greenhouse Strategy called for an integrated assessment framework (Figure 5) for urban transport investment that takes into account greenhouse issues and raised the question of what such a framework would look like and how it might be implemented (Australian Greenhouse Office, 1998). In 2000 this question was answered in a report developed for the Australian Greenhouse Office (Allen Consulting, 2000). The outcome challenged some of the key assumptions of traditional transport evaluations and highlighted some key areas of improvement necessary if evaluation were to play an effective role in transport decision-making. The most significant of these were:

- identifying relevant options to evaluate
- understanding and estimating the cause-effect relationship of interventions
- allowing for feedback
- including all significant outcomes in the evaluation
- exposing rather than hiding component information on costs and benefits (Allen Consulting, 2000).

3.4.2 Sustainability Assessment

Sustainability assessment is more than simply accounting to each of three separate bottom lines:

> Sustainability assessment is designed to work through the social and economic issues in a transparent way (similar to that for environmental considerations) and then to find integrated solutions where trade-offs are minimised or non-existent wherever possible. (Western Australian Government, 2003, p. 39)

This means that the way a project is defined might need to be revisited as more information is obtained on its likely effects and on alternative ways of achieving the objectives. This means that evaluation ceases to be linear and confined; instead, it must be open to influences normally considered beyond its scope in order to facilitate change and improvement in programs, projects and delivery.

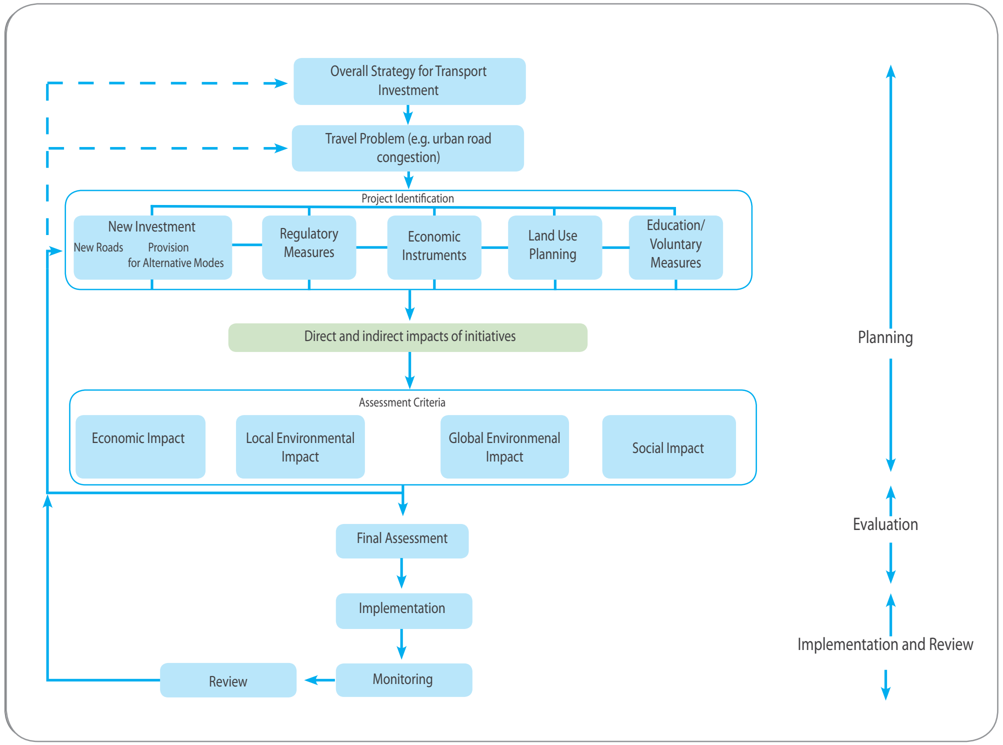


Figure 5: Integrated sustainability assessment framework for transport
Source: Developed from Allen Consulting (2000)

3.4.3 Sustaining the Economic Bottom Line

The urban transport economy is vitally important to the prosperity and wellbeing of individuals and the community. A measure of its importance is the large part of household incomes spent on mobility. On average some 16% of household expenditure was spent on transport in 2006, comparable with housing or food (Australian Bureau of Statistics, 2008). Add to this public expenditure on roads, other transport infrastructure and services, and its significance becomes even greater. Many of these public expenses are externalised—that is, they are not covered by users. Congestion, road traffic injuries and pollution are examples of external costs.

The benefits of mobility are also significant, including access to opportunities for education, recreation and employment, as well as individual, social, community and economic development. But if the cost to households of obtaining these benefits increases, then income available to spend on other items and services, such as housing, food, clothing, health and recreation, will be reduced correspondingly. The petrol price rises beginning in 2004 illustrate this point: higher fuel costs hampered the public's ability to spend in other areas of the economy (Blythe, 2006).

Encouraging active transport provides options for people looking to avoid high fuel costs

Improving the feasibility of walking and cycling as alternatives to driving helps consumers avoid the costs of operating a car at the very minimum. In some cases, households may even be able to dispense with one or more cars, thus saving the costs of ownership (registration, insurance and depreciation) as well. The Royal Automobile Club of Queensland found the cost of owning and operating a medium-sized car to be around $222 per week or $11 544 annually (Royal Automobile Club of Queensland, 2010).

3.4.4 Sustaining the Environmental Bottom Line

Public policy should also be aimed at contributing to environmental sustainability by providing alternatives to car-based travel. There is little argument about the lower levels of environmental impact—including carbon emissions—produced by active transport compared with those created by car travel performing the same task. The debate, where it occurs, is in regard to whether active transport can provide an acceptable alternative that replaces a large enough proportion of car-based travel to make a worthwhile difference.

Motorised transport activities contribute to deterioration of air quality, global climate change (by increasing greenhouse gas emissions), pollution of water run-off and urban noise pollution. These impacts can be limited by restraining the growth of car travel, but only if infrastructure and services for alternative modes of travel are available to attract potential users. Alternatives to driving (such as cycling, walking and public transport), when they serve the need for access effectively, require less land to carry the same number of people, use less fossil fuel and produce lower levels of carbon dioxide and other emissions.

3.4.5 Sustaining the Social Bottom Line

Transport can have a major impact on the social health of communities (Giles-Corti et al, 2010, citing two sources). Public policy should also seek to enhance sustainable social outcomes by maximising opportunities of access for those without a car.

Social exclusion issues can arise when transport opportunities to employment centres and other key destinations are limited to one mode of transport—the private motor vehicle. A substantial proportion of the population either does not have a driver's licence (for reasons of age, disability or choice) or has no guaranteed access to a car for a range of trip purposes (because they do not own a car or there are more drivers than cars in the household).

Poor access to transport, public and private, motorised and non-motorised, can contribute to problems such as long-term unemployment, poor educational outcomes, ill-health and poor social integration. Lack of transport to attend job interviews can be an impediment to taking the first step towards gaining employment in some cases (Mason & Lake, 2000). The more people are both willing and able to use active transport, the less they will be constrained by lack of access to a car or by poor public transport (Social Exclusion Unit, 2003).

Many studies have highlighted the close relationship between social networks on the one hand and morbidity and mortality rates on the other, with some studies concluding that the mortality risk for people without social support is two to three times higher than for people with better social networks (van Kemenade et al, 2003, citing four sources).

The positive effects of social integration and support counter the risks associated with tobacco, obesity, high blood pressure and physical inactivity. There is substantial evidence that streets supportive of active transport enhances social interaction and improves social networks (Hart, 2008).

Low traffic volume streets encourage social interaction

3.5 Key Requirements for Active Transport Evaluation

The two key requirements for evaluating active transport initiatives are the abilities to:

1. Quantify the change in travel activity (increased walking and cycling, reduced driving) that is likely to come about as a result of the initiative. This level of evaluation is dealt with in Section 6.
2. Translate the behaviour change into estimates of those things that are of value to the community, such as improved health, lower cost of transport and better environmental outcomes. This level of evaluation is dealt with in Section 6 and 7.

In some respects, measurement of these will be a valid evaluation outcome in their own right when there is a related strategic policy objective—for example, reduction in sedentary lifestyle disease or reduction in greenhouse gas emissions.

To derive a comprehensive assessment of active travel in a benefit-cost framework, however, it is necessary that, wherever possible, these outcomes be monetised (valued in dollars) as well as quantified. This aspect of evaluation is dealt with in Section 7 and 8.

4 Evaluation Tools and Methodologies

4 Evaluation Tools and Methodologies

Evaluation in the public policy context has to serve (at least) two purposes:

- demonstrate the value of the initiative (program or project) in absolute terms—will the present and future community be better off as a result of it?
- provide comparative information to allow the initiative to be assessed relative to others competing for public funding—will it provide better results than other innitiatives?

In addition, especially for initiatives that generate a revenue stream or an ongoing series of operating costs (such as public transport), a financial analysis is also required to assess the present and future impacts on public sector finances. Financial analysis is relevant for active transport initiatives to the extent that improvements in health will reduce the pressure on the health system.

Evaluation tools for active transport are of two main types:

- *Generic tools* assist in making indicative estimates of the benefits of active transport without reference to any specific program, project or spatial context. By definition, these tools are limited in the extent to which they can reflect specific circumstances. For example, the International Council for Local Environmental Initiatives (ICLEI) and the World Health Organisation (WHO) tools still require independent estimates of the extent of active transport to be provided as inputs to the calculation of benefits (see Section 4.1 over page). Generic tools provide some useful information for evaluation of active transport but are not sufficient in their own right.
- *Specific methodological tools* provide a robust assessment framework comparable to those used for other public sector initiatives and thus provide an ability to compare between projects and programs in the public sector. These tools require independent information on the extent of active transport and on its effects (and the values of those effects). The generic tools may be used to provide indicative information on the latter, but a robust evaluation will require project-specific information.

Evaluation tools for active transport should be structured to capture the unique benefits of walking and cycling.

4.1 Generic Tools for Evaluation of Active Transport

A number of tools have been developed to assist in providing indicative estimates of the benefits of active transport. They generally do so on the basis of the value of a specified increase in active transport, without reference to the feasibility of achieving that level and using generic (albeit research-based) values for the impacts.

The following matrix provides a summary of our evaluation of the best studies and tools that attempt to quantify (and monetise) the benefits of active transport. A more detailed examination of some of the key models follows this matrix.

STUDY OR TOOL	DESCRIPTION	ANALYSIS SCOPE	ANALYSIS METHODOLOGY	STRENGTHS	WEAKNESSES
ICLEI Active Transport Quantification Tool (ICLEI, 2007)	Estimates the health, community and environmental benefits of walking or cycling.	Includes user cost savings, reduced mortality and reduced pollution.	User-specified changes in active transport for each of five types: • walking school bus • walk to school • ride to school • walk to work • ride to work	• Available at no cost as an online tool. • Straightforward to use.	• Incomplete for evaluation purposes. • Only considers some benefit categories. Health effects limited to: o mortality, not morbidity o type 2 diabetes and coronary heart disease. • Mixes financial and economic values–limited suitability for benefit-cost analysis.
World Health Organisation: Health Economic Assessment Tool (Cavill et al, 2007)	Evaluates health benefits of cycling	Health benefits	Quantifies monetised value of health benefits from a specific increase in cycling by a specific population.	• Available at no cost as an online tool. • Straightforward to use. • Based on best current information on cycling health impacts.	• Incomplete for evaluation purposes. • Only considers cycling, not walking. • Health effects limited to mortality (does not include morbidity). • Based on European conditions.
Victorian and Australian Greenhouse Office Workplace Travel Planning Benefits Calculator (Ker & Sidebottom, 2004; Sidebottom, 2005)	Provides indicative estimates of the benefits of workplace travel planning (WTP). Designed as a demonstration tool to interest businesses in WTP.	Identifies benefits to employees, employers and the community, including health benefits.	Research-based estimates of travel outcomes of workplace travel planning in user-defined situations coupled with benefit values derived from Australian and international research.	• Straightforward to use. • Allows user to specify situation for analysis.	• Incomplete for evaluation purposes. • Health effects limited to mortality (does not include morbidity). • Walking based on cycling research. • Values and algorithms are locked and cannot be modified or updated by the user.
Evaluating Non-Motorised Transport Benefits and Costs (Litman, 2010)	Identifies various categories of non-motorised transport benefits and costs.	Broad range of benefits and costs.	Comprehensive framework for evaluating non-motorised transport benefits and costs, including safety and health impacts.	• Comprehensive. • Defines various impacts and describes methods for quantifying and monetising them.	Provides limited detail on each impact. Methodologies and estimates are mainly based on other sources.
UK Transport Analysis Guidance (Departemnet for Transport, 2010a)	Provides official guidance for evaluation of walking and cycling schemes.	Broad range of benefits and costs, including externalities and health effects.	Applies conventional benefit-cost analysis framework to the outcomes of walking and cycling initiatives. Incorporates additional factors, including health benefits, absenteeism, environmental benefits and journey ambience.	• Methodology and values integrated with the overall guidance on appraisal of transport initiatives (DfT, 2010b) and consistent with Treasury requirements for project appraisal (DfT, 2010c).	Health effects limited to mortality (does not include morbidity). Does not deal with behaviour change initiatives as such, although the guidance is likely to be transferrable.

Table 5: Summary of the major studies to quantify and monetise benefits of active transport *(continued over page)*

Continued from previous page

STUDY OR TOOL	DESCRIPTION	ANALYSIS SCOPE	ANALYSIS METHODOLOGY	STRENGTHS	WEAKNESSES
New Zealand Economic Evaluation Manual (Land Transport New Zealand, 2006)	Provides official guidance for evaluation of travel demand management and of walking and cycling schemes.	Broad range of benefits and costs, including externalities and health effects.	Applies conventional benefit-cost analysis framework to the outcomes of travel demand management, walking and cycling initiatives.	• Methodology and values integrated with the overall guidance on appraisal of transport initiatives (LTNZ, 2006). • Provides separate values for walking and cycling.	• Health effects limited to mortality (does not include morbidity). • Does not deal with behaviour change initiatives as such, although the guidance is likely to be transferrable. • Research basis for different walking and cycling values not demonstrated.
Applying Health Impact Assessment To Land Transport Planning (New Zealand Transport Agency, 2009)	Provides guidance for health impact assessment (HIA) in transport planning	Transport planning. Only considers health impacts (no other benefits of non-motorised transport	Describes and reviews the scope and methods used for Health Impact Assesment.	• Discusses best current practices for evaluating health impacts. Recommends comprehensive evaluation of health impacts. Recommends incorporating health impacts into comprehensive benefit/ cost analysis	• Only provides general guidance. Does not include specific monetised values.
The Hidden Health Costs of Transportation (American Public Health Association, 2010)	Estimates the costs of automobile-dependent transport	Includes monetised estimates of obesity, air pollution and accidents	Uses unit costs for obesity, air pollution and crash costs from previously published literature (Fincklestein et al, 2009; Federal Highway Administration, 2000; AAA, 2008).	• Quantifies and monetises three major risks.	• Only provides total costs. Offers little detail or guidance for applying cost values to a particular situation.
Walking, Urban Design, and Health: Toward a Cost-Benefit Analysis Framework (Boarnet, Greenwald and McMillan, 2008)	Provides monetised estimate of physical activity benefits	Develops a framework for valuing the health benefits of urban design improvements that increase walking activity.	Estimates benefits of improving neighbourhood walkability from the 50th percentile to the 75th percentile (lower value) and the 95th percentile (higher value), for a hypothetical 5000-resident neighbourhood.	• Provides quantified values of increased walking.	• Incorporates many assumptions that may not be transferable to other situations. • Only considers certain health benefits.
Cost-Effectiveness of Interventions to Promote Physical Activity (Cobiac, Vos and Barendregt, 2009)	Models the cost impacts and health outcomes of six physical activity interventions in Australia.	Health benefits of specific programs.	Assigns dollar values to various programs that increase disability-adjusted life years (DALYs).	• Provides specific dollar values to specific programs	• Focuses on programs, not transport policy changes. • Uses standard values.
Household TravelSmart evaluations (Ker and James, 2000; Ker, 2004, 2008a; Ker and Ringvall, 2006)	Evaluates benefits and costs of IndiMark™ in Western Australia and Queensland	Broad range of benefits and costs, including externalities and health effects.	Applies conventional benefit-cost analysis framework to the outcomes of travel behaviour change initiatives. Values for benefits derived from international research, except: • congestion (based on BTRE, 2007) • climate change.	• Methodology consistent with national (ATC, 2006) and Queensland (DIP, 2010) transport appraisal guidelines. • Benefit values can be updated and range of values extended on the basis of external evidence. • Allows alternative benefit values to be applied–e.g. where values differ between times and places (such as congestion). • Facilitates sensitivity analysis through application of ranges for any item of cost or benefit. • Methodology and values are transferable to other contexts–e.g. cycling infrastructure (Ker, 2009b) and school active travel (Ker, 2006).	• Benefit values may not be transferrable between situations and places. • Health effects limited to mortality (does not include morbidity).

Table 5: Summary of the major studies to quantify and monetise the benefits of active transport

4.1.1 Active Transport Quantification Tool

The International Council for Local Environmental Initiatives (ICLEI), has developed an 'Active Transport Quantification Tool'. This tool was primarily designed to provide feedback to schools but it could also be used in a larger-scale evaluation context (ICLEI, 2003).

The Active Transport Quantification Tool provides an indication of what might be achievable in a particular scenario, based on reasonable interpretation of experience elsewhere. The tool can be used in ways that support estimation of benefits for these scenarios.

However, the Active Transport Quantification Tool differs from those tools that have been used in previous Brisbane travel-behaviour change evaluations in that it uses different values for some of the key impacts (Ker & Ringvall, 2006; Ker, 2007). More importantly, some of the values used in the Active Transport Quantification Tool are measured as benefits for individuals (financial benefits) whilst others are socioeconomic values, so they cannot easily be aggregated into a single value.

Although there is a substantial emphasis on health, this value is estimated only with respect to mortality, using the concept of population attributable risk (PAR)—a measure of the number of deaths that would not occur in the absence of a risk factor (physical inactivity)—to calculate the benefits of increased physical activity.

The Active Transport Quantification Tool fails to include the increased life expectancy due to greater levels of physical activity. For example, Hillman (1997) estimated that in the United Kingdom, for every life year lost as a result of increased cycling (bearing in mind that cycling has a higher accident rate than motorised modes) 20 life years are gained through improved health and fitness. It is not clear to what extent a similar outcome is achievable through active school travel programs, but it does strongly indicate that the estimates of health benefits derived by the Active Transport Quantification Tool are on the low side.

There is also no reference to or value for mental health effects. The Active Transport Quantification Tool's health benefit value is based on a limited number of (albeit the most important) physical health impacts: coronary heart disease and diabetes. There is no reflection of mental health or psychosocial benefits, which are also likely to result from greater physical activity—especially where this has an element of interacting with others (e.g. walking school bus).

Yet there is evidence that, in addition to increased physical health and fitness, physical activity also provides benefits in terms of mental health. According to the New Economics Foundation (NEF), "regular physical activity is associated with a greater sense of wellbeing and lower rates of depression and anxiety across all age groups. It is not clear, however, if regular exercise has a direct influence on feelings of wellbeing or whether wellbeing is a determinant of regular exercise behaviour" (2008, p. 6).

Finally, the Active Transport Quantification Tool assumes that there is no health/mortality benefit until 10 years after the commencement of active transport, although it acknowledges that many of the non-health benefits would arise at the time the active transport started. The time at which beneficial impacts on health start to manifest themselves is a key issue for evaluating the health benefits of active transport, but not for most of the other impacts that derive directly from the change in travel behaviour.

4.1.2 Health Economic Assessment Tool (HEAT)

The World Health Organisation has developed an economic evaluation tool for assessing the health benefits of cycling (Cavill et al, 2008). The Health Economic Assessment Tool (HEAT) is primarily aimed at answering the question: if X people cycle Y distance on most days, what is the economic value of mortality rate improvements?

The HEAT for cycling is said to be based on the best available evidence, with parameters that can be adapted to fit specific situations. Default parameters are valid for the European context and should not, therefore, be assumed to be appropriate for Queensland.

The HEAT for cycling is based on mortality alone, with no consideration of morbidity or wellbeing, as evidence on morbidity is weaker than for mortality. This will produce very conservative estimates of health benefits from cycling (Cavill et al, 2008).

The HEAT uses the 'value of a statistical life', which is commonly used in transport evaluations, but does not address the important issue of whether the 'human capital' or 'willingness-to-pay' values should be used. Willingness-to-pay is more consistent with the economic theory underpinning benefit-cost analysis, but the human capital approach is most commonly used in transport evaluations. Willingness-to-pay values are typically two to three times the human capital values (Australian Transport Council, 2006a, p. 76) and are used in the United Kingdom (Department for Transport, 2010).

The HEAT adopts (apparently by assumption) a five-year "build-up period" for the health impacts, but it is more likely that this period would vary between the various manifestations of disease due to inadequate exercise and also according to demographic factors including the age of the individual.

Ideally, a methodology for economic appraisal would allow one to assess the health effects related to both walking and cycling, as both will be enhanced by active transport initiatives. However, the evidence is much better for cycling than for walking (Cavill et al, 2008, p. 11) and the HEAT applies only to cycling.

The HEAT for cycling is being used as a component of benefit-cost evaluation for active transport initiatives in several countries within and outside the European region, including Austria, the Czech Republic, Sweden, the United Kingdom and New Zealand. However, only Sweden and the United Kingdom appear to have incorporated it into formal evaluation guidance (World Health Organisation, 2010). The United Kingdom uses the HEAT as the basis for both cycling and walking, but with some strong qualifications (Department for Transport, 2010d, pp. 18–20):

- It is likely to underestimate the health benefits of increased physical activity as it only evaluates the benefit as a result of decreased mortality and ignores benefits due to reduced morbidity or sickness. …The potential morbidity benefits are likely to be relatively significant as well and may even compare at approximately the same level against the reduced mortality benefits.
- There is no detailed evaluation that is specifically applicable to walking (although WHO plan to develop a walking-specific method also). It is intuitive that the relative risk reduction in all-cause mortality of walking is different to that of cycling for the same amount of time travelled. Walking generally should provide greater benefits to the average individual over the same distance travelled.
- A general assumption must be made concerning the impact of a shift to walk or cycle. … An active individual already partaking in physical activities may derive little or no additional benefit from walking or cycling to reduce the chance of death by inactivity, or have a reduced relative risk through being partially active. There are some allowances made for this in the HEAT methodology, although without evidence at likely disproportionate cost, this is rather speculative and subject to a large degree of uncertainty.
- …There is a period where the health benefits will accrue over time until an individual is deemed "fully active" and to derive the full health benefits of their trip-making activities by active modes. Further research is required to better define this accrual period. [Five years is suggested as appropriate.]

4.1.3 Victorian and Australian Greenhouse Office Workplace Travel Planning Benefits Calculator

A comprehensive evaluation tool for workplace travel planning was developed by Ker and Sidebottom (2004) for the Victorian Department of Infrastructure. This specifically identified three areas of stakeholder benefits: employees, employers and the community. Health-related benefits, from different perspectives, feature in each of these three areas.

The community health benefit was based solely on mortality effects, on the basis that there was insufficient information for estimation of wellbeing/quality-of-life effects. The tool did not attempt a formal benefit-cost analysis, partly because the costs and impacts of workplace travel plans are highly variable, but equally because the quality of the process of developing a travel plan is itself a major contributor to effectiveness. As a result, it makes no assumption about the timing of the health effects or the extent to which there would be a build-up period. This tool was subsequently extended from Melbourne to be applicable to all Australian capital cities to reflect specific city situations (Sidebottom, 2005).

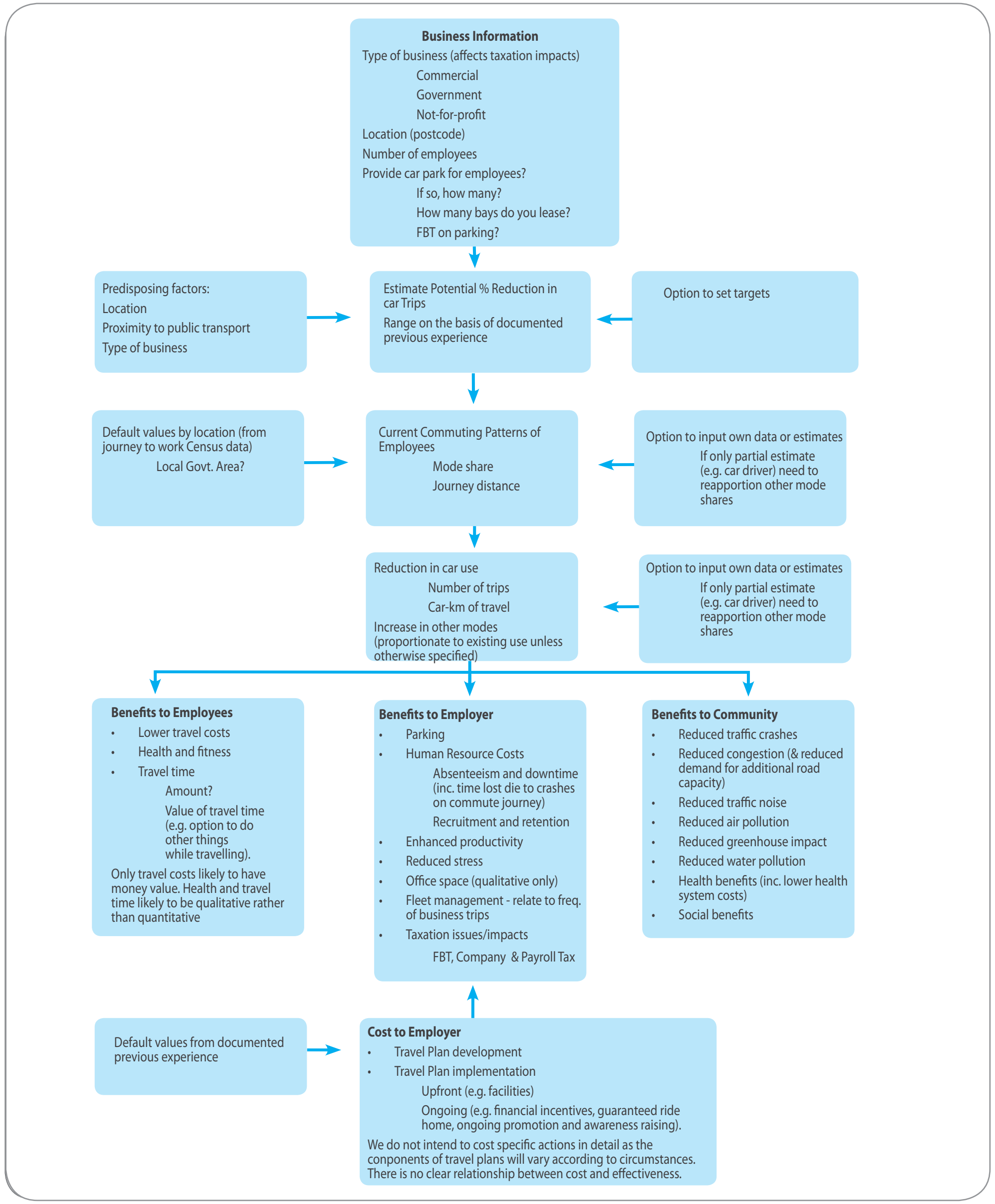


Figure 6: Workplace travel planning benefit assessment framework
Source: Ker & Sidebottom (2004)

This tool was found to be useful in explaining the benefits of workplace travel planning to stakeholders and effective in encouraging businesses to participate in the Victorian Government program. Although it has not been used specifically for evaluation of travel-behaviour change in the workplace context, it could be used in such a way, substituting actual achieved travel-behaviour change for the indicative research-based values contained in the model.

4.2 Specific Evaluation Tools

Each of the generic tools outlined in the previous section can, in principle, be applied to specific situations, but there will almost certainly be situation-specific factors that limit the applicability of the values embedded in them. The most commonly used tools for project evaluation in transport, and probably in the public sector generally, are benefit-cost analysis (BCA) and multi-criteria analysis (MCA). In addition, especially for initiatives that generate a revenue stream or ongoing operating costs (such as public transport), a financial analysis is also required to assess the present and future impacts on public sector finances.

All evaluation methods other than BCA are liable to the criticism that they do not permit objective comparison of disparate projects. Benefit-cost analysis, on the other hand, is criticised for reducing everything to monetary terms. However it is rarely acknowledged that BCA and MCA are mathematically identical, since both require a common unit of measure to compare disparate impacts. Therefore, whilst BCA has often been criticised for reducing everything to monetary terms, the most commonly-used alternative is, in essence, no different. One clear distinction, however, is that BCA makes explicit the way it treats the future relative to the present, whereas in MCA any such treatment is implicit and not specifically stated.

Practitioners of MCA do sometimes apply sensitivity analysis by varying the weighting of component criteria, which is equivalent to the use of a range of values. Vedung (2010) identifies four waves of evaluation:

- the science-driven wave, ideally involving a controlled experimental approach
- the dialogue-oriented wave, sometimes characterised as 'democratic evaluation'
- the neo-liberal wave, placing reliance on the 'presumed efficiency of markets'
- the evidence wave, which places greater emphasis on identifying what works.

These roughly equate to benefit-cost analysis, multi-criteria analysis, financial analysis and integrated analysis respectively.

In Australia—and specifically in the area of transport—the science-driven (BCA) wave was never fully overtaken by the dialogue-oriented wave, largely as a result of the practice of BCA being adopted by road planners and engineers. The neo-liberal wave occurred later in Australia than in many places and lingers in the requirement in all jurisdictions (federal, state and territory) that market-based discount rates be used in BCA, which ignores the requirement for both prices and discount rates to be in real terms.

Infrastructure Australia is an organisation that seeks to identify "reforms and investments which are vital to ensure Australia's economic infrastructure continues to support and drive the nation's economic, social and environmental success" (Infrastructure Australia, 2010, p.3). In their guidelines for making submissions to the organisation's infrastructure planning process, Infrastructure Australia (2010, pp. 22–23) requires a combination of benefit-cost analysis and other methods, so that proposals:

- Demonstrate robust and objective benefit-cost analysis which is supported by strong evidence.
- Consider as many monetised economic benefits and costs as possible.
- Ensure that all benefits and costs are economic impacts and not simply transfers, second-round effects, or financial in nature; all impacts are incremental; and all are directly associated with the initiative.
- Consider non-monetised benefits and costs. Where impacts cannot be robustly expressed in money units ('non-monetised'), Infrastructure Australia will nevertheless incorporate them into the appraisal process and requests proponents to provide supporting information on the scale of these impacts.
- Consider both the overall efficiency of an initiative (the combined scale of benefits and costs), as well as its equity and distributional impacts.
- Consider issues of risk and uncertainty. Infrastructure Australia is fully aware that the future cannot be predicted with certainty, and that economic growth, individuals' behaviour, oil prices, carbon prices and so on may vary over time. To ensure that the appraisal process is robust to potential changes, Infrastructure Australia requests a series of sensitivity tests of the demand modelling and benefit-cost analysis results.

4.2.1 Benefit-Cost Analysis

Benefit-cost analysis is a means of comparing the costs and impacts of a proposed project. Impacts can be both positive (benefits) and negative (usually treated as negative benefits). However, the scope of BCA is limited to those impacts that can reasonably be given a monetary value, either because they are traded in a market or because people can be observed making trade-offs with other items that are traded in a market.

In general terms:

- Economic impacts are most likely to have an observable monetary value.
- Environmental impacts often have estimated monetary values, but these estimations have limitations as the observed trade-offs are usually based on imperfect information, especially with regard to long-term issues.
- Social impacts rarely have estimated monetary values.

As BCA primarily reflects the economic bottom line, even when dealing with environmental or social impacts, other assessment methods, such as multi-criteria analysis or additional (quantitative and qualitative) methods, are necessary to fully reflect the value to the present and future community.

Social benefit-cost analysis is not a form of financial analysis, although it uses much of the same nomenclature (e.g. monetary units of value) and many of the same methods (e.g. discounting the future) as financial analysis does. Social benefit-cost analysis is much broader than financial analysis in scope, in that it incorporates effects beyond those experienced by those responsible for the initiative or even by the users and direct beneficiaries. This is important because:

> ...what counts as a benefit or loss to one part of the economy—to one or more persons, or groups—does not necessarily count as a benefit or loss to the economy as a whole. …In cost-benefit analysis we are concerned with the economy as a whole; with the welfare of a defined society and not any smaller part of it. (Mishan, 1971, p. 6)

The Conceptual Basis for Benefit-Cost Analysis

Benefit-cost analysis is an application of what is known as welfare economics, which is a branch of economics that seeks to evaluate economic policies in terms of their effect on the wellbeing (originally referred to as "utility" in Pigou, 1961) of the community, which is, in turn, seen as being comprised of the sum (no more, no less) of the individuals that comprise it.

The fundamental rationale is not the oft-quoted 'Pareto principle', which states that there is a welfare improvement from social state A to social state B if at least one person prefers B and no one else opposes it (often explained as a change qualifying as a welfare improvement if at least one person is better off and none are worse off). Instead, BCA separates itself from equity and distributional issues by using the concept of 'potential Pareto improvement', in which it would be theoretically possible for those who gain (benefit) to compensate those who lose—more simply expressed as the aggregate benefits exceeding the aggregate losses (or costs). In practice, it is rarely possible for the gainers to compensate the losers as doing so would involve a substantial cost, even if it were technically feasible.

This inability to formally consider distributional, equity and related issues is a limitation of BCA that has become of increasing concern as social consequences have become an increasingly important part of evaluation in the form of the triple bottom line. Because social issues (including health) are relatively recent additions to the transport evaluation paradigm, there is a much smaller body of evidence on which to base benefit-cost evaluation.

Benefit-cost analysis has some important strengths in developing and assessing public policy:

- It provides a consistent and coherent framework.
- It reduces diverse components to a small number of values.
- It is readily amenable to sensitivity analysis.

On the other hand, BCA can be criticised on the basis that:

- It can give a spurious impression of precision and certainty by reducing diverse effects to a single value.
- It favours the status quo because of its investment in methodology and monetisation of benefits as ways that things have historically been done.
- The emphasis on 'no double counting' precludes consideration of intermediate outcomes, even though these can be legitimate policy objectives in their own right.

Traditional socioeconomic evaluation methods have consistently resisted the tendency to double count benefits. For example, it is well established that travel-time savings from urban transport improvements are, to a large extent, capitalised into property values. Therefore only the travel-time savings are counted and the property value impacts are regarded as a distributional issue. This is entirely correct when we are attempting to encapsulate evaluation in a single value. But what if we are specifically interested in the distribution of benefits, as we are when addressing the triple bottom line? In this case, we must clearly present all impacts in a disaggregate form, provided we make it clear where the benefits end up. Thus, it is important we demonstrate where travel-time savings end up (for example, they may be taken out in travelling further for the same activities rather than in travelling the same amount in less time and using the time for something other than travel).[4]

Some of the limitations regarding BCA include:

- It does not deal with distributional/equity issues.
- It entails assumptions about monetisation. There is much concern about converting some impacts (especially those relating to human wellbeing) to monetary values. However, values in BCA are largely derived from choices people and communities already make, either in exchange for money (in the case of effects for which there is an observable market) or in trade-offs with other things for which there is a market and price.
- It cannot effectively incorporate qualitative factors.
- It entails discounting the future, which may conflict with sustainability (see "Discounting the Future" below).

Overall, BCA is a proven way of dealing with objective evidence on diverse outcomes of proposed programs and projects. Monetary values in BCA are derived from observable behaviour, with the result that conclusions and decisions based on those conclusions are transparent and verifiable and, in turn, provide accountability for those decisions and conclusions (Ergas, 2009). Benefit-cost analysis can also be progressively improved with experience, as Ergas (2009, pp. 2–3) explains:

> [Benefit-cost analysis] attempts to systematically measure impacts and the values placed upon them and does so in a way that is comparable from study to study. The repeated attempts generate:
>
> - A body of quantitative techniques for measuring impacts with some degree of rigour
> - Better tools for understanding how people actually behave in the face of changes…
> - Lessons from the falsification of specific types of past analysis…
> - A body of evidence accumulates over time and across countries that can be used to calibrate future models better.

[4] The average travel time per person per day is consistently 55-65 minutes, irrespective of the type of city, predominant mode of transport or average speed of travel, for the same number of activities.

Discounting the Future: Compatibility with Sustainability

Benefit-cost evaluation requires that the future be given a lower value than the present, through the application of a discount rate that reflects a combination of community time-preference (for having something now rather than later) and opportunity cost (what else could be done with the resources).

According to the Australian Transport Council (ATC), "discounting is necessary because a dollar of benefit in the future is worth less than a dollar of benefit today" (2006a, p. 74). The ATC states that the most appropriate discount rate to use for BCA is the government bond rate. The nominal bond rate needs to be adjusted for inflation to obtain the real rate. The private sector practice of adding a risk premium to the discount rate is not appropriate for evaluation of public sector initiatives (Australian Transport Council, 2006b, p. 84). The long-term government bond rate is currently (November, 2010) 5.34% with a 10-year mean of around 5.5%. Over most of the same period inflation, as measured by the Consumer Price Index, has been running at around 3.4% per year, implying a real discount rate of a little over 2% per annum. In practice, the discount rate is nominated by the funding jurisdiction and this is often based on market interest rates. For example, the Western Australian Department of Treasury and Finance currently specifies a rate of 7% per annum. New Zealand currently uses a discount rate of 8% (New Zealand Transport Agency, 2010a).

Infrastructure Australia requires, "in accordance with the majority of national, state and territory guidelines", the presentation of summary results using 4%, 7% and 10% discount rates. It does however acknowledge that, "where a different real discount rate is used in an appraisal, the Summary of Appraisal Key Results and Assumptions should specify the basis for doing so". (2010a, p. 6)

The Queensland Government, however, requires discount rates to be set on the basis of "the interest rate for government borrowings for a term relevant to the expected duration of the project with an allowance for inflation deducted from this rate, as costs and benefits are to be expressed in real terms" (Department of Infrastructure & Planning 2010b, p. 37). This is consistent with the Australian Transport Council advice.

Even excluding recent events that have seen official interest rates fall substantially (albeit possibly temporarily), the specified discount for transport project evaluation rate has been consistently higher than the long-term government bond rate, which has hovered around 6% or lower since 1996 (Reserve Bank of Australia, 2009). The bond rate, by definition, includes inflationary expectations, which, in turn, are highly influenced by recent and current rates of inflation. Benefit-cost evaluation requires that values exclude the effects of inflation and that, therefore, an adjustment of 3-4% (the recent rate of inflation) be made.[5] The resulting discount rate of 3% is a useful sensitivity test. Using a lower discount rate is more consistent with long-term sustainability concerns and increases the value of benefits more than it does costs—because most costs occur up-front and therefore receive little or no discounting, whilst benefits often occur later and over a longer period of future years.

The UK Treasury specifies a real discount rate of 3.5% to be used in benefit-cost evaluation (see Department for Transport, 2010b). The United States also requires that a real discount rate be used in BCA (Kokoski, 2010) with a specified value of 2.7% per annum for long-term projects and lower rates for programs of les than 10 years' duration (US Office of Management and Budget, 2009a). The US revises the specified discount rates every year, in line with variations in government bond rates and inflation, which has led to some substantial variations, from a high of 7-8% in the early 1980s to the current low of 2.7%, but there has been relative stability for the past decade, with values below 4% (US Office of Management & Budget, 2009b).

Risk and Uncertainty

Risk and uncertainty both relate to limits on our ability to specify the outcomes that will be achieved. Risk is distinguished from uncertainty by the extent to which we have information about both the expected outcome and the magnitudes and probabilities of possible variations. Risk implies reasonable ability to quantify the range of possible outcomes, whereas uncertainty indicates that we cannot do so.

It is sometimes argued that discount rates should be higher to allow for risk and uncertainty. Since, by definition, neither risk nor uncertainty can be quantified, there is no acceptable basis for this suggestion. All a higher discount rate achieves, with any certainty, is to pay less attention to the longer-term future, favouring projects and programs with short-term (and finite-term) benefits at the expense of those with longer-term and continuing benefits. Since there will usually be greater uncertainty about the achievable outcomes of a new initiative than about conventional approaches, a higher discount rate is tantamount to a bias against innovation. It is more appropriate to deal with risk and uncertainty through the use of sensitivity analysis, either for both costs and benefits (Australian Transport Council, 2006b) or for benefits alone, with costs incorporating a correction for 'optimism bias', which can be progressively reduced as a project becomes further advanced (Department for Transport, 2010c).

[5] To illustrate the importance of this, in the late 1980s after an extended period of hyperinflation, the long-term government bond rate was as high as 14%, but with a current inflation rate of over 7%, implying a real discount rate of 6-7%.

Defining Costs and Benefits

In Australian transport practice, capital (investment) costs are generally regarded as costs whereas operating and maintenance costs are included as negative benefits (or a net reduction is counted as a positive benefit) (Australian Transport Council, 2006a). This has no impact on the calculation of net present value but can be critical to the calculation of benefit-cost ratio. In the specific context of parking management for activity centres, the definition of the project to be evaluated is critical, as parking management through restriction of supply would actually reduce costs (for parking and road infrastructure), but such management is only likely to be effective in maintaining commercial viability in conjunction with other initiatives (such as improved public transport) that require additional investment. It is also important not to include ongoing operating or maintenance costs when it comes to prioritising within a constrained budget for the period of the investment.

Active transport initiatives, except where they involve the construction of infrastructure, are usually regarded as one-off activities without the need for maintenance or operating costs, although there have been instances where maintenance or reinforcement has been incorporated in evaluation (Ker, 2004). Benefit-cost analysis deals with a stream of investment costs over a period of time in the same way as it does a stream of benefits.

Most costs of public sector initiatives are readily identifiable and quantifiable in monetary terms. This is far less so for benefits—especially the environmental and social impacts, which may be either positive or negative benefits, depending on the project.

Operating costs are treated as negative benefits, rather than as costs, since the intent of the BCA is to assess the value of the investment in assets. A community socioeconomic evaluation of investments that create a continuing stream of benefits with offsetting effects such as reduced operating costs for one part of the community (users) and higher operating costs for another (the public transport provider) must treat these offsetting effects in the same way.

4.2.2 Multi-Criteria Analysis

Multi-criteria analysis establishes preferences between project options by referring to an explicit set of objectives that the decision-making body has identified, and by establishing measurable criteria to assess the extent to which those objectives are achieved by each project. Although MCA offers a number of ways of aggregating the data on individual criteria (such as weighting the criteria) to provide indicators of the overall performance of options, it is primarily useful in comparing projects that have broadly similar outcomes.

The United Kingdom's Department for Communities and Local Government highlight the limitations that must be considered when using MCA for program evaluation:

> A key feature of MCA is its emphasis on the judgment of the decision making team, in establishing objectives and criteria, estimating relative importance weights and, to some extent, in judging the contribution of each option to each performance criterion. The subjectivity that pervades this can be a matter of concern. Its foundation, in principle, is the decision makers' own choices of objectives, criteria, weights and assessments of achieving the objectives. (Department of Communities and Local Government, 2009, p. 46)

Multi-criteria analysis can bring a degree of structure, analysis and openness to classes of decision that lie beyond the practical reach of BCA, but it is not always transparent in the ways in which assessment against the criteria is undertaken. Multi-criteria analysis does not explicitly take account of the timing of when the effects of a project arise, so projects with immediate or short-term pay-offs can be disadvantaged.

The last 15 years has seen the development of a hybrid form of MCA for transport evaluation—despite long-held views among BCA practitioners that it is too difficult to interpret and does not give unique and clear results. In the United Kingdom, the development of a "new approach to appraisal" (Department of Environment, Transport & Regions, 1998) has been incorporated into formal guidance on evaluation in transport (Department for Transport, 2010a). This includes the development of an "appraisal summary table" (AST) as the core of the integrated assessment process—this is effectively a goals achievement matrix. Moreover, this form of disaggregated presentation of impacts has been demonstrated to have a systematic and transparent influence on decision-making (Nellthorp & Mackie, 2000).

From an Australian perspective, Dobes and Bennet (2009) are clear in their view that BCA is superior in the overall context of public sector decision-making, which requires comparisons between a range of disparate projects and outcomes, as illustrated below:

> An essential aspect to decision-making in government is the opportunity to consider the relative merits of alternative courses of action. Even if a Minister champions a particular proposal as potentially the best thing since sliced bread, his or her colleagues will often wish to know what alternatives are feasible and available, or whether the resources could be better used elsewhere.
>
> Multi-criteria analysis is incapable of comparisons between unrelated programs, because their impacts or attributes are so different. A distinct advantage of cost-benefit analysis, on the other hand, is that it permits comparisons between projects as diverse as hospital construction, new schools, roads, environmental conservation, and so on, because it evaluates all projects and policies on the basis of a common numeraire underpinned by a common theoretical construct. Cost-benefit analysis therefore complements the system of Cabinet deliberation used by Australian governments and other democracies to choose between competing priorities. (Dobes & Bennet, 2009, p. 20)

Ker (2010a) has argued that evaluation (whether BCA or MCA) based on technical information and professional judgment alone, whilst important to inform decision-making, should not be assumed to capture and reflect all of the values of the community and stakeholders.

> Benefit-cost analysis supplemented by some form of goals achievement matrix is the most appropriate way of evaluating active transport initiatives.

If stakeholders have been effectively included in the project development process, they should be able to interpret the technical information from the community/stakeholder point of view in an informed way. Both technical analysis and stakeholder perceptions have value for assessing priorities and will affect both the feasibility and effectiveness of implementation. Any substantial differences between the technical/professional and the community/stakeholder assessment is a strong indication of one of the follow:

- Those doing the planning have not adequately communicated the basis for their conclusions to stakeholders.
- The aspirations, expectations and concerns of stakeholders have not been appropriately incorporated into the identification of issues and the development of responses to them.

It is essential that any process with stakeholders be professionally facilitated, independently of the team carrying out the project, to ensure that stakeholder responses are informed but not unduly influenced. For more information on the strengths and limitations of BCA and other evaluation methodologies see Ker, 2010b, which concludes that BCA supplemented by some form of goals achievement matrix is the most appropriate way of evaluating active transport initiatives.

4.3 Evaluation Issues for Active Transport Programs

4.3.1 Benefits Not Included

Not all the beneficial effects of active transport are able to be valued for evaluation purposes at this stage as there is insufficient knowledge to ascribe credible values. Some of the benefits that cannot be included in evaluation for these reasons are:

- *Individual learning* may be enhanced for a number of reasons, including more direct interaction with the social and physical environment when walking and, to a lesser extent, cycling. More active transport to and from school may also reduce the incidence of behavioural issues that can be disruptive in the learning environment.
- *Independent mobility* may improve life-skills (beyond simply the ability to use alternatives to the car when a car is not available—or even when one is) by increasing the individual's ability to cope with a complex social and physical environment. Even supervised active transport (such as the walking school bus) has been shown to make parents more willing to allow independent mobility to their children (Kingham & Ussher, 2007; Collins & Kearns, 2007).

Prioritising active transport creates streets conducive to social interaction

- *Community cohesion* (positive interactions among members of a community) may be increased as walking provides an opportunity for people who live and work in an area to meet their neighbours. Pedestrian environments (particularly public sidewalks and paths) are an important part of the public realm where people often meet and socialise. Increased community cohesion can provide a variety of benefits, including improved security and safety, social development, and mental health benefits.

4.3.2 Benefits Only Partially Assessed

Evaluations of active transport and related initiatives have almost all relied on mortality effects for estimating health benefits, without values being attributed to morbidity or wellbeing effects. Whilst this is commonly noted as meaning that values for the benefits of active transport will be conservative, there is very limited information on which to base values for morbidity/wellbeing (Cavill et al, 2007).

4.3.3 Effects by Demographic Group

Monitoring of active transport can, in principle, measure the change in travel behaviour in any context, although there may be methodological and statistical issues about the robustness of such measurement (Brög & Ker, 2009).

Many of the benefits of active transport can be valued directly from the change in travel behaviour itself. However, evaluation of the health effects of such change depends critically on understanding how the additional active transport affects the health of those who change their travel behaviour. There are many issues here, including the current level of physical activity and whether the additional activity is truly additional to or simply replaces existing activity. It is also necessary to understand the effects on children as distinct from adults and the effects on adults of different ages. The evidence base for this is not as strong as it is for the population as a whole or even for adults alone (Cavill et al, 2008).

It may also be important to know whether the active travel program is preventative (targeting people before they start to show symptoms related to lack of physical activity) or restorative (targeting people who already have inadequate physical activity in their lives). This, in turn, enables an understanding of the differences between preventative and restorative programs in both extent and timing of health benefits. This is particularly important for initiatives aimed at a specific age demographic, such as schools.

4.3.4 Durability

There is limited evidence of the durability of travel-behaviour change outcomes—especially for school and workplace programs, where even short-term monitoring is often poor and long-term monitoring is made problematic by the rapid turnover of population and consequent difficulties in tracking individuals from the original intervention.

Household/community interventions have shown sustained reductions in car use for 4–7 years (Roth et al, 2003). Bus ticketing data in Cambridge, Western Australia, has shown a consistent (and, if anything, growing) increase in public transport use.

The most likely time for 'disillusionment' to be experienced and reversion to previous behaviour to occur is within the first few months of the changed behaviour. Since 'after' surveys are typically undertaken 6–9 months after the intervention, it is unlikely that those who had a negative experience with the non-car alternatives would still be using them months afterwards. According to Maunsell Australia, "previous experience indicates that for household/community initiatives there appears to be some reversion to previous travel choices over the first nine months following the [travel-behaviour change] project but that people who have not reverted by this time tend to stay with their new travel choice" (2004a, p. 57). On this basis, the 'after' survey will already incorporate the most substantial part of any reversion to previous behaviour.

There are strong arguments to support at least medium-term durability, provided those who change continue to experience the same level of service in their newly adopted modes. In the case of primary school based initiatives however, this may require some reinforcement at the transition from primary to high school (Ker, 2008a).

4.3.5 Social Learning and Diffusion

People learn through observing others' attitudes, behaviours, and the outcomes of those behaviours. Most human behaviour is learned observationally through modelling: from observing others, one forms an idea of how new behaviours are performed, and on later occasions this coded information serves as a guide for action. Social learning theory explains human behaviour in terms of continuous reciprocal interaction between cognitive, behavioural, and environmental influences (Learning Theories, 2008).

A good experience will generate not only sustainability but also additional interest and take-up. Correspondingly, a bad experience will turn people (both participants and observers) away from the product/service and it will be very difficult to get them to return.

Diffusion within a school (i.e. amongst the students for school travel) will already be incorporated in the measurement of travel-behaviour outcomes, but diffusion is further possible to other travel by those children (i.e. for non-school purposes), parents, staff and even the neighbouring community. There do not appear to be any documented examples of attempts to measure this diffusion effect.

Diffusion

There are three main innovation diffusion models, each arising from a different account of how innovations spread (Young, 2007):

Contagion. People adopt an innovation when they come into contact with someone who has already adopted it.

Social threshold. People adopt an innovation when enough others in the group have adopted it. Social threshold effects are most likely to occur where the innovation is clearly visible to the casual observer.

Social learning. People adopt an innovation once they see enough evidence among prior adopters to convince them that the innovation is worth adopting. Social learning provides an explanation of why a person would adopt an innovation given that others have adopted it—the adoption decision flows directly from expected utility maximisation. Specifically, the decision is based on a reason to believe the innovation is better than what they were doing, where the evidence comes from directly observing the outcomes among prior adopters.

4.3.6 Evidence for Valuation of Walking Health Benefits

The evidence base for cycling is much stronger than for walking and many more evaluations of cycling initiatives have been undertaken (Cavill et al, 2009). Although strategic public policy increasingly supports walking for exercise and for transport, evaluation of walking initiatives is rarely undertaken, probably because measurement of walking activity can be more difficult than for cycling and short walking trips may not involve sufficient activity to reach the threshold required for some health benefits.

5

Health Impacts of Active Transport: Summary of Evidence

5.1 Introduction

Active transport has multiple benefits for health, the environment, community liveability and transport (Forsyth et al, 2009). Economic appraisals of active transport interventions that include these health and social benefits are in their infancy, but evidence thus far indicates that benefit-cost ratios (BCRs) are very favourable (generally between two and 20), with health benefits comprising about one half to two-thirds of th monetised benefits (Garrard et al, 2010). Both the overall BCRs and the health proportion of benefits are likely to be underestimates, as current appraisals have generally included only a limited number of health outcomes associated with the increased levels of physical activity and other health benefits that flow from a mode shift from car travel to active travel. In addition, few economic appraisals have included children and young people.

> Poor diet, inactive lifestyles and rising obesity is predicted to fuel a 55% increase in type 2 diabetes disease burden in Queensland over the next 10 years.
>
> *Queensland Government, 2008, p. 33*

This section provides the evidence foundation for a more comprehensive assessment of the benefits of achieving a shift from inactive (principally car use) to active (principally walking and cycling) modes of travel for the relatively short distances[6] that comprise the majority of transport trips in urban areas and regional centres in Australia.

5.2 Review Methods

The overall aim of this section of the study is to review research findings on the health impacts of interventions aimed at increasing rates of active transport. Because few studies measure the health outcomes of active transport interventions directly, the review is conducted in two stages: (i) the health impacts of active transport; and (ii) the impacts of active transport interventions on rates of active travel. Because some of the key health impacts of active transport vary for young people and adults, the evidence is reviewed separately for these two population groups.

[6] National data for all transport trips is not collected, but, based on the 2007-08 Victorian Integrated Survey of Travel and Activity (VISTA), 50% of all weekday trips by householders in metropolitan Melbourne were less than 4.7 km (50% of trips were less than 5 km in Victorian regional centres). Department of Transport (2009). Victorian Integrated Survey of travel and activity 2007 (VISTA 2007). Melbourne, Department of Transport.

Active transport results in multiple health benefits for both young people and adults—chief among them being the numerous health impacts associated with increased levels of physical activity. When increases in active travel are also associated with reduced motor vehicle travel, additional health benefits accrue from improved air quality, reduced noise pollution, climate change abatement, and improved community liveability. This review is principally a 'review of reviews' (systematic reviews and meta-analyses where available; and narrative reviews when systematic reviews are not available) due to the large number of health benefits associated with active transport for both young people and adults. It is not possible, within the scope of this project, to conduct individual systematic reviews for each relevant health topic.[7] Review findings are complemented by findings from recent research studies which have not yet been incorporated into evidence reviews, and in areas where no reviews have been conducted. This is a key component of the current study, because investigation of the health impacts of active transport is a relatively recent research field. For the same reason (i.e. lack of research), this study includes evidence of the relationship between physical activity (in general) and some health outcomes, because research linking active transport specifically to the full range of health outcomes is not currently available.

Searches of the published research literature were conducted using the following databases: Academic Search, Cochrane Database of Systematic Reviews, CINAHL, Environment Complete, ERIC, Medline, PsycARTICLES, Science Direct, and SPORTDiscus. Unpublished literature was obtained through web-based searches and consultations with team members and colleagues working in the area of active transport.

In terms of study inclusion/exclusion criteria, the review did not exclude studies solely on the basis of study design, as occurs for most Cochrane-style systematic reviews. This is because interventions to increase active transport are often multifaceted interventions in complex social settings that are often not suited to the controlled study designs preferred in Cochrane-style reviews (see Section 6.6.3). Instead, quality is judged to be acceptable if:

- the publication is from an internationally recognised peer-reviewed journal or other trusted source
- the methodology, analysis and interpretation appear robust
- findings are relatively consistent across studies.

'One-off' studies are referred to as such to indicate that research evidence on the topic is currently limited.

[7] Systematic reviews, by definition, focus on a specific health topic (e.g. the relationship between active transport and cardiovascular disease in adults).

5.3 Review structure

As previously mentioned, transferring car trips to active transport has a number of important impacts, as outlined in Table 6 below. In addition to the health impacts listed below, reductions in car use come with a range of transport benefits as discussed in Section 7, such as reduced congestion, oil dependence and household transport costs.

As indicated in Table 6, some health benefits of a mode shift from inactive to active travel result from an increase in active travel (e.g. the health benefits of increased physical activity) and some are associated with reduced car use (e.g. reduced air pollution). Some impacts (e.g. increased physical activity) have multiple health benefits and these are described in detail in this section. Impacts can vary for young people and adults and therefore they are described separately.

IMPACTS		INCREASE IN ACTIVE TRANSPORT	DECREASE IN MOTOR VEHICLE USE
Health	Physical activity	✓	
	Other health conditions	✓	✓
	Social inclusion	✓	
	Health equity	✓	
Environment (impacts on human health)	Air pollution		✓
	Noise		✓
	Climate change		✓
Community liveability (health impacts)	Social interaction	✓	✓
	Crime	✓	

Table 6: Impacts of a mode shift from inactive to active travel

There is good evidence that increasing active transport to school does not replace other forms of physical activity

Some studies measure health impacts of active transport directly (e.g. the relationship between active transport and cardiovascular disease, cancer or all-cause mortality), while in other cases, individual studies have examined one or more components of the causal pathway. For example, there is good evidence that:

- cycling to school increases aerobic fitness (Voss & Sandercock, 2010; Andersen et al, 2009)
- active travel to school does not replace other forms of physical activity (Davison et al, 2008; Shephard, 2008)
- aerobic fitness increases intelligence quotient, cognitive function and educational attainment (Åberg et al, 2009; Sibley & Etnier, 2003)

In this example, it can therefore be concluded that regular cycling to school is likely to increase IQ, cognitive function and educational attainment.

> Active travel to school does not replace other forms of physical activity.
>
> *Davison et al, 2008; Shephard, 2008*

A great deal of research has examined the link between physical activity and health, but much of this research has not looked specifically at active transport (Woodcock et al, 2010). However, walking and cycling for transport have been shown to meet the health-enhancing requirements of moderate intensity physical activity (Shephard, 2008). It can therefore be concluded that cycling and brisk walking are likely to achieve the benefits that have been established for moderate-intensity physical activity in general. This is particularly relevant for research into the relationship between physical activity and mental health, where nearly all studies have used structured exercise programs and there appear to be no studies based on active transport.

This review includes the multiple health benefits associated with a shift to active travel as summarised in Table 5. However, it focuses on the health benefits associated with increased population prevalence of physical activity as this is the key benefit area for active transport, and the area that has the strongest evidence base. Accordingly, the review commences with an introductory examination of the potential for achieving the health benefits of physical activity through active transport in the Australian context. This is followed by a review of research findings based on the framework in Table 6, together with a review of evidence for the impacts of active transport initiatives on the use of active transport modes.

5.4 Physical activity participation in Australia and Queensland

The potential for improving the health of the population through increased levels of physical activity in the form of active transport is substantial. Physical activity has considerable health benefits, and a sizeable proportion of young people and adults in Australia do not achieve recommended levels of physical activity (Australian Institute of Health and Welfare, 2010a). Active transport levels in Australia are low in comparison to several other OECD countries (see Figure 7), particularly for the relatively short trips that can be feasibly undertaken by foot (up to about one kilometre) and bicycle (up to about six kilometres). Comparison of trip mode by distance for Australia and the Netherlands demonstrates the potential for short trips to be undertaken by walking or cycling (Figures 8 and 9).

> A sizeable proportion of young people and adults do not achieve recommended levels of physical activity.
> *Australian Institute of Health and Welfare, 2010a*

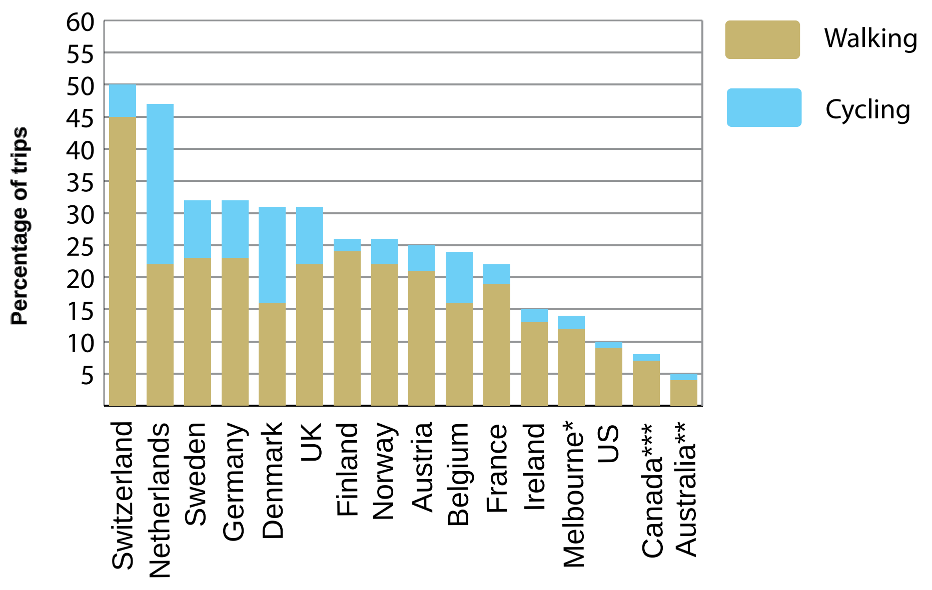


Figure 7: Active travel trips (walking and cycling) by country
Source: Pucher et al, 2008; Bassett et al, 2008; Ironmonger, 2008; Bartley Consulting Pty Ltd, 2008.
**All trips (VISTA, 2007)*
***Journey to work (2006 Census)*
****Work trips only*

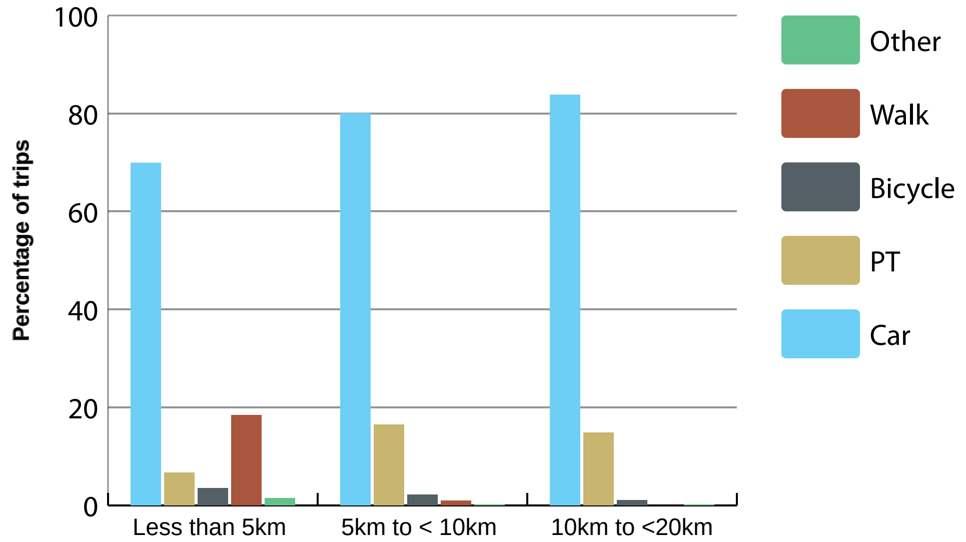


Figure 8: Travel mode to work and education by distance, Australia
Source: ABS, 2009a

Fifty-seven per cent of Australian adults currently meet the recommendation for 150 minutes per week of at least moderate-intensity physical activity, comprising ≥ 30 minutes per day (which can be accumulated in 3 x 10 minute sessions) on most days of the week. The remaining 43% of Australian adults are 'inadequately active', with more than a third of Australian adults (34.6%) currently classified as sedentary—that is, reporting no exercise (for fitness, recreation or sport) in the two weeks prior to interview (ABS, 2009b).

In Queensland, insufficient inactivity was the third largest single determinant of burden of disease in 2003. *Queensland Health, 2008*

Physical inactivity is responsible for 6.6% of the total burden of disease and injury in Australia (Begg et al, 2007), resulting in an estimated direct gross cost to the Australian health budget of $1.49 billion per annum (Econtech, 2007).

In Queensland, insufficient physical activity was the third largest single determinant of burden of disease in 2003, causing 6.2% of the burden for males and 6.8% for females (Queensland Health, 2008). Insufficient activity is particularly associated with four areas of concern: women, older adults, socioeconomic disadvantage and geographical remoteness (with the exception of 'very remote') (Figures 10-12).

Walking and cycling provide physical activity that is continuous, of sufficient intensity, and can be performed by most adults and children. *Garrard et al, 2010*

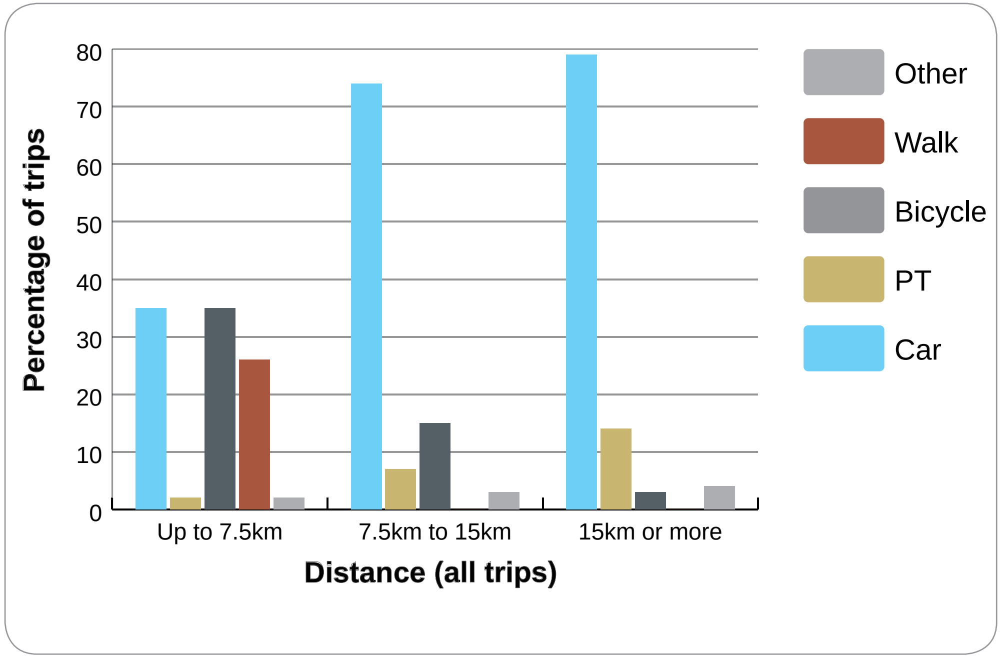


Figure 9: Travel mode by distance, The Netherlands
Source: Ministry of Transport Public Works and Water Management, 2007

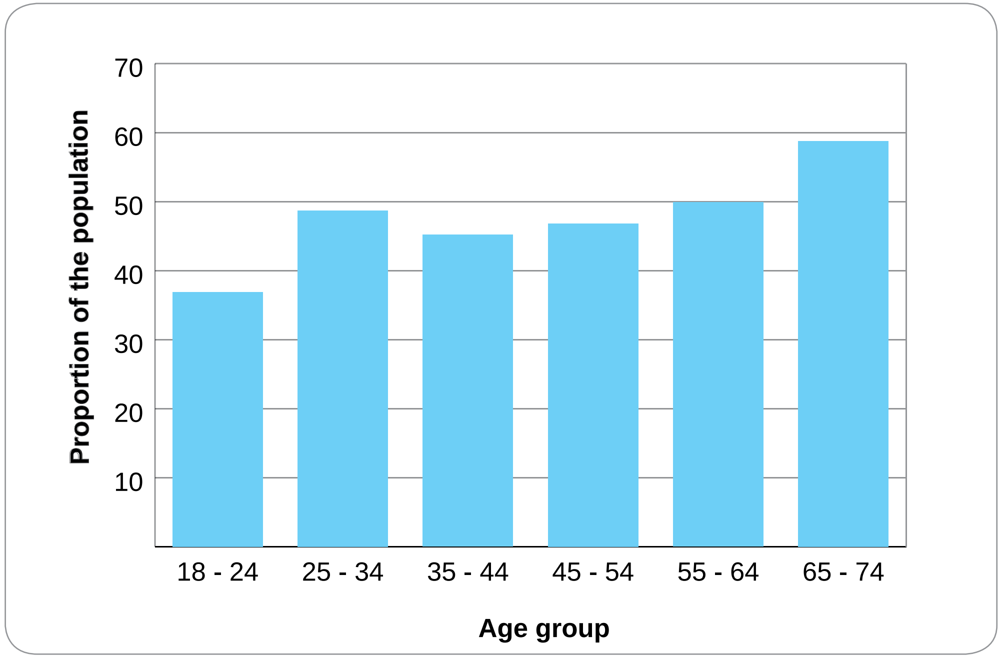


Figure 10: Insufficient activity by age group
Source: Queensland Health, 2008

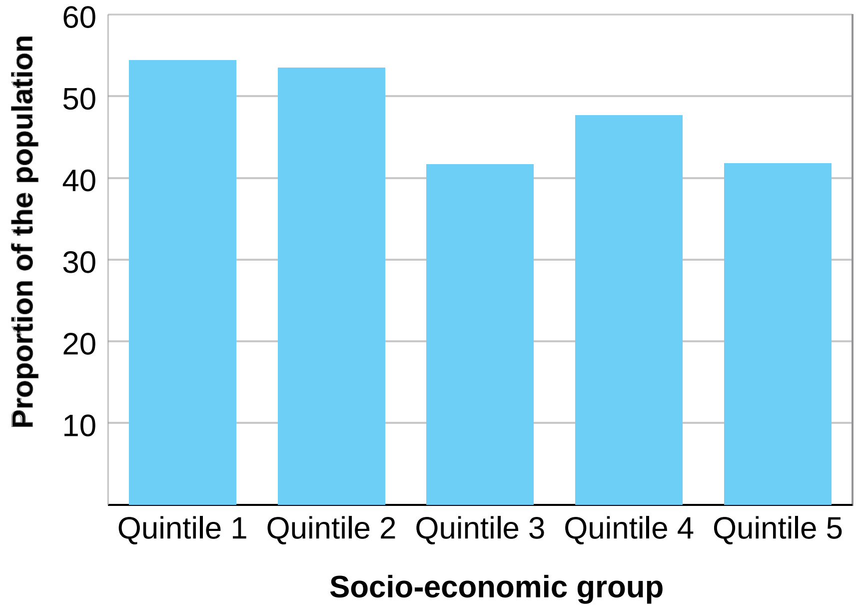


Figure 11: Insufficient activity by socioeconomic group (Quintile 5 = most socioeconomically advantaged)

Source: Queensland Health, 2008

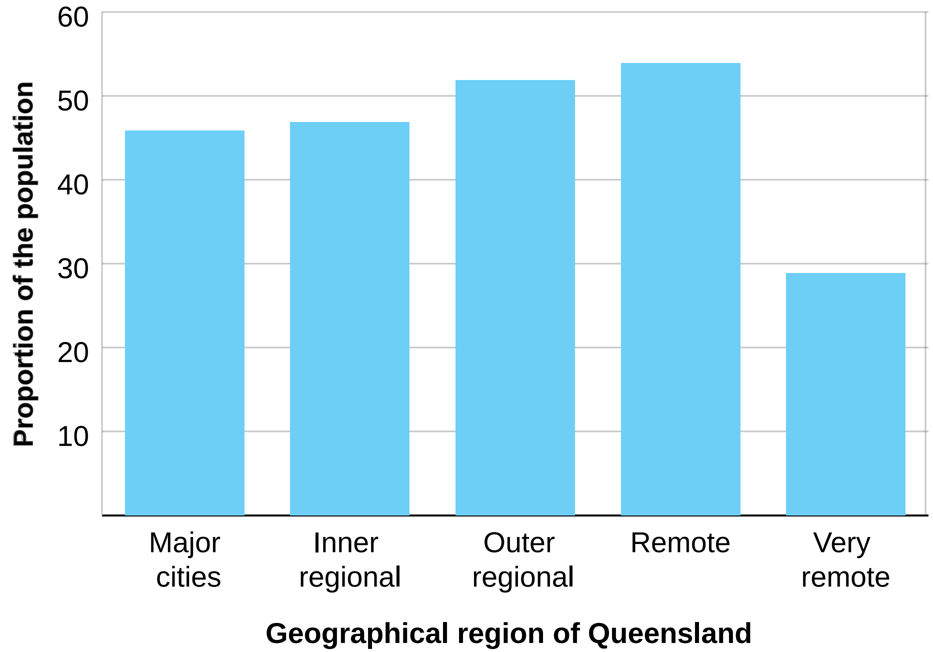


Figure 12: Insufficient activity by geographic area

Source: Queensland Health, 2008

Research evidence presented in Section 6.3 indicates that physical activity through active transport can assist in reducing the social gradient associated with insufficient activity in at least three out of the four areas of concern—namely, women, older adults and those who are socioeconomically disadvantaged (also see Appendix A).

Moderate-intensity activity is defined as that between 3–6 METs[8] (i.e. 3-6 times the energy expenditure at rest) (Pate, 1995), with walking at the lower end of the range and cycling at the top end of the range, having about twice the intensity of walking. In general, both walking and cycling provide physical activity that is continuous, of sufficient intensity, and can be performed by most adults and children (Garrard et al, 2011).

The Australian Department of Health and Ageing recommends that children should accumulate at least 60 minutes (and up to several hours) of moderate to vigorous physical activity (MVPA) every day (Department of Health and Ageing, 2004). Based on data from the 2007 Australian Children's Nutrition and Physical Activity Survey, 32% of Australian children aged 9–16 years met the guidelines for MVPA (i.e. accumulated at least 60 minutes of MVPA on each of the four days sampled), while 58% achieved this level of MVPA on most (i.e. three or more) of the four days sampled (Department of Health and Ageing 2008). Girls are less likely to meet the guidelines than boys, and MVPA declines with age, particularly for older girls. For girls aged 14–16, only 13% met the "all four days" recommended MVPA level, and 33% met the "most days" level.

Pedometer data showed that the majority of Australian children aged 9–16 do not meet the internationally recommended number of steps per day (15 000 for boys and 12 000 for girls). The data also showed that the number of steps per day declined rapidly with age; only 13% of boys and 16%[9] of girls aged 14–16 met the recommended number of steps (Department of Health & Ageing 2008).

[8] The Metabolic Equivalent of Task (MET) expresses the energy expenditure of physical activities as multiples of the resting metabolic rate; with 1 MET defined as the metabolic rate at rest.
[9] The higher percentage for girls is due to the lower recommended number of steps for girls.

5.5 Extent of Active Transport in Australia and Queensland

National data on mode share of all trips undertaken by Australian adults and young people is not available, though data on the mode of travel to work are available from the population census for persons aged 15 years and over. This data shows that, for Australia as a whole on census day in 2006, 4.9% of persons walked to work and 1.2% cycled; while in Queensland 4.8% of persons walked to work and 1.4% cycled. For the Brisbane Statistical Division, 3.7% of persons walked to work, and 1.1% cycled (ABS, 2008). This data, however, is subject to the following limitations:

- the census day is in mid-August (winter) and therefore may not represent active travel rates on other days of the year
- walking data is for walk-only trips and excludes walking to and from public transport, which can be substantial (see below)
- data is for the journey to work only, and therefore excludes active travel trips for all other purposes.

Travel modes for all trips undertaken by all household members are available from the South East Queensland Travel Survey 2003-04, and have been analysed for the Brisbane Statistical Division (Burke & Brown, 2007). The authors reported the following proportions of trip stages (i.e. including all components of multi-mode trips) as: vehicle driver or passenger (69.7%); walking (20.4%); cycling (1%); public transport (8.4%); and other (0.5%) (Figure 13).

Incidental physical activity through active transport reaches population groups that are less likely to participate in leisure-time physical activity.

Cycling is a small but growing mode of transport in many parts of Australia.

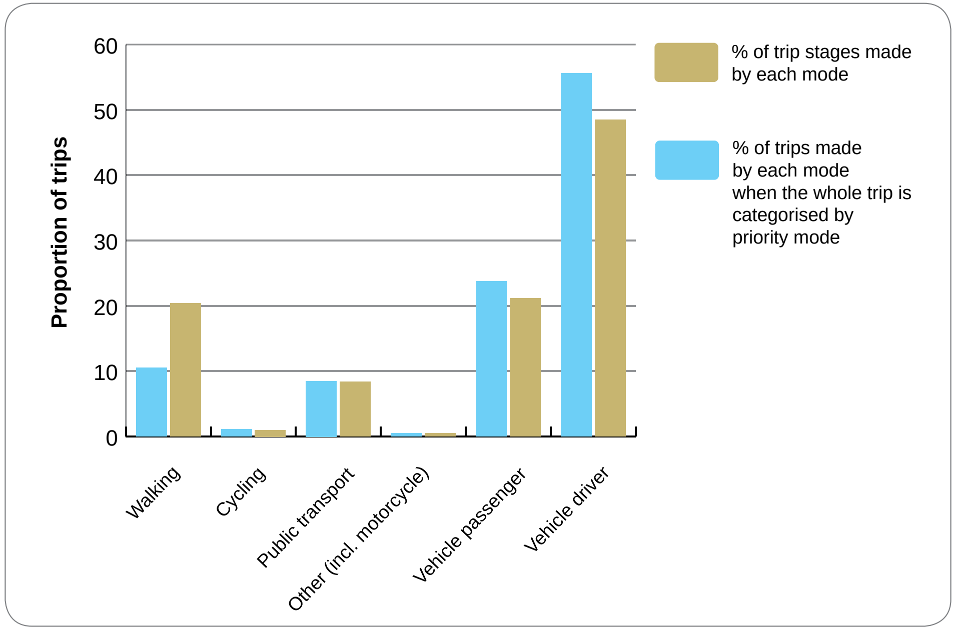


Figure 13: Mode share for trips and trip stages, Brisbane

Source: Burke & Brown, 2007

As noted above, active travel trips can consist exclusively of walking or cycling, or can be undertaken in association with public transport use. Data on the time spent walking or cycling to and from public transport is not available for Australia nationally, but in the United States, Besser and Dannenberg (2005) reported that "Americans who use transit spend a median of 19 minutes daily walking to and from transit." The Bus Association of Victoria conducted an (unpublished) analysis of data from the 2007 Victorian Integrated Survey of Travel and Activity (VISTA). The analysis found that:

> people who used public transport on a particular day also spent an average 41 minutes walking and/or cycling as part of their travel. This is five times more physical activity than those who only use private transport (i.e. cars, taxis and/or motorcycles), who on average only spend eight minutes walking or cycling for transport. (Bus Association Victoria, 2010, see http://busvic.asn.au/news/news_item.aspx?id=233)

It is important to note, however, that the "41 minutes" is total active travel and not just travel associated with public transport use. This analysis does indicate, however, that the level of physical activity associated with private transport (mainly car use) is low.

In Queensland, data on the distances people walk for transport purposes are available from the South East Queensland Travel Survey 2003-04, and have been analysed for the Brisbane Statistical Division (Burke & Brown 2007). The authors report on the distances walked for transport from homes to other places, as well as for travel made between places other than homes. While single-mode walk trips are longer than the walk trip stages made to and from public transport, both in terms

Walking and even cycling can be important components of a public transport journey

of distance and time, there are more than twice as many walk trip stages made to and from public transport. The median distance people walked from home to all other places for the walk mode was 780 metres, from home to all public transport stops it was 600 metres, and from public transport stops to end destinations it 470 metres. People who use public transport in Brisbane each weekday (12.8% of the population) walk, on average, more than 2.3 kilometres and over 28 minutes to and from public transport. The authors noted that, for these travellers, public transport-related walking almost meets the Australian daily minimum physical activity recommendation of 30 minutes.

There is some evidence that 'incidental' physical activity through active transport reaches population groups that are less likely to participate in leisure-time physical activity. While socioeconomically advantaged population groups are about twice as likely as disadvantaged groups to participate in leisure-time physical activity or sports (ABS, 2009c), the reverse relationship is often observed for active transport. Higher levels of participation in active travel for socially disadvantaged population groups or areas have been reported in Denmark (Andersen et al, 2000), Canada (Barnett et al, 2008), the Netherlands (van Lenthe et al, 2005), China (Matthews et al, 2007) and the United States (Agrawal & Schimek 2007; Berrigan et al, 2006). The distribution of income groups for pedestrians and cyclists for journey-to-work trips in Victoria broadly follows that of the total journey-to-work population (Bartley Consulting Pty Ltd, 2008), indicating absence of the social gradient found for leisure-time physical activity and sports in Australia (ABS, 2009c). Physical activity in the form of active travel therefore appears to be more equitably distributed than leisure-time physical activity. Consequently, increasing the population prevalence of active transport in Australia may contribute to reducing health inequalities.

In addition to socioeconomically disadvantaged population groups, other priority groups for the promotion of physical activity in Australia include women, adolescent girls and older adults. In countries with high rates of active travel, these population groups achieve high levels of physical activity through active transport as a 'habitual' part of daily life (see Appendix A). Data from the Australian Children's Nutrition and Physical Activity Survey indicate that, in contrast to sport and play, active travel tends to increase with age, and has similar participation rates for girls and boys at most age levels (Figure 14). Similar findings have been reported internationally. In a large UK study, Year 10 females were 6.5 times more likely to meet recommended levels of physical activity if they actively commuted to school (Smith et al, 2008). Building physical activity into the routines of daily life makes regular physical activity achievable for people who don't have the time, interest or money to participate in organised sports, exercise or fitness programs—or who don't see themselves as 'sporty types'. In the VicLANES study in Victoria, up to one third of respondents cited 'not the sporty type' as a barrier to physical activity, second only to 'lack of time' for most gender/SES groups (Kavanagh et al, 2007).

Physical activity in the form of active travel appears to be more equitably distributed than leisure-time physical activity.

Building physical activity into the routines of daily life makes regular physical activity achievable for people who don't have time, interest or money to participate in organised sports, exercise or fitness programs.

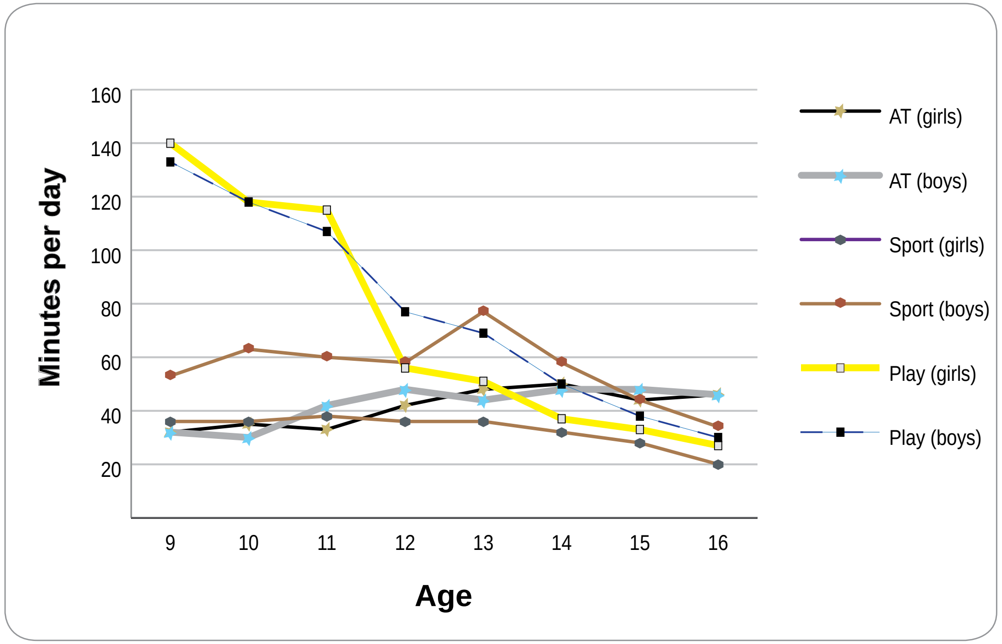


Figure 14: Age and gender-related patterns in MVPA and some of its components (free play, sport, and active transport (AT))

Source: Department of Health and Ageing, 2008

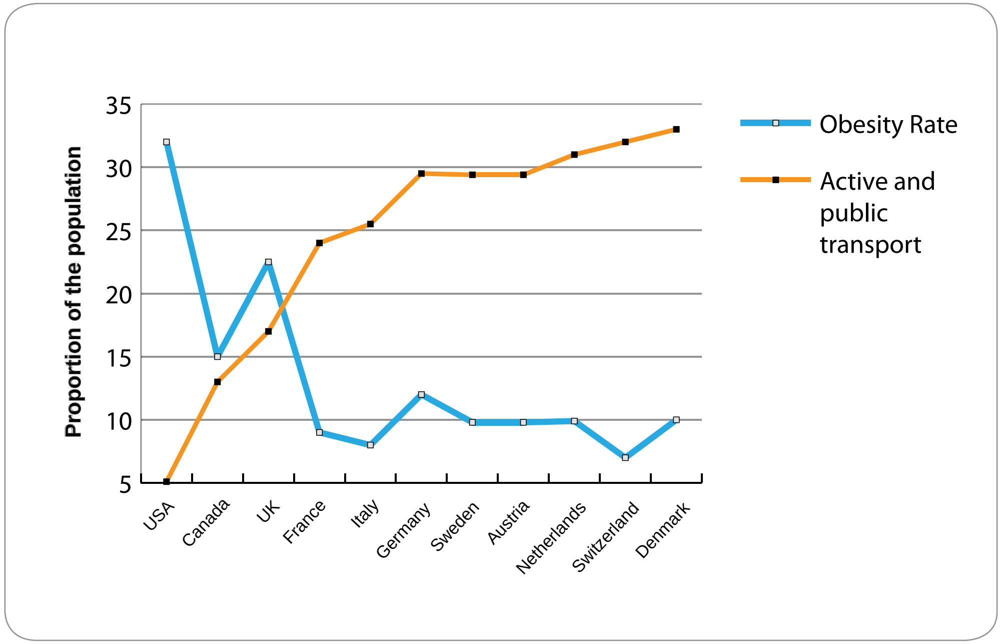


Figure 15: Obesity rates and active transport

Source: Bassett Jr et al, 2008

The socially inclusive, population-wide participation associated with active travel in high active-travel countries may help to explain the inverse relationships between active travel rates and obesity, and active travel and type 2 diabetes internationally (Bassett Jr et al, 2008; Pucher et al, 2010) (see Figure 15).

More than 50% of adults in Queensland are either overweight or obese.

Queensland Health, 2008

More than 50% of adults in Queensland are either overweight or obese—62.7% for males and 50.6% for females (Queensland Health, 2008). There are 600 000 obese Queenslanders and a further 1.6 million who are overweight. The prevalence of obesity in the Aboriginal and Torres Strait Islander population is twice that of the general community (Queensland Health, 2008). Obesity tends to increase with age, with 37% of 15–24 year-olds overweight or obese, increasing to 74% of those 55 years and above (Australian Institute for Health and Welfare, 2008).

In Queensland, there has been a 45% rise in the proportion of obese adults in recent years and Queensland Health forecast that by 2025 the prevalence of obesity will double, with 1.4 million Queenslanders expected to be obese (Queensland Health, 2008).

The National Health Survey 2007-08 reported that the proportion of overweight and obese children aged 5–17 years old increased from 20.8% in 1995 to 24.9% in 2007–08 (ABS, 2009b). An additional 1% of children become overweight in Australia each year and this is one of the fastest rates of increase globally (Queensland Government, n.d.).

With some 30% of car trips in Australia under three kilometres and over 50% under five kilometres, considerable potential exists to boost the level of active transport participation.

Austroads, 2005b

Many European nations have high levels of active transport and low levels of obesity

It is now widely acknowledged that substantial improvements in the high and inequitably distributed health burden associated with low levels of physical activity in Australia and internationally are unlikely to be achieved through structured exercise programs and sports participation (Bauman et al, 2008). The emphasis is now on fostering 'active living' by building regular physical activity into daily life (World Health Organisation, 2006). Levels of active transport are currently low in Australia, providing an excellent opportunity to achieve the levels of incidental activity that have been achieved in several other OECD countries. With some 30% of car trips in Australia under three kilometres and over 50% under five kilometres, considerable potential exists to boost the level of active transport participation (Austroads, 2005b).

The following section reviews the research literature on the health impacts of active travel and reduced private motor vehicle use. The review is structured according to the framework outlined in Table 5, with research related to children and young people presented first, followed by research findings for adult populations.

A significant proportion of car trips in Australia are surprisingly short - 30% under 3km

5.6 Health Impacts of Active Travel and Reduced Private Motor Vehicle Use: Children and Young People

5.6.1 Physical activity

The health benefits of increased physical activity (through active travel) for young people include:

- healthy child development (bone, muscle, joint health)
- aerobic fitness
- healthy weight
- mental health
- cognitive functioning and educational attainment

Healthy Child Development (Bone, Muscle, Joint Health)

Moderate to vigorous weight-bearing physical activity during childhood is essential for optimal skeletal, joint and muscle growth. Physical activity creates higher bone density and bone mineral content, both of which are vital for protecting against osteoporosis in later life (Matthews et al, 2007; Strong et al, 2005). Walking is a weight-bearing form of physical activity; cycling is less so, depending on cycling style (e.g. standing up/sitting down) and the terrain covered. While the benefits of weight-bearing physical activity are well documented, there appear to be no studies that have specifically examined the relationship between active transport in young people and osteoporosis or osteoporotic fractures later in life.

Aerobic Fitness

Several recent studies have reported significantly higher cardiovascular fitness among young people who cycle to school (Cooper et al, 2006; Cooper et al, 2008; Andersen et al, 2009), including in one study that controlled for non-travel physical activity (Voss & Sandercock, 2010). Evidence for the relationship between improved cardiovascular fitness and walking to school is less consistent, possibly due to the higher MET value for cycling compared with walking.

Voss and Sandercock (2010) reported adjusted odds ratios for the likelihood of being classified as 'fit' according to travel mode (with 'passive transport users' as the reference group) (see Table 7). Consistent with other studies, the greatest benefits appear to be for cycling compared with walking, and for girls compared with boys. Girls were nearly eight times more likely to be classified as 'fit' if they cycled to school, after adjusting for covariates[10], including other forms of physical activity.

IMPACTS		WALK	CYCLE
Adjusted OR (not including PA)	Girls	1.31 (1.03–1.66)	9.99 (1.30–76.59)
	Boys	1.20 (1.00–1.43)	1.31 (1.00–1.72)
Adjusted OR (including PA)	Girls	1.34 (1.05–1.71)	7.94 (1.05–60.23)
	Boys	NS	NS

Table 7: Odds ratios[11] (OR) for likelihood of being classified as 'fit' by travel mode.

The odds ratios were adjusted for age and BMI (and physical activity (PA) in the last 2 rows). Subjects in this study were English school children.
Source: Voss & Sandercock, 2010

The authors noted that the definition of 'fit'[12] used in the study may have resulted in lower odds ratios than found in other studies; however, the definition enabled direct associations with adult health. Consequently, children categorised as 'fit' in the study may have a reduced risk of developing chronic disease in adulthood (Voss & Sandercock, 2010).

Healthy Weight

Multiple sources and types of evidence point to a negative relationship between young people's physical activity levels and overweight/obesity and a negative relationship between active transport and overweight/obesity, though not all studies report a relationship.

Ecological studies show an inverse relationship between the proportion of total distance travelled by young people by active modes and overweight/obesity (Figure 16) (Garrard, 2009a).

[10] A covariate is a variable that is possibly predictive of the outcome under study. A covariate may be of direct interest or it may be a confounding or interacting variable..

[11] Odds ratio is a measure of effect size, describing the strength of association or non-independence between two binary data values. An odds ratio of 1 indicates that the condition or event under study (i.e. 'fit') is equally likely to occur in both groups (e.g. active or passive transport users). An odds ratio greater than one indicates that the condition or event is more likely to occur in the comparison group (e.g. walk) than in the referent group (passive transport). And an odds ratio less than 1 indicates that the condition or event is less likely to occur in the comparison group.

[12] FITNESSGRAM PACER Healthy Fitness Zone classification: "fit" met or exceeded minimum amount of sex-and age-specific shuttle runs. The test requires volunteers to run back and forth over a marked distance of 20 metres at gradually increasing speeds.

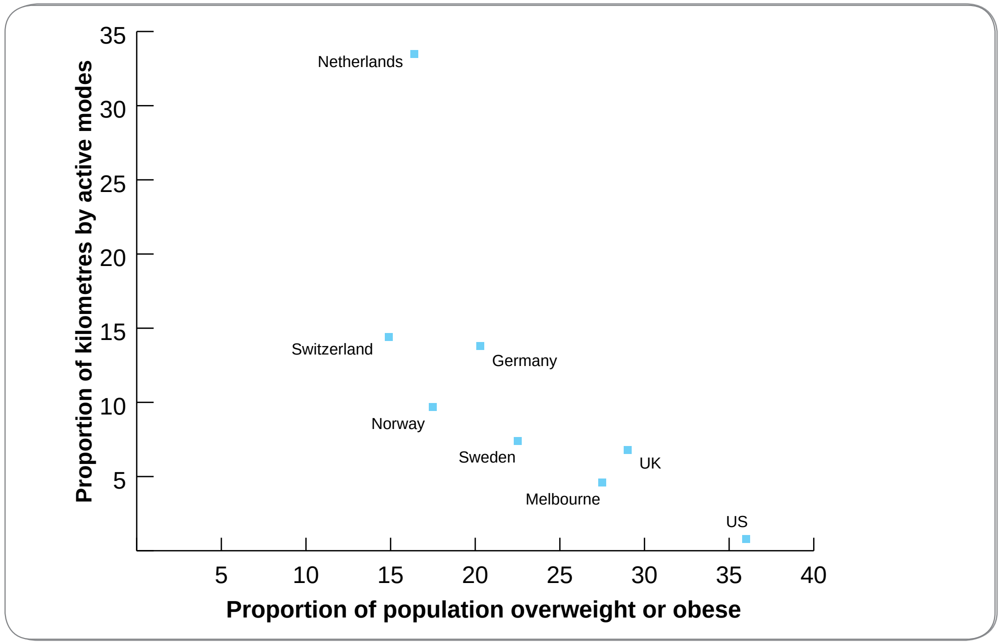


Figure 16: Children's active travel distance and overweight/obesity

Sources: Christie 2004; International Obesity TaskForce, 2009

Note: Melbourne Statistical Division travel data included in absence of Australian national data for children's active travel distance.

The 2007 Australian National Children's Nutrition and Physical Activity Survey reported that obese young people aged 9–19 had lower levels of physical activity than normal weight or overweight children (Department of Health and Ageing, 2008). A survey of 5–12 year old children from Brisbane found that approximately 14.7% did not meet the recommended 60 minutes of daily MVPA and 20% of the sample were overweight or obese (Spinks et al, 2007). Children who did not engage in at least 60 minutes of MVPA a day were 28% more likely to be overweight (Spinks et al, 2007). Odds ratios were adjusted for socio-demographic factors, but not for dietary intake. These studies, however, are cross-sectional, and it is possible that children who are overweight or obese choose not to participate in physical activity. Intervention studies comprising moderately intense exercise of 30 to 60 minutes duration for three to seven days a week have been shown to reduce total body and visceral adiposity in overweight children and adolescents; but greater amounts of vigorous activity may be needed to reduce adiposity in normal-weight youth (Strong et al, 2005).

An international study involving 137 593 child participants across 34 countries found childhood obesity was strongly associated with lower levels of daily physical activity and increased hours spent watching television (Janssen et al, 2005). Adjusted odds ratios (OR) for physical activity participation (average number of days per week of ≥ 60 minutes MVPA) ranged from 0.80 to 0.96 across the 34 countries, and nearly all ORs were significant ($p \leq 0.05$). The ORs were adjusted for age, gender, presently trying to lose weight (yes or no), and other lifestyle variables (e.g. diet, television watching).

Obesity in young people is associated with psychological problems, inappropriately fast growth and development, abnormal lipid/body fat profile, high blood pressure and abnormal glucose tolerance/metabolism (The Obesity Society, n.d.). Overweight and obese children can experience negative body image, have low self-esteem, experience recurrent suicidal ideation, demonstrate obsessive-compulsive behaviour, and report generalised social anxiety (Chess & Thomas, 1984, cited in Kelty et al, 2008). Ridicule and social ostracism occurring across a range of social domains (at school, in the community and at home) creates or exacerbates the psychological distress that overweight young people experience (Wodarski & Wodarski, 2004, cited in Kelty et al, 2008).

Obesity during childhood (and adolescence in particular) is also associated with obesity as an adult, with associated increased risks of developing chronic diseases in adulthood (Booth et al, 2006; The Obesity Society, n.d.).

Although cross-country comparative data indicates an inverse relationship between child obesity and active travel (see above), studies within countries such as Australia that have low active travel rates show no consistent relationship (Davison et al, 2008; Booth et al, 2006; Lee, 2008; Voss & Sandercock, 2010). Failure to detect a relationship in these studies may be due to the limited range of energy expenditure on active travel in Australia (i.e. children in the highest active travel categories in Australia have low levels of active travel compared with children in several European countries). Children in European countries with high active travel rates frequently cover relatively large distances by foot or bicycle (see Table 7), thereby increasing the potential for active travel to contribute to energy expenditure and consequently the maintenance of healthy weight. In Australia, most active travel to school is by walking, and cycling rates are very low, potentially leading to lower energy expenditure than in countries where children have relatively high rates of cycling to school. Andersen et al (2009) reported that adolescents who cycle to school (almost two-thirds of the participants in the Danish Youth and Sports Study) have higher aerobic power (4.5% for girls and 5.9% for boys) than both walkers and passive travellers.

A study of the contribution of physical activity and diet to ethnic differences in BMI among adolescents in the Netherlands found that differences with regard to commuting actively to school between Dutch and Non-Western adolescents partly explained the ethnic differences in BMI in the study sample (BMI was higher for the Non-Western adolescents). In contrast, differences in organised or unorganised sport did not contribute to explaining differences in BMI. The authors noted that although the average difference in active commuting to school was small (9–10 minutes per day), even small differences such as these can have a significant impact on body composition over extended periods of time (Singh et al, 2009).

This finding is consistent with a recent analysis of the energy imbalance that underlies the development of childhood and adult obesity in the United States. Boys and girls aged 2–7 years in the US 1988-1994 National Health and Nutrition Examination Survey gained, on average, an excess of 0.43 kg/year over the 10-year period to 1999-2002 (aged 12–17 years). It was estimated that an average energy intake or expenditure of 110–165 kcal/day (0.461–0.691 MJ/day) was required to counterbalance the energy imbalance. The authors noted that a 30 kg boy would need to replace sitting for 114 minutes with walking for 114 minutes or cycling for about 54 minutes for an extra 150 kcal (0.628 MJ). Based on Dutch children's mean annual cycling travel distance (Table 8), the mean energy expenditure per day is 67 kcal[13] representing 45% of the energy imbalance estimated in the US study. Thus, high levels of active travel may contribute to a sizeable proportion of Dutch children maintaining healthy weight.

In contrast, an economic analysis of the Walking School Bus program in Victoria reported only small impacts of the program on Grades Prep to 2 children's BMI. Moodie et al (2009) estimated median BMI reductions of 0.03 kg/m2 for girls and boys based on children walking to and from school for 28 minutes one day a week for 40 weeks of the year (average of once a week during school weeks) (see Appendix B for details of the parameters used in the modelling analysis).

In population terms, active transport cannot prevent all young people from becoming overweight, or provide a stand-alone intervention for weight loss among overweight young people; however, it can contribute to reducing the prevalence of overweight and obesity in the population of young people.

COUNTRY	DISTANCE WALKED PER CHILD PER YEAR (KILOMETRES)	DISTANCE CYCLED PER CHILD PER YEAR (KILOMETRES)	PROPORTION OF TOTAL DISTANCE TRAVELLED USING ACTIVE MODES (%)
USA	123	n/a	0.8[14]
UK	396	79	6.8
NZ	n/a	232	n/a
Norway	550	370	9.7
Sweden	275	424	7.4
Germany	431	518	13.8
Switzerland	773	535	14.4
Netherlands	180	2200	33.5
Melbourne[15]	182	26	4.6

Table 8: Distance walked and cycled per child (10–14 years) per year (kilometres)
Source: Christie et al, 2004

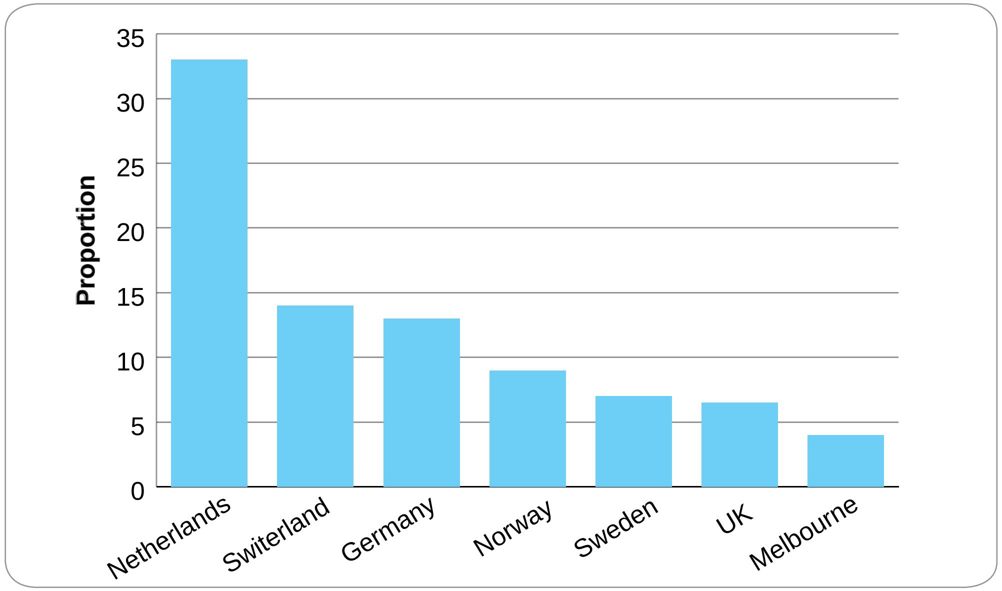


Figure 17: Proportion of total distance travelled by active modes (children)
Source: Ironmonger & Norman, 2007.
Note: Cycling rates are not included in US data because they are very low.
Melbourne data: Melbourne Statistical Division (Greater Melbourne Metropolitan Area), children aged 0–14 years, VATS 1994–99 average

[13] Assuming cycling at a speed of 15 km/hr.
[14] Walking only - cycling rates are not included in US data because they are very low.
[15] Melbourne Statistical Division (Greater Melbourne Metropolitan Area), children aged 0-14 years, VATS 1994-99 average (Ironmonger & Norman, 2007).

Note that there is no current national data available on children's walking and cycling trip distances to school and other destinations in Australia. However, data from the South East Queensland Travel Survey 2003–04 for the Brisbane Statistical Division showed that primary school students' walk trips to school in the Brisbane Statistical Division were for a mean distance of 0.92 kilometres and a median distance of 0.79 kilometres (Burke & Brown, 2007). In NSW, Booth et al (2007) reported that, for secondary school students who walked or used public transport to travel to school, the median times spent walking were 10–15 minutes and five minutes per trip, respectively. This data is for school travel only. An Adelaide study found that active travel to and from school was associated with more frequent walking and cycling to other destinations. Young people aged 5–15 years who travelled to school using active modes were about 30% more likely to travel actively to other neighbourhood destinations (Dollman & Lewis, 2007).

Mental Health

Rates of mental health problems in children and adolescents are increasing (ABS, 2007) and several cross-sectional and intervention studies have demonstrated inverse relationships between physical activity and psychological distress in adolescents. Based on a systematic review of evidence, Strong et al (2005) report that intervention studies demonstrate that physical activity participation improves anxiety and depressive symptoms; and global, social and academic self-concept among school-age young people.

In a recent study involving younger children only, both television and screen entertainment (TVSE) time and physical activity were independently associated with children's Strengths and Difficulties Questionnaire (SDQ) total difficulties score, after adjustment for age, gender, index of deprivation, single-parent status, chronic medical conditions, and various dietary indicators. The SDQ includes subscales of hyperactivity, emotional symptoms, conduct problems and peer problems (Hamer et al, 2009). Out of a maximum SDQ score of 40, children aged 4–12 years with high levels of physical activity (≥ 10 physical activity sessions a week of ≥ 15 minutes) had an adjusted mean score of 7.60 (95% CI: 7.11–8.09) compared with 8.61 (8.13 9.10) for children with low levels of physical activity (≤ 6 physical activity sessions a week of ≥ 15 minutes). These and other authors note, however, that the cross-sectional nature of many studies in this area cannot rule out the possibility of either reverse causality or confounding from unmeasured variables.

Cognitive Functioning, Intelligence Quotient and Educational Attainment

A meta-analysis of the relationship between physical activity and cognitive functioning in children, which included 16 published and unpublished randomised controlled trials, found a significant positive relationship between physical activity and cognitive function, with an overall effect size (estimated using Hedge's g metric) of 0.32 (SD=0.27) (Sibley & Etnier, 2003).

Active transport can increase academic performance

A recent landmark study of all Swedish men born between 1950 and 1976 who were enlisted for military service at age 18 (N=1 221 727) found that cardiovascular fitness, measured by ergometer cycling, was positively associated with intelligence (Wechsler Adult Intelligence Scale) after adjusting for relevant confounders including parental educational level (Åberg et al, 2009). A longitudinal component of the study found that changes in cardiovascular fitness between age 15 and 18 years also predicted cognitive performance at 18 years. Data linking also demonstrated an association between cardiovascular fitness and school achievement and subsequent socioeconomic status. Five points on the Wechsler IQ Scale corresponded to 60 Watt in maximal load on an ergometer cycle. Young men with fitness levels 6–9 were 78% more likely to have obtained a university degree than young men with fitness levels 1–4; and 51% more likely to have an occupation with a high socioeconomic index compared to an occupation with a low socioeconomic index. In contrast to cardiovascular fitness, muscle strength was not associated with cognitive performance, suggesting that the findings may not be due to confounding.

Consistent with these findings, a review of "physical education, physical activity and academic performance" conducted by the US Active Living Centre (see Active Living Research, 2009) concluded that:

Physically active and fit children tend to have better academic achievement.

- Studies consistently show that more time in physical education and other school-based physical activity does not adversely affect academic performance.
- In some cases, more time in physical education leads to improved grades and standardised test scores.
- Physically active and fit children tend to have better academic achievement.
- Evidence links higher levels of physical fitness with better school attendance and fewer disciplinary problems.
- There are several possible mechanisms by which physical education and regular physical activity could improve academic achievement, including enhanced concentration skills and classroom behaviour.
- Additional research is needed to determine the impact of physical activity on academic performance among those children who are at highest risk for obesity in the United States, including black, Latino, American Indian and Alaska Native, and Asian-American and Pacific Islander children, as well as children living in lower-income communities.

As discussed previously, there is good evidence that cycling[16] to school increases aerobic fitness (Voss & Sandercock, 2010). There is also good evidence that active travel to school does not replace other forms of physical activity (Davison et al, 2008; Shephard, 2008). It is therefore likely that regular cycling to school contributes to young people's cognitive functioning and educational attainment.

[16] The evidence is less consistent for walking

5.6.2 Other Health Benefits of Active Travel

A shift from inactive to active travel modes is also associated with health benefits other than those that result from increased physical activity (as described above). The non-physical-activity health benefits and risks (in the case of injury) of active travel for young people include:

- social interaction
- mobility skills (e.g. navigation, traffic safety) and independence
- positive affect (enjoyment and 'green exercise')
- traffic injury.

There is limited research on these health benefits of active travel for children, and they can be difficult to quantify—with the possible exception of traffic injury, though this too is complex.

Traffic Injuries and Active Transport

A recent comparative analysis of 30 OECD countries found highly variable traffic crash fatality rates for young people aged 0–16 years. Fatality rates varied by country, travel mode (walking, cycling, car passenger), measures of traffic exposure (fatalities per population, number of trips, or distance travelled), road safety policies, and a range of socio-demographic factors (Christie et al, 2004; Christie et al, 2007).

Absolute risk of fatality is low for all modes of travel in most countries, including Australia, which has 1.69 child car passenger fatalities per 100 000 child population (ranked 21st[17] out of 26 OECD countries); 0.86 child pedestrian fatalities per 100 000 child population (ranked 13th); and 0.39 child cyclists fatalities per 100 000 child population (ranked 13th). Based on theis data, an Australian child is nearly twice as likely to be killed as a car passenger than as a pedestrian, and more than four times as likely to be killed as a car passenger than as a cyclist (Christie et al, 2004).

These absolute levels of risk are relatively low; however, relative risks based on traffic exposure (i.e. relative fatality rates per trip or per kilometre travelled) result in a different pattern of risks by travel mode. Exposure-based relative risks are generally higher for pedestrians and cyclists than for car passengers, but with large variations between countries. Even in the current traffic environments in United States and New Zealand[18], one fatality occurs for about 10 million kilometres walked or cycled, decreasing to one for about 100 million in the high active travel countries (Christie et al, 2004).

[17] Japan is ranked first (i.e. safest), with a fatality rate of 0.37 per 100 000 child population; with Turkey ranked 26th (4.03 per 100 000). Australia, the US and NZ have among the highest fatality rates for child car passengers (21st, 23rd and 24th respectively) (Christie et al, 2004).
[18] Australian data is not available.

It is interesting to note the impact on children's active travel of parents' perceptions of risk, and of relative risk (walking/cycling/car passenger) rather than absolute risk of injury. Australia, the United States and New Zealand have among the highest fatality rates (per child population) in OECD nations for child car passengers (21st, 23rd and 24th respectively), largely due to greater distances travelled, but it is unlikely that parents choose to drive less (with their children as passengers) to reduce their children's risk of injury. On the other hand, parents do restrict their children's walking and cycling because of injury concerns (Garrard et al, 2009). These risk perceptions can contribute to what Horton (2007) refers to as the "fear of cycling". Jacobsen et al (2009) also describe how motor vehicle domination of transport infrastructure creates fear of walking and cycling, leading to declining levels of active transport, thereby setting in train a cycle of continuing retreat of cyclists and pedestrians from public spaces, which increasingly dominated by cars (see Figure 18).

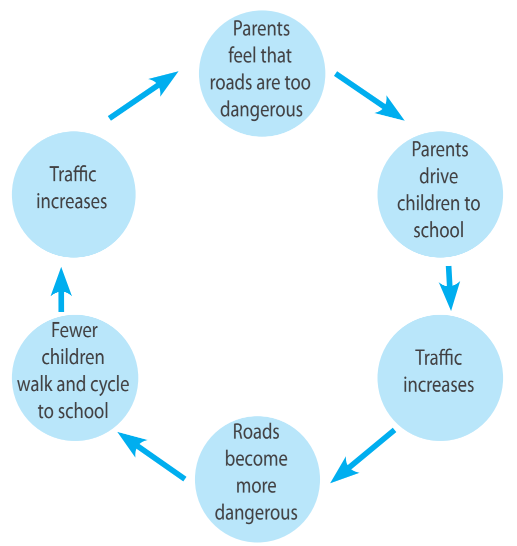


Figure 18: The reinforcing cycle of car dependent children
Source: Sustrans, 1996

5.7 Environmental Impacts of Motor Vehicle Use on Child Health

5.7.1 Air Quality

Motor vehicles are a major source of air pollution in most cities, comprising up to 80% of air pollution (depending on pollutant) in large cities such as Melbourne and Sydney (Bureau of Transport and Regional Economics, 2005). In Australia, from a population of about 20 million people, between 900 and 4500 cases of cardiovascular and respiratory disease occurred due to motor-vehicle related air pollution in 2000, costing between $0.4 billion and $1.2 billion. In addition, 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). These premature deaths, which are comparable to the number of people killed in road crashes (1464 in Australia in 2008), have been labelled "the silent road toll".

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 kilometres) effective ranges, tapering to neutral after three kilometres. Over 24% of child cancers are attributable to these exposures, with roads exerting the major effect (Knox, 2006).

The Australian Institute of Health and Welfare (2010b) recently developed a method for estimating the contribution of air pollution to asthma hospitalisations. The study used Melbourne in 2006 as a case study. The adjusted results of the case study suggest that:

- Approximately 3% of all asthma hospitalisations in Melbourne in 2006 were related to exposure to nitrogen dioxide (60% of which is due to motor vehicle emissions).
- Approximately 4% of asthma hospitalisations of 0–14 year olds were related to particulates in the air (30% of which are due to motor vehicle emissions).

5.7.2 Noise Pollution

Noise pollution associated with motor vehicle traffic also impacts on human health (Niemann et al, 2006). There is emerging evidence of an association between hypertension, heart disease and high levels of noise. Findings from a preliminary study by the World Health Organisation suggest that, for adults, long-term exposure to traffic noise may account for 3% of deaths from ischaemic heart disease in Europe—typically heart attacks (Coghlan, 2007). Traffic noise is also damaging to children's respiratory health (possibly operating through emotional stress) (Niemann et al, 2006); Ising et al, 2004).

> 70% of people hear traffic noise in their homes and over one million Victorians are annoyed by it.
>
> *EPA, 2007*

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, reducing enjoyment of home life and causing 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).

In the 2008–09 ABS report on crime victimisation in Australia, dangerous/noisy driving was the most frequently reported perceived neighbourhood problem, ahead of vandalism/graffiti, housebreakings, drunkenness, louts/gangs, car theft and illegal drugs (See Figure 25) (ABS 2010).

5.7.3 Climate Change

Transport is a significant and growing source of the greenhouse gas emissions that contribute to climate change. Transport accounts for 14.6% of total Australian emissions and rose 29.2% between 1990 and 2008 (Department of Climate Change and Energy Efficiency, 2010). The Australian Greenhouse Office reports that 34% of household emissions are generated from motorised transport (Department of the Environment, Water, Heritage and the Arts, 2008).

The environmental consequences of climate change, which include sea-level rise, degraded air quality and extreme weather events (droughts, floods, heat waves, more intense hurricanes and storms), affect human health both directly and indirectly. The health effects of climate change include heat-related mortality and morbidity, injuries, drowning, vector-, food- and water-borne diseases, food and water shortages and malnutrition, international conflict, cardiovascular disease, stroke, cancer, exacerbation of respiratory diseases such as asthma, respiratory allergies and airway diseases, and mental health and stress-related disorders (USA Interagency Working Group on Climate Change and Health, 2009).

> 34% of household emissions are generated from motorised transport.
>
> *Department of the Environment, Water, Heritage and the Arts, 2008*

5.8 Community Liveability and Child Health

5.8.1 Social Interaction/Social Severance

Human-scale urban environments that support cycling and walking and discourage car use can improve community cohesion (the quantity and quality of social interactions within a community) and increase community attachment, liveability and amenity (Litman & Doherty, 2009). The provision of road space to enable high volume, high speed car travel comes at a cost to other road users and local residents in terms of community disruption, noise pollution, social isolation, urban sprawl, restrictions on 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, 2009; Frumkin et al, 2004; Social Inclusion Unit, 2003; Dora & Phillips, 2000; Ewing et al, 2003). Appleyard's original research, which found that heavy traffic is associated with reduced street-based activities and social interactions between neighbours (Appleyard & Lintell, 1980), has now been replicated in other settings (Bosselmann & MacDonald, 1999; Hart, 2008).

In a survey of primary school students conducted as part of the evaluation of the Victorian Ride2School program, "socialising with friends" was one of the three most frequently cited reasons for liking walking to school (Garrard et al, 2009).

5.8.2 Crime

There is evidence that the more compact, permeable urban designs that support cycling and walking lead to crime reduction through increased street activity and "natural surveillance" (Cozens et al, 2005). In a detailed study in the United Kingdom, Hillier and Sahbaz (2006) concluded that reduced risk of crime arises from "the ordinary co-presence of people that everyday movement and activity brings". This reduces crime risk for young people, as well as the community generally.

Permeable, traffic calmed streets provide a safe environment for walking and cycling, as well as passive surveillance, which deters crime

5.9 Potential for Mode Shift to Active Travel among Young People: The Role of Trip Distance

One of the most consistently reported reasons for driving children to school in Australia is that the trip distance is too far for walking or cycling (Garrard et al, 2009). This section presents data which indicate substantial potential for increasing active travel to school in terms of walkable and bikeable distances.

The following discussion is based on the most recent, comparable data for mode share of trips to and from education by trip distance. The data was collected by the ABS for travel to and from education in Victoria in 1984 and 1994. Victorian data is used because the ABS ceased collection of national data for all modes of travel in 1984 (and Victorian data in 1994).

Walking trips up to about one kilometre are generally considered feasible for young people, as are cycling trips up to about six kilometres. Figures 19 and 20 show mode share changes in travel to school over time in Victoria (1984 to 1994) for trips less than one kilometre (Figure 19) and trips between one kilometre and less than five kilometres (Figure 20). This data shows substantial decreases in active travel between 1984 and 1994 for the relatively short distances that are considered feasible for walking (up to one kilometre) and cycling (up to six kilometres).

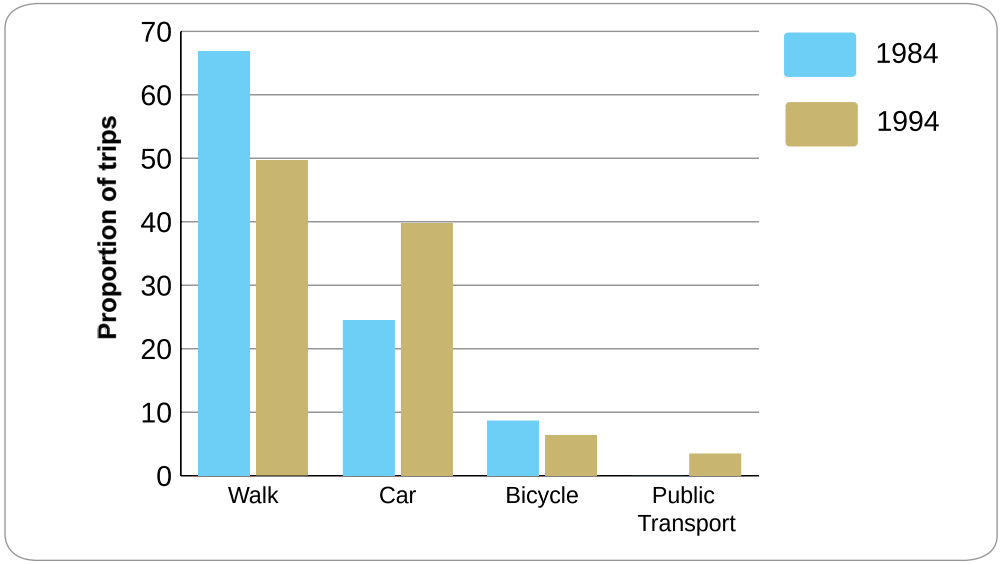


Figure 19: Mode of travel to school (1984) or education (1994) for trips less than one kilometre, respondents' usual mode of travel (%), Victoria

Source: Australian Bureau of Statistics (1995) and Australian Bureau of Statistics Victorian Office (1985)

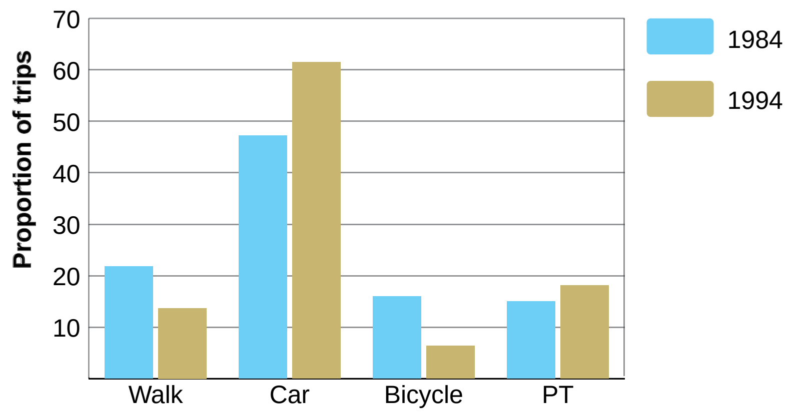


Figure 20: Mode of travel to school (1984) or education (1994) for trips between 1 kilometre and less than 5 kilometres, respondents' usual mode of travel (%), Victoria
Source: Australian Bureau of Statistics (1995) and Australian Bureau of Statistics Victorian Office (1985)

International comparative data also shows a pattern of low rates of active travel to school in Victoria, relative to other countries, for walkable and bikeable distances. Figure 21 shows that car trips were the predominant mode of travel to education for all distances between 500 metres and 10 kilometres in 1994 in Victoria. In contrast, data from 10 municipalities in Denmark shows that walking and cycling are the predominant modes of travel to school for distances up to three kilometres, and cycling rates remain substantial for all trip distances (up to and beyond eight kilometres) (Figure 22).

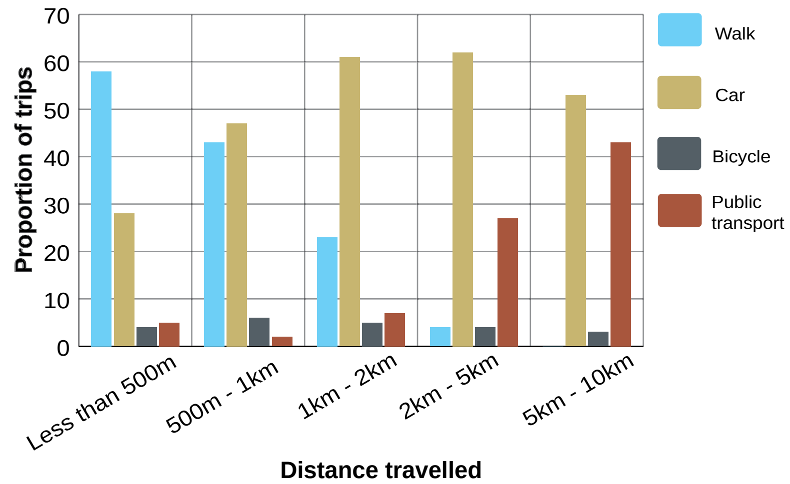


Figure 21: Main method of travel to an educational institution (primary, secondary, higher education) by distance travelled, Victoria, 1994[19]
Source: ABS, 1995

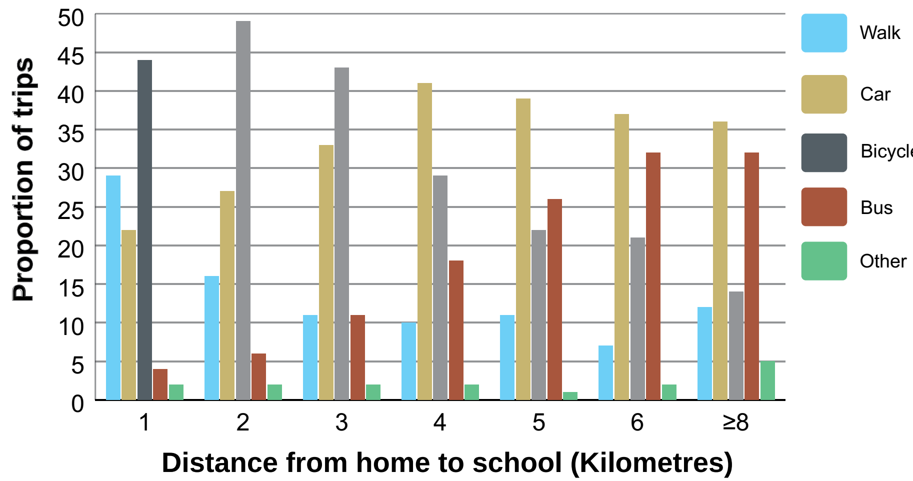


Figure 22: Mode share of all trips to/from school by distance, 10–15 year olds, 10 Danish municipalities, 1998–2000
Source: Jensen & Hummer, 2003

[19] The most recent data available on school travel mode by distance at national or state level.

In summary, it appears that compact urban form facilitates short walking trips (e.g. UK, the Netherlands, Germany) (see Table 7), but good system-wide cycling conditions (cycling infrastructure, traffic calming and car restrictions) are required to support cycling to school as trip distances increase (the Netherlands, Germany, Denmark) (Garrard, 2009). In countries with good provision for cycling, young people cycle relatively long distances to school, including in suburbs not dissimilar to those surrounding Australian cities (van Dyck et al, 2009). In contrast, in Australia, the United Kingdom, the United States and Canada, car trips largely replace walking trips for trip distances greater than about one kilometre.

Compact urban form and low speed streets have helped make cycling to school the norm in some European cities and towns

5.10 Health Impacts of Active Travel and Reduced Private Motor Vehicle Use: Adults

The health benefits of increased physical activity include:

- reduced all-cause mortality
- aerobic fitness
- healthy weight
- mental health
- prevention of:
    - cardiovascular disease
    - cancer (colon and breast)
    - type 2 diabetes
    - osteoporosis
    - depression.

In some cases these benefits have been measured directly for active transport, while in other instances, evidence is available only for physical activity in general. However, given that walking and cycling for transport are classified as forms of moderate to vigorous physical activity (MVPA), it is reasonable to assume that the benefits of MVPA apply to walking and cycling for transport (Shephard, 2008). Research on the energy expenditure of walking and cycling is summarised in the following section.

Australian physical activity guidelines for adults recommend that adults spend 150 minutes on MVPA per week, equivalent to energy expenditure of approximately 800 kcal (3.35 MJ) per week (Egger et al, 1999). Based on energy expenditures for walking and cycling used by Shephard (2008), the gross energy cost of walking at 5 km/h over a smooth, level surface is about 18 kJ/min (depending on an individual's body mass), and about 36 kJ/min for cycling (at a speed of about 16 km/h on urban streets). Thus a total energy expenditure of 3.35 MJ per week would require walking 1.6 kilometres for 19 minutes in each direction, five days a week, or cycling 2.5 kilometres for 10 minutes in each direction, five days a week.

In an assessment of the contribution of active transport to achieving adequate levels of physical activity, Merom et al (2010) conducted an analysis of data from continuous Sydney Greater Metropolitan Area Household Travel Surveys (1997–2007), including only those living in the house aged ≥15 years. The study found that in 2005, 39.2% of householders walked at all[20], 24.7% walked at least one trip of ≥10 minutes, 17.8% achieved the recommended 30 minutes a day (regardless of whether or not trip times were ≥10 minutes), and 14.3% achieved the recommended 30 minutes a day of ≥10 minute sessions).

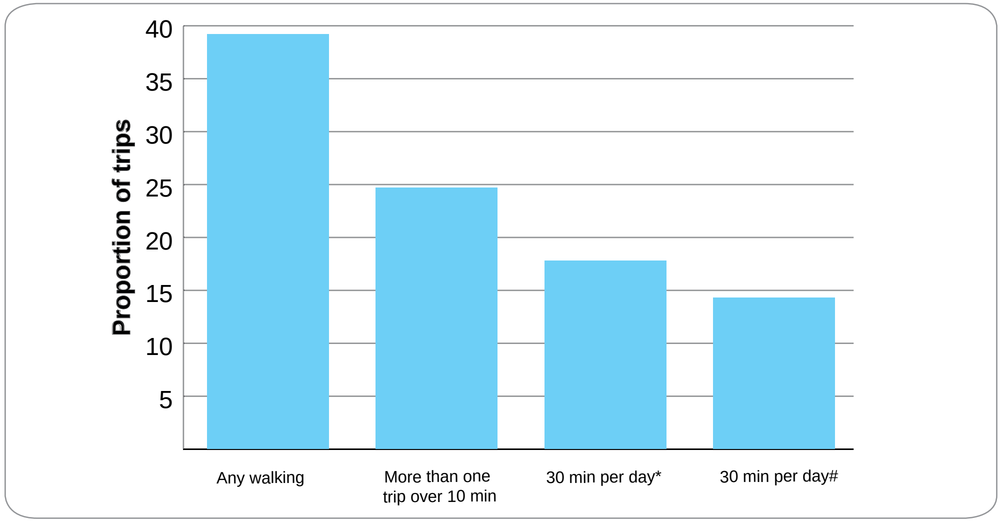


Figure 23: Walking, Sydney Greater Metropolitan Area
Source: Merom et al, 2010
****Regardless of whether trip times were ≥10 minutes***
#Trips ≥10 minutes

Cycling prevalence was low (<1.5%) but utilitarian cycling trips were of longer duration (medians=10–15 minutes) than utilitarian walking trips (medians=5–7 minutes) (Merom et al, 2010). It is not known if this level of active travel for respondents on the day of the survey represents a 'usual day's travel' (respondents completed a one-day travel diary). If respondents achieve these levels of active travel on five or more days a week, a sizeable proportion of the population (14.3–17.8%) would be adequately active through active transport alone. If respondents achieve these levels of active transport for 2–4 days a week, this still represents a substantial contribution to the recommended 150 minutes of MVPA per week.

Bauman et al (2008) have argued that modelling of individuals' 24-hour energy expenditures from all sources demonstrates the need for active living (including active transport) as a means of increasing population levels of physical activity for the purpose of obesity prevention. The following modelling demonstrates the impact of one, two and three 20-minute sessions a week of walking or cycling on the proportion of Australian adults who are adequately active (Garrard et al, 2011).

[20] Including multi-trip journeys such as walking to a railway station

Cycling provides a low impact form of physical activity suitable for a wide variety of fitness levels

Data from the 2000 Australian National Physical Activity Survey indicates that 57% of adults met the recommendation for 150 minutes per week of at least moderate-intensity physical activity, and 43% were 'insufficiently active'. Data was modelled to assess what difference it would make to the population prevalence of 'sufficiently active' adults, if a conservatively estimated 20% of people walked or cycled more often. The modelling estimated the prevalence of sufficient activity if this sub-group of people walked or cycled once a week for 20 minutes, twice a week for 20 minutes, and three times a week for 20 minutes. Then, the analysis was confined to only those who were insufficiently active and 20% of them adopted these amounts of walking or cycling activity. These estimates are shown in Figure 24. Given a baseline of 57% sufficiently active, if 20% of Australian adults walked or cycled 20 minutes once, twice and three times per week, the prevalence of adequately active would increase to 59, 60.5 and 64.5% respectively. If only the inactive were targeted, the prevalence increases would be even larger: to 61, 67 and 72%. Since few population- or community-wide interventions to promote physical activity have achieved anywhere near a 5% absolute increase in sufficient physical activity, the public health potential for active transport is large, even at modest amounts and frequency of activity, and especially if currently inactive people adopt some walking or cycling.

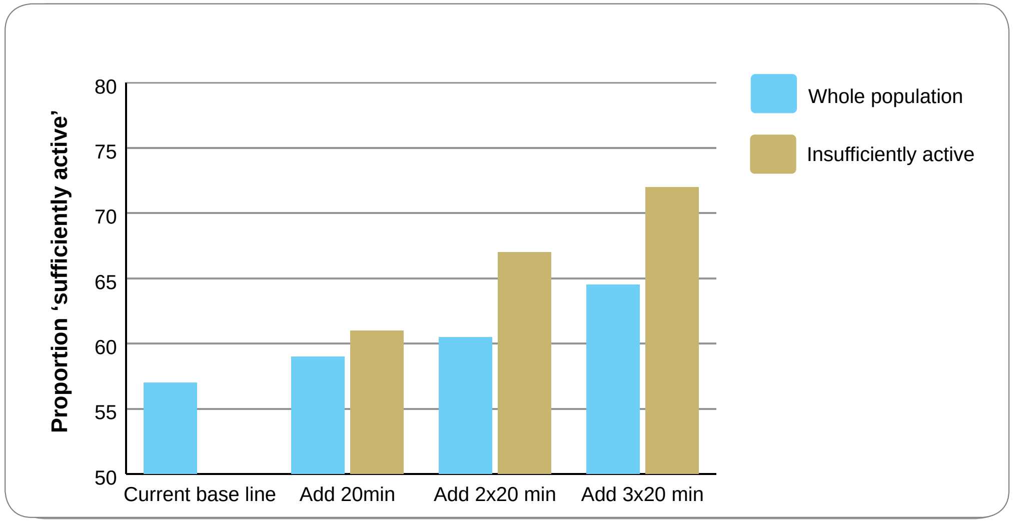


Figure 24:Effect of adding episodes of cycling/week on population level (%) of 'sufficiently active' for (i) 20% of the adult population, and (ii) 20% of adult population who are 'insufficiently active'
Source: Garrard et al, 2011, based on data adapted from National Physical Activity Survey, Australia, 2000

Small increases in active travel as a part of daily life, which do not necessarily move people into the adequately active category, can also contribute to health gains. In an analysis of the impacts of increased prevalence of footpaths in Dane County, Wisconsin, Guo and Gandavarapu (2010) estimated that the provision of footpaths along all roadways currently without them in an individual neighbourhood would equate to about 1.7 minutes of additional physical activity per person per day. The authors estimated that, assuming an average walking speed of 5.6 km/h, the extra 45.6 kJ of energy expenditure (for an average 68 kg person) could off-set weight gain[21] in about 37% of the population (based on median daily energy accumulation in the population).

[21] Refers to weight gain of any amount, i.e., should not be interpreted as "preventing 37% of people from becoming overweight".

5.10.1 Reduced All-Cause Mortality

Walking and cycling for transport (Andersen et al, 2000; Matthews et al, 2007) and walking in general (Woodcock et al, 2010) have been shown to reduce all-cause mortality, though not in all studies for both men and women. In a study in Finland, Barengo et al (2004) reported that reduced all-cause mortality was associated with active commuting for women only. In a UK study of men (as part of the Whitehall study), active transport was not associated with all-cause mortality after adjustment for a number of factors (Batty et al, 2001). However, the adjustment included factors such as BMI and lung function that may lie on the activity-mortality causal pathway. Their inclusion as potential confounding variables is therefore questionable.

Numerous studies have found the health benefits of cycling to work outweigh the risks

A systematic review and meta-analysis of non-vigorous physical activity and all-cause mortality found that, compared with no walking, 2.5 hours of brisk walking a week (~11 MET-hours/week) was associated with a relative risk of 0.89 (95% CI 0.82–0.96) (Woodcock et al, 2010).

A study of Chinese women found a 21% reduced risk of all-cause mortality for 0.1-3.4 MET-hours/day cycling to work, and a 34% reduced risk for at least 3.5 MET-hours/day cycling to work (p for trend=0.018). Walking to work and other destinations was also associated with reduced risk, but the association was not significant (p for trend=0.071).

The risk ratios were adjusted for a number of demographic and health covariates, including other forms of physical activity such as exercise and housework (Matthews et al, 2007).

For the Copenhagen City Heart Study cohort (13 375 women and 17 265 men), Andersen et al (2000) reported that cycling to work was associated with a 28% reduced risk of all-cause mortality after multivariate adjustment, including leisure-time physical activity.

> **The health benefits of commuter cycling outweigh the health risks.**
>
> *Andersen et al, 2000; Matthews et al 2007*

The studies by Andersen et al (2000) in Denmark, and Matthews et al (2007) in China (N=67 143, women only) are particularly important as both were large cohort studies that reported significant reductions in all-cause mortality associated with cycling to work, including after adjusting for leisure-time physical activity. These findings indicate that:

- The health benefits of commuter cycling outweigh the health risks (e.g. injury, air pollution)[22,23]
- Active commuting either does not displace other forms of physical activity or, if it does, has greater health benefits than the leisure-time physical activity it displaces.

These studies also demonstrated that active transport provides health benefits for the more socially disadvantaged population groups that often have low levels of participation in sport and active recreation (ABS, 2009).

5.10.2 Aerobic Fitness

Commuter cycling improves the physical performance (maximal external power [Wmax] and maximal oxygen uptake [O2max]) of men and women—particularly for those with a low initial fitness level, for whom a single trip distance of three kilometres per day on at least four days per week was sufficient to improve physical performance (Hendriksen, 1996; Hendriksen et al, 2000). After six months of commuter cycling, with a mean single trip distance of 8.5 kilometres and a mean frequency of more than three times a week, a significant increase of 13% was found in Wmax in both sexes. The improvement in O2max was significant for men (6%) but not for women (-2%). Lower physical performance at the start of the study and the higher distance cycled resulted in higher gains in Wmax. The authors concluded that cycling to work can achieve similar improvements in physical performance as specific training programs.

In an assessment of the contribution of active transport to population health, Shephard (2008) reported that the energy cost of commuter walking may be insufficient to improve the aerobic fitness of young males, although sufficient to improve the fitness of a very unfit young adult or an older adult. On the other hand, the intensity of effort for urban cycling was estimated to fall into the cardiorespiratory training zone for younger adults. The author concluded that the usual intensity of walking may be insufficient to benefit the cardio-vascular health of fit young adults, and that increased effort would assist in reaching the aerobic training threshold.

5.10.3 Cardiovascular Disease

A recent meta-analysis of eight studies of the relationship between active commuting and cardiovascular risk reported an 11% overall reduction in cardiovascular risk, based on end-points including mortality, incident coronary heart disease, stroke, hypertension and diabetes (Hamer & Chida, 2008a). A meta-analysis of 18 studies on walking reported risk reductions of 31% for cardiovascular disease, and 32% for all-cause mortality (Hamer & Chida, 2008b). The greater risk reductions for walking than 'active commuting' may be due to the low levels of active commuting observed in most of the studies, which were largely conducted in countries with relatively low levels of active travel. If the range of activity levels in the sample is low (i.e. little difference between people with 'high' and 'low' levels of active commuting), relative risk reductions are correspondingly low. In countries with high levels of active transport, reductions in all-cause mortality associated with active commuting (principally cycling) are relatively high: 28% in Copenhagen and 34% in Shanghai (Andersen et al, 2000; Matthews et al, 2007).

5.10.4 Cancer

A recent review of the association between physical activity and cancer concluded that there is strong and consistent evidence that physical activity reduces the risk of several of the major cancer sites, and that between 9% and 19% of cancer cases could be attributed to lack of sufficient physical activity in Europe (Friedenreich et al, 2010). The evidence was assessed as convincing or probable for colon, breast and endometrial cancers; and weaker for ovarian, lung and prostate cancers. The authors estimated that between 165 000 and 330 000 cases of the six major cancers (breast, colon, lung, prostate,

[22] Confirming previous studies indicating favourable benefit-risk profiles for cycling
[23] An assessment of the health benefits and risks of cycling in the Netherlands found that for individuals who shift from car to bicycle, the beneficial effects of increased physical activity are substantially larger (3–14 months gained) than the potential mortality effect of increased inhaled air pollution doses (0.8–40 days lost) and the increase in traffic accidents (5–9 days lost).

endometrium and ovarian) could have been prevented in 2008 in Europe alone if the population had maintained sufficient levels of physical activity. Physical activity has also been shown to improve cancer survival (Orsini et al, 2008).

Some researchers have studied cancer risk and active transport. Bicycling alone was not protective for ovarian cancer (Biesma et al, 2006), and there have been inconsistent findings for breast cancer. A study of Chinese women found no association between cycling and breast cancer (Matthews et al, 2001), but a German study reported lower risk of breast cancer among women who reported the highest levels of cycling (Steindorf et al, 2003).

For colon cancer, a case-control study in older adults reported a 40% decreased risk among active commuting men and women (Hou et al, 2004). Similar results were seen in the Shanghai women's health cohort, where cycling more than 40 minutes a day significantly reduced all-cause and cancer mortality risk (Matthews et al, 2007).

> The overall burden of preventable chronic disease in Queensland is predicted to rise by more than 20% between 2006 and 2016. Major increases in type 2 diabetes are fuelling much of this growth.
>
> *Queensland Government, 2008, p. 32*

5.10.5 Type 2 Diabetes

The health benefit of regular physical activity on reducing the incidence of type 2 diabetes is well documented for both aerobic and resistance types of physical activity, with each increase of 500 kcal (2.1 MJ) in energy expenditure per week estimated to be associated with a decreased incidence of type 2 diabetes of 6% (Helmrich et al, 1991). The protective effect of physical activity was strongest for those most at risk of type 2 diabetes (i.e. people with a high body mass index, a history of hypertension, or a parental history of diabetes).

A study that examined the impact of different types of physical activity (occupational, commuting and leisure-time physical activity) on risk of type 2 diabetes reported adjusted hazard ratios (HR) of diabetes of 1.00, 0.96, and 0.64 (p=0.048 for trend) for none, 1–29, and more than 30 minutes per day of walking or cycling to and from work respectively. The effect of 30 minutes of walking or cycling for commuting was similar to that of high levels of leisure-time physical activity (HR=0.61) (Hu et al, 2003). Partially consistent with these findings from cohort studies, an ecological study (including 14 countries, all 50 US states, and 47 of the 50 largest US cities) reported a negative association between population rates of active travel and type 2 diabetes at the US state and city levels, but not at the country level (Pucher et al, 2010).

5.10.6 Osteoporosis, Fractures and Falls

Risk factors for falls among older adults include muscle weakness, impaired balance, gait deficit, and limited mobility. Exercise interventions have been found to be effective approaches for the prevention of fall injuries among community-dwelling older people. Physical activity can help improve muscle strength and balance, which in turn improves mobility and functional capacity, and reduces the risk of falls and injuries. A meta-analysis of studies on falls prevention interventions found that exercise-alone programs were about five times more effective than multi-factorial interventions (risk ratio=0.45, 95% CI: 0.29–0.71) (Petridou et al, 2009).

An inverse association between physical activity and risk of fractures is also well established, with a recent meta-analysis of 13 prospective cohort studies reporting that moderate to vigorous physical activity is associated with a hip fracture risk reduction of 45% (95% CI 31–56%) for men and 38% (95% CI 31–44%) for women (Moayyeri, 2008). A study that examined how this association varies according to the type of physical activity undertaken found that walking for leisure or transport was associated with lower risk of fracture in both men and women. In a combined analysis including both men and women, walking for any duration was associated with reduced risk of fracture (any fracture HR=0.74, 95% CI 0.58–0.93; hip fracture HR=0.57, 95% CI 0.37–0.87) (Moayyeri et al, 2010). There appear to be no studies of the relationship between cycling and risk of fracture.

5.10.7 Cognitive Functioning

The large US Nurses' Health Study found that long-term regular physical activity, including walking, was associated with significantly better cognitive function and less cognitive decline in older women. The study found a 20% lower risk of cognitive

> 25% of trips by people aged 65+ in the Netherlands are by bicycle.
>
> *Pucher & Buehler, 2008*

impairment for women in the highest quintile of activity compared with women in the lowest physical activity quintile (Weuve et al, 2004). In a US study of community-dwelling older men and women, higher levels of physical activity were associated with reduced risk for Alzheimer's disease. The hazard ratio (HR) for 'much' physical activity compared with 'no' physical activity was 0.67 (Scarmeas et al, 2009). A systematic review of cognitive functioning in older people concluded that physical activities that improve cardiorespiratory fitness are also beneficial for cognitive function in healthy older adults. Effects include improvement in motor function, cognitive speed, delayed memory functions and auditory and visual attention (Angevaren et al, 2008).

The prevention of dementia through physical activity has the potential to impact on a large and growing global health issue. Dementia is one of the most common causes of institutionalisation, morbidity and mortality among the elderly. It has been estimated that globally 24–30 million people have dementia, with four to six million new cases diagnosed each year, and the number of people affected doubling every 20 years (Mechling, 2008). The Australian Institute of Health and Welfare (2008) report that dementia and related disorders rank as the 11th leading cause of death for men and the 4th leading cause of death for women, accounting for 2.2% and 5.2% of total deaths in Australia respectively. Moreover, dementia is a leading cause of 'years lost due to disability' (Australian Institute of Health and Welfare, 2008). In countries, such as the Netherlands, Denmark, Germany and Japan, that have established a culture of everyday active transport, walking and cycling trips comprise a high proportion of trips by older adults—for example, 25% of trips by people aged 65+ in the Netherlands are by bicycle. (Pucher & Buehler, 2008).

5.10.8 Mental Health

In an Australian study, physical activity in older adults (55–89 years, mean age 65.2 years) was found to be related to positive mental health. People who were either moderately (150–420 minutes per week) or highly active (>420 minutes per week) had significantly higher mental health status (assessed using the SF-12 health survey questionnaire) than those who were inactive (<150 minutes per week) after controlling for physical health status (Mummery et al, 2004).

> Exercising in the presence of nature improves self-esteem and mood.
>
> *Barton & Pretty, 2010*

Of particular relevance for active transport is the growing body of research indicating that there are health benefits associated with contact with the outdoor environment. A recent review of research into 'green exercise' found that exercising in the presence of nature (including both urban and rural settings) improves self-esteem and mood, with a synergistic effect for exercise and exposure to nature (Barton & Pretty, 2010). Active transport is a form of physical activity that usually occurs outdoors, but there appear to be no studies of active travel specifically.

A recent systematic review of the relationship between physical activity and depression (including one study that involved pedalling on a stationary bicycle) concluded that exercise reduces the symptoms of depression (Mead et al, 2009). Based on this evidence, the recent UK National Institute of Clinical Excellence (NICE) guideline for depression recommends the inclusion of regular exercise in the treatment of mild depression (NICE, 2007). Others state that aerobic exercise may be considered a potential stand-alone treatment for mild depression, or used in conjunction with antidepressant medication (Mago & Mahajan, 2009).

5.10.9 Healthy Weight

A number of studies have reported a negative association between active travel and overweight/obesity (Bassett Jr et al, 2008; Wen & Rissel, 2008; Pucher et al, 2010). Similarly, in an Australian study, driving to work was associated with a 13% increased risk of being overweight or obese (Wen et al, 2006) after controlling for leisure-time physical activity and other confounders. Similar associations between time spent driving and obesity have been found in other parts of the world, including the United States (Frank et al, 2004) and China (Bell et al, 2002). A survey conducted in Adelaide found that regular active transport appeared to moderate the relationship between TV-viewing time and BMI, while leisure-time physical activity did not—that is, in contrast to leisure-time physical activity, BMI did not differ across TV-time categories for regular active transport users (Sugiyama et al, 2010).

An ecological study (including 14 countries, all 50 US states, and 47 of the 50 largest US cities) reported a negative association between population rates of active travel and obesity at all three geographic levels (Pucher et al, 2010).

An intervention study aimed at reducing waist circumference for abdominally obese women in Sweden by increasing active commuting reported waist reductions for both moderate- and low-intensity programs (-2.1 and -2.6 cm respectively) and reductions in commuting by car and public transport of 34% and 37% respectively (Hemmingsson et al, 2009).

5.10.10 Workplace Absenteeism and Job Satisfaction

Workplace wellness programs (including those that promote physical fitness) can result in lower rates of absenteeism and increased job satisfaction (Parks & Steelman, 2008). A meta-analysis of workplace physical activity interventions reported significantly positive effects for work attendance (effect size 0.19) and job stress (effect size 0.33) (Conn et al, 2009). A cross-sectional survey of 1236 Dutch employees found that the mean total duration of absenteeism during the study year was significantly shorter for employees who cycled regularly (one-way cycling distance of ≥3 km and a cycling frequency of at least three times a week, or one-way cycling distance of ≥2 km and cycling frequency of at least four times a week) compared to non-cyclists, with the cyclists averaging 7.4 days and the non-cyclists averaging 8.7 days (Hendriksen et al, 2010).

Walking and cycling to work has been shown to reduce absenteeism and improve workplace productivity

5.10.11 Additional Health Benefits of a Mode Shift from Car Use to Active Transport for Adults

The research summarised above focused on the health benefits of physical activity (and active transport in particular, where available). However, as outlined in Table 6 there are multiple health benefits associated with a mode shift from car use to active transport. These are mainly associated with reduced car use, and include the health benefits associated with environmental improvements (air and noise pollution, climate change) and improved community liveability. The benefits associated with reduced traffic congestion are not covered in this section of the report, though it is important to note that traffic congestion also impacts on health and wellbeing as well as affecting the efficiency of the transportation system.

The environmental health benefits, and improvements in community liveability associated with a mode shift from car use to active transport were outlined earlier in the section dealing with the health impacts of active transport for children and young people. It is difficult to disaggregate these benefits for population sub-groups such as children and adults, and this information is not repeated here.

The benefits of improved community liveability can also be difficult to quantify, even though—as proposed by Forsyth et al (2009)—community liveability may represent the most important of the four main benefit areas (community liveability, health, transport and the environment) associated with a mode shift from car use to active transport.

As an illustration of the multiple, and often relatively unrecognised ways that motor vehicle use can adversely impact on community liveability, the 2008–09 ABS survey of crime victimisation in Australia included data on perceived neighbourhood problems from crime or nuisance. Sixty-nine percent of Australians perceived that their neighbourhood had specific problems from crime or public nuisance; with dangerous or noisy driving the most commonly perceived problem (see Figure 25), followed by vandalism, graffiti or damage to property (35%); and housebreakings, burglaries or theft from homes (29%) (ABS, 2010).

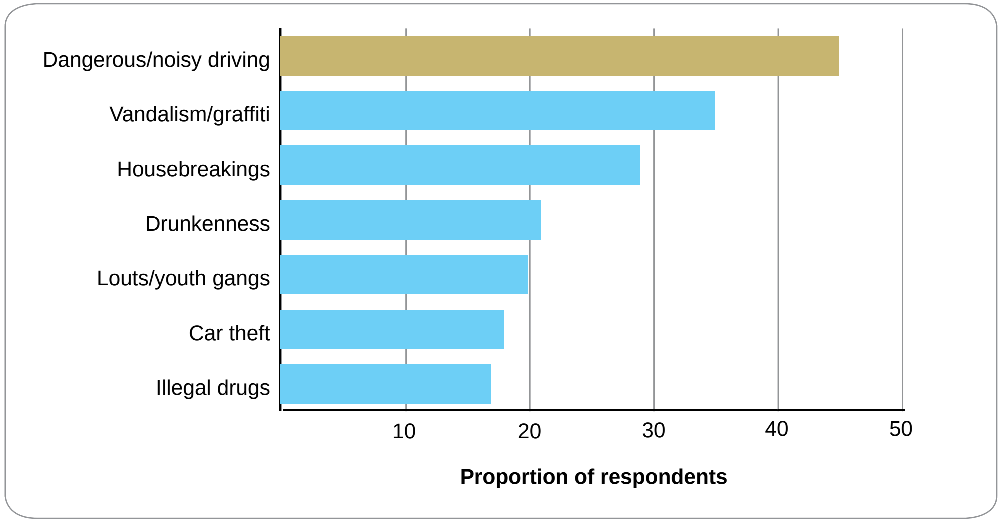


Figure 25: Perceived neighbourhood problems
Source: ABS, 2010

5.10.12 Other Health Factors Associated with a Mode Shift from Car Use to Active Transport

While there are substantial health benefits associated with a mode shift from car use to active transport as outlined above, there are also some health costs. The principal health risks of active travel relative to car travel are road traffic injury and exposure to air pollutants.

Traffic Injury

Pedestrian and cyclist fatality and injury rates based on distance travelled are generally higher than for car drivers and passengers (World Health Organisation, 2009). There is, however, substantial variation between countries (Pucher & Buehler, 2008), indicating that appropriate road safety measures can reduce both road traffic injury rates (based on population, trips or distance travelled) and the differential between pedestrians/cyclists and motor vehicle occupants. Improved pedestrian and cyclist safety, together with reduced car travel, appears to have an overall societal benefit in terms of road traffic injuries, with cross-country comparative data demonstrating an inverse association between active travel rates and overall road traffic fatalities (Garrard, 2009).

National data for pedestrian and cyclist fatality and injury rates based on distance travelled is not available as Australia does not have national data on distances travelled for all trip purposes. Household travel data that include all trip modes and distances is available for the greater metropolitan areas of Sydney and Melbourne (about 75% of the population in NSW and Victoria respectively). This data has been used to calculate cyclist fatality and injury rates per vehicle kilometre travelled (VKT) and the relative risk of fatality and injury for cyclists compared with car occupants (Garrard & Greaves, 2010) (see Table 9). Hospital data (Melbourne) is for serious injuries (involving admission to hospital for one or more days). Police data (Sydney) includes serious and minor injuries. While injury rates based on distance travelled is a better measure of risk exposure than rates based on population or number of trips, injury rates based on travel time are preferable if available.

	CYCLIST FATALITIES PER 100 MILLION KILOMETRES	CYCLIST INJURIES PER 100 MILLION KILOMETRES	CAR OCCUPANT FATALITIES PER 100 MILLION KILOMETRES	CAR OCCUPANT INJURIES PER 100 MILLION KILOMETRES	BICYCLE/ CAR RISK RATIO FATALITY	BICYCLE/ CAR RISK RATIO INJURY
Melbourne[24]	1.1	124 (P) 315 (H)	1.1	9.6 (P) 9.4 (H)	4.5	13 (P) 34 (H)
Sydney [25]	5.3	557 [26]	0.37	34[26]	14.3	19[26]

Table 9: Cyclist and car occupant fatalities and injuries, Sydney and Melbourne
Source: Garrard & Greaves, 2010
P = Police data; H = Hospital data. It is well established that police data underreports cyclist serious injuries.

A number of studies have reported inverse, non-linear associations between cyclist and pedestrian numbers and rates of cyclist and pedestrian injuries, suggesting that as levels of cycling and walking increase, injury rates decrease. Correlational and time-trend analyses have been conducted nationally (Jacobsen 2003), regionally (Knowles et al, 2009; Jensen et al, 2000, cited in Wittink, 2003), and at selected sites within cities (Turner et al, 2010). These studies have generally reported injury-rate reductions with increased numbers of pedestrians and cyclists, though with some variation in the magnitude of the rate reduction across studies. While there is good evidence for an association between numbers and safety, there is some debate as to whether or not the relationship is causal (Knowles et al, 2009; Bhatia & Wier, 2011), and, if it is causal, as to the likely mechanism. The key explanatory mechanism that has been proposed is that drivers modify their behaviours when they expect or experience people walking or cycling (Jacobsen, 2003). However, it is also likely that the relationship between increased numbers and increased safety is at least partially confounded by improvements in cycling and walking conditions (e.g. infrastructure provision, traffic calming) leading to both increased walking and

[24] For financial year 2007–08. Note that there is high random variation by year, particularly for cyclist fatalities.
[25] Average for the years 2002 to 2005.
[26] Includes minor injuries.

cycling and increased safety. Most 'safety in numbers' studies do not control for this likely confounding factor, and cities that have successfully increased transportation cycling and improved cycling safety have generally implemented integrated packages of measures designed to increase both cycling and safety (Pucher et al, 2010). Unsurprisingly, a substantial mode shift from car use to walking and cycling is likely to result in improved safety for pedestrians and cyclists due to reduced exposure to motor vehicles (Elvik, 2009).

In summary, pedestrian and cyclist safety may improve with increased levels of walking and cycling (with or without a concurrent decrease in car travel) but even if the relationship is indeed a causal one, it should be seen as an ancillary benefit of effective active transport promotion and safety improvement initiatives, rather than a stand-alone pedestrian/cyclist safety strategy (Bhatia & Wier, 2011). A large online survey of cyclists in Queensland found that cyclist injury rates (for adults) declined with cycling experience (adjusted for age, gender, cycling frequency and other covariates), and injury rates appeared to be higher for recreational and competition cycling than for transportation cycling (Heesch et al, 2010).

Exposure to Air Pollutants

Motor vehicles emit a variety of air pollutants that are known to be associated with adverse health effects. Common air pollutants emitted by motor vehicles include fine particles, nitrogen dioxide and volatile organic compounds (VOCs). Exposure to fine particles is associated with short- and long-term adverse health effects on the lungs and heart, including premature death (World Health Organisation, 2000). Motor vehicles are a major source of air and noise pollution in Australian cities (Standing Committee on Environment and Heritage, 2005; Commissioner for Environmental Sustainability, 2007; Bureau of Transport and Regional Economics, 2005). As previously stated, between 900 and 4500 cases of cardiovascular and respiratory disease occurred due to motor vehicle related air pollution in 2000, costing between $0.4 billion to $1.2 billion. In addition, 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).

> In Australia, air pollution caused by motor vehicles accounts 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*

Cars are a major source of air pollution, with occupants exposed to higher levels than ambient urban concentrations

Investigations in a number of cities around the world have shown that exposure to air pollutants for commuters in motor vehicles is considerably higher than ambient urban concentrations, and also often higher than concentrations found in other urban transport modes such as train, bus, cycling and walking (Chertok et al, 2004; Batterman et al, 2002; California Air Resources Board, 1999; Duffy & Nelson, 1997; Lawryk & Weisel, 1996; Giles-Corti et al, 2010).

One explanation given for the high exposure of motor vehicle occupants to air pollutants is that it is the nature of traffic that a vehicle travels in a generated tunnel of pollutants, and that once these pollutants are in the cabin of the motor vehicle they do not readily disperse (van Wijnen 1995; Taylor & Fergusson 1998). Pollutants do disperse in the open air, and cyclists or walkers, who are often slightly (or substantially in the case of cyclists using off-road paths or quiet streets) further away from traffic and so are generally less exposed. On the other hand, the higher respiration rates for cyclists compared with motor vehicle occupants (estimates range from 2.3 to 4.3 times higher) can result in cyclists experiencing greater inhaled quantities of some pollutants than car passengers (Panis et al, 2010).

This is a complex area, with study findings varying for different pollutants, locations, weather conditions, vehicle types, driving styles and study methods (Panis et al, 2010). What is certain, however, is that reduced motor vehicle use will reduce the health risks of air pollution for all people in urban areas. Choosing low traffic cycling routes can also reduce cyclist exposure to air pollution, especially particulate matter, which is emitted in higher concentrations by diesel-fuelled vehicles such as buses and trucks.

The health risks of active transport in the form of exposure to road traffic injury and air pollution can detract from substantial health benefits in other areas. However, to date, assessments of the health benefits and costs indicate a substantial overall benefit (British Medical Association, 1992; Roberts et al, 1996).

A recent assessment of the impact on all-cause mortality of 500 000 people shifting from car to bicycle for short trips on a daily basis in the Netherlands found that for individuals who shift from car to bicycle, the beneficial effects of increased physical activity are substantially larger (3–14 months gained) than the potential mortality effect of increased inhaled air pollution (0.8–40 days lost) and the increase in traffic crashes (5–9 days lost). The authors noted that the benefits to the population as a whole are even larger due to small reductions in air pollution, greenhouse gas emissions and traffic crashes (de Hartog et al, 2010).

In summary, walking and cycling are accessible, affordable and achievable by people of all ages. There is good evidence that the benefits outlined above can be achieved by a mode shift from inactive to active transport for trip distances up to one kilometre for walking, and up to about six kilometres for cycling. These active travel trip distances are achievable in Australia where, in spite of relatively low population density (including in urban areas), the majority of everyday trips by householders are less than five kilometres (see Figure 8).

6

The Extent of Change in Active Transport: Intervention Types and Evaluation Approaches

6.1 Interventions

A number of interventions aimed at increasing active transport have been implemented and evaluated. These interventions, which take many forms, can be categorised according to the four determinants domains shown in Figure 26.

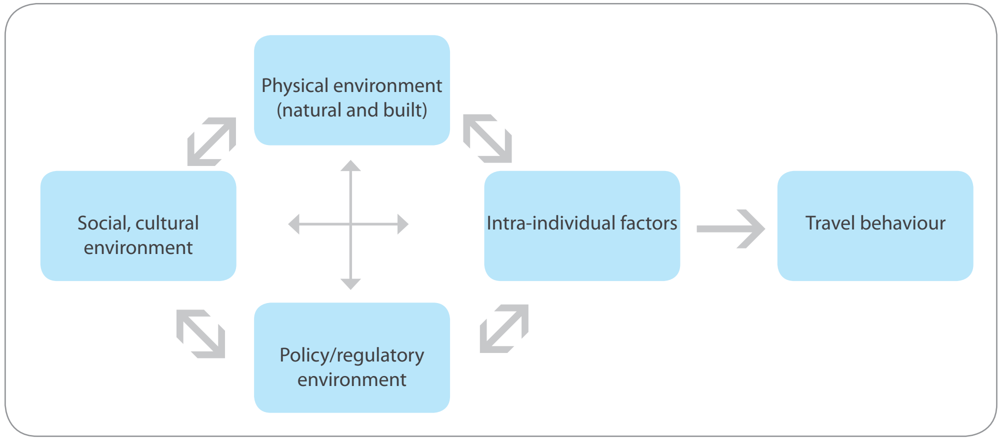


Figure 26: Determinants of travel modes
Adapted from Gebel et al, 2005

The two areas that have been investigated most thoroughly are individual-focused behaviour change programs (directly addressing mainly intra-individual factors) and active travel infrastructure (the built environment), with some interventions addressing both areas. Few studies have evaluated policy/regulatory interventions (e.g. reduced speed limits), and it appears that no evaluated interventions have focused primarily on social/cultural factors, although some individual-focused behaviour change programs incorporate social elements.

> Culture, custom and habit tend to foster cycling in cities with high levels of cycling but deter cycling, especially among non-cyclists, in cities with low levels of cycling.
>
> *Pucher et al, 2010*

As noted by Pucher et al (2010), culture, custom and habit tend to foster cycling in cities with high levels of cycling but deter cycling, especially among non-cyclists, in cities with low levels of cycling, where it can be viewed as a fringe mode. A recent study reported an association between 'social control' (defined operationally as parental beliefs about whether neighbours will watch out for children) and children's use of active travel modes on the trip to school (McDonald et al, 2010); and at the more macro level, Garrard (2009a) has noted a negative association between children's per capita active travel distance and income inequality[27] in OECD countries.

Not surprisingly, interventions based on these social/cultural factors have not been implemented or evaluated. Nevertheless, their potential importance needs to be acknowledged. In their review of the determinants of walking and cycling for transport, Krizek et al (2009) note that:

> Fully understanding NMT [non-motorised travel] is an extremely complex endeavour that requires the analyst to wade through muddied waters and to consider multiple reasons for use and multiple outcome measures.

And:

> In most studies aiming to predict various dimensions of travel behaviour, more than 70% of the variation in the data goes unexplained. (Krizek et al, 2009 p. 10)

It is likely that a number of social/cultural and policy/regulatory factors contribute to this 70% 'black hole'. In terms of evaluating the effectiveness of interventions, case studies of comprehensive, region-wide strategies aimed at increasing active travel can assist in capturing the impacts of these mediating factors.

Interventions can also be classified according to whether they target increased active travel, or reduced car use or both. The Community-Based Social Marketing (CBSM) model for fostering behaviour change (in a range of sustainability areas including active transport) recognises that the decision to use active travel (i.e. walk or cycle) involves weighing up (often implicitly) the perceived benefits and barriers of both the target behaviour (active travel) and the competing behaviour (driving) (McKenzie-Mohr & Smith, 1999) (see Table 10). The CBSM approach involves a series of steps aimed at identifying and addressing perceived benefits and barriers to the new behaviour (i.e. walking or cycling) and the alternative behaviour (i.e. travelling by car).

	TARGET BEHAVIOUR (ACTIVE TRAVEL)	COMPETING BEHAVIOUR (TRAVELLING BY CAR)
Perceived benefits	Improved health	Saves time
Perceived barriers	Access to safe walking/cycling routes	Difficult/expensive to park car

Table 10: Examples of perceived benefits and barriers of active and inactive modes of travel

[27] More equal societies are characterised by higher levels of trust, social cohesion, and involvement in community life; and lower levels of violence (Wilkinson & Pickett 2009). These features could well influence parents' willingness to allow their children the level of independent mobility that characterises children's use of public space in more equal societies, and in previous generations in Australia.

Creating the conditions in which cycling becomes the norm helps break down social barriers to cycling

The active transport evaluation literature focuses primarily on individual behaviour change programs—often called 'soft' transport policy measures in contrast to 'hard' infrastructure measures. Typical examples of soft transport policy measures are workplace travel plans, personalised travel planning, public transport marketing, and travel awareness campaigns (Möser & Bamberg, 2008). Although categorised as 'soft', some behaviour change programs include infrastructure measures such as secure bicycle parking; changing facilities, showers and lockers; and services on site to reduce the need to travel (e.g. cafeteria, cash dispenser, convenience store). Policy measures sometimes incorporated into behaviour change programs include preferential car parking for car-sharers, workplace bicycle travel distance allowance, car sharing schemes, parking 'cash out' (paying employees a small sum on days they do not drive), car parking restricted to essential users and parking charges (Möser & Bamberg, 2008).

The other main area that has been subjected to evaluation research is the provision of active transport infrastructure (i.e. 'hard' measures). These interventions are more difficult to evaluate than direct behaviour change programs. For example, new bicycle lanes along a particular route often lead to increased use, but the possibility that existing cyclists are simply swapping to the new route cannot be ruled out. Evidence for the impacts of infrastructure measures comes predominantly from cross-sectional analytic studies and stated preference studies rather than intervention studies.

6.1.1 Evaluation approaches

Evaluation of the impacts of active transport interventions can also be categorised into *program evaluation* (e.g. evaluation of TravelSmart programs in community or school settings) and *policy evaluation* (e.g. monitoring changes in transport mode share in areas that have implemented an integrated package of measures aimed at increasing active travel). This review includes both types of evaluation findings. Macro-level policy evaluation is less precise than program evaluation in terms of quantifying the impacts of specific components of a multi-component strategy, but it provides a better assessment of the reach, effectiveness and sustainability of holistic efforts to achieve change at the societal level.

The evaluation findings summarised below come from three sources: evidence reviews (narrative, systematic and meta-analyses); findings from individual program evaluations (recent and/or Australasian); and policy evaluations of integrated packages of measures at regional, city or town levels, often in the form of case studies.

Where appropriate, interventions have been categorised into the commonly used settings of schools, workplaces and communities.

6.2 Interventions in School Settings

6.2.1 Evidence Reviews

Recent evidence reviews that include school programs aimed at increasing active travel to school and/or reducing car travel are summarised in Table 11.

Möser and Bamberg (2008) describe typical school travel plan measures as including:

- special walking or cycling promotion day
- a program of pedestrian and cycle training for children
- bicycle parking
- improvements to bus or train services
- reduced public transport fares

> Learning to ride a bike is, for most people, a defining moment in childhood—a first step towards independence and a moment of dawning excitement at being able to go further and faster than you ever could on your own two feet.
>
> *Anthony Albanese MP, Minister for Transport and Infrastructure, 2010*

- car sharing schemes for families living in the same neighbourhood
- activities as part of the curriculum to promote the benefits of sustainable transport
- physical changes to the streets around the school, such as 40 km/h limits, traffic calming, pedestrian crossings and bicycle lanes
- developing a school travel policy and/or home-school agreement.

Providing high quality bicycle parking in prominent locations is an important requirement for encouraging children to cycle to school

AUTHORS	TYPE OF REVIEW	OUTCOME MEASURE	FINDINGS	COMMENTS
Môser and Bamberg (2008)	Meta-analysis of 'soft' transport policy measures[28] (25 studies)	Car use	For school travel plans: before the intervention the estimated pooled proportion of pupils not coming to school by car was 60%. Mean increase to 64% after the intervention.	Evidence that multi-component strategies are more effective than single-component strategies (e.g. school bus provision and/or promotion). High variability in program impacts.
Ogilvie et al (2007)	Systematic review (three studies)	Walking for transport	Only one of the three studies—a small non-randomised trial of an active commuting pack—found a significant net increase in self-reported walking on the school journey.	
Hosking et al (2010)	Systematic review (10 studies)	Change in travel mode	Two cluster randomised controlled trials in the school setting showed either no change in travel mode or mixed results. Two controlled before-after studies found that school travel interventions increased walking.	Study numbers small because only controlled studies included.
Pucher et al (2010)	Narrative review	Cycling	Only four of the 125 Safe Routes to School projects reviewed in a California study have measurements of bicycling and walking activity. In only one case did the number of students bicycling to and from school change noticeably, from 23 before the project to 39 after.	
Yang et al (2010)	Systematic review—one study: Bike Texas Safe Routes to School	Cycling	No Significant differences in mean number of days cycled to school	Significant increase in recreational cycling

Table 11: Review findings for school-based active travel interventions

[28] In this review, 'soft' measures include some infrastructure and policy components as outlined above

Methodological limitations in the studies reviewed by Möser and Bamberg (2008) included:

- weak quasi-experimental designs (pre-post measures with no comparison group)
- low statistical power (generally small sample sizes)
- limited external validity due to non-representativeness of study sample
- report bias (particularly for community travel planning interventions—i.e. effective interventions more likely to be reported publicly than ineffective interventions).

6.2.2 Recent studies

Some recent evaluations have been reported in Australia and New Zealand. An evaluation involving five out of 15 primary schools in suburban Sydney that participated in the NSW TravelSmart program reported that active travel to school (defined as walking, cycling or public transport) increased over the program period in three out of the five schools[29] (Fry, 2008). The Central Sydney Walk to School Research Program, which comprised a randomised controlled trial involving 24 government primary schools in inner suburban Sydney, reported inconsistent evidence of an impact on students' walking trips to and from school. Parent-reported data showed an increase in students' walking trips, but student-reported data showed no significant changes (Wen et al, 2008).

Ride2School Program (Victoria)

The aims of the Ride2School program, which commenced in Victoria in 2006, are to increase the number of individuals using active modes to and from school and to increase the frequency of active transport trips to and from school (i.e. more young people travelling actively to school more often). The Ride2School program incorporates a number of key activities, including:

- three cycling and active travel events (Ride2School Day, Walk and Wheel-a-thon, 500 kilometre Gold Medal Challenge)
- infrastructure initiatives (including wombat crossings and Quiet Neighbourhood Routes to School)
- a website
- a monthly email newsletter
- incentives (e.g. 1000 Bikes Student Leadership Rewards)
- school bike clubs
- a volunteer program.

The Ride2School program was implemented in several phases:

1. a pilot phase involving three 'model' primary schools (two of which participated in the evaluation)
2. implementation of the program in 13 'coach'[30] primary schools
3. an ongoing component which involves schools registering online with the Ride2School program, receiving online support to implement active travel to school activities (particularly the annual Ride2School Day in March), and participating in an incentive-based activity involving submitting monthly Hands Up! data of students' modes of travel to school.

For the two pilot 'model' schools that participated in the evaluation (one in an inner Melbourne metropolitan area and one in an outer suburban area), the inner suburban primary school had a 7.6%[31] increase in active travel to school based on whole-school observation (from 31.4% in mid-2006 to 39.0% in mid-2007) and an 8.8% increase based on classroom surveys of grades 5 and 6 students, compared with a 4% decrease in the comparison school. There was no consistent pattern of change in the outer suburban 'model' school relative to the outer suburban comparison school (Garrard et al, 2009). The variable findings for the inner suburban school and outer suburban school demonstrate the important influence of contextual factors on the effectiveness of active travel interventions in schools.

There was inconsistent evidence of change for the 13 'coach' schools, with parent-reported travel data showing a small increase (1.7%) between early 2007 and late 2007; student-reported data showing a small decrease (-2.4%); and considerable variation between schools. These 13 schools had baseline rates of active travel to school (average 51.1% based on student-reported data, and 47.9% based on parent-reported data) that are substantially higher than the Victorian average (26.5%), suggesting that they were schools with a pre-existing interest in, and commitment to, active travel to school. Commencing from a relatively high baseline may have made further improvements difficult.

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[29] Aggregated findings across the five schools were not included in the report.

[30] Ride2School activities were piloted in three 'model' primary schools, and revised and implemented in 13 'coach' primary schools for approximately two school terms. Ongoing support was provided via email and telephone contact, and through the provision of online resources.

[31] In this study, "active transport" included walking, cycling, scooting and skating, but not bus or public transport based on evidence that bus and public transport trips to primary school in Australia have mostly have no active travel component (median time of 0.0 minutes) (Booth et al, 2006).

The 152 Schools that participated regularly in monthly Hands Up! surveys (six or more in the 20-month period from March 2007 to October 2008) reported increases in active travel to school on the monthly data collection days (42.7% average active travel mode share in March 2007; 53.3% average active travel mode share in October 2008). The Ride2School program provides incentives for schools (and students) to use active travel to school on the monthly survey days, and many schools encourage students to walk or cycle to school on these days. Consequently, this data may not be representative of students' regular modes of travel to school.

A related program—the 'Go for your life' Bike Shed Seeding Grants program—provided $400 000 over two years to Victorian primary and secondary schools to enable them to:

- design and build a bike shed
- use an existing shed or area in the school and convert it into secure bike storage facilities
- purchase a propriety shed or structure and fit it out with bike storage facilities.

Prior to construction of the bike storage facilities, an average of 13 bikes per day per school (for the 40 schools that received funding) were counted in the school grounds for a 5-day period. Following construction of the bike storage facilities, an average of 21 bikes per day were counted (for 36 schools), an increase of 61.5%. Assuming each bike counted represents a bike trip to and from school, this data indicates an increase of 576 bike trips per day (to and from school) across the 36 schools that provided follow-up data. This data might underestimate the impact of the bike storage facilities, as the follow-up data collection period included all three winter months (which have lower cycling rates than the other three seasons), while the baseline data was collected largely outside the winter months. While it is likely that many of these trips replaced car trips, swapping from other active modes such as walking or scooting cannot be ruled out.

Active School Travel Program (Brisbane)

The Brisbane Active School Travel (AST) program, delivered by the Brisbane City Council, commenced in its current format in 2004. The program was conducted in eight schools in the first year of operation, 10 schools in 2005 and 2006, 13 schools in 2007 and 2008, and a total of 21 schools in 2009, including one high school. Each year, the cohort of participating schools includes some existing and some new schools.

The AST program aims to achieve a target of 10% reduction in sole family car trips to school. Within the AST program, council assists each school to develop a school travel plan (STP), which is a framework to facilitate behaviour change towards active and sustainable transport modes. The STP is supported by a number of initiatives that reinforce the aim of the project, including:

- bike skills training
- 'Walking Wheeling Wednesday'
- walking school buses
- 'Park and Stride'
- carpooling
- road safety education.

Active School Travel project officers work with school communities for an initial intensive year to integrate these initiatives into a sustainable school travel plan. The school travel plan is then incorporated into the school's operational plan. From 2009 the AST program included council officer support for schools who had previously undertaken the AST program (2007–2008). The support was limited to schools who actively engaged with council to continue AST activities. The AST program has been developed into a three-year program with varying levels of support given to schools as the program becomes more sustainable.

Cycling promotion programs within schools have successfully increased levels of physical activity

School staff conduct pre and post 'hands up' surveys of students' travel modes to and from school over five consecutive day periods in November each year.

For participating schools in 2008 there was a reported 24.8% increase in active travel mode share *to* school and an 18.1% increase in active travel mode share *from* school across the 13 primary schools that participated in the 2008 AST program. Walking trips to school increased by 19.1% (from 19.0% to 38.1%), and cycling trips by 3.1% (from 3.9% to 7.0%) (Brisbane City Council, 2009).

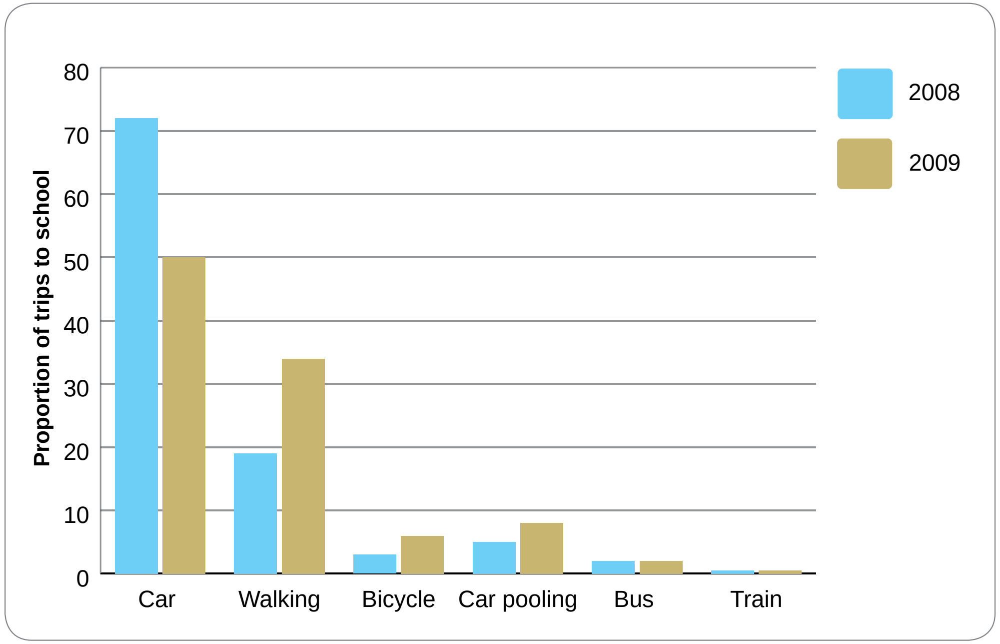

Figure 27: Impacts of the 2009 Brisbane Active School Travel program
Source: Brisbane City Council, 2010

Travel modes *from* school were not included in the 2010 report. It is not known what proportion of students' school trips are linked trips (drive-walk or drive-cycle). Part-way active trips are encouraged through the 'Park and Stride' component of the program, and students who walked or cycled part-way may have answered as either walk/cycle or car. It is likely that the major or last part of the journey would be recorded, but this was not specified in the data collection. In terms of the likely active commute distance for linked trips, the program recommends to parents that 500 metres is the minimum (as detailed in the school's AST 'travel map' where a 500 metre ring is drawn around the school), however adherence with this recommendation has not currently been assessed.

At the time of the 2009 AST evaluation, five out of the original 13 schools from 2007 and seven out of the 13 schools from 2008 were still engaged with the AST program. It is not known to what extent schools which no longer participate in annual data collection continue to support active travel to school, or whether they continue to maintain or further increase initial post-program increases in active travel to school. Further information on the AST program can be found in Section 10.1.1.

Auckland School Travel Plans

In New Zealand, the Auckland Regional Transport Authority's 2007 school travel plan evaluation, based on 'roll call' data collected from 35 153 students across 68 primary and secondary schools, reported a reduction in travel by family car of 3.4% (Sullivan & Percy, 2008). In Auckland, changes in the use of active and public transport ranged from +14.9% to -15.6%, with two-thirds of schools experiencing increases and one-third decreases. Overall, the Auckland school travel program has achieved:

- a decrease of 3.4 percentage points (approx. 7% relative) in car use
- an increase of 2.4 percentage points (approx. 7% relative) in active travel (walking and cycling)
- an increase of 1.0 percentage point (approx. 9% relative) in public transport use. (Hinkson et al, 2008)

There is no clear evidence of the extent to which formal school travel planning influences the actual effectiveness of the initiatives undertaken, but a lack of coordination between component initiatives (e.g. Western Australia) will increase the workload on schools and make them reluctant to take up a full range of options (UrbanTrans ANZ, 2008).

Successful programs build up progressively. For the achievement of sustainable long-term outcomes, it is important to retain schools in the program (as active implementers) as well as to recruit new schools. The Auckland experience also indicates the potential for continuing the program into high schools as parents and children graduate beyond primary school. Progressive expansion of the program in this way also provides an opportunity for 'diffusion by demonstration', potentially enhancing the willingness of further schools to become part of the AST program and increasing the support of school communities for effective implementation.

There is little information about the longevity of school travel behaviour impacts or diffusion to other travel purposes or to other people who have some connection with the program. However, a recent assessment of the Auckland Regional School Travel Plan Program found that:

> …schools that have participated for one or two years average a 3.0% increase in active and public transport. This rises to 4.0% in schools with a School Travel Plan for three years. These patterns suggest that the maximum benefits may require three years of implementation. Whether or not subsequent years would result in further improvements requires further investigation.
> (Hinckson et al, 2008, p. 16)

They also note that the benefits of school travel plans appear to plateau after two to three years of implementation, which is apparently inconsistent with the previous observation. One reason for this, however, could be seasonality, as the 2007 surveys (third year of implementation) were undertaken in winter, whereas previous ones were in summer. This points to the importance of appropriate design of survey programs to avoid or at least account for seasonal factors.

Summary of Experience with Active Transport Initiatives in Schools

In summary, variable program impacts occur both between programs and for individual schools within multi-site programs. Much of this evaluation literature is relatively recent, and there has been little systematic assessment of the reasons for variable program impacts. However, based on limited process/implementation evaluation data to date, the determinants of success are likely to include factors associated with schools and their social, cultural and built environments, program type, and quality of program implementation. Evaluation designs and methods also impact on evaluation findings.

6.2.3 Aggregate Level Change

Active school travel programs can often lead to increased levels of active travel to school in selected program schools as outlined above, but in countries like Australia, which have low rates of active travel, there is little evidence of an overall mode shift to active travel.

A recent analysis of school travel data found few statistically significant changes in young people's modes of travel to and from school in Victoria between 2006 and 2009, or in the greater Sydney Metropolitan area between 2005 and 2008 (Garrard, 2010). While there is no evidence of a decrease in car travel or an increase in active travel to school among (principally) primary school students in Victoria, and primary and secondary school students in Sydney in this time period, it is possible that the long-term trend of increasing car use and decreasing active travel may have stalled. If so, this is the first step in reversing the trend.

> In Victoria 61% of 1–2 kilometre trips to school are by car.
> *ABS, 1995*

Cycling England's 'Cycling Demonstration Towns' project showed an increase in cycling in program (primary) schools but little community-wide increase. Pooled data from 'hands up' surveys (conducted in 2006–07 and 2007–08) of students in 'Bike It' schools (primary schools which received the intensive support of a 'Bike It' officer) showed a 20.4% increase in the proportion of students cycling to school every day or "once or twice a week" (from 8.7% to 29.1%). By comparison, school census data (all schools, students up to 15 years old, 2006–07 to 2007–08) reported an increase of 0.1% (1.5% to 1.6%) in the number of students for whom cycling is the usual mode of travel to school (Sloman et al, 2009). The census data includes some secondary school students (up to 15 years old), and, because students were asked about "usual mode of travel", occasional cycling trips were not captured (as they were in the 'hands up' surveys). Nevertheless, both secondary and primary schools students were potentially exposed to the community-wide components of the cycling promotion interventions in the demonstration towns. Similar findings have been reported in Scotland—namely, an increase in active travel to school in program schools but little community-wide increase. A survey in September 2009 of about 415 000 children (approximately 59% of all pupils in Scotland), conducted by Hands-Up Scotland in partnership with Sustrans and local authority school travel coordinators, found a 1.3 percentage point decrease in the number of children walking to school and a 0.5 percentage point decrease in the number of children cycling on the same journey. The number of children who travelled to school by car increased by just over one percentage point. This aggregate data, however, disguises improvements in some localities. It was reported that 13 of the 31 local authorities that took part in the survey in 2009 have seen an increase in some modes of active travel.

Monitoring results from Sustrans' flagship "Tackling the School Run" program in 2007–08 found that investment in promoting active travel to school led to an increase in the number of children travelling to school by cycle or on foot. The results indicated a doubling (on average) of the use of cycling and walking routes around schools where new paths have been constructed or upgraded. It was estimated that, as a result of the funding in 2007–08, 135 690 more cycling and walking trips to school were made throughout Scotland, and that approximately 30 929 pupils across Scotland now have access to safer walking and cycling routes to school.

In contrast to Australia, England and Scotland, high area-level rates of active travel to school have been achieved in countries such as Denmark and the Netherlands. Analysis of school travel mode by trip distance demonstrates that these differences are not primarily due to greater travel distances in Australia and the United Kingdom (Garrard, 2010). For example, data from 10 municipalities in Denmark show that walking and cycling are the predominant modes of travel to school for distances up to three kilometres, and cycling rates remain substantial for all trip distances (up to and beyond 8 kilometres) (Jensen & Hummer, 2003). In contrast, 61% of 1–2 kilometre trips to school in Victoria are by car (see Figure 22).

Reports from Denmark and the Netherlands indicate how addressing issues of safety for student cyclists and pedestrians may be related to high rates of active travel. Jensen and Hummer (2003) describe active travel in the Danish context:

> Legislative reform in Denmark in 1977 stipulated that if a school route is assessed as dangerous, the municipality must either make the route safer by implementing physical measures, or provide free travel to school (by bus). Municipalities therefore had a financial incentive, in the form of reduced costs for school buses, to improve road safety for children and to increase walking and cycling to school. Both of these objectives were partly achieved. Safety measures, which were implemented after extensive consultation with students, parents, schools, police and roads authorities, focused on a wide range of traffic calming measures and provision of better facilities for pedestrians and cyclists. The child casualty rate on Danish roads, which was among the highest in Europe in the 1960s and early 1970s, decreased faster in Denmark than in most other European countries during the 1980s and 1990s. While car trips to school increased between 1993 and 1998–2000, the level is low (26% in 1998–2000) and the increase relatively small (from 17% to 26%) [compared with countries like Australia].

The Netherlands Ministry of Transport, Public Works and Water Management 2007 report, Cycling in the Netherlands, give a description of the Dutch context:

> Many children cycle to school—with or without supervision. That is how it used to be and still is. Of primary schoolchildren, 49% cycle, 37% walk and only 14% are brought and collected by car, mainly children who live a long distance from school. In secondary school, the cycling share is even higher. However in the larger cities, there is more walking and a greater use of public transport. The bicycle routes to primary schools are not often joined: after all, the distance to the primary school is small. Generally it is only in the vicinity of the school that one could really refer to school routes. Improvement of primary school routes thus rapidly translates into the approach to traffic safety in the entire neighbourhood, or the complete town core. Improving the school environment requires a broad approach, with the deployment of a variety of instruments, including infrastructural measures, traffic education, enforcement and communication with the parents. Shared responsibility is a key concept in resolving problems surrounding school routes. Many parties are always involved in traffic issues within the school vicinity: school authorities, (traffic) parents, teachers, the children themselves, but consider too those living in the vicinity, the police and the municipality.

Danish law requires municipalities to have bicycle friendly routes connecting schools to the local community – or pay for the children to catch the bus

In the United States, the Safe Routes to Schools program operates in over 7622 schools (as of mid-2010) across the country, as outlined in Figure 28 below.

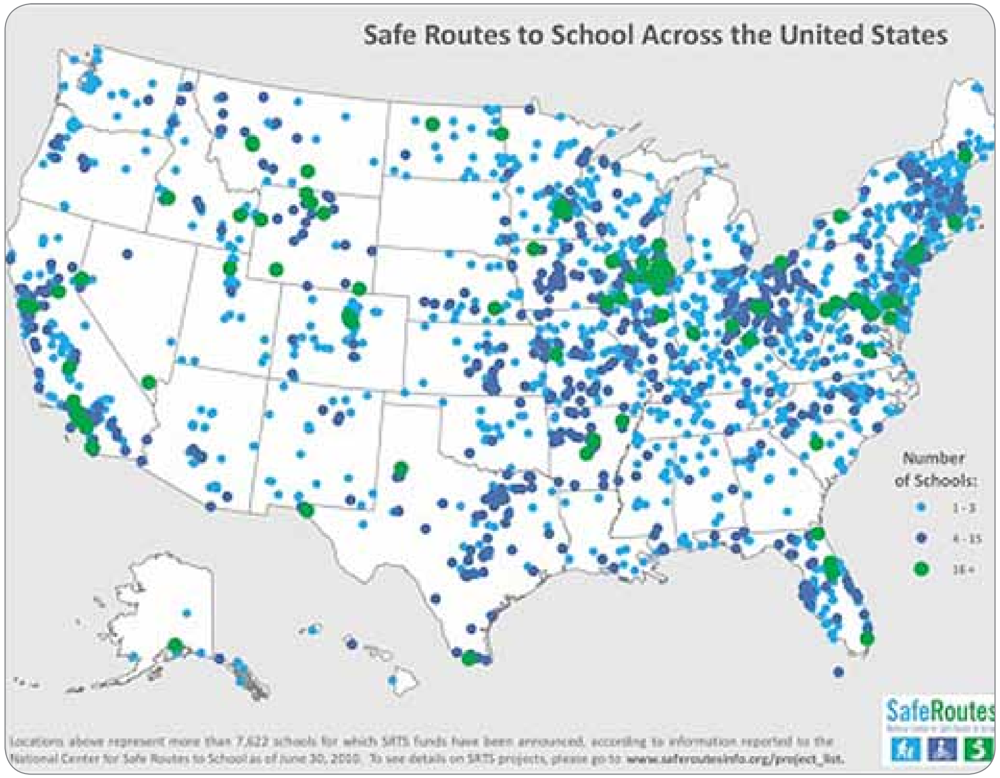

Figure 28: Safe Routes to School Distribution
Source: National Center for Safe Routes to Schools, 2010.

A nation-wide survey was recently completed in order to gather baseline data from parents and children regarding their travel behaviour and attitudes to school transport. Over 130 000 parents were surveyed as well as over a million students using a 'Hands Up' survey. Travel behaviour was found to be strongly influenced by the distance between home and school (Figures 29 and 30), although a significant proportion of very short trips were completed by motor vehicle (Figure 31). For parents whose children live within 800 metres of school but do not allow their children to walk or cycle, safety was the primary issue stated.

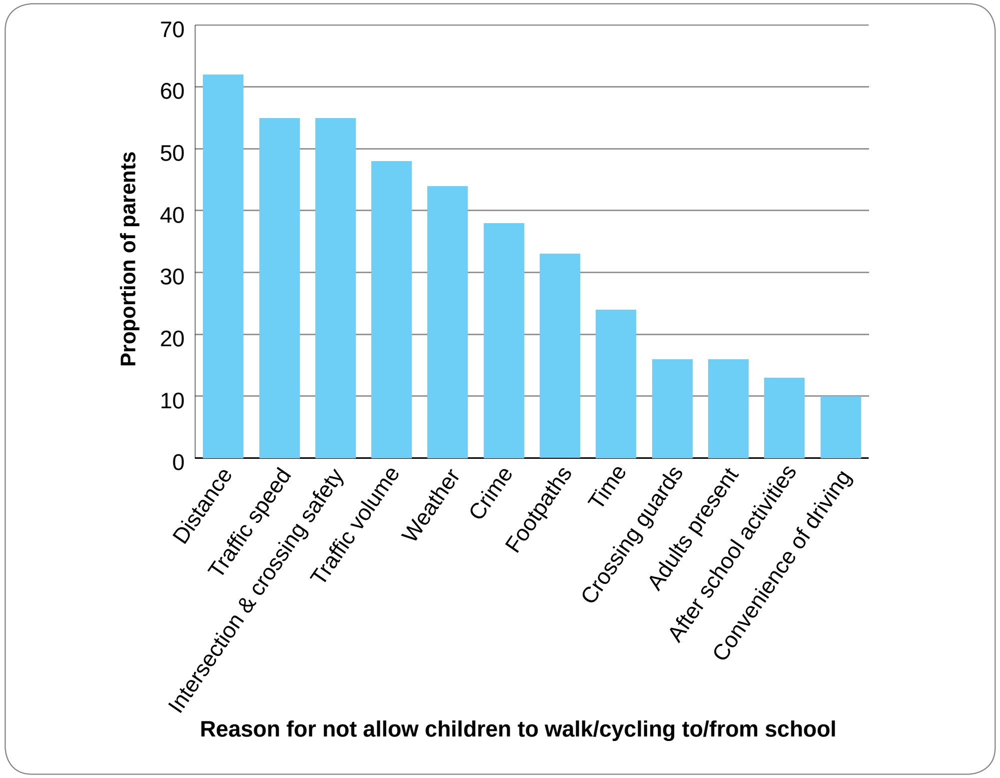

Figure 29: Reason parents do not allow their child to walk/cycle to school
Source: National Center for Safe Routes to Schools, 2010.

Figure 30 below shows the strong influence distance has on whether children walk or cycle to school. For trips under 400 metres, almost half of all journeys to school are completed by active modes, whereas for distances between 1.6 kilometres and 3.2 kilometres, only 4% are via active modes (National Center for Safe Routes to Schools, 2010).

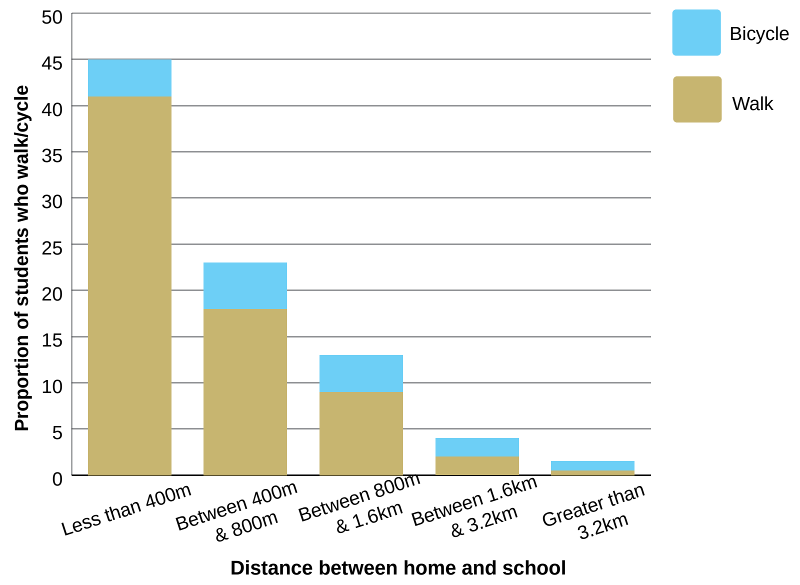

Figure 30: Walking and cycling participation by distance between home and school
Source: National Center for Safe Routes to Schools, 2010

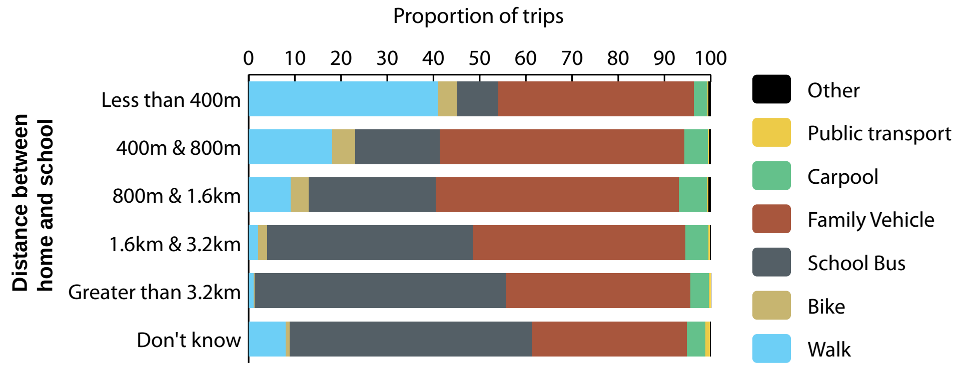

Figure 31: Modes of travel to school variation by distance between home and school
Source: National Center for Safe Routes to Schools, 2010

Figure 31 highlights that even for trips less than 400 metres, the car is used for 42% of trips, rising to 53% for distances between 400 metres and 1.6 kilometres.

The case studies outlined above demonstrate that high area-level rates of active travel to school are achievable. Currently in Australia (and the United Kingdom) interventions to increase active travel to school have had variable impacts in the school settings in which they were implemented and little or no impact on area-wide modes of travel to school.

These findings suggest that, in order to achieve the multiple and substantial benefits of active travel at the population level, behaviour change programs with demonstrated efficacy will need to be implemented with fidelity and wide program reach, and supported by environmental and policy changes that help to make active travel choices easy choices. As outlined in the case study above, the Netherlands does not have 'safe routes to school' as such; rather, the whole neighbourhood is safe.

Implementing active travel initiatives and assessing their effectiveness in participating schools (the focus of current evaluation research) is important, but we also need to answer key questions about:

- the program and contextual factors that shape the effectiveness of interventions
- the sustainability of change
- the reach of active travel initiatives
- the diffusion of travel behaviour change across the community.

Health strategies in areas such as tobacco control, road safety and child immunisation are successful because they have achieved measurable improvements at the population level, and not just in selected schools or communities. The multiple and substantial benefits of active travel will be fully realised when measurable change occurs at the population level.

6.3 Interventions in Community Settings

6.3.1 Evidence Reviews

In their meta-analysis, Möser and Bamberg (2008) categorised 'soft' transport policy measures as including:

- workplace travel plans
- school travel plans
- personalised travel planning
- travel awareness campaigns
- public transport information marketing.

The last three were combined into one group, categorised as 'community interventions' in the current report. These interventions are defined by Möser and Bamberg (2008) as:

> Targeted marketing techniques providing travel advice and information to people based on an understanding of their personal trip patterns. Employees, school children or households in a particular area might be contacted to find out which of a range of services, information, and incentives they would find useful. The items on offer might include: pocket sized public transport timetables for the main routes into town; a timetable specifically for their nearest bus stop; a personalised journey plan for a trip they make on a regular basis; a free public transport trial ticket for people who do not already use public transport; the offer of a visit from someone who can provide personal travel advice; a map of walking and cycle routes in their area; and loan of a bike. Participants are sometimes asked to keep a travel diary and may be given tips and suggestions for how to use their cars less.

Recent evidence reviews that include community-based programs aimed at increasing active travel and/or reducing car travel are summarised in Table 12.

AUTHORS	TYPE OF REVIEW	OUTCOME MEASURE	FINDINGS	COMMENTS
Möser and Bamberg (2008)	Meta-analysis of soft transport policy measures (72 studies)	Car use	For travel planning/awareness campaign/PT marketing before the intervention, the estimated pooled proportion of trips not conducted by car was 34%. A Cohen's h of 0.11 indicates a mean increase of this proportion to 39% after the intervention.	Möser and Bamberg's data on community interventions include so many errors that the specific conclusions are invalid despite the stated statistical test (Wall et al, 2008). The results from one specific methodology (individualised marketing) have been shown to be consistently between 5% and 15% reduction in car driver trips (Ker, 2008).
Ogilvie et al (2007)	Systematic review	Walking for transport	The authors concluded that successful interventions could lead to an overall 15 to 30 minutes/week mean increase in walking as a mode of transport.	The benefits seemed to be independent of demographic or socioeconomic group. Most interventions associated with an increase in walking as a mode of transport were offered only to those individuals or households identified through prior screening as already motivated to change their behaviour.
Oglivie et al (2004)	Systematic review (22 studies)	Mode shift from car to walking or cycling	Targeted programs can change the behaviour of motivated subgroups. At a population level (in the main TravelSmart study) this resulted in around 5% of all household trips being shifted from cars to walking and cycling. Emerging findings from contemporary interventions such as the London congestion charge or the National Cycle Network suggest that these may be encouraging walking and cycling. Inconsistent evidence for mode shift due to improvements in walking and cycling infrastructure.	
Pucher et al (2010)	Narrative review (139 studies)	Cycling for transport	See below for a summary of findings for a range of 'hard' and 'soft' interventions.	
Yang et al (2010)	Systematic review (20 studies)	Cycling	For individualised marketing of sustainable travel modes, there was an average net effect of about eight additional cycling trips per person per year in the targeted population. A small number of multi-faceted interventions at town or city level had net increases of up to 3.4 percentage points in the population prevalence of cycling or the proportion of trips made by bicycle.	

Table 12: Review findings for community-based active travel interventions

Findings from the Pucher et al (2010) Review of the Impacts of Cycling Interventions

Pucher et al (2010) reviewed a range of infrastructure measures and reported that, while associations are often (but not always) found between provision and use, it is difficult to measure impacts due to lack of appropriate evaluations that can disentangle the direction of the cause-effect relationship between cycling levels and cycling infrastructure. It is also difficult to attribute increased use of facilities with increased cycling due to possible relocation from other routes following construction of a bike path or lane. A major (but not conclusive) source of evidence therefore comes from analytic cross-sectional studies. Examples of cross-sectional studies include a study conducted at the city level of over 40 US cities which found that each additional mile of bike lane per square mile was associated with an increase of approximately one percentage point in the share of workers regularly commuting by bicycle (Dill & Carr, 2003, cited in Pucher et al, 2010). A study of Seattle residents, however, found no relationship between the presence of bike lanes and the odds of bicycling. It did, however, find increased (mainly recreational) cycling associated with living near a bike trail (Vernez-Moudon et al, 2005, cited in Pucher et al, 2010).

Active transport infrastructure, such as pedestrian and cycle bridges make cycling and walking safer and more direct

Traffic calming measures have been implemented widely in countries with high levels of active travel, but evidence of their impacts is limited because traffic calming is rarely a stand-alone measure for increasing active travel. In addition, evaluation of traffic calming measures focuses predominantly of traffic safety, not walking or cycling rates (Garrard, 2008). Among the few studies that have been reported, a Danish study noted a 20% increase in bicyclists crossing a major road after traffic calming in one of three towns (Herrstedt, 1992, cited in Pucher et al, 2010).

> Each additional mile of bike lane per square mile was associated with an increase of approximately 1% in the share of workers regularly commuting by bicycle.
>
> *Dill & Carr, 2003, cited in Pucher et al, 2010*

Multivariate analysis of the UK National Travel Survey (Wardman et al, 2007, cited in Pucher et al, 2010) found significant impacts of bicycle parking on cycling to work. Compared to the baseline bicycle mode share of 5.8% for work trips, outdoor parking was estimated to raise that share to 6.3%, indoor secure parking to 6.6%, and indoor parking plus showers to 7.1%.

The 'Cycle Instead' campaign in Perth, Australia, involved two 30-second commercials, shown over a period of four weeks, plus supporting activities (e.g. community events) and media (e.g. newspaper ads, giveaway items). Cycling among surveyed respondents increased from 29% to 36% (Greig, 2001, cited in Pucher et al, 2010).

Evidence of an increase in bicycle mode share after implementation of bike share programs is generally confounded by improvements in bicycling facilities made at the same time. Bicycle mode share in Barcelona reportedly increased from 0.75% in 2005 to 1.76% in 2007 (Romero, 2008, cited in Pucher et al, 2010). In Paris, the site of the world's largest bicycle share scheme (over 20 000 bikes), bicycle mode share increased from 1.0% in 2001 to 2.5% in 2007 (Nadal, 2007 cited in Pucher et al, 2010; City of Paris, 2007, cited in Pucher et al, 2010). In Lyon, site of one of the world's first large-scale share schemes, modal share rose from 0.5% in 1995 to 2% in 2006 (Bonnette, 2007 cited in Pucher et al, 2010; Velo'v 2009, cited in Pucher et al, 2010).

In the "BikeBus'ters" pilot project in Arhus, Denmark in 1995–1996, participants were given a new bicycle and free bus tickets for a year, as well as other services, in exchange for signing a contract promising to reduce driving. Cycling for "everyday trips" increased from 8% to 40%, while cycling to work increased from 15% to 60% (Bunde, 1997, cited in Pucher et al; Overgaard-Madsen et al., in press, cited in Pucher et al, 2010). In the "Cycle 100" program in Western Australia, 100 public transport workers who were given a mountain bike, lights, helmet and lock replaced 12 000 kilometres of commuting by car with cycling (Bauman et al, 2008).

6.3.2 Recent Studies

Brisbane North TravelSmart Project

The key objective of the Brisbane North TravelSmart project (based on the IndiMark model) was to encourage people to make greater use of alternatives to car travel by offering them personalised travel information, and advice and incentives to explore travel alternatives. Rather than encouraging a particular mode shift for a particular journey (e.g. work trips) the project focused on enabling participants to make small to moderate changes to their everyday travel choices (Socialdata Australia Pty Ltd, 2007).

The IndiMark process is based on the principle that people's reluctance to use alternatives to personal car use is largely due to a lack of information and motivation. The key elements of the IndiMark process are to:

- personally contact all target households
- motivate them to think about their travel behaviour
- inform them about the alternatives in their travel mode choice (Socialdata Australia Pty Ltd, 2007).

The report stated that more than 277 000 people in 113 000 households live in the North Brisbane project area, which is bordered in the south by the Brisbane River and stretches from the inner city suburbs of Red Hill, Paddington and New Farm some 20 kilometres north to the beaches of Brighton and Shorncliffe. The area is bounded on the east by Nudgee and in the west by Keperra, a distance of 12 kilometres. The area contains several parks and cycling routes. Independent before and after (March/April 2006 and March/April 2007) cross-sectional travel surveys were conducted using random samples of households in the study area. The survey data indicated pre- and post-intervention travel modes shares (adjusted for travel mode changes in a comparison area) as shown in Figure 32.

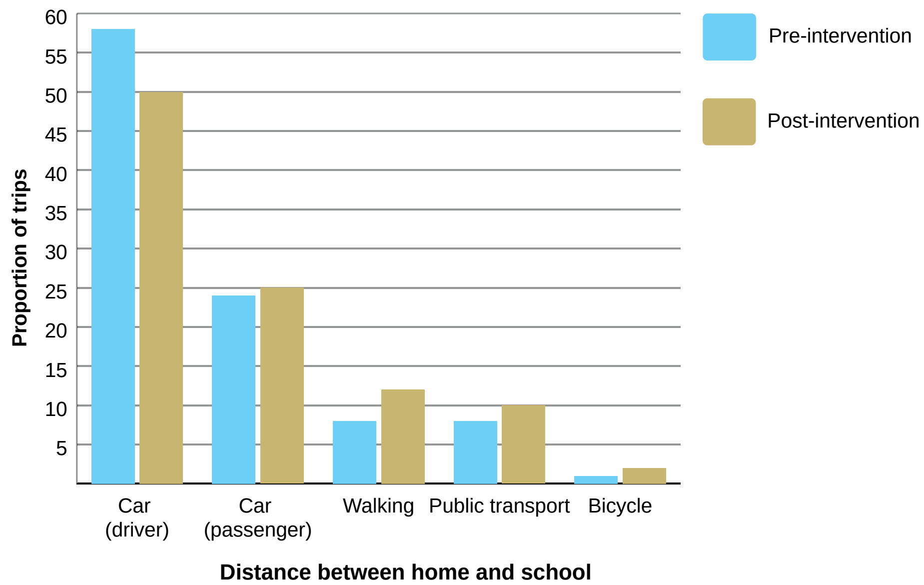

Figure 32: Impacts on travel mode share of the Brisbane North TravelSmart program
Source: Socialdata Australia Pty Ltd, 2007

The study also reported an average reduction of 3.1 kilometres (from 25.8 km down to 22.7 km) of car and other private motor vehicle travel per day (excluding holiday and business trips), equivalent to 114 million car kilometres per year in the project area. The average increase in time spent in active travel (walking and cycling) was estimated to be 16 hours per person per year across the Brisbane North project area (18.4 minutes per week). Additional analysis of overall physical activity levels found that, post-program, the proportion of householders classified as 'active' increased from 62% to 65%, while those categorised as 'low' declined from 15% to 14%, and the proportion categorised as 'nearly there' declined from 23% to 21% (Socialdata Australia Pty Ltd, 2007).

Cycling Connecting Communities Project (Sydney)

The aim of the Cycling Connecting Communities (CCC) project was to assess the effectiveness of a community-based program aimed at encouraging the use of newly completed off-road cycle paths through south-west Sydney. The project included a range of community engagement and social marketing activities, such as organised bike rides and events, cycling skills courses, the distribution of cycling maps of the area, and coverage in the local press. Pre- and post-intervention telephone surveys in program and comparison areas indicated a significant increase in the use of bicycle paths in the intervention area (28.3% versus 16.2%), but the program (which had limited resources) had limited reach into the community and did not increase population cycling levels (Rissel et al, 2010).

Australian TravelSmart Programs

A review of Australian TravelSmart programs reported that the larger household projects routinely show decreases in car use of 4–15%, and increases in use of walking, cycling and public transport (Australian Greenhouse Office, 2006). The report stated that the results are consistent with findings from Europe and North America. Only one project conducted follow-up surveys to assess the maintenance of immediate post-program impacts. The South Perth project, which was undertaken by Socialdata in 2000, reported little loss of impact based on annual surveys conducted between 2000 and 2004 despite no reinforcement of behaviour change (Australian Greenhouse Office, 2006).

A recent modelling study of the cost-effectiveness of interventions to promote physical activity estimated the effect of TravelSmart programs to be 57 MET-minutes per week (Cobiac et al, 2009). This estimate was based on 20 programs with sufficient data to evaluate an intervention health effect—ten in Australia, six in the United Kingdom, three in the United States and one in Germany. Each study involved a telephone survey of independent community samples before and after the intervention. An increase in physical activity time was derived from the change in trips per person per year, either walking or by bicycle, and the average minutes per trip by each mode of transport. For eight studies that did not report trip times, the minutes per trip for each mode were estimated as the weighted average of the other eleven studies that did report trip times. The increase in physical activity time was combined with activity intensity (3.5 METs for walking and 5 METs for bicycling) to determine the average change in energy expenditure due to the intervention. It was assumed that the increase in time spent in active transport was not counteracted by a reduction in other activity (e.g. leisure time activity) (Cobiac et al, 2009).

The Pan-European Program on Transport, Health and the Environment

The Pan-European Program on Transport, Health and the Environment (PEP) includes an online 'Toolbox of Promising Practice' site (see http://www.healthytransport.com/promising-practices/), which provides summaries of interventions in Europe aimed at replacing car travel with active travel. Not all of the programs include evaluation data, but

Mass marketing campaigns can highlight smarter transport choices. Using the back of this London bus directly targets car drivers at a receptive moment, when stuck in traffic

one community-based program conducted in Graz, Austria, in 2001 reported a reduction of 11.6 car kilometres per person per week for the 'coached' group (100 participants), and 4.8 car kilometres for a non-intensive (no coaching) comparison group. The coaching component focused on awareness, information, and behaviour change strategies. In the 12-month period between baseline and follow-up surveys, the coach group participants replaced 14 480 kilometres of car travel with active travel.

The Stockholm Trial: The Effects of Congestion Tax on Air Quality and Health

The Stockholm Trial: The effects of congestion tax on air quality and health is a report on the trial of a congestion tax, conducted under the auspices of Stockholm City Council. It used economic, regulatory, investment, behaviour, awareness and innovation initiatives to reduce motor vehicle traffic in Stockholm. The Stockholm Trial consisted of three parts:

- extending public transport (16 new bus lines)
- instituting a congestion tax
- creating more park-and-ride sites in the city and the county.

The total public transport service was extended by 7% and the park and-ride capacity was extended by 29%. The trial reported the following findings:

> Based on measured and modelled changes in road traffic, it was estimated that the trial resulted in a 15 per cent reduction in total road use within the charged cordon. Total traffic emissions in this area of NOx and PM10 fell by 8.5% and 13% respectively. Air quality dispersion modelling was applied to assess the effect of the emissions reductions on ambient concentrations and population exposure. For the situations with and without the trial, meteorological conditions and other emissions than from road traffic were kept the same. The calculations show that, with a permanent congestion tax system like the Stockholm Trial, the annual average NOx concentrations would be lower by up to 12% along the most densely trafficked streets. PM10 concentrations would be as much as seven per cent lower. The limit values for both PM10 and NO2 would still be exceeded along the most densely trafficked streets. The total population exposure of NOx in Greater Stockholm (with a population of 1.44 million people) was estimated to decrease by 0.23 g/m3. However, based on a long-term epidemiological study that found an increased mortality risk of 8% per 10 g/m3 NOx, it was estimated that 27 premature deaths would be avoided every year. According to life-table analysis this would correspond to 206 years of life gained over 10 years per 100 000 people following the trial if the effects on exposures were maintained. The effect on mortality is attributed to road-traffic emissions (most likely vehicle exhaust particles). (Note that NOx was used as an indicator of traffic exposure). (The PEP Toolbox, 2009)

6.3.3 Aggregate Level Change

Sustainable Travel Towns (United Kingdom)

Three towns in the United Kingdowm participated in the Sustainable Travel Towns project. Strategies included:

- personal travel planning
- travel awareness campaigns
- cycling and walking promotion
- public transport information and marketing
- school travel planning
- workplace travel planning
- development of a strong brand identity.

Between 2004 and 2008, the proportion of respondents in household travel surveys who did not walk or cycle (i.e. reported that they "almost never walked or cycled") fell by 2.5 percentage points from 23.4% to 20.9%. The proportion of respondents who reported that they walked or cycled "almost daily" increased by 2.8 percentage points from 46.6% to 49.4% (UK Department for Transport, 2010).

Case Studies of Comprehensive Strategies to Increase Cycling (Pucher et al, 2010)

Pucher et al (2010) stated that it is difficult to isolate the separate impacts of individual policy interventions designed to promote cycling, as measures to promote cycling are expected to be interactive and synergistic. For example, marketing programs are likely to be influenced by the extent and quality of the bicycle network. Case studies provide an opportunity to examine the impacts of packages of mutually supportive cycling promotion policies. To complement evaluation evidence for specific interventions, the review by Pucher et al (2010) included case studies of 14 cities that have implemented a wide range of measures to increase cycling and improve cycling safety.

The cities are diverse in terms of geography, size, and pre-intervention levels of transportation cycling. Details of the components of the package of cycling promotion measures in each city are available in Pucher et al (2010).

CITY	CHANGE IN BICYCLE MODE SHARE
London, UK	1.2% to 1.6% (2003 to 2006) (all trips)
Bogota, Colombia	0.8% to 3.2% (1995 to 2003) (all trips)
Berlin, Germany	5% to 10% (1992 to 2006) (all trips)
Paris, France	1% to 2.5% (2001 to 2007) (all trips)
Barcelona, Spain	0.75% to 1.76% (2005 to 2007) (all trips)
Amsterdam, the Netherlands	25% to 37% (1970 to 2005) (all trips)
Portland, USA	1.1% to 6.0% (2003 to 2006) (work commute trips)
Copenhagen, Denmark	25% to 38% (1998 to 2005) (all trips for 40+ age group)
Muenster, Germany	29% to 35% (1982 to 2001) (all trips)
Freiberg, Germany	15% to 27% (1982 to 2007) (all trips)
Odense, Denmark	23% to 25% (1994 to 2002) (all trips)
Groningen, the Netherlands	Stable 40% bicycle share of trips since 1990
Boulder, USA	8% to 14% (1990 to 2006) (work commute trips)
Davis, USA	28% to 14% (1980 to 2000)[32] (work commute trips)

Table 13: Impacts of 'packages' of active travel measures in small, medium and large cities
Source: Pucher et al, 2010

Finally, it should be noted that the Brisbane North TravelSmart program described in Section 6.3.2 also achieved change at the overall population level.

[32] The first city in the US to install bike lanes in the 1960s and promote cycling. There was been a gradual reduction in cycling programs since the 1980s along with changing demographics.

6.4 Interventions in Workplaces

6.4.1 Evidence Reviews

Möser and Bamberg (2008) define workplace travel plans as:

> A bundle of measures put in place by an employer to encourage more sustainable travel, particularly less single occupancy car use. Typical elements of workplace travel plans may involve:
>
> - new public bus or rail services linking to the site
> - dedicated 'work buses' shuttling between the site and the town centre
> - public transport information for all staff
> - personalised journey plans offered to staff
> - interest-free season ticket loans or other special deals to reduce the cost of bus and rail travel for employees
> - secure cycle parking, changing facilities, showers and lockers
> - business cycle mileage allowance
> - car sharing scheme and preferential car parking for sharers
> - parking 'cash out' (paying employees a small sum on days they do not drive)
> - car parking restricted to essential users
> - parking charges
> - services on site to reduce the need to travel (e.g. cafeteria, cash dispenser, convenience store)
> - encouraging teleworking and other variations on the five-day week (e.g. compressed working hours).

As for the school-based interventions described in Section 6.2.1, these interventions include individual-focused behaviour change and infrastructure measures (although labelled as "soft transport policy measures" in the Möser and Bamberg (2008) review).

Findings from reviews of workplace active travel promotion interventions are summarised in Table 14.

AUTHORS	TYPE OF REVIEW	OUTCOME MEASURE	FINDINGS	COMMENTS
Möser and Bamberg (2008)	Meta-analysis of soft transport policy measures (44 studies)	Car use	For the 44 studies evaluating work travel plans before the intervention, the estimated pooled proportion of employees not reaching their working place by car is 35%. A Cohen's h of 0.24 indicates a mean increase of this proportion to 47% after the intervention.	
Oglivie et al (2007)	Systematic review	Walking for transport	A directive that employers should subsidise employees who chose not to commute by car was associated with a significant increase in the proportion walking to work, and a three-year multifaceted initiative to promote cycling in a city was associated with a net increase in walking after adjustment for trends in control areas and other confounders. Two less robust studies of a sustainable transport campaign and a car sharing club found no significant effect on walking.	
Hosking et al (2010)	Systematic review (5 studies)	Change in travel mode, health	A randomised controlled trial in the workplace setting, conducted in a pre-selected group who were already contemplating or preparing for active travel, found improved health-related quality of life on some sub-scales, and increased walking.	Study numbers small because only controlled studies included.
Pucher et al (2010)	Narrative review	Cycling for transport	There is some evidence that 'Bike to Work Days' increase cycling both during and beyond the event. The number of "first-time riders" has increased in many programs: in Seattle, from 845 new commuters in 2004 to 2474 in 2008; in Portland, from 433 in 2002 to 2869 in 2008. In San Francisco in 2008, bicycle counts at a central point were 100% higher on 'Bike to Work Days' (BWD) and 25.4% higher several weeks later. Bicycle share was 48.3% before BWD, 64.1% on BWD, and 51.8% afterwards. In Victoria, Australia, 27% of first time riders on BWD were still bicycling to work five months later (Rose and Marfurt, 2007).	
Australian Greenhouse Office (2006)	Narrative review of Australian TravelSmart programs	Travel mode	Variable impacts reflecting the diversity of organisations' travel needs, internal cultures and locations. Reported reductions in car use of 0–60%, increases in public transport of up to 50% (usually off low baselines), and modest increases in walking and cycling.	Projects have been evaluated in a variety of ways, so it is difficult to make direct comparisons between them.

Table 14: Review findings for workplace active travel interventions

6.5 Summary

Active transport as a regular part of daily life can substantially improve the health of individuals and the environment. The replacement of short car trips with active trips can also contribute to the efficiency of urban transportation systems and enhanced community liveability. International comparative data demonstrate considerable potential for a mode shift from inactive to active modes in Australia, including in the relatively low population density suburbs that surround Australia's capital cities.

Interventions to increase active travel in countries such as Australia are relatively recent, and evaluation findings point to considerable variability in program impacts both between programs, and within individual settings in multi-site programs. Consequently, it is unlikely that a 'one size fits all' approach will result in substantial and sustained increases in active travel, and there is much to learn about what works for whom in what settings. Programmatic interventions also need to be nested within an overall strategy that includes an integrated package of programs and supportive policies. Evidence in areas such as tobacco control, road safety and childhood immunisation indicates that returns on investments in comprehensive public health strategies can be substantial for both government and society (Applied Economics, 2003).

7

Valuing the Impacts of Change in Active Transport

7.1 Benefit and Cost Categorisation and Quantification

Improving walking and cycling conditions, increasing walking and cycling activity, creating more diverse transport systems, and reducing automobile ownership and use can provide a variety of benefits to users and society. Table 15 summarises these benefits.

IMPACT CATEGORY	DESCRIPTION
Direct User Benefits	***Benefits from improved walking and cycling conditions***
Benefits to users	Increased convenience, comfort and safety to walkers and bicyclists.
Option value and emergency response	Increased mobility options, in case they are ever needed, including the ability to evacuate and deliver resources during emergencies.
Improved accessibility	Increased level and types of access to valuable services and activities such as education, employment, healthcare and shopping.
Equity	Improved accessibility for economically, socially or physically disadvantaged people.
More Active Transport	***Benefits from increased walking and cycling activity***
Fitness and health benefits	Improved physical fitness and health as a result of increased walking and cycling activity.
Reduced Vehicle Travel	***Benefits from reduced motor vehicle ownership and use***
Congestion reduction	Reduced traffic congestion from automobile travel on congested roadways.
Reduced barrier effect	Improved non-motorised travel conditions due to reduced traffic speeds and volumes.
Vehicle cost savings	Reduced consumer costs from vehicle ownership and use.
Avoided chauffeuring	Reduced chauffeuring responsibilities due to improved travel options.
Roadway cost savings	Reduced roadway construction, maintenance and operating costs.
Parking cost savings	Reduced parking problems and facility cost savings.
Energy conservation	Increased economic and environmental benefits from reduced energy consumption.
Pollution reductions	Increased economic and environmental benefits from reduced air, noise and water pollution.
Land Use Impacts	***Benefits from more walkable land use development***
Transportation land	Reduced land area required for roads and parking facilities.
Efficient land use development	More efficient land use, such as more compact, mixed, multi-modal development, which increases overall accessibility and reduces sprawl.
Property value increases	Increased local property values due to improved walking and cycling conditions (capitalised value of perceived future user benefits).
Economic Development	***Benefits from increased productivity and employment***
Support for specific industries	Increased support for specific industries, particularly retail and tourism, as a result of improved walking and cycling conditions (e.g. streetscaping, walking and cycling paths etc.).
Increased productivity	Increased productivity and reduced costs to governments and businesses as a result of transport-related savings (i.e. reduced congestion, parking, consumer, healthcare and energy costs).

Table 15: Potential Benefits. This table summarises potential walking and cycling benefits

The variety and magnitude of these benefits varies depending on specific conditions. A single pedestrian or cycling improvement (such as an improved footpath, a new shared path, or traffic calming in a particular area) may provide only modest benefits, particularly if evaluated in terms of a single planning objective, such as congestion reduction or improved public health. However, comprehensive walking and cycling improvements can provide large total benefits, particularly if they leverage additional vehicle travel reductions by helping to create more multi-modal transport systems and more accessible land use development patterns. Various issues related to the analysis of these benefits are discussed below. For more information see *Transportation Cost and Benefit Analysis* (Litman, 2009). Specific values for use in benefit-cost evaluation of active transport will be developed and documented in a forthcoming report on the evaluation framework.

7.2 User Benefits

Improving walking and cycling conditions (better footpaths, intersections, shared paths, bike lanes, bicycle parking, traffic calming, more walkable community design, and financial rewards for non-motorised travel) benefit users by increasing their convenience, comfort and safety. Both existing users (people who would walk or bicycle even without the improvements) and new users (people who increase their walking or cycling in response to the improvements) benefit directly.

For non-drivers, walking and cycling improvements increase accessibility and therefore increase economic opportunity (improved access to education, employment and shopping options), social and recreation opportunities (being able to visit friends and parks or sporting events), and feelings of independence.

Limited attempts have been made to quantify, and place a monetary value on, the amenity value of walking and cycling facilities to their users. Department for Transport (2010, p. 16–18) presents values for 'journey ambience' for a range of walking and cycling facilities, but acknowledges "the limitations of these values... in that they [each] apply to a specific study and hence a specific situation". Moreover, the cycle study (Hopkinson & Wardman, 1996) is 15 years old and does not appear to have been updated.

7.2.1 Valuing Benefits

Several methods can be used to quantify the value that users place on walking and cycling improvements ("Quantification Techniques" in Litman, 2009):

- *Contingent valuation* surveys ask people the amount they would hypothetically be willing to pay for a particular improvement or the amount they would need to be compensated for degradation of these modes. Most communities spend about a hundred dollars annually per capita on local parks and recreation centres. This suggests that walking and cycling improvements that allow more people to engage in non-motorised travel for both transport and recreational purposes provide benefits of significant value.
- *Revealed preference* studies observe how much people pay in money or time to access services or facilities. For example, if somebody spends 20 minutes and $2 for fuel to drive to a trail to walk or bike, this suggests they value trail use more than those costs, and they might be willing to pay to help develop a closer trail that is cheaper to access.
- *Hedonic pricing* studies indicate that walking and cycling improvements do tend to increase local property values (Pivo & Fisher, 2010). Cortright (2009) found a significant positive association between neighbourhood 'Walk Score' (an indicator of neighbourhood walkability) and home values. Similarly, Pivo and Fisher (2010) found that office, retail and apartment values increased 1% to 9% for each 10-point increase in the 100-point Walk Score index. Buchanan (2007) found 5.2% higher residential property values and 4.9% higher retail rents in London neighbourhoods that have good walking conditions (wide, smooth and clean sidewalks, moderate reduced traffic volumes, and perceived security). Eppli and Tu (2000) found that new urbanist[33] community property values are 11% higher than otherwise comparable homes in more conventional, automobile-dependent communities. Song and Knaap (2003) found that house prices average 15.5% higher if located in more walkable neighbourhoods. Research summarised by Bartholomew and Ewing (2010) indicates that property values increased in walkable transit-oriented developments more than near transit stations designed with large parking lots for park-and-ride access.

Several hedonic pricing studies indicate that residential property values tend to increase with proximity to public trails. Karadeniz (2008) found that each foot closer to Ohio's Little Miami Scenic Trail increases single-family property sale prices $7.05, indicating that home values increase 4% if located 1 000 feet closer to the trail (this paper provides a good overview of the literature on this subject, including a summary of previous studies). Some studies indicate that proximity to trails and bike paths reduces nearby property values, particularly for abutting properties due to reduced privacy and fear of increased crime (Krizek 2006). After reviewing this literature, Racca and Dhanju (2006) conclude:

> The majority of studies indicate that the presence of a bike path/trail either increases property values and ease of sale slightly or has no effect. Studies have shown that neighbours of many bike paths/trails feel that the quality of life of their neighbourhood has been improved, that the trails were a good use of open space, and in the case of abandoned railways were an improvement from before the trails went in. There is definitely a large portion of the population that sees bike paths as an amenity and will seek out residences near trails, parks, and other natural resource areas. Some studies express that those recently moving into areas near bike paths are generally more favourable to the paths than those who have lived in neighbourhoods before the construction of a trail. In some areas a large majority of neighbours are very happy with the trails, even some who were originally opposed to their construction.

Paths and trail benefits are likely to be largest in communities where walking and cycling are widely accepted and supported, and if residents are able to self-select—so people who value walking and cycling are able to locate near such facilities, and people who dislike such facilities can move away.

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[33] 'New urbanism' is a set of development practices designed to create walkable, lively neighbourhoods in which a variety of land use types (housing, shops and services) are co-located, in order to encourage pedestrian and bicycle friendly districts.

7.3 Option Value

Option value refers to the value people may place on having a facility or service available even if they do not currently use it, such as the value ship passengers place on having lifeboats available in an emergency, and the value physically able people place on having facilities that accommodate wheelchairs in case they are needed in the future ("Transport Diversity" in VTPI, 2010). Many people value having good walking and cycling facilities available, even if they do not currently use them, in case they are needed sometime in the future. Because walking and cycling can serve many important roles in an efficient transport system (including basic mobility for non-drivers, affordable transport, recreation and exercise), it is likely that many people recognise non-motorised transport option value. Ageing population, rising fuel prices, urbanisation and traffic congestion, and increased health and environmental concerns are likely to increase the future value of non-motorised travel, justifying more support for alternative modes in preparation for future demands.

> Getting children out of cars, and using active transport instead, is believed to be the single most effective way to improve physical activity rates and reduce obesity in children.
>
> *National Cycling Strategy, 2010, p. 10; citing Mackett, 2005*

Option value can be quantified using contingent valuation, by asking people how much they would hypothetically be willing to pay for walking and cycling improvements, even if they do not expect to use them immediately. The UK Department for Transport developed specific guidance for evaluating option value (Department for Transport, 2003).

7.4 Equity Benefits

Walking and cycling help provide basic mobility—that is, they provide access to activities that society considers essential or important, such as medical services, education, employment and basic commercial and social activities ("Basic Access" in VTPI, 2004). This provides benefits both to users and to society overall, by improving people's opportunities to participate in economic and social activities.

7.5 Health and Fitness Benefits

As discussed in Section 5, non-motorised transport provides physical exercise that can provide substantial health benefits ("Health and Fitness" in VTPI 2004; Alliance for Biking and Walking, 2010; Pucher et al, 2010). Inadequate physical exercise and excessive body weight contribute to various medical problems including cardiovascular diseases, bone and joint injuries, diabetes and cancer. Although there are many ways to be physically active, increased walking and cycling are among the most practical and effective, particularly for inactive and overweight people (Sevick et al, 2000). Research indicates that residents of more walkable communities exercise more and are less likely to be overweight than residents of automobile-oriented communities (Ewing, Schieber & Zegeer, 2003; Frank, 2004), and commuters who walk or bicycle tend to be more productive and take fewer sick days (Queensland Transport, 1999).

> Research indicates that residents of more walkable communities exercise more and are less likely to be overweight than residents of automobile-oriented communities.

Some studies have monetised (measured in monetary values) the health benefits of improved walking and cycling ("Safety and Health" in Litman, 2009; Boarnet, Greenwald & McMillan, 2008; SQW, 2007; Cavill et al, 2008). Cavill, Cope and Kennedy (2009) estimated that an integrated program to encourage walking in British towns has a benefit-cost ratio of 2.59 (£2.59 of benefits for each £1 spent) as a result of reduced mortality. Including other benefits (reduced morbidity, congestion and pollution) would increase this value. The Department for Transport found even higher economic returns (Department for Transport, 2010).

Health benefits have typically been evaluated solely on the basis of mortality, albeit with that these evaluations are conservative because of non-consideration of morbidity and wellbeing effects of greater physical activity. Even in the context of mortality, the range of diseases considered varies between studies and most have considered only part of the range of diseases known to be affected by physical activity (Cavil & Kahlmeier, 2007). See Appendix C for further details.

The Active Transport Quantification Tool (ICLEI, 2007), described in Section 4.1.1 above, provides a methodology for valuing the active transportation benefits, including savings from avoided driving, increased happiness, and reductions in coronary heart disease, diabetes risk, congestion, pollution and crash risk. Guo and Gandavarapu (2010) conclude that the incremental costs of residential neighbourhood footpath construction is repaid by resulting health benefits of increased physical fitness and reduced vehicle air pollution. They estimate that building footpaths increases residents' average daily non-motorised travel by 0.097 miles, and reduces average automobile travel by 1.142 vehicle-miles. The increased walking and cycling would provide an average of 15 kcal/day in additional physical activity. They estimated that this intervention could offset weight gain in about 37% of the population, which can be monetised based on healthcare cost increase of $560 annually per obese resident.

Land Transport New Zealand's Economic Evaluation Manual (Land Transport New Zealand, 2006) outlines standards for the economic evaluation of both transportation infrastructure projects and transportation demand management (TDM) measures in New Zealand. It provides monetary values for the health benefits of active transportation resulting from both TDM measures and active transport infrastructure. It assumes that half of the benefit is internal to the people who increase their activity level by walking or cycling, and half are external benefits to society such as hospital cost savings.

	2005 NZ$/KM	2007 US$/KM
Cycling	0.16	0.12
Walking	0.40	0.30

Table 16: Active Transportation Health Benefits. This indicates the estimated health value of increased walking and cycling.
Source: Land Transport New Zealand, 2006

In a study conducted by Sælensminde (2004), it was found that physically inactive people who shift from automobile use to bicycle commuting provide an economic benefit to the community of approximately €3000–4000 per year (Sælensminde, 2004). Table 17 summarises some of the results of this study. Similarly, meta-analysis indicates that people who shift from car driving to bicycling enjoy substantially larger health benefits (3–14 months gained) than the potential mortality effect of increased inhaled air pollution doses (0.8–40 days lost) and the increase in traffic accidents (5–9 days lost) (de Hartog et al, 2010). Societal benefits are even larger due to reductions in air pollution and accident risk to other road users. The researchers conclude that the estimated health benefits of cycling were substantially larger than the risks relative to car driving for individuals shifting mode of transport.

Shared path improvements have been found to more than pay for themselves through the increase in physical activity they foster

STUDY	ANNUAL VALUE PER ADDITIONAL CYCLIST	NOTES
SQW calculations	£22 for 16–44 years £235 for over 45 years	Inactive people achieving definition of active (30 minutes a day, five times a week) as a result of cycling.
	£11.16 for 16–44 years £99.53 for 45–64 years £242.07 for 65 years and over £58.77 weighted average	Values calculated using National Heart Forum results. Assumes a step increase in physical activity associated with cycling e.g. sedentary people become lightly active, lightly active people become moderately active etc. Shown by age and includes stroke and cancer reduction benefits.
DCMS Game Plan (2002)	Between £40.79 and £50.73 depending on scenario	Implied value from report results. Uses foregone earnings, not full welfare costs.
Copenhagen Heart Study/Rutter	£498	Based on all cyclists (not just those becoming active) and all causes of mortality. Applied to UK mortality data and DfT value of life by Rutter.
DfT/Sustrans model	£123	Uses number of deaths through inactivity and the National Heart Forum average values.
TfL Business case (2006)	£88	As above, but using London data.
MACAW model	40 pence per kilometre	Assumed to be part of long term regular cycling.

Table 17: Active transportation health benefits
Source: SQW, 2007

7.6 Congestion Reduction

Traffic congestion costs consist of the incremental travel time, vehicle operating costs, stress and pollution emissions that each vehicle imposes on other road users.

The key feature of congestion is that its cost increases more rapidly than the volume of traffic. In technical terms, the marginal cost exceeds the average cost. A small increase or decrease in traffic on a given road system has a disproportionate effect on the cost of congestion and the extent of this itself increases with the volume of traffic. Estimates for Brisbane indicate that the marginal cost of congestion will double by 2020 for an expected 50% increase in traffic (Bureau of Transport & Regional Economics, 2007).

School travel by car is to a large extent a suburban phenomenon, whereas traffic congestion is most severe in inner urban areas. Morning school travel, however, is during peak traffic periods and contributes substantially to regional congestion as well as local congestion around schools themselves. Around 20% of peak period trips are for 'serve passenger'[34] purposes and the majority of these are for school travel (Corpuz, 2006).

Traffic congestion in Brisbane currently costs over $1.2 billion and is expected to more than double by 2020 to $3 billion, according to the Bureau of Transport and Regional Economics (2007)

Walking and cycling can reduce traffic congestion by reducing urban-peak vehicle travel, both directly and in conjunction with ridesharing and public transit. Where walking and cycling conditions are poor, people drive even for short trips. Such trips can significantly increase traffic volumes and congestion. For instance, in Victoria, some 60% of trips between one and two kilometres are by car (Department of Transport, 2010). On many urban and suburban roadways, 10–30% of vehicle traffic consists of trips that could shift to non-motorised travel, and such trips tend to contribute relatively large delay because they often include manoeuvres that cause traffic friction such as exiting and entering driveways, passing through intersections, and making right turns.

[34] Serve passenger' journeys are those where the primary purpose of the trip is to take someone other than the driver to a destination (e.g. taking a child to school).

Analysis of the benefits of active transport in reducing congestion can be difficult because walking, cycling, public transport and traffic congestion all tend to increase with city size and density. As a result, simplistic analysis may indicate a positive association between non-motorised mode share and congestion intensity. Studies indicate that, all else being equal, per capita congestion costs decline as public transport travel increases, and walking and cycling improvements probably contribute to this effect by substituting for short automobile trips and by supporting public transit travel (Litman, 2007). Targeted research is needed to better quantify the traffic congestion reduction impacts of walking and cycling improvements.

To analyse bicycle congestion impacts, road conditions are divided into four classes:

1. *Uncongested roads and separated paths*
   Bicycling on uncongested roads causes no traffic congestion.

2. *Congested roads with space for bicyclists*
   Bicycling on a road shoulder (common on highways), a wide curb lane (common in suburban and urban areas), or a bike lane contributes little to traffic congestion except at intersections where turning manoeuvres may be delayed. Table 18 summarises congestion impacts of bicycling by road width, although traffic volume and intersection design are also factors.

	< 11 FT LANE	11–14 FT LANE	> 14 FT LANE
Riding With Traffic	1.0	0.2	0.0
Riding Against Traffic	1.2	0.5	0.0

Table 18: Passenger-car equivalents[35] for bicycles by lane width
Source: AASHTO, 1990

3. *Narrow, congested roads with low speed traffic*
   Bicycling on a narrow, congested road where cyclists can keep up with traffic (common on urban streets) probably causes less congestion than an average car due to the bicycle's smaller size.

4. *Narrow, congested roads with moderate to high-speed traffic*
   Bicycling on a narrow, congested road where the rider cannot keep up with traffic and faster vehicles cannot easily pass can cause significant congestion delay.

Congestion is reduced when motorists shift to bicycling under the first three conditions. Only under the fourth condition does a shift fail to reduce congestion. This represents a small portion of cycling travel because most bicyclists avoid riding under such conditions, and bicycling is forbidden altogether on urban freeways. Similarly, walking generally imposes minimal congestion. SQW (2007) estimates that a traveller shifting from driving to cycling for 160 annual trips averaging 3.9 kilometres reduces congestion costs to other road users £137.28 (£0.22 per kilometre) in urban areas and £68.64 (£0.11 per kilometre) in rural areas.

Various studies indicate that congestion costs average 6¢ to 22¢ per urban-peak vehicle kilometre—more on major arterials (Litman, 2009; Texas Transportation Institute, 2007). Congestion reduction benefits are estimated to be worth an average of 16¢ per urban-peak vehicle kilometre of congestion reduced and 1¢ per kilometre under urban off-peak conditions. No congestion benefit is assumed for rural travel. Targeted research is needed to better quantify how active transport can help reduce traffic congestion, with specific attention to Queensland traffic conditions. The assessments of the Bureau of Transport and Regional Economics (2007) will be used to derive the best possible estimates for Brisbane.

60 cars *60 pedestrians (one bus)* *60 cyclists*
Source: City of Muenster

[35] "Passenger car equivalents" are a measurement unit of the amount of traffic congestion imposed by a particular vehicle, with lower values for smaller and more maneuverable vehicles (bicycles and motorcycles) and higher values for larger, heavier vehicles (buses and trucks).

7.7 Barrier Effect

The barrier effect (also called severance) refers to delays, discomfort and lack of access that vehicle traffic imposes on non-motorised modes ("Barrier Effect" in Litman, 2009). The barrier effect is equivalent to traffic congestion imposed on non-motorised vehicles (most congestion cost estimates ignore non-motorised travel impacts). In addition to travel delays, vehicle traffic imposes crash risk and pollution on non-motorised travellers. The barrier effect reduces non-motorised accessibility, which tends to be inequitable and can force people to shift from non-motorised to motorised travel, which increases various external costs.

Large-scale motorised transport infrastructure can act against active transport modes and reduce public amenity

The Swedish and Danish roadway investment evaluation models incorporate methods for quantifying barrier effects on specific lengths of roadway ("Barrier Effect" in Litman, 2009). The UK Department for Transport has developed a guidance document for evaluating severance (Department for Transport, 2009). These estimate demand for walking and cycling across the roadway (assuming no barrier existed) based on residential, commercial, recreation, and municipal destinations within walking and bicycling distance, and calculate the difficulty they face crossing the roadway. This takes into account roadway width, traffic volumes and speeds, share of trucks, and quality of pedestrian crossings. The increased travel costs (for example, if people must travel longer distances to cross, or shift from non-motorised to motorised modes) are monetised similar to traffic congestion delay costs.

Various studies indicate that barrier effect costs average 0.3¢ to 0.9¢ per vehicle kilometre under urban conditions, although conceivably much higher under some conditions or using more comprehensive analysis.

7.8 Roadway Savings

Roadway construction and maintenance costs are a function of vehicle size, weight and speed. These costs average about 2.5¢ per kilometre for automobiles, with higher costs for heavier vehicles (US Department of Transportation, 2006; Litman, 2009). Motorised transport also requires various traffic services, such as policing, signals and emergency response. Walking and cycling impose minimal roadway wear, and their traffic service costs tend to be lower than for motor vehicle traffic since pedestrians and cyclists travel slower (reducing potential conflicts) and impose less risk on others. Footpaths and shared paths are relatively inexpensive to build and maintain. Most cities have approximately similar kilometres of roads and footpaths/shared paths, but devote at least five to 10 times as much money to motorised as non-motorised facilities.

Although state highways are funded primarily by motor vehicle user fees such as fuel taxes, local roads (which pedestrians and cyclists use most) are mostly funded by local taxes, which residents pay regardless of how they travel. As a result, these can be considered external costs, and shifts from motorised to non-motorised travel reduces local government roadway costs. It is important to be conscious of the possibility of double counting between congestion and roadway construction savings, as realisation of road infrastructure savings would reduce the extent to which congestion itself was reduced.

7.9 Parking Cost Savings

A typical car parking space requires 13–19 square metres of land. Land costs per acre vary from thousands of dollars in regional areas, to well over $1 000 000 in urban settings. The land required for parking is often high value because it must be located near the relevant drivers' destinations and these are typically high-demand locations. There is usually an opportunity cost associated with devoting land to parking, as it could be used for building or open space, or it could be leased or sold. Similarly, kerbside parking can be used for a busway, bicycle lane or additional footpath width. In addition to the costs associated with the space occupied by car parking, the construction, operation and maintenance costs of such developments can be considerable. In Australia, construction costs are typically $2000 per space at-grade, $15 000 per space undercover in a building and $25 000 per space underground—although little rigorous quantification has occurred in this area (Young, 2010). Typical urban parking facility cost estimates range from $50 to $100 per month, or about $2.50 to $5.00 per day—higher in major urban centres (Litman, 2009). Brisbane has particularly high parking costs, with Figure 33 below demonstrating that unreserved monthly parking costs in the Brisbane CBD are among the highest internationally. Whilst this refers to the market rate rather than the true cost (Shoup, 2005), it provides an indication of the potential financial savings presented by cycling as a replacement for driving to Brisbane's CBD.

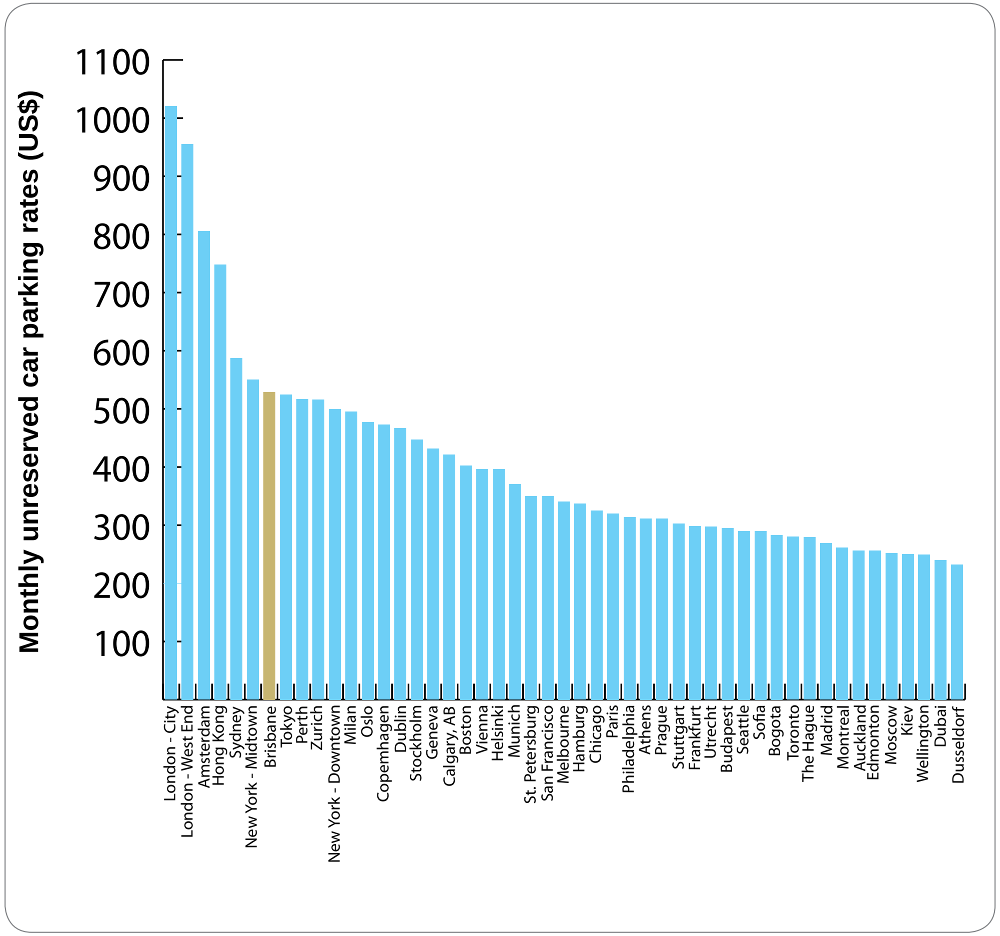


Figure 33: Global comparison of unreserved monthly car parking rates of top 50 cities
Source: Colliers International, 2009

Bicycle parking is generally free, with the exception of venues that offer under cover parking, showers, lockers and other end of trip facilities, such as the Brisbane Cycle Centre. Up to 20 bicycles can be stored in the space required for one automobile, and bicycles are often stored in otherwise unused areas.

In the short run, reduced automobile trips may simply result in unoccupied parking spaces, but over the long run most parking facilities have significant opportunity costs: reduced parking demand allows property owners to avoid expanding parking capacity or they can be rented, sold or converted for other uses (Shoup, 2005).

7.10 Vehicle Cost Savings

Direct automobile operating costs (fuel and tyre wear, tolls and parking fees) average about 17¢[36] per kilometre for a medium sized car (Royal Automobile Club of Queensland, 2010). Vehicle operating costs tend to be about 50% higher for short urban trips, due to cold starts (before the vehicle engine has warmed up) and congestion. Fixed vehicle costs (costs that vehicle owners pay regardless of how much a vehicle is driven) average about $5 per day ("Vehicle Costs" in Litman, 2009).

> With only about a decade of known oil resources remaining at today's production rates, Australia is looking down the barrel of a $25 billion trade deficit in petroleum products by 2015.
>
> *The Hon Martin Ferguson AM MP, APPEA Conference, 7th April, 2008*

A $50 pair of shoes typically lasts 1600 kilometres of walking (about one year of normal use), or 3¢ per kilometre walked. A $750 bicycle ridden 2200 kilometres annually requires about $100 annual maintenance and lasts 10 years, giving an average cost of 3¢ per kilometre cycled. These costs are subtracted from the vehicle costs to determine net vehicle savings. Walking and cycling use food for fuel, but this is generally small (a 68 kg person walking a mile burns an additional 80 calories, the energy in about one slice of bread, and cycling 1.6 kilometres burns half that), and most people enjoy eating and consume too many calories, and so this energy consumption is generally a benefit rather than a cost.

[36] Specific values will be developed for the Evaluation Framework section of the Stage Two report.

Transport is the second largest category of expenditures in a typical household (after housing expenses) due to the high cost of owning motor vehicles (Australian Bureau of Statistics, 2006). Increased use of non-motorised modes can provide significant consumer savings, particularly for lower-income households. For example, improved walking and cycling conditions may allow a household to own one rather than two cars, or even give up car ownership altogether, providing thousands of dollars in annual savings.

7.11 Road Traffic Injury Impacts

Road trauma in Australia costs $17 billion a year. This is equal to 2.3% of Australia's gross domestic product (Connelly & Supangan, 2006). There is increasing evidence that higher levels of motor vehicle use increase the risk of road trauma (Litman & Fitzroy, 2006). Traffic accidents are a primary cause of deaths and disabilities among people in the prime of life. Monetised crash costs are among the largest costs of motorised transport ("Crash Costs" in Litman, 2009; Litman & Fitzroy, 2006). Although walking and cycling have higher per-kilometre accident casualty rates than automobile travel, the incremental risk of a shift from driving to non-motorised modes is much lower due to the following factors (de Hartog, 2010; World Health Organisation, 2008):

1. Non-motorised travel imposes minimal risk to other road users.
2. High walking and cycling casualty rates partly reflect special risk factors by some user groups, including children and people with disabilities. A responsible adult who shifts from driving to non-motorised travel and takes basic precautions such as observing traffic rules and wearing a helmet tends to have less than average risk.
3. Road users tend to be more cautious where they expect to encounter walkers and cyclists. As a result, per-mile casualty rates tend to decline as walking and cycling activity increases in a community, called the "safety in numbers" effect (Jacobsen, 2003, cited in Robinson, 2005).
4. Increased walking and cycling may spur communities to implement non-motorised safety improvements.
5. Non-motorised trips tend to be shorter than motorised trips, so total per capita kilometres decline. A local walking trip often substitutes for a longer automobile trip, and people who rely primarily on non-motorised modes tend to travel significantly less than people who depend on automobiles, due to differences in their travel and location decisions.
6. Some walking and cycling promotion programs include education and facility improvements that reduce per-kilometre bicycle crash rates.
7. The overall health benefits of increased walking and cycling are many times greater than the incremental risk (British Medical Association, 1992; de Hartog, 2010), so people who regularly walk and bicycle tend to live longer than people who live sedentary lives.

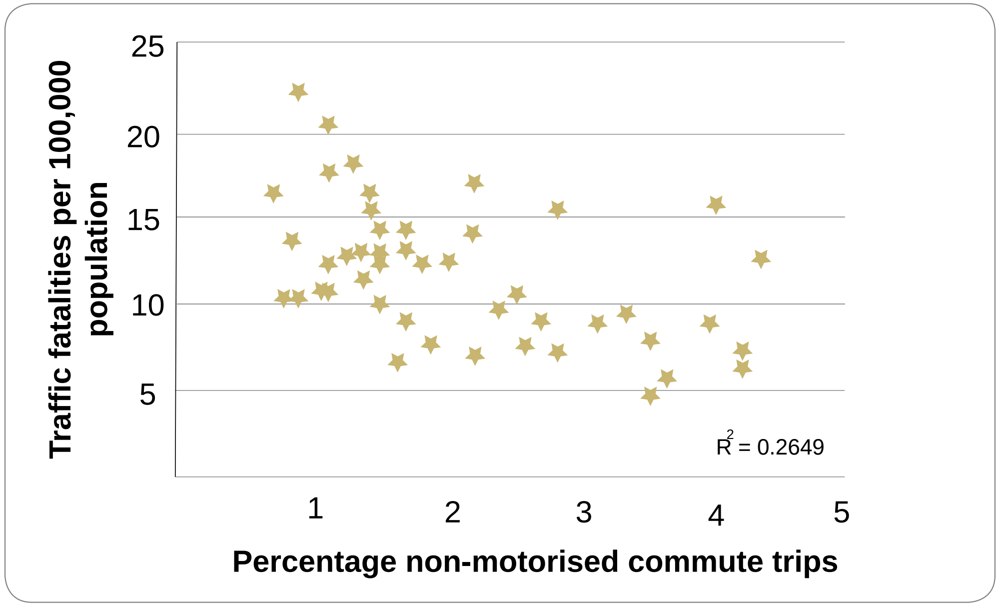


Figure 34: Traffic fatalities vs. non-motorised transport

Source: US Census, 2000

Per capita traffic fatality rates tend to decline as non-motorised travel increases. (R^2 is an indication of the statistical strength of a relationship).

Empirical evidence indicates that shifts from driving to non-motorised modes tend to reduce total per capita crash casualty rates in an area, as indicated in Figures 34 and 35. For example, walking and cycling travel rates are high in Germany and the Netherlands yet the per capita traffic death rates are relatively low (Pucher & Dijkstra, 2003; Fietsberaad, 2008; Alliance for Biking & Walking, 2010). Pedestrian fatalities per billion kilometres walked are less than a tenth as high, and bicyclist fatalities are only a quarter as high, in Germany and the Netherlands as the same fatalities in the United States.

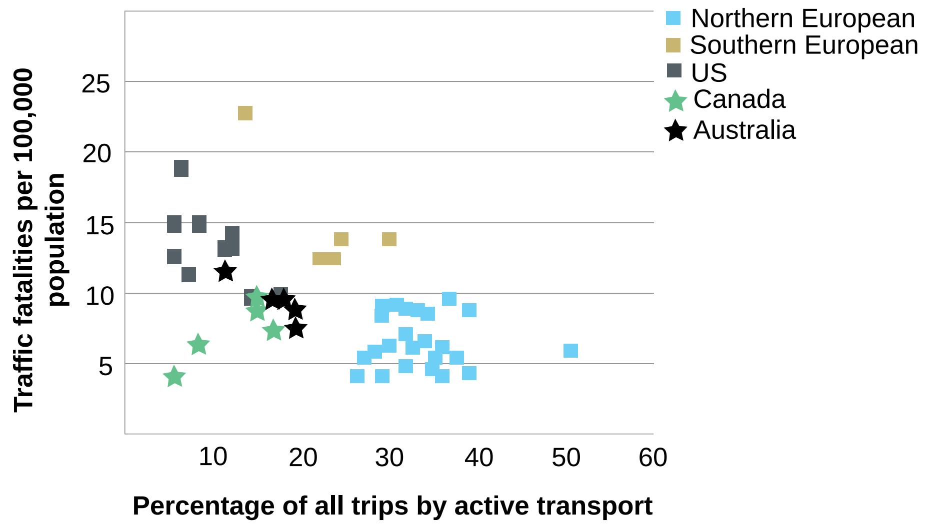


Figure 35: Traffic fatalities vs. non-motorised transport
Source: Kenworthy & Laube 2000
Per capita traffic fatalities tend to decline as the portion of non-motorised urban travel increases.

Wardlaw (2001) and Jacobsen (2003) find that the per capita collisions between motor vehicles and non-motorised travellers decline with increased non-motorised travel. Jacobsen calculates that the number of motorists colliding with pedestrians and cyclists increases at roughly 0.4 power of the number of people walking or cycling (e.g. doubling active transport in a community will increase pedestrian/cycling injuries by 32%). However, whilst the number of motorists colliding with pedestrians and cyclists increases when the number of people walking or cycling increases, this increase in collisions is not proportional to the original risk of such collisions before the increase in the number of pedestrians and cyclists. Thus, whilst the total number of collisions may be higher after an increase in active transport, the actual risk of collisions is lower—for example, if walking and cycling in an area is doubled, the risk of being hit as a pedestrian declines by 34%. Robinson (2005) found similar results using Australian data: doubling bicycle travel reduces cyclist risk per kilometre by about 34%; and conversely, halving bicycle travel increases risk per kilometre by about 52%.

Several studies indicate that motor vehicle external accident costs average 1¢ to 8¢ per automobile kilometre, depending on vehicle type and driving conditions. Collision rates per vehicle kilometre tend to increase with traffic density, although fatality rates tend to decline as congestion reduces traffic speeds.

7.12 Energy Conservation

Concerns over oil depletion raise serious questions about Australia's long term energy needs and future prosperity. Figure 33 below illustrates that the majority (61%) of fuel consumption for road transport can be attributed to car use. Australian oil production peaked in 2000/01 (Geoscience Australia, 2006), resulting in greater dependence on imports—often from unstable regions of the world. In fact, only 53% of Australian oil consumption is from domestic production (Australian Bureau of Agricultural and Resource Economics, 2008). By 2020, this is expected to drop to 27% (Australian Petroleum Production and Exploration Association, 2007).

Automotive gasoline imports have jumped 209.8% between 2000/01 to 2005/06. Over the same period, domestic crude oil production dropped by 37.2% (Australian Bureau of Statistics, 2008). Using figures from the 2006 census, commuter cyclists in Australian capital cities save approximately $35 million on fuel (calculated at 2008 prices).

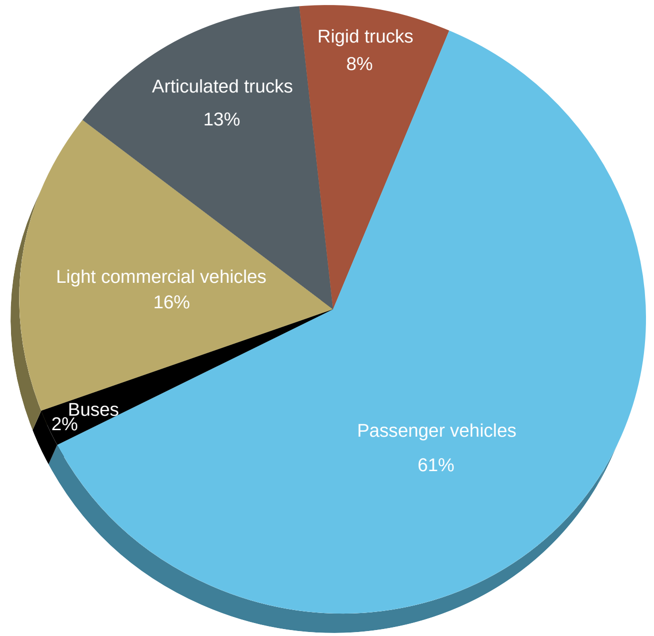


Figure 36: Australian road fuel consumption by type of vehicle, 2005-06
Source: Apelbaum Consulting Group, Australian Transport Facts, 2007, cited in Australian Bureau of Agricultural and Resource Economics, 2008.

7.13 Climate Change

Transport is among the fastest growing sources of greenhouse gas emissions in Australia (Eddington, 2008). For the average Australian household, pollution from transport accounts for 34% of emissions (Australian Greenhouse Office, 2006). Between 1990 and 2005, these emissions grew by 30% per cent (Department of Climate Change, 2008, cited in Eddington, 2008).

Figure 37 illustrates the greenhouse intensity of different modes of transport.

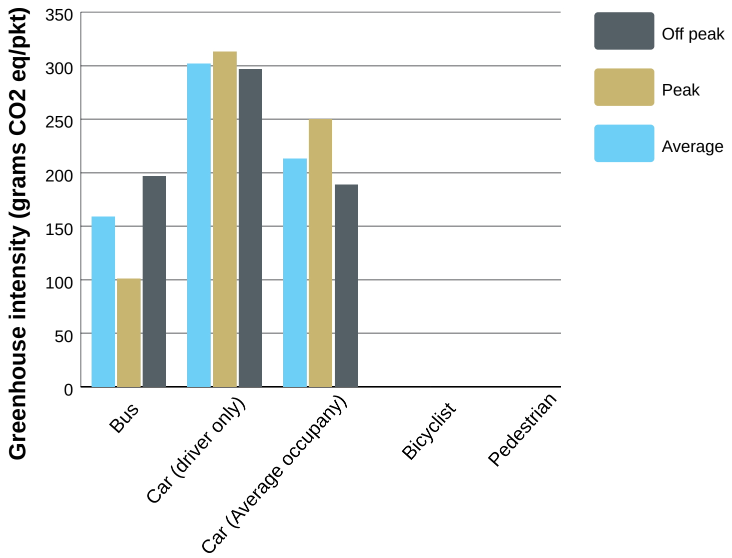


Figure 37: Greenhouse gas intensity of different transport modes
Source: Commissioner for Environmental Sustainability, 2008

As Figure 37 above illustrates, walking and cycling are the only modes of transport that do not produce greenhouse gas emissions. Shifting short/medium car trips to active transport provide greater per kilometre emission reductions because short, cold-start trips have high emission rates. Each 1% of automobile travel replaced by walking or cycling decreases motor vehicle emissions by 2% to 4% (Komanoff & Roelofs, 1993).

A UK study (SQW, 2007) estimates that shifting from automobile to cycling provides air pollution reductions valued at 11.1 British Pence per car kilometre in major cities and 2.1 British Pence in rural areas. Table 19 below offers individual values for different vehicle fuel types.

We are using more energy and producing more harmful greenhouse gases than our parents and grandparents before us. Without emission cuts, temperatures will continue to rise. This has the potential to put our sensitive ecosystems and life as we know it at risk.

Queensland Government, 2008, p. 20

	URBAN (BRITISH PENCE)	RURAL (BRITISH PENCE)
Petrol cars	5.8	2.1
Diesel cars	32.2	2.0
Weighted Average	11.1	2.1

Table 19: Pollution reduction values for different fuel types
Source: SQW, 2007

7.14 Noise Reduction

Vehicle noise imposes disturbance and discomfort. Motor vehicles are a major source of noise pollution in Australian cities (Standing Committee on Environment and Heritage, 2005; Commissioner for Environmental Sustainability, 2007; Bureau of Transport and Regional Economics, 2005). Estimates of noise costs range from 0.2¢ to 3¢ per vehicle kilometre, depending on location and type of vehicle (Litman, 2009). These costs are supported by Austroads (2008), which gives figures of 0.91¢ per car kilometre and 2.22¢ per bus kilometre (figures updated for 2010 using CPI).

Noise costs are greatest in dense urban areas where exposure is greatest (i.e. people are located close to roads). Cycling therefore offers significant potential to reduce this cost, as these dense urban areas are also the most amenable to cycling, due to trip distances often being shorter than in outer areas (Cycling Promotion Fund, 2008).

7.15 Strategic Land Use Development Objectives

Non-motorised transport can help achieve various strategic land use planning objectives by reducing the amount of land that must be paved for roads and parking facilities and encouraging more compact development patterns (Litman, 1995; "Land Use Evaluation" in VTPI, 2004). Non-motorised transportation supports smart growth (also called 'new urbanism') which refers to policies designed to create more resource efficient and accessible land use patterns. These concepts are consistent with the overall direction of the South East Queensland Regional Plan 2009–2031. Table 20 lists potential smart growth benefits.

ECONOMIC	SOCIAL	ENVIRONMENTAL
Reduced development and public service costs	Improved transport choice, particularly for non-drivers	Green space and wildlife habitat preservation
Consumer transport cost savings	Improved housing choices	Reduced air pollution
Economies of agglomeration	Community cohesion and social interaction	Reduced resource consumption
More efficient transport system		Reduced water pollution
		Reduced 'heat island' effect

Table 20: Smart growth benefits
Source: Burchell et al, 1998; Litman, 1995
This table summarises various benefits to society of smart growth development patterns.

Developing compact residential development close to services and employment centres can help reduce car dependence

7.16 Economic Development

Improved walking and cycling conditions and shifts from motorised to non-motorised modes can increase economic productivity and development (Buis, 2000; "TDM and Economic Development" in VTPI, 2004; League of American Bicyclists, 2009). Significantly improved walking conditions often increases local retail sales and property values (Local Government Commission, 2001). Non-motorised facilities (trails and footpaths) attract residents and industries that value environmental quality, physical fitness and outdoor recreation (National Bicycle and Pedestrian Clearinghouse, 1995). According to a survey of 2000 representative home-buying US households, 27% would like to be able to walk to more places from their home and the following community amenities rated important or very important: jogging/bike trails (36%), sidewalks (28%) shops within walking area (19%) (National Association of Realtors & National Association of Home Builders, 2002).

Cortright (2009) evaluated the effects of walkability on housing prices using the Walk Score (see www.walkscore.com) and 95 000 real estate transactions, controlling for house (size and age) and neighbourhood characteristics (proximity to the CBD, income, and accessibility to jobs). He found that walkability had a statistically significant, positive impact on housing values. In a typical metropolitan area, each Walk Score point increase was associated with a $700 to $3000 increase in home values. For example, shifting from a 50th to a 75th percentile Walk Score increases a house's value between $4000 and $34 000, depending on the market and other factors holding constant. This reflects the value consumers attach to walkable neighbourhoods, which tend to be denser, mixed-use neighbourhoods with good accessibility, including quality public transport.

> A car parking space in inner Melbourne could produce 3.6 times greater retail expenditure if it was used for bicycle parking.
>
> *Lee, 2009*

Walking and cycling facility improvements and promotion programs can provide economic development benefits by increasing shopping opportunities (Transportation Alternatives & Schaller Consulting 2006; League of American Bicyclists, 2009; Sztabinski 2009) and tourism activity (National Bicycle and Pedestrian Clearinghouse, 1995). One study estimates that rail trails in Australia provide an average of $258 per cycle tourist per day (Beeton 2006; cited in Cycling Promotion Fund, 2008).

Various studies indicate that well-planned non-motorised transportation improvements can increase customer visits and local business activity (Hass-Klau, 1993; Lane, 2001). A German study showed that (European Commission, 1999):

- Motorists are not better customers than cyclists, pedestrians, or public transport users.
- Because they buy smaller quantities, cyclists shop more frequently (11 times a month on average, as opposed to seven times a month for motorists).
- Approximately 75% of motorists purchase two or less bags of goods, and so could carry their goods by foot or bicycle.
- Most shopping trips involve distances that could be walked or cycled.

Reducing vehicle expenditures tends to increase regional employment and business activity because fuel and vehicles are generally imported from other areas (Litman & Laube, 1998; Litman, 2009). This is particularly true for Queensland, which has no major vehicle manufacturing centres. Shifting a million dollars in consumer expenditures from automobiles to a normal bundle of goods creates about nine regional jobs and increases regional income by approximately $250 000 (Miller, Robison & Lahr, 1999).

Bicycle infrastructure development creates a similar number of jobs as conventional road projects on a per dollar basis

It is also important to note that $1 million invested in walking and cycling infrastructure creates a similar number of jobs as the same about of money spent on car based, road infrastructure (Bureau of Transport Economics, 1995).

7.17 Community Liveability and Social Benefits

Community liveability refers to the quality of an area perceived by residents, employees, customers and visitors (Litman, 1995; "Liveability" in VTPI, 2004). This includes safety and health (traffic safety, personal security, public health), local environmental conditions (cleanliness, noise, dust, air quality, water quality), social interactions (neighbourliness, respect, community identity and pride), opportunities for recreation and entertainment, aesthetics, and the existence of unique cultural and environmental resources (e.g. historic structures, mature trees, traditional architectural styles).

Automobile-oriented transport tends to result in community development patterns that are suboptimal for other community objectives (Forkenbrock & Weisbrod, 2001). Wide roads and heavy traffic tend to degrade the public realm (public spaces where people naturally interact) and reduce liveability in other ways. Reduced vehicle traffic tends to increase neighbourly interactions and community involvement (Appleyard, 1981). Untermann & Vernez Moudon (1989) comment:

> A deeper issue than the functional problems caused by road widening and traffic build-up is the loss of sense of community in many districts. Sense of community traditionally evolves through easy foot access—people meet and talk on foot, which helps them develop contacts, friendships, trust, and commitment to their community. When everyone is in cars there can be no social contact between neighbours, and social contact is essential to developing commitment to neighbourhood.

Improved walking and cycling conditions, increased non-motorised travel and reductions in motorised travel tend to increase community liveability. Walking and cycling provide a more intimate connection between people and their surroundings than can generally occur when people drive. To the degree that shifts to non-motorised travel reduce motor vehicle traffic volumes and parking demand, it increases design flexibility that helps preserve cultural features (e.g. preserving historic sites), improve community services (provide more space for footpaths, parks and landscaping), and support other community development objectives (such as urban redevelopment and reduced sprawl).

On average, Queenslanders travel more kilometres by passenger vehicle than any other state or territory—14 800 kilometres per vehicle in 2006 compared with the national average of 13 900 kilometres.

Queensland Government, 2008, p. 23

Developing a network of 'neighbourhood streets', in which people rather than traffic becomes the priority increases urban liveability and social interaction

8 Costs of Active Transport

This section discusses possible costs associated with active transport improvements and increased walking and cycling activity.

8.1 Facility Costs

Costs include expenditure for facilities and programs, and sometimes reduced motor vehicle travel speeds. Bicyclepedia (see www.bicyclinginfo.org/bikecost) provides information on bicycle facility costs, including typical construction costs for shared use paths, bike lanes, intersection improvements and support facilities. The table below provides typical costs for various non-motorised facilities. Of course, actual costs vary significantly depending on conditions, and these facilities have additional maintenance and operating costs. Dutch cities typically spend between €10 and €25 per capita annually on cycling facilities, which is considered high and results in high rates of cycling activity (Fietsberaad, 2008).

Table 21 below provides some indicative costs for the construction of active transport related infrastructure.

MEASURE	TYPICAL COSTS
On-road bike lanes*	$200 000 per kilometre (both sides of street)
Bicycle parking	$300 per bicycle rack (parks two bikes)
Zebra crossing*	$5000 ($10 000 when requiring electrical connection)
Three metre wide shared path*	$600 000 per kilometre
Speed table (bicycle friendly)*	$10 000 per unit

Table 21: Typical facility costs

Obtained from Queensland Department of Transport and Main Roads. Actual figures will vary considerably depending on local conditions and construction costs

8.2 Travel Time Costs

Travel time is the largest variable cost for many trips. Because non-motorised modes tend to be slower than motorised modes some analysts conclude that walking and cycling are costly and inefficient. However, this is not necessarily true, with some active transport trips having door-to-door travel times competitive with automobile travel. This is particularly true with supportive transport and land use planning which provides an efficient network of facilities that includes pedestrian and cycling shortcuts where feasible, and compact, mixed land use so common destinations are close together. Figure 38 below demonstrates that, for trips up to five kilometres, cycling is competitive with car travel. For very short trips, walking can be the fastest door-to-door form of transport.

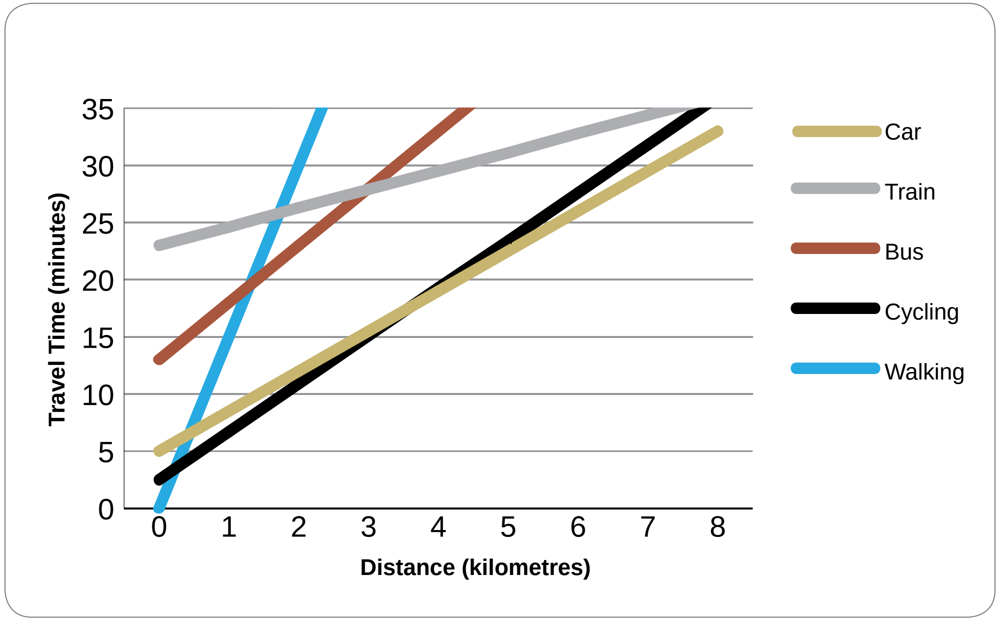


Figure 38: Time competitiveness of various transport modes

Adapted from Dekoster & Schollaert, 1999

Travel time unit costs (cents per minute or dollars per hour) vary significantly depending on conditions and individual preferences. Where walking and cycling conditions are unfavourable, travel time costs can be high, but under favourable conditions they tend to be low or even negative (time spent walking or cycling can be considered a benefit rather than a cost). In particular, many people value walking or cycling 30–60 daily minutes for enjoyment and exercise, and so will choose these modes for transport even if they take longer than driving (Ellison & Greaves, 2010). This means that if somebody is forced to walk or bike in unfavourable conditions their travel time costs may increase, but if positive incentives (improved non-motorised travel conditions or financial rewards) cause people to shift mode, they must benefit overall, even if the travel takes more time, or they would not change.

It is also important to consider the total time costs associated with different modes of transport. Examining the total time devoted to each mode of transport enables us to calculate the 'effective speed' of these modes (Tranter, 2004). This includes not just the time while in the car, but also the investment of time needed to earn the money to pay for all the costs associated with the car (including not only fuel costs, but also registration, insurance, depreciation, tolls and parking charges). Effective speed calculations for car drivers in Canberra show that a large four wheel drive could have a speed as low as 12.8 km/h—far slower than a bicycle, which has an effective speed of 18 km/h. This is due to the amount of time required to earn the money to cover the costs associated with purchasing and maintaining such a vehicle. The total time devoted to transport by cyclists is mainly concerned with their time actually travelling because bicycle-operating costs are negligible. Some car owners can devote a third of their time at work to their cars, depending on their wage and vehicle costs. Figure 39 illustrates the effective speed of various transport modes.

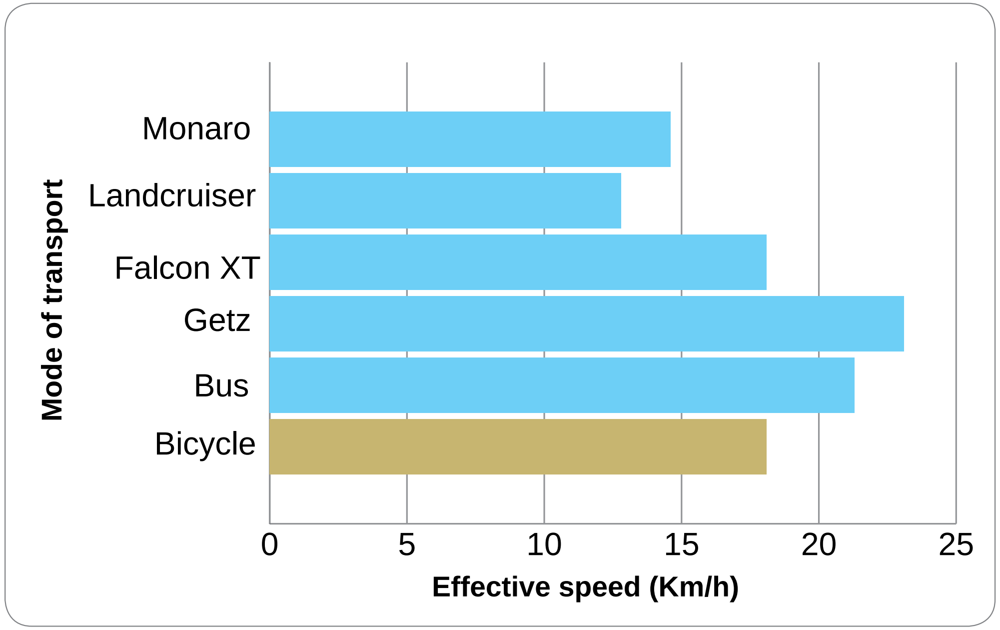


Figure 39: The effective speed of different vehicles
Source: Tranter, 2004.

Various methods can be used to measure the value of changes in travel time, including consumer surplus analysis (Litman, 2009). Travel time is generally valued at one-third to one-half of prevailing wages, with higher rates for walking in undesirable conditions, and lower or zero-cost value under favourable conditions. When shifts from motorised to non-motorised travel result from positive incentives, additional travel time can be considered to have no cost, or may be considered a benefit by users.

9

The Economic Basis of Benefit-Cost Analysis

Introduction

Transport policy and planning decisions have many impacts, including some that affect non-market goods—that is, goods not generally bought and sold in a competitive market, such as personal time, safety, health, and environmental quality. For example, a transport agency may face a decision that requires a trade-off between improved safety and environmental protection, and so must make judgments about the value that people would place on these goods. One approach to this type of analysis is to monetise (measure in monetary values) such impacts.

9.1 Techniques for Monetising Non-Market Goods

Transport economists have extensive experience monetising non-market goods, including incremental changes in travel time, accident risk, and environmental values. Some of the techniques they use are described below (Litman, 2009; Economic Development Research Group, 2007):

9.1.1 Damage Costs

This reflects the total estimated amount of economic losses produced by an impact. For example, the damage costs of traffic crashes include vehicle damages, costs of providing medical and emergency services, lost productivity when people are disabled or killed, plus any non-market costs, such as pain, suffering and grief. Since this often involves different types of costs, measuring them requires different approaches and techniques.

9.1.2 Hedonic Methods (also called 'Revealed Preference')

Hedonic pricing studies observe how walking and cycling improvements affect nearby property values or wages. For example, if houses on streets with heavy traffic are valued lower than otherwise comparable houses on low traffic streets, the cost of traffic (or, conversely, the value of a quiet neighbourhood, clean air, safety and privacy) can be estimated. If employees who face a certain discomfort or risk are paid higher than otherwise comparable employees who don't, the costs of that discomfort or risk can be estimated.

9.1.3 Contingent Valuation (also called 'Stated Preference')

Contingent valuation involves asking people how much they value a particular non-market good. For example, residents may be asked how much they would be willing to pay for a certain improvement in air quality, or acceptable compensation for the loss of a recreational site. Such surveys must be carefully structured and interpreted to obtain accurate results.

9.1.4 Control or Prevention Costs

A cost can be estimated based on prevention, control or mitigation expenses. For example, if industry is required to spend $1000 per ton to reduce pollutant emissions we can infer that society considers those emissions to impose costs at least that high. If both damage costs and control costs can be calculated, the lower of the two are generally used for analysis on the assumption that a rational economic actor would choose prevention if it is cheaper, but will accept damages if prevention costs are higher.

9.1.5 Compensation Rates

Legal judgments and other damage compensation can be used as a reference for assessing non-market costs. For example, if crash victims are compensated at a certain rate, this can be considered to represent the damages. However, many damages are never compensated, and it would be poor public policy to fully compensate all such damages, since this may encourage some people (those who put a relatively low value on their injuries) to take excessive risks or even to cause a crash in order to receive compensation. As a result, compensation costs tend to be lower than total damage costs.

9.1.6 Travel Cost Method

This method uses visitors' travel costs (monetary expenses and time) to measure consumer surplus provided by a recreation site such as a park or other public lands. Care is needed to accurately interpret and apply these monetised cost values. For example, many non-motorised impacts are measured based on analysis of consumers' willingness to pay for improved safety or environmental quality, or willingness to accept compensation for reduced safety or environmental quality. Although the analysis methodologies are basically the same, the results often differ. For example, people may only be willing to pay a $20 per month rent premium for a 20% reduction in noise impacts (perhaps by moving to a quieter street or installing sound insulation in their homes), but would demand $100 per month in compensation for a 20% increase in residential noise. This reflects a combination of budget constraints (they simply don't have much extra money to pay more for rent), and consumer inertia (the tendency of people to become accustomed to a particular situation, so they place a relatively small value on improvements and a relatively large value on degradation).

Whether willingness-to-pay or willingness-to-accept is the proper perspective for evaluating an impact depends on property right—that is, people's right to impose impacts on others. If safety and environmental quality are considered rights then traffic crash risk and emission costs should be based on recipients' willingness-to-accept incremental harms. If people are considered to have a certain right to impose risk or release pollution, then crash and pollution costs should be calculated based on victims' willingness to pay for an incremental reduction in risk and environmental degradation.

Many monetised estimates of impacts, such as pollution and human illness, only reflect a portion of total damages. For example, some air pollution cost estimates only reflect human health impacts of ozone or particulates, but other harmful emissions and agricultural and ecological impacts are ignored. Some estimates only count health impacts that require medical treatment, but ignore less severe discomfort, and preventive actions such as foregoing outdoor recreation. It is important that people working with such values understand what portion of total impacts they reflect and what impacts are excluded. For example, it may be inaccurate to say that a particular study indicates the costs of vehicle pollution; rather, it should be considered to indicate certain vehicle pollution costs. Which impacts are included, and which are not, must be identified.

Similarly, some estimates of human health costs only consider economic costs such as medical care and disability payments ("Safety and Health" in Litman, 2009). Comprehensive monetisation of health impacts should consider:

- healthcare costs of injuries, disabilities and illnesses
- productivity impacts (lost work due to injuries, disabilities and illnesses) and disability payments
- non-market values (pain, lost quality of life, grief from lost loved ones) as measured by people's willingness to pay for marginal increases in health quality and marginal reductions in the risk of injury, disability, illness or death.

9.2 Methodology

Table 22 below illustrates the overall framework used in this report to determine the economic value of a particular transport policy or planning decision.

The health costs and benefits must be comprehensively assessed before major investments in transport infrastructure are undertaken.

STEPS FROM DECISIONS TO ECONOMIC VALUATION	INFORMATION REQUIREMENTS
Public Policy And Planning Decisions (infrastructure funding and pricing, facility design, facility management, land use development, encouragement programs, etc.) ↓	Types of policy and planning decisions (including innovative and indirect strategies such as pricing reforms and changes in land use development patterns), their design, duration, integration (with other transport and land use policies), level of community support, and responsiveness to user demands.
Change in Travel Conditions (better footpaths, shared paths and bike lanes, higher fees for driving, slower motor vehicle traffic, closer destination, etc.) ↓	Multi-modal evaluation which measures the relative quality of travel by different modes under particular conditions. For example, walking and cycling level-of-service rating which indicate the quality of walking and cycling conditions and how they would be improved by a particular policy or project.
Changes In Travel Activity (less driving, more walking and cycling, more ridesharing, more public transport use, more reliance on local services which reduces average trip distances, etc.) ↓	Multi-modal transport modelling that can accurately predict how specific changes in walking and cycling conditions (including the quality of non-motorised facilities, roadway design, traffic volumes and speeds, transport pricing, and land use patterns) will affect the use of active modes. This should be disaggregated by demographic factors (who would change their travel activity) and trip type (what types of travel would change, such as commuting, errands, recreation, etc.).
Land Use Changes (less land devoted to roads and parking facilities, more compact, mixed, connected development) ↓	Integrated transport and land use modelling that indicates how changes in travel conditions and activity affect development patterns. This should include analysis of demand for more walkable and bikeable locations.
Transport Impacts (changes in traffic congestion, consumer time and money costs, road and parking facility costs, accident rates, emissions, physical activity and health, mobility for non-drivers, etc.) ↓	Quantify various impacts of travel activity changes, including congestion delays, facility costs, user time and financial costs, accidents, emissions, physical activity and health, accessibility and affordability for disadvantaged people, etc. Since public health is particularly important for this project, special attention should be given to health-related impacts. This should be disaggregated by demographic factors (identify who benefits).
Economic Valuation (financial costs to consumers, businesses and governments, monetised value of changes in health and travel time, sum of all monetised values) ↓	Apply various accounting and monetisation techniques to calculate the dollar value of various benefits and costs. Since public health is particularly important for this project this will include monetisation of traffic accidents, vehicle pollution, physical fitness and related health benefits, and (if appropriate) mental health impacts.
Optimisation (determine what policies and planning options are most cost effective)	Create a model that allows various policies and planning options to be tested to determine which provide the greatest net benefits, considering all impacts.

Table 22: Evaluation framework.

This table summarises the various steps to be considered in this analysis, and the information needed for each, to evaluate policies and planning decisions that affect active transport activity.

10 Active Transport Evaluations

Introduction

Evaluation is often considered in terms of specific projects or programs. Such evaluations often have limitations of methodology, data and broad applicability. Meta-evaluation, which may be defined as an 'evaluation of evaluations', can overcome many of those limitations by increasing the range of situations and approaches involved. Where sample surveys are used for monitoring, meta-evaluations can increase the effective sample size and hence improve statistical reliability.

> Meta-evaluations generally show a consistent pattern of results that demonstrates the positive changes from active transport and travel-behaviour change programs.

Active transport (and related travel-behaviour change) initiatives have often not been monitored or evaluated well. Whilst many household/community-based initiatives have been the subject of benefit-cost evaluations, school- and workplace-based initiatives have mainly been evaluated solely in terms of the extent of the change in travel behaviour (that is, monitoring the direct effect rather than assessing what those effects are worth to the community). Moreover, even where evaluation has been done, there have been differences of approach, of assumptions and values. This has led to strong debate regarding the merits of the initiatives themselves. However, meta-evaluations generally show a consistent pattern of results that demonstrates the positive changes from active transport and travel-behaviour change programs.

10.1 Project and Program Evaluation

Where evaluations of multifaceted active transport and travel-behaviour change initiatives have been undertaken, they consistently show a high level of benefit relative to cost. The same cannot be said of initiatives that consist of a single action, such as the walking school bus (Ker, 2009a), which are often either more resource-intensive (especially where volunteers are needed) or have narrower scope over which to support the overheads of generating and maintaining enthusiasm in the relevant community.

Most commonly, however, evaluation has only been in terms of monitoring the extent of mode-shift, usually from car-driver to other modes, not all of which can be equally classed as active transport.

10.1.1 School-Based Active Transport Programs

Brisbane City Council Active School Travel Program

As previously described in Section 6, the Brisbane City Council Active School Travel program (see http://www.brisbane.qld.gov.au/traffic-transport/school-transport/active-school-travel/index.htm) is run cooperatively by council and participating schools. The program aims to reduce traffic congestion around schools and improve road safety awareness. It encourages parents, staff and children to walk, cycle, car pool or use public transport to get to or from school. Its stated objectives and benefits include:

- less traffic at the school gate
- healthier students and parents
- a cleaner environment
- a stronger school community
- street-safe students.

A conventional BCA of the Brisbane City Council Active School Travel Program (Ker, 2008) found that:

- The present value of benefits (even with a highly conservative view of durability) exceeded that of costs by:
  - a factor of between 2.6 and 4.2 (benefit cost ratio)
  - between $0.7 million and $1.3 million (net present value).
- Direct health (mortality) benefits represented 6.5% of the benefits.
- Both road safety and air pollution benefits have substantial components.
- Road safety benefits (mostly fatality- and injury-related) represented 16% of benefits.

Health-related benefits were up to an estimated 35% of the total, but this took no account of the time possibly required for direct health benefits (i.e. excluding road safety) to build up to maximum values. The breakdown of all benefits calculated as part of the program can be seen in Figure 40 below:

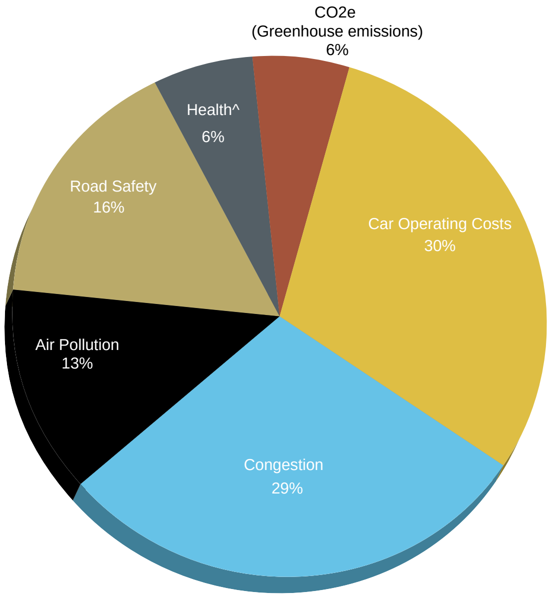


Figure 40: Benefits of the Brisbane City Council Active School Travel program
Source: Ker, 2008 ^mortality only—no morbidity/wellbeing

Walking School Bus, Western Australia

A 'walking school bus' is a group of children walking to school with one or more adults. It can be as informal as two families taking turns walking their children to school or as structured as a route with meeting points, a timetable and a regularly rotated schedule of trained volunteers.

Experience, in Australia and overseas, clearly shows that the walking school buses are an important and popular component of active school travel programs that perform well. However, the Walking School Bus program in Western Australia was a limited program operating in a small number of schools and operated largely in isolation from other active school transport initiatives.

On its own, the walking school bus appears to be of limited effectiveness and value as it was then delivered in Western Australia. In large part, this was attributable to:

- the small scale of the program
- the high rate of turnover of schools in the program (often as a result of loss of parent volunteers)
- isolation from other school travel initiatives such as TravelSmart Schools.

For a single year program, taken on its own (both in temporal and program terms), the quantified benefits from the current WA Walking School Bus program are substantially lower than the costs. Even allowing for subsequent years in the program, the high rate of loss of schools from the program means an average participation of around three years resulted in the quantified benefits remaining below the costs (Ker, 2009a).

Ker (2009a) found a number of reasons, however, as to why these results should be regarded as conservative. In particular, it was highly affected by the large amount of churn in the program and the continuing need to recruit new schools with considerable up-front costs, including training of parent volunteers. Should measures be found that significantly reduce the school drop-out rate, the cost effectiveness of the Walking School Bus program would be enhanced considerably.

10.1.2 Household and Community-Based Active Transport Programs

Household and community active transport programs are based on the realization that many people would like to use their cars less but may lack information or incentive to make the change to walking, cycling or public transport. Typically, there is a feasible alternative to driving a car for up to half the trips people currently make by car (Socialdata, 2000).

Benefit-cost evaluations of household/community-based interventions have shown benefits substantially exceeding costs. The returns on investment in active transport and travel-behaviour change are broadly three to ten times higher than those from transport infrastructure investments, for which benefit-cost ratios of 2:1 or 3:1 are typical.

TravelSmart Household was developed in Perth through a pilot project in South Perth. A conservative evaluation of this pilot project, using conventional BCA methodologies and values demonstrated benefits 13 times the cost of the project (Ker & James, 2000).

More recently, evaluation of the North Brisbane TravelSmart Household project found that the benefits exceeded the costs (in present-value terms) by a factor of 36:1, including the purchase of additional buses and trains to accommodate the additional public transport passengers in the morning peak period. Sensitivity tests based on higher congestion costs, periodic reinforcement of IndiMark and a lower discount rate (more in line with sustainability requirements) indicated a range from 24:1 to 50:1 (Ker, 2008a).

Sustrans (2009, p. 7) estimates that household TravelSmart projects in the United Kingdom have achieved a benefit-cost ratio of 7.6:1 through savings on "running cars, maintaining roads, providing health services and other costs of unsustainable travel".

Cairns et al (2004), after investigating the effectiveness of social marketing and other travel demand management initiatives concluded:

> Soft factor interventions offer very acceptable value for money. Using current DfT [Department for Transport] practice for estimating the value of the effects on travel times of a reduction in the number of vehicles, each £1 spent on soft measures could produce benefits of about £10 on average, and considerably more in congested conditions. Inclusion of values for potentially positive effects on safety, health or the environment would further increase the value for money. This gives a good margin of robustness to changes in assumptions or methods of calculation. (Cairns et al, 2004, p. 363)

Even allowing for greater levels of congestion in some areas of the United Kingdom compared to Queensland, the strong benefit-cost ratio found by Cairns et al (2004) is supportive of the cost-effectiveness of soft measures aimed at boosting levels of active transport.

Potential for Change in Perth

One fifth of all trips are made by walking, cycling and public transport. Four out of five trips are made by car (drivers and passengers). Research shows that, for 36% of all trips, the car is the only real option (e.g. for long distances, carrying heavy loads, taking passengers) and for 13% of trips the car is not available. This leaves 48% of trips where there are choices between active and sedentary transport—with almost all choosing the sedentary option (41% vs. 7%). These trips are the TravelSmart potential for change.

Socialdata, 2000

10.1.3 Workplace-Based Active Transport Programs

Evaluation of workplace interventions, mainly workplace travel planning, has almost entirely been in terms of the impacts on travel behaviour and the cost-effectiveness with which it achieves reductions in car use for commuting to and from work. For example, the primary measure used by Cairns et al (2004) is cost per kilometre of car travel reduction.

The main conclusion from evaluation of workplace travel planning (the main means of promoting active transport in workplaces) is that both the outcomes and the costs of workplace initiatives vary greatly, with no clear relationship between the two. Low-cost plans can deliver substantial reduction in car driving to work and a high-cost plan is no guarantee of success, as shown in Figures 41 and 42 (Ker, 2003a).

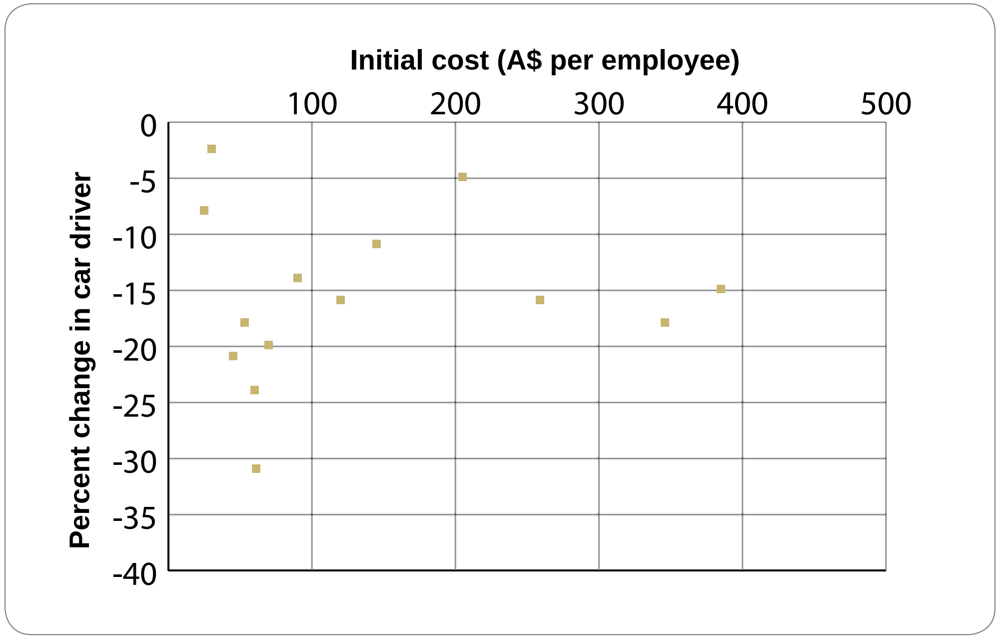


Figure 41: Cost-effectiveness of low-cost workplace travel plans
Source: Ker (2003a)

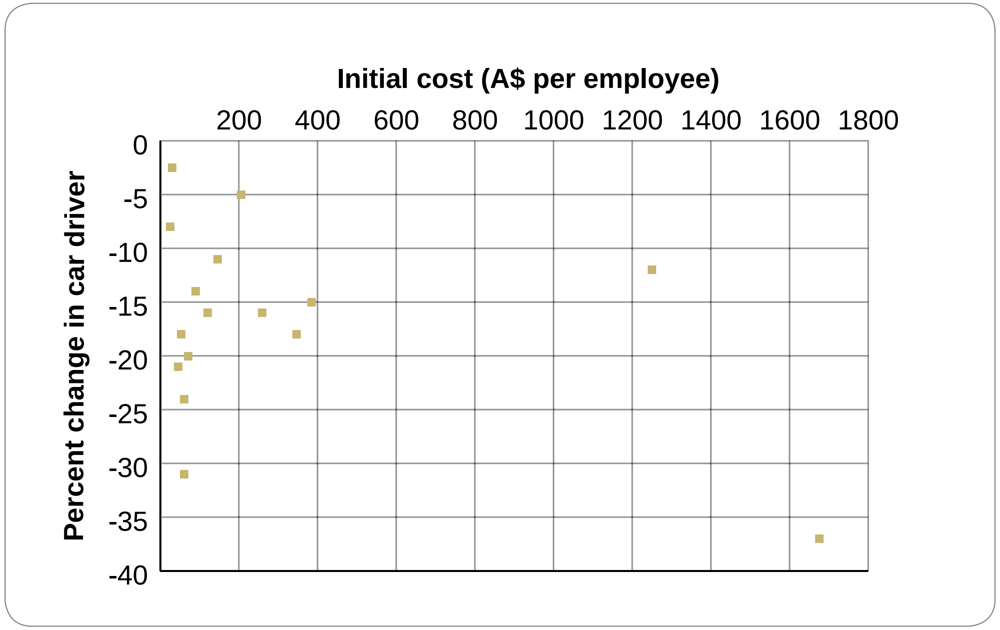


Figure 42: Cost-effectiveness of high-cost workplace travel plans
Source: Ker (2003a)

10.1.4 Walking and Cycling Initiatives

Despite the considerable investment in cycling facilities in many places over the past several decades, there have been few published formal evaluations of walking or cycling programs. In most cases, evaluation has used benefit-cost analysis as the principal tool. However such evaluation is often hampered by poor information on both existing and anticipated usage, which is essential for any quantitative analysis of benefits. Many evaluations also acknowledge non-quantifiable effects (mainly benefits) without incorporating them into the evaluation framework (AECOM, 2010). Such non-quantified benefits may include:

- journey time reliability compared to travelling by car, especially at times of peak traffic
- decongestion benefits for public transport. Congestion reduction for roads can be quantified and valued either directly through road traffic models or indirectly using the work of the Bureau of Transport and Regional Economics (2007)
- integration with other modes—the bicycle's role in multi-modal trips tends to be excluded from demand estimation
- option values—that is, having an alternative to car and public transport available for unforeseen circumstances
- equity—that is, better access to resources and opportunities for those without access to a car
- reduced fossil fuel dependence—cycling and walking do not require oil or other fossil fuels, which will be in increasingly scarce (and unpredictable) supply as production peaks and then declines (the 'peak oil' phenomenon) while demand continues to increase
- wider economic benefits—spillover effects on the local economy through increased accessibility to retail or tourism areas where visitors are prone to spend. Furthermore, cycling can offer a means for travellers to access a broader set of labour markets. (AECOM, 2010)

It is difficult to compare reported evaluations of cycling facilities because of differences in methodology, the range of benefits quantified and values applied to benefit items. However, recent evaluations of bicycle facilities, using conventional benefit-cost analysis and similar values to those used for other transport evaluations, demonstrate a return that is at least competitive with other urban transport investments.

An evaluation of the proposed Sydney Inner City Bicycle Network demonstrated a benefit-cost ratio of 3.88:1 (up to 11.08:1, depending on assumptions made about the level of cycle usage), with net present value of $507-$1800 million (AECOM, 2010). According to AECOM (2010), around one-quarter of the benefits are health benefits, although the following should also be considered:

- Health benefits are offset to an extent by a net increase in road trauma costs.
- Health benefits are for mortality only (not morbidity or wellbeing, although a sensitivity test based on Ker (2004a) is incorporated.[37]

[37] As AECOM (2010) acknowledges, the value suggested by Ker (2004a) was for sensitivity purposes and has not been empirically tested or proven. However, AECOM also states that Ker's is "the only known study that has factored reduced morbidity into account". However, Genter et al (2008, p. 54) implicitly recommends an addition of between 25% and 50% to mortality values for morbidity.

- Around three-quarters of the net health benefit is due to reductions in employee sickness (time off work) and improved productivity from a healthier and fitter workforce. This component is relevant to school-based active transport initiatives insofar as it is the result of diffusion of travel-behaviour change into the adult community or it arises in the longer-term future when students who have benefited from the initiative enter the workforce. However, there might well be a similar reduction in time off school due to sickness.

The estimated health benefit is comparable to the benefit from 'user cost and time-savings' and to the estimated 'government infrastructure and operating cost savings' (parking, road infrastructure, bus and train long-run marginal costs). The government infrastructure and operating cost savings are likely to depend very substantially on circumstances and location, being highest in congested inner-city areas. There is also potential for double-counting of benefits (with congestion reduction), as reducing the extent to which additional road capacity is provided would offset reductions in traffic congestion.

An evaluation of a proposed new cycle river crossing (to replace an existing substandard facility) in Perth reported a BCR of 3.18:1 and a net present value of $52.9 million for what was, by its nature, a very high-cost project at around $24.5 million for less than 1 kilometre of cycle path (Ker, 2009a). This evaluation did not deal with the non-quantified/non-monetised impacts but did incorporate the impacts of increasing motor vehicle fuel prices in two respects:

- as an exception to the 'constant prices' requirement for BCA, on the basis that the real resource price of petrol will continue to increase (to $2/litre by 2020, according to an analysis of petrol prices in Perth)
- as a positive influence on the level of cycling activity (Ker 2009a).

Sustrans (2010) reported benefit-cost evaluation results for its Links to Schools program that ranged from 15:1 to 33:1 (average 20:1). These links support the utilisation of existing facilities by linking schools to current networks, which enhances the overall amount of cycling generated by the new facilities. In addition to conventional benefit-cost analysis, the framework includes:

- *Public Accounts Table*: the financial costs and, where appropriate, revenues from the project. Project revenues can be negative, for example through loss of fuel tax revenues. The net impacts on local and central government are combined and inserted in "total present value of costs (PVC)".
- *Economic Efficiency of the Transport System*: consumer benefits such as travel time benefits. Salary cost savings through reduced absenteeism are recognised as a direct impact on businesses resulting from cycling and walking schemes. The "net consumer benefits" and the "net business impact" are combined as the "present value of transport economic efficiency benefit".
- *Appraisal Summary Table*: The "qualitative impacts" cells contain a short description of how the project impacts on particular aspects of the environment, safety, economy, accessibility and integration. The "quantitative impacts" cells contain only a description of the nature of the information entered as a value in the "assessment" column, if applicable. The "assessment" column may contain a value or a neutral/beneficial/ detrimental typology of the effect of the project.

This approach is essentially that set out in the UK Transport Analysis Guidance (Department for Transport, 2010a) for appraisal of walking and cycling schemes.

10.2 Meta-Evaluations

Meta-evaluations, especially for school and workplace initiatives, are hindered by the lack of consistent monitoring and evaluation of individual initiatives. The Australian Greenhouse Office (2005, p. 5) concluded, in respect of Australian interventions:

> Households are the most thoroughly explored of TravelSmart projects. Larger household projects routinely show decreases in car use of 4–15%, and rises in use of walking, cycling and public transport. The sample sizes used in the smaller household pilots are too small to draw conclusions from, although two of the three provided showed similar results to the larger interventions. These results are consistent with findings from Europe and North America. There is also a small amount of evidence that changes appear to be sustained for at least five years without maintenance or further intervention.
>
> Workplace results are much more variable, reflecting the diversity of organisations' travel needs, internal cultures, and locations. Projects have been evaluated in a variety of ways, so it is difficult to make direct comparisons between them. However, the data provided to us reports reductions in car use of 0–60%, increases in public transport of up to 50% (usually off low baselines), and modest increases in walking and cycling.

Household and community-based travel-behaviour change programs, mainly under the TravelSmart banner, have almost certainly been more intensively studied and evaluated than any other transport initiative. To a significant extent, this has been a result of the accessible publication of most results (e.g. http://www.transport.wa.gov.au/travelsmart and http://www.travelsmart.gov.au), but it also stems from the way in which TravelSmart appears to run counter to decades of 'predict and provide' [38] transport planning and the conventional marketing approaches to public transport and, to a lesser extent, other alternatives to car driving. Notwithstanding this, the Australian Greenhouse Office (2006, p. 53) concluded:

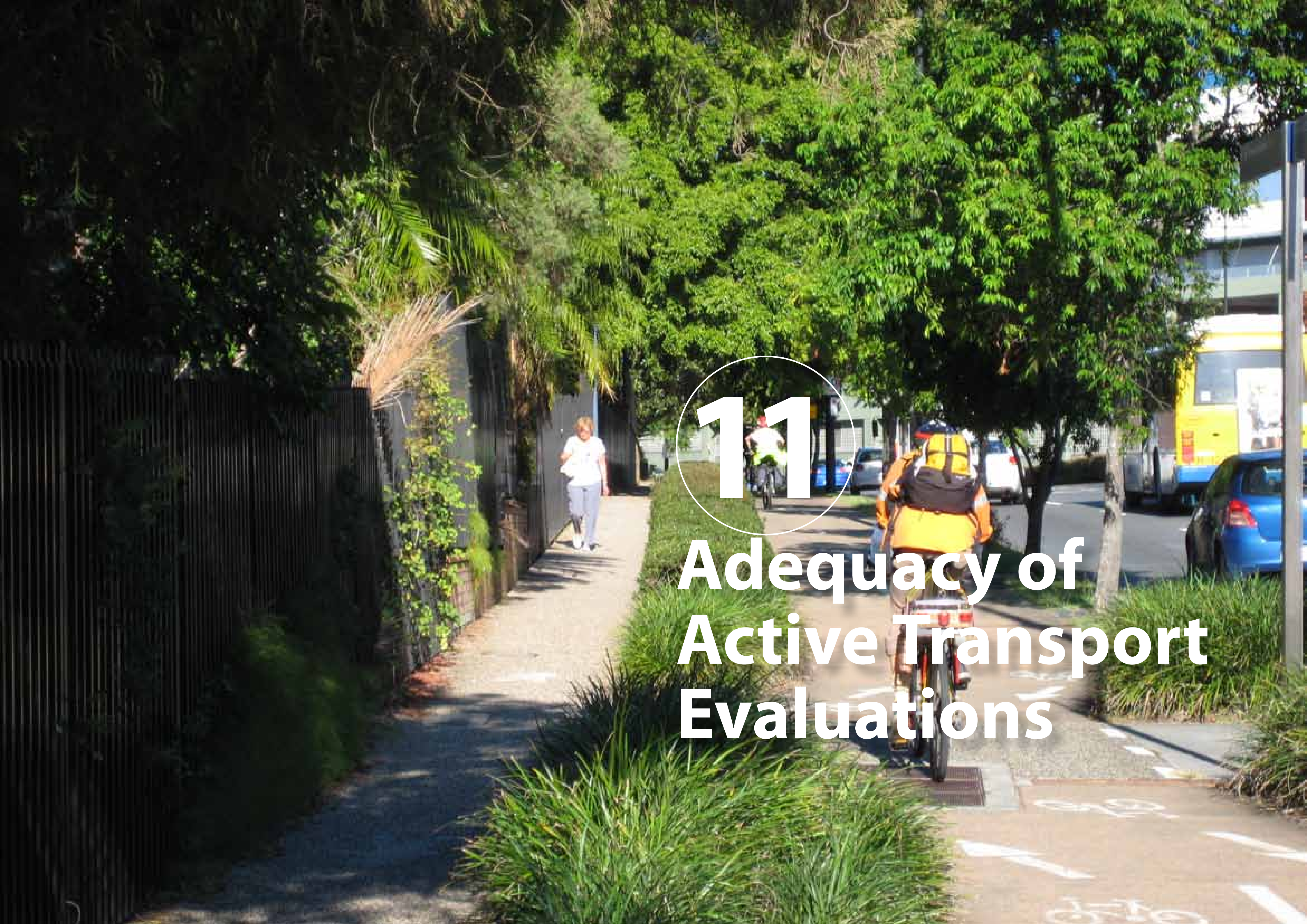
> For households, predicting the effectiveness of a TravelSmart project is now essentially a solved problem. The eleven Australian projects evaluated here join over 50 other formal evaluations conducted internationally and many other informal assessments. (See Ker, 2003; Maunsell Australia, 2004 and UK Department of Transport, 2004 for a list of some other evaluations.) While individual outcomes vary with geographic location, what can be said broadly is that community-based household projects will achieve a reduction in car travel of 5–15%, and this change appears to be sustained for several years without further intervention. Methods for achieving these results are now well understood, and further evaluations are unlikely to add much to existing knowledge.

10.3 Financial Evaluations

Governments (and, in particular, Treasury departments) are concerned not only about the impacts of travel-behaviour change on the broad welfare of the community, but also about the financial impacts on the public sector. Despite this, there have been very few financial evaluations of travel-behaviour change initiatives. This is probably because, to the extent that such programs get people out of cars into walking and cycling, there is no obvious direct revenue stream created—although in the case of health improvements there should at least be a cost-reduction effect.

Most evaluations of travel-behaviour change and active transport have focused on the socioeconomic impacts—with the exception of the financial impacts on public transport (fare revenues and government payments to operators). However, there are other financial impacts on state government through a range of consequences of reduced car use, including health system costs. Ker (2002) estimated these financial benefits to be worth between three and seven times the required investment in household travel-behaviour change, with health system benefits being between 0.8 and 3.5 times the investment in their own right.

[38] Predict and provide' is a phrase that indicates the mentality of transport planning in which future demand for motor vehicle use is forecast and this dictates the program of road building. 'Debate and decide" planning offers an opposing perspective in which the level of future car use considered optimal (from a sustainability perspective) is decided upon, then investments are made in the transport system accordingly.



11 Adequacy of Active Transport Evaluations

Active transport and travel-behaviour change evaluations, including generic tools developed to support formal and informal evaluation, have supported the validity of BCA as an appropriate evaluation methodology.

Evaluations of active transport and travel-behaviour change initiatives have consistently reported high returns in excess of those typically estimated for conventional, motorised transport investments (both urban and rural). The only exception to this appears to be the walking school bus when implemented as a stand-alone program (Ker, 2009a) or when assessed solely in terms of the health benefits (Shiel, 2007). Similarly, Cobiac et al (2009) assess TravelSmart as performing relatively poorly among physical activity interventions when assessed with respect to health impacts only (as measured by quality-adjusted life years—i.e. morbidity and mortality) and without including the range of transport, environmental and other social benefits.

On this basis, appropriately designed socioeconomic BCA is likely to be an effective tool for effectively investigating the case for active transport programs but the analysis must be comprehensive in terms of the range of effects included in the evaluation. Partial or selective evaluation (e.g. focusing on health effects) will not demonstrate the community value of active transport initiatives.

Some of the key values for benefit-cost evaluation (congestion costs, air pollution, road trauma) will vary from place to place and the extent of benefits will vary from program to program (a workplace program will have a more concentrated impact on peak period travel in congested areas than a general household program). It is important, therefore, that locally appropriate and program-specific values are derived for benefit-cost evaluation.

Most of the impacts of active transport and travel-behaviour change programs can be evaluated using methods and values that are already accepted in transport evaluation, although some refinements and developments are desirable. These include:

- estimation of marginal congestion cost values, especially given the coincidence of the journey to school and the peak period for commuting to work, when road traffic congestion is at its heaviest
- derivation of an agreed approach to 'peak oil'—that is, increasing real petrol price and potential fuel scarcity (CSIRO, 2008)
- acceptance of a real discount rate for public policy purposes that appropriately reflects the real rate of social time-preference, rather than the financial market rate of interest.[39]

In regards to developing and assessing a program of active transport for school aged children, it is proposed in this report to address the issues listed above in the following way:

- *Congestion cost* will be assessed using marginal values derived from the best existing information (Bureau of Transport and Regional Economics, 2007; Australian Transport Council, 2006), whilst noting that this will underestimate the benefits of traffic reduction in the peak periods in urban areas.
- *Peak oil* will be addressed by increasing the effective real price of petrol by 75% by 2031 (equivalent to $3/litre real price ($5+ pump price), whilst incorporating a 30% improvement in fuel efficiency (including alternative fuels) across the vehicle fleet.
- *The discount rate* used will be determined on the basis of the interest rate for government borrowings for a term relevant to the expected duration of the project, with an allowance for inflation deducted from this rate, as costs and benefits are to be expressed in real terms (Department of Infrastructure & Planning, 2010).

However, the health effects of active transport are a highly problematic area of evaluation in three respects:

1. estimation of the effects of active transport initiatives on the use of active transport modes (walking and cycling)
2. identification and quantification of the health effects resulting from the changes in active travel
3. valuation of the health effects resulting from the changes in active travel, beyond the relatively simplistic valuation of mortality effects.

[39] The rate of social time-preference is the rate at which society is willing to substitute present for future consumption of natural resources. When costs and benefits are valued in real terms (i.e. without allowance for inflation), the rate of time preference should be similarly expressed in real terms. Market interest rates include expectations of future inflation.

12 Conclusion and Recommendations

Active transport initiatives can be and have been evaluated using traditional benefit-cost methodologies, with results that compare more than favourably (exceeding in most cases) the evaluations of more conventional transport investments. In many cases, however, there has been little or no monitoring of the effects on travel behaviour itself, and, even where such monitoring has been undertaken, the results have not been translated into evaluations of the outcomes to demonstrate the value of the initiative.

Active transport and travel-behaviour change initiatives affect a range of stakeholders. Most evaluations have not clearly identified the impacts on different stakeholders, although program material does often promote the benefits to a range of beneficiaries (e.g. students, parents, school and community in the case of school-based programs). Identification and enunciation of specific stakeholder benefits, using evaluation techniques to estimate their extent and value can play an important role in gaining acceptance of an active transport initiative.

The primary focus of active transport and travel-behaviour change initiatives has been on urban areas. There has been no comparative evaluation of urban and non-urban initiatives.

Anecdotal evidence suggests that the 'diffusion effect' can be significant, from school students to their families and from their families into the community. The measurement of impacts from household programs implicitly incorporates at least local diffusion by measuring across the whole community, but this is not the case with school and workplace programs, which have generally been restricted to the immediate population of students or employees.

The health effects of active transport are the single most problematic area of evaluation due to the difficulties involved in estimating how effective initiatives are in increasing the use of active transport, identifying and quantifying the health effects of active transport, and appropriately valuing those health effects.

Evaluations of active transport have included a limited range of health benefits, primarily related to mortality rather than morbidity or wellbeing. The results of such approaches will be conservative as they exclude the benefits of improved wellbeing, as expressed, for example, in the concept of the 'quality-adjusted life year'. The consensus is that there is insufficient data or information to permit robust assessment of the quality-of-life effects of active transport, although there is agreement that these effects would be positive.

In Australia, mortality valuation in transport and road safety uses the 'human capital' approach instead of the more appropriate 'willingness to pay' method. This results in the understating of the socioeconomic value of mortality-related impacts by a factor of between two and three.

The evidence base for the health effects of walking as a component of active travel programs is much more limited than for cycling, but, for primary schools with relatively small catchments, walking is often a more feasible and attractive alternative to the car than cycling.

Evaluations generally do not address the time required for benefits to manifest themselves in the health area. Whereas the 'traditional' benefits of transport initiatives occur immediately and can be directly related to travel behaviour, the health benefits may require repeated behaviour before they become manifest and significant. Equally, evaluations usually lack information about the durability of the behaviour change brought about by active transport or travel-behaviour change initiatives. There is some evidence that travel-behaviour change from household programs is maintained at the same level for up to five years, but little is known in the case of school-based initiatives. Theoretical considerations suggest that, provided the quality of the alternative experience is maintained, the reduced level of reliance on the private car will continue.

Notwithstanding these qualifications, evaluations of active transport initiatives and travel-behaviour change have consistently reported high returns in excess of those typically estimated for transport improvements (whether urban or rural). On this basis, appropriately designed socioeconomic benefit-cost analysis is an effective tool for demonstrating the case for active transport programs, especially if supplemented by qualitative strategic analysis to place active transport in the appropriate public policy and community values context.

12.1 Recommendations for Further Research

In reviewing the current state of knowledge and practice of active transport, with particular reference to the health benefits, it has become clear that there are substantial deficiencies that could be overcome (or at least ameliorated) through further research.

In the area of active transport and health:

1. Better information is needed on the effects of active transport on health for different age groups, especially for children, and the extent to which physical activity (including active transport) in childhood carries over into later life both in terms of physical activity levels and residual health benefits.

2. Greater understanding is needed of the time period for benefits to become apparent and to achieve their maximum potential. This is likely to vary between (a) the various diseases that are exacerbated by inadequate physical activity and (b) the age group targeted by the active transport intervention.

3. Improved information is needed on the short- and long-term health effects of walking in active transport initiatives, especially for primary-school interventions.
4. Australian-specific research is needed to evaluate the incremental change in accident and health risk of specific policies and programs that affect walking and cycling activity, taking into account direct user (walkers and cyclists) risk per kilometre of travel, safety in numbers effect, changes in total travel activity, risk to other road users, and possible risk reduction strategies.

Many of the benefits beyond health are well-established in evaluation of transport projects, but emerging areas are less well-served:

5. Better information is required on the quality-of-life benefits of active transport, including (a) how to identify, measure and quantify them and (b) how to place a socioeconomic value on them for benefit-cost analysis purposes.
6. In the absence of (b) above, an evaluation framework capable of incorporating non-monetary (either quantitative or qualitative) values should be developed to demonstrate the existence, direction and, where possible, extent of the quality of life effects of active transport.
7. More research is required to identify the other social benefits of active transport in schools, including improved learning outcomes and enhanced independence.
8. Better understanding is needed of the durability of the effects of active travel programs, especially those aimed at school children. Life-stage transition, including between primary and high school, have impacts on capabilities, travel needs and opportunities that could diminish or enhance the effects of programs in primary school.

In relation to active transport more generally, in the context of transport planning and sustainability:

9. Standard definitions and questions to include in travel surveys should be established to collect better information on active transport demand and activity. Current practices are fragmented and non-uniform, making it difficult to accurately compare transport patterns across different jurisdictions, or even the same jurisdiction over time.
10. Travel surveys should be designed to collect better information on short trips, travel by children, walking and cycling links of motorised trips and more detailed user information, such as people's physical ability and health, income, vehicle access, and perceptions of walking and cycling conditions.

    Travel survey data should report the amount of time spent travelling by various modes. In addition, travel surveys should be coordinated with public health studies to allow research on the relationships between transport conditions (e.g. active transport, emissions) and health outcomes (e.g. road traffic injuries, body weight, diabetes and cardiovascular diseases). Federal or state governments or professional organisations should work to establish standard travel survey questions to ensure consistency.

    Targeted research is required to improve the ability of existing transport models and to develop new models for predicting how specific policy changes and projects affect active travel activity. This research must include the impact improvements to motorised transport infrastructure have on active transport. Of special importance is the need to investigate latent demand for active transport.
11. Additional research is needed to better understand how changes in active transport affects motorised travel, including substitution rates and leverage effects, and the types of motorised travel reduced, such as urban-peak vehicle travel (which reduces traffic congestion) and driving by young males (which reduces crash risk). It would be helpful to analyse leverage effects using Australian data.

References

AAA, 2008 *Crashes vs. Congestion? What's the Cost to Society?* Cambridge, MD: Cambridge Systematics, Inc. http://www.aaanewsroom.net/Assets/Files/20083591910.CrashesVsCongestionFullReport2.28.08.pdf

Abbott RA, Macdonald D, Mackinnon L, Stubbs CO, Lee AJ, Harper C, Davies PSW., 2007 *Healthy Kids Queensland Survey 2006 - Summary Report*. Queensland Health: Brisbane, Australia.

Åberg MAI, Pedersen NL, Torén K, Svartengren M, Bäckstrand B, Johnsson T, Cooper-Kuhn CM, Åberg ND, Nilsson M, Kuhn HG., 2009 *Cardiovascular fitness is associated with cognition in young adulthood*. Proceedings of the National Academy of Sciences 106(49): 20906-209011.

Active Living Research, 2009 *Active Education: Physical Education, Physical Activity and Academic Performance*, San Diego University: San Diego; at: http://www.activelivingresearch.org/files/Active_Ed_Summer2009.pdf

Active Living by Design (www.activelivingbydesign.org) encourages physical activity and health through community design and public policy strategies.

AECOM, 2010 *Inner Sydney Regional Bicycle Network: Demand Assessment and Economic Appraisal*. AECOM Australia FOR City of Sydney: Sydney, NSW.

Agrawal A, Schimek P., 2007 *Extent and correlates of walking in the USA*. Transportation Research Part D 12(8): 548-563.

American Journal of Health Promotion, 2003 *Special Issue: Health Promoting Community Design*. American Journal of Health Promotion (www.healthpromotionjournal.com), Vol. 18, No. 1, Sept./Oct. 2003.

Allen Consulting., 2000 *Urban Transport and Climate Change: Developing an Integrated Investment Framework*, The Allen Consulting Group FOR Transport WA, Australian Greenhouse Office, Transport Queensland and Victorian Department of Infrastructure: Perth, WA and Brisbane, Queensland

Alliance for Biking and Walking, 2010 *Bicycling and Walking in the U.S.: 2010 Benchmarking Report, Alliance for Biking & Walking*, (www.peoplepoweredmovement.org); at www.peoplepoweredmovement.org/site/index.php/site/memberservices/C529.

American Academy of Pediatrics, 2009 *The Built Environment: Designing Communities to Promote Physical Activity in Children*. Pediatrics Vol. 123 No. 6, June 2009, pp. 1591-1598 (doi:10.1542/peds.2009-0750). http://aappolicy.aappublications.org/cgi/content/full/pediatrics;123/6/1591.

American Public Health Association, 2010 *The Hidden Health Costs of Transportation: Backgrounder*. American Public Health Association (www.apha.org/advocacy/reports/reports); at http://www.apha.org/NR/rdonlyres/E71B4070-9B9D-4EE1-8F43-349D21414962/0/FINALHiddenHealthCostsShortNewBackCover.pdf.

Andersen L, Lawlor D, Cooper A, Froberg K, Anderssen S., 2009 *Physical fitness in relation to transport to school in adolescents: the Danish youth and sports study*. Scandinavian Journal of Medicine and Science in Sports 19(3): 406-411.

Andersen LB et al., 2000 *All-Cause Mortality Associated With Physical Activity During Leisure Time, Work, Sports and Cycling to Work*. Archives of Internal Medicine, Vol. 160, No. 11 (http://archinte.ama-assn.org/issues/v160n11/full/ioi90593.html), June 12, 2000, pp. 1621-1628.

Angevaren M, Aufdemkampe G, Verhaar H, Aleman A, Vanhees L., 2008 *Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment*. Cochrane Database of Systematic Reviews Apr 16;(2):CD005381.

Appleyard D, Lintell M., 1980 *The environmental quality of city streets: the residents' viewpoint*. Journal of the American Institute of Planners 38: 84-101.

Applied Economics, 2003 *Returns on investment in public health: an epidemiological and economic analysis*. Department of Health and Ageing: Canberra, Australia.

Australian Bureau of Agricultural and Resource Economics, 2008 *Energy in Australia 2008*. Department of Resources, Energy and Tourism, Australian Government: Canberra, Australia. http://www.abareconomics.com/publications_html/energy/energy_08/energyAUS08.pdf

Australian Bureau of Statistics, 1995 *Travel to work, school and shops, Victoria, October 1994.* Cat No. 9201.2. ABS: Canberra, Australia.

Australian Bureau of Statistics, 2007 *Health of Children in Australia: A Snapshot, 2004-05*. Cat No. 4829.0.55.001 ABS: Canberra, Australia.

Australian Bureau of Statistics, 2008 2006 *Census Data Online* from http://www.abs.gov.au/websitedbs/d3310114.nsf/home/Census+data.

Australian Bureau of Statistics, 2009a *Environmental issues: waste management and transport use*. Cat No. 4602.0.55.002. ABS: Canberra, Australia.

Australian Bureau of Statistics, 2009b *National Health Survey 2007-08: summary of results*. Cat No. 4364.0. ABS: Canberra, Australia.

Australian Bureau of Statistics, 2009c *Perspectives on Sport*. Cat No. 4156.0.55.001. ABS: Canberra, Australia.

Australian Bureau of Statistics, 2010 *Crime Victimisation, Australia, 2008-09*. ABS: Canberra, Australia.

Australian Greenhouse Office, 1998 *The National Greenhouse Strategy*, Australian Greenhouse Office, Canberra

Australian Greenhouse Office, 2006 *Evaluation of Australian TravelSmart Projects in the ACT, South Australia, Queensland, Victoria and Western Australia:2001–2005*. AGO: Canberra, Australia. http://www.travelsmart.gov.au/publications/pubs/evaluation-2005.pdf

Australian Institute of Health and Welfare, 2008. *Australia's health 2008*. Cat. no. AUS 99. Canberra, Australian Institute of Health and Welfare, Canberra.

Australian Institute of Health and Welfare, 2010a *Australia's health 2010*, Australian Institute of Health and Welfare, Canberra.

Australian Institute of Health and Welfare, 2010b *Monitoring the impact of air pollution on asthma in Australia: a methods paper*, Cat. no. ACM 18, Australian Institute of Health and Welfare, Canberra.

Australian Petroleum Production and Exploration Association, 2007 *Key Statistics* Australian Petroleum Production and Exploration Association: Canberra, Australia. http://www.appea.com.au/content/pdfs_docs_xls/Statistics/key_stats_2008_6.pdf

Australian Transport Council, 2006a *National Guidelines for Transport System Management in Australia: Part 3 – Appraisal of Initiatives*. Australian Transport Council of Ministers: Canberra, Australia. http://www.atcouncil.gov.au/documents/NGTSM.aspx

Australian Transport Council, 2006b *National Guidelines for Transport System Management in Australia*: Part 5 – Background Material. Australian Transport Council of Ministers: Canberra, Australia. http://www.atcouncil.gov.au/documents/NGTSM.aspx

Austroads, 2005a *RoadFacts* 2005. Austroads: Canberra, Australia.

Austroads, 2005b *The Australian National Cycling Strategy 2005-2010*, Austroads: Sydney, Australia. www.austroads.com.au/documents/

Austroads, 2008 *Guide to Project Evaluation: Part 4 – Project Evaluation Data*. Austroads: Sydney, Australia.

Austroads, 2010 *National Cycling Strategy: Gearing up for active and sustainable communities 2011–2016*, Austroads, Sydney

Ball J, Ward M, Thornley M, Quigley R., 2009 *Applying Health Impact Assessment To Land Transport Planning*. Research Report 375, New Zealand Transport Agency (www.ltsa.govt.nz). www.nzta.govt.nz/resources/research/reports/375/docs/375.pdf.

Barengo N, Hu G, Lakka T, Pekkarinen H, Nissinen A, Tuomilehto J., 2004 *Low physical activity as a predictor for total and cardiovascular disease mortality in middle-aged men and women in Finland*. European Heart Journal 25(24): 2204-11.

Barnes G, Krizek K., 2005 *Tools for Predicting Usage and Benefits of Urban Bicycle*. Humphrey Institute of Public Affairs, University of Minnesota (www.lrrb.org/pdf/200550.pdf). Also see Estimating Bicycling Demand.
(www.hhh.umn.edu/img/assets/11475/biking_demand.pdf).

Barnett TA, Gauvin L, Craig CL, Katzmarzyk PT., 2008 *Distinct trajectories of leisure time physical activity and predictors of trajectory class membership: a 22 year cohort study*. International Journal of Behavioral Nutrition and Physical Activity 5: 57 doi:10.1186/1479-5868-5-57.

Bartholomew K, Ewing R., 2010 *Hedonic Price Effects of Pedestrian- and Transit-Designed Development*. under review by the Journal of Planning Literature. http://faculty.arch.utah.edu/bartholomew/Individual%20Files/12_Hedonic_Price_Effects.pdf.

Bartley Consulting Pty Ltd., 2008 *Walking and cycling: census analysis*. Bartley Consulting Pty Ltd: Melbourne, Australia.

Barton J, Pretty J., 2010 *What is the Best Dose of Nature and Green Exercise for Improving Mental Health? A Multi-Study Analysis*. Environmental Science and Technology March 25.

Bassett D, Pucher J, Buehler R, Thompson DL, Crouter SE., 2008 *Walking, Cycling, and Obesity Rates in Europe, North America, and Australia*. Journal of Physical Activity and Health, Vol. 5 (www.humankinetics.com/jpah/journalAbout.cfm), pp. 795-814.
http://policy.rutgers.edu/faculty/pucher/JPAH08.pdf.

Batterman SA, Peng C-Y, Braun J., 2002 *Levels and composition of volatile organic compounds on commuting routes in Detroit, Michigan*. Atmos Environ 36(39-40): 6015-30.

Batty G, Shipley M, Marmot M, Smith G., 2001 *Physical activity and cause-specific mortality in men: further evidence from the Whitehall study*. European Journal of Epidemiology 17(9): 863-9.

Bauman A, Rissel C, Garrard J, Ker I, Speidel R, Fishman E., 2008 *Cycling: Getting Australia Moving: Barriers, facilitators and interventions to get more Australians physically active through cycling*. Cycling Promotion Fund: Melbourne, Australia.

Bauman A, Allman-Farinelli M, Huxley R, James W., 2008 *Leisure-time physical activity alone may not be a sufficient public health approach to prevent obesity - a focus on China*. Obesity Reviews 9 (Supplement 1): 119-126.

Begg S, Vos T, Barker B, Stevenson C, Stanley L, Lopez AD., 2007 *The burden of disease and injury in Australia 2003*. Australian Institute of Health and Welfare: Canberra, Australia.

Beimborn E., 1995 *A Transportation Modeling Primer*. Center for Urban Transportation Studies University of Wisconsin-Milwaukee (www.uwm.edu/Dept/CUTS); at www.uwm.edu/Dept/CUTS/primer.htm

Belden, Russonello, Stewart., 2004 *American Community Survey*, National Association of Realtors (www.realtor.org) and Smart Growth America (www.smartgrowthamerica.org); at www.brspoll.com/Reports/Smart%20Growth.pdf.

Bell CA, Ge K, Popkin, BM., 2002 *The road to obesity or the path to prevention: motorized transportation and obesity in China*. Obes Res 10: 277–283.

Bell J, Cohen L., 2009 *The Transportation Prescription: Bold New Ideas for Healthy, Equitable Transportation Reform in America*. PolicyLink and the Prevention Institute Convergence Partnership (www.convergencepartnership.org/transportationhealthandequity).

Berke EM, Gottlieb LM, Moudon AV, Larson EB., 2007 *Protective Association Between Neighborhood Walkability and Depression in Older Men*. Journal of the American Geriatrics Society (www.blackwell-synergy.com), Vol. 55, No. 4, pp. 526–533.

Berrigan D, Troiano RP, McNeel T, DiSogra C, Ballard-Barbash R., 2006 *Active Transportation Increases Adherence to Activity Recommendations*. American Journal of Preventive Medicine 31(3): 210-216.

Besser L, Dannenberg A., 2005 *Walking to public transit: steps to help meet physical activity recommendations*. American Journal of Preventive Medicine 29(4): 273-280.

Bhatia R, Wier M., 2011 Safety in Numbers re-examined: *Can we make valid or practical inferences from available evidence?*, Accident Analysis and Prevention 43(1): 235-40.

Biesma R, Schouten L et al., 2006 *Physical activity and risk of ovarian cancer: results from the Netherlands Cohort Study (The Netherlands)*. Cancer Causes Control 17(1): 109 - 15.

Blythe M., 2006 *Economic Issues: Petrol prices, Crossing the threshold, Commonwealth Research*, Commonwealth Bank of Australia: Sydney

Boarnet MG, Greenwald M, McMillan TE., 2008 *Walking, Urban Design, and Health: Toward a Cost-Benefit Analysis Framework*. Journal of Planning Education and Research, Vol. 27, No. 3, pp. 341-358; at http://jpe.sagepub.com/cgi/content/abstract/27/3/341.

Booth ML, Okely AD, Denney-Wilson E, Hardy L, Yang B, Dobbins T., 2006 *NSW Schools Physical Activity and Nutrition Survey (SPANS) 2004: Full Report*. NSW Department of Health: Sydney, Australia.

Booth M, Okely A, Denney-Wilson E, Hardy L, Dobbins T, Wen L, Rissel C., 2007 *Characteristics of travel to and from school among adolescents in NSW, Australia*. Journal of Paediatrics and Child Health 43(11): 755-61.

Bosselmann P, MacDonald E., 1999 *Livable streets revisited*. Journal of the American Planning Association 65(2).

Brisbane City Council, 2009 *Active School Travel Program: 2008 summary evaluation* report. Brisbane City Council: Brisbane, Australia.

Brisbane City Council, 2010 *Active School Travel Program: 2009 summary evaluation* report. Brisbane City Council: Brisbane, Australia.

British Medical Association, 1992 *Cycling towards health and safety*. Oxford University Press: United Kingdom.

Brog W, Ker I., 2009 Myths, (Mis)*Perceptions and Reality in Measuring Voluntary Behavioural Changes*. In Bonnel P, Lee-Gosselin M, Zmud J, Madre JL., 2009 *Transport Survey Methods: Keeping Up With a Changing World*. Emerald Group Publishing: Bingley, UK.

Built Environment and Active Transportation (BEAT), 2008 *Benefits of Investing In Active Transportation*. BEAT, ActNow BC (www.physicalactivitystrategy.ca); at http://physicalactivitystrategy.ca/pdfs/BEAT/BEAT_Publication.pdf. General overview of the economic benefits of nonmotorised transport.

Buis J., 2000 *The Economic Significance of Cycling: A Study to Illustrate the Costs and Benefits of Cycling Policy*, VNG (The Haag, the Netherlands; www.vnguitgeverij.nl) and Interface

for Cycling Expertise (www.cycling.nl).

Bureau of Transport and Regional Economics, 2005 *Health impacts of transport emissions in Australia: economic costs*. Department of Transport and Regional Services: Canberra, Australia.

Bureau of Transport and Regional Economics, 2007 *Estimating urban traffic and congestion cost trends for Australian cities*, Working Paper No 71, Bureau of Transport and Regional Economics: Canberra, Australia. http://www.btre.gov.au/info.aspx?ResourceId=249&NodeId=59

Bureau of Transport and Regional Economics, 2005 *Health impacts of transport emissions in Australia: Economic costs*, Working paper 63, Department of Transport and Regional Services, Australian Government: Canberra, Australia.
http://www.btre.gov.au/info.aspx?ResourceId=94&NodeId=59

Bureau of Transport and Regional Economics, 2007 *Estimating urban traffic and congestion cost trends for Australian cities*, Working Paper No 71, Bureau of Transport and Regional Economics: Canberra, Australia. http://www.btre.gov.au/info.aspx?ResourceId=249&NodeId=59

Bureau of Transport Economics, 1995 *Employment Effects of Road Construction*, Working Paper 29, Commonwealth of Australia, Canberra.

Burke M, Brown AL., 2007 *Distances people walk for transport*. Road & Transport Research, Vol. 16, No. 3.

Bus Association Victoria, 2010 *Public transport use a ticket to health*. Bus Association Victoria: Melbourne, Australia.

Bussmann W., 2010 *Evaluation of Legislation: Skating on Thin Ice*, Evaluation, 16 (3), 279-293, July.
http://evi.sagepub.com/content/16/3/279

Cairns S, Sloman L, Newson C, Anable J, Kirkbride A, Goodwin P., 2004 *Smarter Choices – Changing the Way We Travel: Final report of the research project: 'The influence of soft factor interventions on travel demand'*. Department for Transport: London, England.
http://www.dft.gov.uk/pgr/sustainable/smarterchoices/ctwwt

California Air Resources Board, 1999 *Measuring Concentrations of Selected Air Pollutants Inside Californian Vehicles*. Californian Environment Protection Agency: Orange County, USA.

Carver A, Timperio A, Crawford D., 2008a *Playing it safe: The influence of neighbourhood safety on children's physical activity--A review*. Health & Place 14(2): 217-227.

Carver A, Timperio A, Crawford D., 2008b *Perceptions of Neighborhood Safety and Physical Activity Among Youth: The CLAN Study*. Journal of Physical Activity and Health 5(3): 430-44.

Cavill N., 2001 *Walking & health: making the links*, World Transport Policy & Practice, 7 (4) 33-38.
http://www.eco-logica.co.uk/pdf/wtpp07.4.pdf

Cavill N, Kahlmeier S., 2007 *Economic analyses of transport infrastructure and policies including health effects related to cycling and walking: a systematic review*. European Centre for Environment and Health, World Health Organisation: Rome, Italy.

Cavill N, Kahlmeier S, Rutter H, Racioppi F, Oja P., 2007 *Economic Assessment of Transport Infrastructure and Policies: Methodological guidance on the economic appraisal of health effects related to walking and cycling*, European Centre for Environment and Health, World Health Organisation: Rome, Italy.
http://www.euro.who.int/__data/assets/pdf_file/0008/87479/E90944.pdf (6 September 2010)

Cavill N, Kahlmeier S, Rutter H, Racioppi F, Oja P., 2008 *Economic Analyses Of Transport Infrastructure And Policies Including Health Effects Related To Cycling And Walking: A Systematic Review*, published as, "Review Of Transport Economic Analyses Including Health Effects Related To Cycling And Walking, Transport Policy, Vol. 15, pp. 291–304; at www.euro.who.int/__data/assets/pdf_file/0010/53857/E92660.pdf.

Cavill N, Cope A, Kennedy A., 2009 *Valuing Increased Cycling in the Cycling Demonstration Towns*. Cycling England, Department for Transport (www.dft.gov.uk); at www.dft.gov.uk/cyclingengland/site/wp-content/uploads/2009/12/valuing-increased-cycling-in-the-cycling-demonstration-towns.pdf. Also see www.dft.gov.uk/cyclingengland/site/wp-content/uploads/2010/02/091223-cdts-bcr-analysis-final-edit.pdf.

Center for Disease Control, 2008 *How Much Physical Activity Do You Need?* CDC Physical Activity Recommendations. Center for Disease Control (www.cdc.gov); at www.cdc.gov/nccdphp/dnpa/physical/recommendations/index.htm.

Center for Disease Control, 2010 CDC *Transportation Recommendation*, Center for Disease Control and Prevention (www.cdc.gov/transportation/default.htm).

Cervero R., 2007 *Transit Oriented Development's Ridership Bonus: A Product Of Self Selection And Public Policies*. Environment and Planning, Vol. A, No. 39, pp. 2068-2085; at www.uctc.net/papers/765.pdf.

Chambers LC, Ker IR., 1997 *Paradigm Shifts in Transport: Today's Heresy/Tomorrow's Wisdom*, Proceedings 21st Australasian Transport Research Forum, Adelaide, South Australia.

Chertok M, Voukelatos A, Sheppeard V, Rissel C., 2004 *Comparison of air pollution exposure for five commuting modes in Sydney – car, train, bus, bicycle and walking*. Health Promotion Journal of Australia 15(1): 63-67.

Christie N, Cairns S, Towner E, Ward H., 2007 *How exposure information can enhance our understanding of child traffic "death leagues"*. Injury Prevention 13(2): 125-129.

Christie N, Towner E, Cairns S, Ward H., 2004 *Children's road traffic safety: an international survey of policy and practice*. Road Safety Research Report No. 47. Department for Transport: London, UK.

Chu X., 2006 *The Relative Risk between Walking and Motoring In the United States*. Transportation Research Board 85th Annual Meeting (www.trb.org).

City of Jacksonville, 2010 2030 *Multi-Modal Transportation Study*. City of Jacksonville (www.coj.net); at www.coj.net/Departments/Planning+and+Development/Community+Planning/Mobility+Plan.htm.

Cobiac LJ, Vos T, Barendregt JJ., 2009 *Cost-Effectiveness of Interventions to Promote Physical Activity: A Modelling Study*. P Library of Science Med 6(7); at www.plosmedicine.org/article/info:doi/10.1371/journal.pmed.1000110#pmed-1000110-t001.

Coghlan A., 2007 *Dying for some quiet: The truth about noise pollution*. New Scientist Magazine.

Colagiuri S, Lee CMY, Colagiuri R, Magliano D, Shaw JE, Zimmet PZ, Caterson ID., 2010 *The cost of overweight and obesity in Australia*. Medical Journal of Australia, Vol. 192, No. 5, pp. 260-264; www.mja.com.au/public/issues/192_05_010310/col10841_fm.html.

Colliers International, 2009 *Global CBD Car Parking Rates*, Colliers International.
http://campaigns.colliers.com.au/ve/YU59977782sblkQ0

Collins D, Kearns R., 2007 *Status of Walking School Buses in the Auckland Region, 2006*. Auckland Regional Transport Authority: Auckland, New Zealand.

Commissioner for Environmental Sustainability, 2007 *Creating a city that works: Opportunities and solutions for a more sustainable Melbourne*, Victorian Government, Melbourne

Committee on Physical Activity, Health, Transportation, and Land Use, 2005 *Does the Built Environment Influence Physical Activity? Examining the Evidence*, TRB Special Report 282, Transportation Research Board (www.trb.org).
http://trb.org/publications/sr/sr282.pdf.

Conn V, Hafdahl A, Cooper P, Brown L, Lusk S., 2009 *Meta-analysis of workplace physical activity interventions*. American Journal of Preventive Medicine 37(4): 330-9.

Connelly LB, Supangan R., 2006 *The Economic Costs of Road Trauma: Australia, States and Territories*. Accident Analysis and Prevention, Vol.38 No.6, pp.1087-93. http://dx.doi.org/10.1016/j.aap.2006.04.015

Cooper AR, Wedderkopp N, Wang H, Andersen LB, Froberg K, Page AS., 2006 *Active Travel to School and Cardiovascular Fitness in Danish Children and Adolescents*. Medicine and Science in Sports & Exercise, Volume 38 - Issue 10 – pp. 1724-1731.

Cooper A, Wedderkopp N, Jago R, Kristensen P, Moller N, Froberg K, Page A, Andersen L., 2008 *Longitudinal associations of cycling to school with adolescent fitness*. Preventive Medicine 47(3): 342-328.

Corpuz G., 2006 *Analysis of Peak Hour Travel Using the Sydney Household Travel Survey Data*. Proc. 29th Australasian Transport Research Forum: Gold Coast, Australia.

Cortright J., 2009 *Walking the Walk: How Walkability Raises Home Values in U.S. Cities*. CEOs for Cities (www.ceosforcities.org). www.ceosforcities.org/files/WalkingTheWalk_CEOsforCities1.pdf.

Cozens P, Saville G, Hillier D., 2005 *Crime prevention through environmental design (CPTED):a review and modern bibliography*. Property Management 23(5): 328-56.

CSIRO, 2008 *Fuel for Thought; The future of transport fuels: challenges and opportunities*, CSIRO.

Curtain R, 2000 "Good Public Policy Making: How Australia Fares" in *Agenda*, 16 (3); at: http://epress.anu.edu.au/agenda/008/01/8-1-A-3.pdf

Cycling Promotion Fund, 2008 *Economic benefits of cycling*. Cycling Promotion Fund: Melbourne, Australia.

Cycling Promotion Fund, 2008 *Cycling > Moving Australia Forward*, Cycling Promotion Fund: Melbourne, Australia.

Danish Road Directorate, 1992 *Evaluation of Highway Investment Projects* (undersogelse af storre hovedlandeveejsarbejder. Metode for effektberegninger og okonomisk vurdering), DRD, (www.vejdirektoratet.dk).

Davison K, Werder J, Lawson C., 2008 *Children's active commuting to school: current knowledge and future directions*. Preventing Chronic Disease: Public Health Research, Practice and Policy 5(3): 1-11.

De Hartog JJ, Boogaard H, Nijland H, Hoek G., 2010 *Do The Health Benefits Of Cycling Outweigh The Risks*. Environmental Health Perspectives, doi:10.1289/ehp.0901747, (http://ehp03.niehs.nih.gov/article/info%3Adoi%2F10.1289%2Fehp.0901747).

Dekoster J, Schollaert U., 1999 *Cycling: the way ahead for towns and cities*. Office for Official Publications of the European Communities: Luxembourg. http://ec.europa.eu/environment/archives/cycling/cycling_en.pdf

Department for Transport, 2003 *Travelling to School: A good practice guide*. Department for Transport: London, England.

Department for Transport, 2009 *Transport Analysis Guidance: 3.6.2: The Severance Sub-Objective*, Department for Transport (www.dft.gov.uk); at www.dft.gov.uk/webtag/documents/expert/unit3.6.2.php.

Department for Transport, 2010e *Cycling Demonstration Towns – Development of Benefit-Cost Ratios* by the UK Department for Transport www.dft.gov.uk/cyclingengland/site/wp-content/uploads/2010/02/091223-cdts-bcr-analysis-final-edit.pdf.

Department for Transport, 2010a Transport Analysis Guidance: 3.14.1: *Appraisal of Walking and Cycling Schemes*, Department for Transport (www.dft.gov.uk); at www.dft.gov.uk/webtag/documents/expert/unit3.14.1.php.

Department for Transport, 2010b *Cost-Benefit Analysis* (Draft). TAG Unit 3.5.4, Transport Analysis Guidance. Department for Transport: London, England. http://www.dft.gov.uk/webtag/documents/expert/pdf/unit3.5.4d.pdf

Department for Transport, 2010c *Transport Appraisal and the Treasury Green Book (Draft)*. TAG Unit 2.7.1, Transport Analysis Guidance. Department for Transport: London, England. http://www.dft.gov.uk/webtag/documents/project-manager/pdf/unit2.7.1d.pdf

Department for Transport, 2010d *Appraisal of Walking and Cycling Schemes*. TAG Unit 3.14.1, Transport Analysis Guidance. Department for Transport: London, England. http://www.dft.gov.uk/webtag/documents/expert/unit3.14.php

Department of Climate Change and Energy Efficiency, 2010 *Australian National Greenhouse Accounts*, Commonwealth of Australia.

Department of Communities and Local Government, 2009 *Multi-Criteria Analysis: A Manual*. Department for Communities and Local Government: London, England. http://www.communities.gov.uk/documents/corporate/pdf/1132618.pdf

**Department of Environment, Transport and Regions, 1998 *A New Deal for Transport: Better for Everyone*. Government White Paper on the Future of Transport. Department of Environment,Transport and Regions. HMSO, Cmnd 3950: London, England. http://webarchive.nationalarchives.gov.uk/+/http://www.dft.gov.uk/about/strategy/whitepapers/previous/anewdealfortransportbetterfo5695

Department of Health and Ageing, 2004 *Australia's physical activity recommendations for 5-12 year olds*. Department of Health and Ageing: Canberra, Australia.

Department of Health and Ageing, 2008 2007 *Australian National Children's Nutrition and Physical Activity Survey: main findings*. Department of Health and Ageing: Canberra, Australia.

Department of the Environment Water Heritage and the Arts, 2008 *Households and climate change*.
http://www.environment.gov.au/settlements/gwci/households.html.

Department of Health and Human Services (DHHS), 2008 *Physical Activity Guidelines For Americans*, Physical Activity Guidelines Advisory Committee Report, DHHS (www.health.gov).
www.health.gov/paguidelines/report.

Department of Infrastructure and Planning, 2010c *Project Assurance Framework*. Department of Infrastructure and Planning: Brisbane, Australia.
http://www.dip.qld.gov.au/guidelines/project-assurance-framework-guidelines.html

(2010a). *Policy Overview*.
http://www.dip.qld.gov.au/resources/guideline/project-assurance-framework/paf-policy-overview.pdf

(2010b). *Cost-Benefit Analysis*.
http://www.dip.qld.gov.au/resources/guideline/project-assurance-framework/paf-cost-benefit-analysis.pdf

Department of Transport, 2009 *Victorian integrated survey of travel and activity 2007* (VISTA 2007). Department of Transport: Melbourne, Australia.

Department of Transport, 2010 *Pedestrian Access Strategy*. Victorian Government: Melbourne, Australia.
http://www.transport.vic.gov.au/DOI/Internet/ICT.nsf/AllDocs/3CD45929D980794ACA257792001E5E97?OpenDocument.

Department of Transport and Main Roads, n.d *Sustainable transport*, Department of Transport and Main Roads, Website, Queensland Government, Brisbane.
http://www.tmr.qld.gov.au/Community-and-environment/Environmental-management/Sustainable-transport.aspx

Department of Transport, 2009 *Victorian Integrated Survey of Travel and Activity*, Department of Transport, Victorian Government: Melbourne, Australia.

Department of Treasury, 2010 *Intergenerational Report 2010: Australia for 2050: future challenges*, Commonwealth of Australia: Canberra, Australia.

Dixon L., 1996 *Bicycle and Pedestrian Level-of-Service Performance Measures and Standards for Congestion Management Systems*. Transportation Research Record 1538, TRB (www.trb.org), pp. 1-9.

Dobes L, Bennet J., 2009 *Multi-Criteria Analysis: "Good Enough" for Government Work? Agenda, 16 (3)*.
http://epress.anu.edu.au/agenda/016/03/mobile_devices/ch02.html

Dollman J, Lewis N., 2007 *Active transport to school as part of a broader habit of walking and cycling among South Australian Youth*. Pediatric Exercise Science 19(4): 436-43.

Dora C, Phillips M., 2000 *Transport, Environment and Health*, World Health Organisation Regional Publication, European Series, No. 89: Copenhagen, Denmark.
www.euro.who.int/document/e72015.pdf

Dora C., Racioppi F., 2003 *Including health in transport policy agendas: the role of health impact assessment analyses and procedures in the European experience, in Bulletin of the World Health Organisation*, 81: 399-403

Dowling R et al., 2008 *Multimodal Level Of Service Analysis For Urban Streets*, NCHRP Report 616, Transportation Research Board (www.trb.org).

Duffy BL, Nelson PF., 1997 *Exposure to emissions of 1,3-butadiene and benzene in the cabins of moving motor vehicles and buses in Sydney, Australia*. Atmos Environ 31(23):3877-85.

East Carolina University, 2004 *Physical Inactivity Cost Calculator* (www.ecu.edu/picostcalc), College of Health & Human Performance, East Carolina University (www.ecu.edu).

Eckersley R., 1997 *Perspectives on Progress: is life getting better?* Working Paper 97/27, Resource Futures Program, CSIRO Wildlife and Ecology.

Econtech, 2007 *Economic Modelling Of The Net Costs Associated With Non-Participation In Sport And Physical Activity*. Econtech: Canberra, Australia (www.econtech.com.au): at
www.econtech.com.au/information/Social/Medibank_Sports_Final_300707.pdf.

Eddington R., 2008 *Investing in Transport: East West Links Needs Assessment*, for the Victorian Government: Melbourne, Australia. http://www.transport.vic.gov.au/DOI/Internet/planningprojects.nsf/AllDocs/E195C22162760C83CA2571ED0080D1E5?OpenDocument

Economic Development Research Group, 2007 *Monetary Valuation of Hard-to-Quantify Transportation Impacts: Valuing Environmental, Health/Safety & Economic Development Impacts*, NCHRP 8-36-61, TRB (www.trb.org/nchrp).

Edwards P, Tsouros AD., 2008 *A Healthy City Is An Active City: A Physical Activity Planning Guide*, World Health Organisation: Europe (www.euro.who.int); at: www.euro.who.int/__data/assets/pdf_file/0012/99975/E91883.pdf.

Egger G, Donovan R, Swinburn B, Giles-Corti B, Bull F., 1999 *Physical Activity Guidelines for Australians: Scientific Background Report*. The University of Western Australia and The Centre for Health Promotion and Research: Sydney, Australia.

Ellison R, Greaves S., 2010 *Travel time competitiveness of cycling in Sydney*, Institute of Transport and Logistics Studies, University of Sydney. ATRF 2010 Proceedings.

Elvik R., 2009 *The Non-Linearity of Risk and the Promotion of Environmentally Sustainable Transport*. Accident Analysis and Prevention, Vol. 41, pp. 849–855.

Environmental Protection Authority, 2007 *Noise surveys 2007*. EPA: Melbourne, Australia.

Eppli M, Tu CC., 2000 *Valuing the New Urbanism; The Impact of New Urbanism on Prices of Single-Family Homes*. Urban Land Institute (www.uli.org).

Ergas H., 2009 *In Defence of Cost-Benefit Analysis*, Agenda, 16 (3). http://epress.anu.edu.au/agenda/016/03/mobile_devices/ch03.html

European Commission, 1999, *Cycling: The Way Ahead For Towns And Cities: A Handbook for Local Authorities*, Environment DG, European Commission: at: http://europa.eu.int/comm/images/language/lang_en3.gif

Ewing R, Schieber RA, Zegeer CV., 2003 Urban Sprawl As A Risk Factor In Motor Vehicle Occupant And Pedestrian Fatalities, in American Journal of Public Health, Vol. 93, No. 9 (www.ajph.org), Sept. 2003, pp. 1541-1545.

Ewing R et al., 2003 Relationship Between *Urban Sprawl and Physical Activity, Obesity, and Morbidity*. American Journal of Health Promotion, Vol. 18, No. 1 (www.healthpromotionjournal.com), Sept/Oct. 2003, pp. 47-57, at: www.smartgrowth.umd.edu/pdf/JournalArticle.pdf.

Federal Highway Administration, 2006 *Shared-Use Path Level of Service Calculator*. Turner-Fairbank Highway Research Center (www.tfhrc.gov), Federal Highway Administration, USDOT; at www.tfhrc.gov/safety/pedbike/pubs/05138

Federal Highway Administration, 2000 *Addendum to the 1997 Federal Highway Cost Allocation Study Final Report*, U.S. Department of Transportation Federal Highway Administration; at http://www.fhwa.dot.gov/policy/hcas/addendum.htm

Fietsberaad, 2008 *Cycling in the Netherlands*, Ministry of Transport, Public Works and Water Management: The Netherlands. www.fietsberaad.nl/library/repository/bestanden/Cycling%20in%20the%20Netherlands%20VenW.pdf

Finkelstein EA, Trogdon JG, Cohen JW, Dietz W., 2009 *Annual Medical Spending Attributable To Obesity: Payer- And Service-Specific Estimates*, Health Affairs, 28(5): w822–w831. http://win.niddk.nih.gov/statistics/index.htm - econ

Forkenbrock DJ, Weisbrod GE., 2001 *Guidebook for Assessing the Social and Economic Effects of Transportation Projects*, NCHRP Report 456, Transportation Research Board, National Academy Press (www.trb.org)

Forsyth A, Krizek KJ, Rodríguez DA., 2009 Chapter 3. *Non-motorised travel research and contemporary planning initiatives*. Progress in Planning 71(4): 170-183.

Franco OH et al., 2005 *Effects of Physical Activity on Life Expectancy With Cardiovascular Disease*. Archives of Internal Medicine, Vol. 165 No. 20 (http://archinte.ama-assn.org/cgi/content/abstract/165/20/2355), Nov. 2005, pp. 2355-2360.

Frank L., 2004 *Obesity Relationships with Community Design, Physical Activity and Time Spent in Cars*. American Journal of Preventive Medicine (www.ajpm-online.net/home), Vol. 27, No. 2, June, 2004, pp. 87-97.

Frank L et al., 2006 *Many Pathways From Land Use To Health: Associations Between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality*. Journal of the American Planning Association, Vol. 72, No. 1 (www.planning.org), Winter 2006, pp. 75-87.

Frank L, Andresen M, Schmid T., 2004 *Obesity relationships with community design, physical activity, and time spent in cars*. American Journal of Preventative Medicine 27: 87–96.

Frank L et al., 2010 *Carbonless Footprints: Promoting Health and Climate Stabilization Through Active Transportation*. Preventive Medicine, Vol. 50, Supplement 1, pp. S99-S105; at www.activelivingresearch.org/resourcesearch/journalspecialissues.

Friedenreich C, Neilson H, Lynch B., 2010 *State of the epidemiological evidence on physical activity and cancer prevention*. European Journal of Cancer 46(14): 2593-604.

Frumkin H, Frank L, Jackson R., 2004 *Urban sprawl and public health. Designing, planning and building for healthy communities*. Island Press: Washington, USA.

Fry D., 2008 New South Wales *Travelsmart Schools Program 2006-2007*. Sydney South West Area Health Service: Sydney, Australia.

Gallin N., 2001 *Quantifying Pedestrian Friendliness - Guidelines For Assessing Pedestrian Level Of Service*. Road and Transport Research; at: http://findarticles.com/p/articles/mi_qa3927/is_200103/ai_n8933986.

Garrard G, Rissel C, Bauman A., 2010 (in press) *Cycling and health*, in Pucher J and Buehler R (Eds), City cycling: pedalling for a purpose. MIT Press.

Garrard J., 2008 *Safe speed: promoting safe walking and cycling by reducing traffic speed*. National Heart Foundation: Melbourne, Australia.

Garrard J., 2009a *Active transport: children and young people. An overview of recent evidence*. Victorian Health Promotion Foundation: Melbourne, Australia.

Garrard J., 2009b *Active transport: adults. An overview of recent evidence*. Victorian Health Promotion Foundation: Melbourne, Australia.

Garrard J., 2010 *Active school travel research project: final report*. Unpublished report prepared for the Victorian Department of Planning and Community Development: Melbourne, Australia.

Garrard J, Crawford S, Godbold T., 2009 Evaluation of the Ride2School Program: final report. Deakin University: Melbourne, Australia.

Garrard J, Greaves S, Ellison A., 2010 *Cycling injuries in Australia: road safety's blind spot?* Journal of the Australasian College of Road Safety 21(3): 37-43.

Garrard J, Rissel C, Bauman A., in press, 2011 *"Cycling and health" in City cycling: pedalling for a purpose*, J. Pucher and R. Buehler (Eds), MIT Press

Gauderman WJ, Avol E, Gilliland F, Vora H, Thomas D, Berhane K, McConnell R, Kuenzli N, Lurmann F, Rappaport E, Margolis H, Bates D, Peters J., 2004 *The effect of air pollution on lung development from 10 to 18 years of age*. The New England Journal Of Medicine 351(11): 1057-1067.

Gebel K., 2005, *Creating healthy environments: A review of links between the physical environment, physical activity and obesity*, NSW Health Department and NSW Centre for Overweight and Obesity: Sydney

Genter JA, Donovan S, Petrenas B, Badland H., 2008. *Valuing the health benefits of active transport modes*. NZ Transport Agency research report 359. 72 pp.

Geoscience Australia, 2006 *Oil and Gas Resources of Australia 2004*, Department of Industry, Tourism and Resources, Commonwealth of Australia: Canberra, Australia. http://www.ga.gov.au/image_cache/GA8550.pdf

Giles-Corti B, Foster S, Shilton T, Falconer R., 2010 *The co-benefits for Health of Investing in Active Transportation* NSW Public Health Bulletin Vol. 21, No5–6, pp. 122-127. www.ncbi.nlm.nih.gov/pubmed/20637168.

Goodwin P, Hallett S, Kenny F, Stokes G., 1991 *Transport: The New Realism*, Report to the Rees Jeffreys Fund, Guo JY, Gandavarapu S., 2010 An Economic Evaluation Of Health-Promotive Built Environment Changes. Preventive Medicine, Vol. 50, Supplement 1, January 2010, pp. S44-S49; at www.activelivingresearch.org/resourcesearch/journalspecialissues.

Hamer M, Chida Y., 2008a *Active commuting and cardiovascular risk: a meta-analytic review*. Preventive Medicine 46(1): 9-13.

Hamer M, Chida Y., 2008b *Walking and primary prevention: a meta-analysis of prospective cohort studies*. British Journal of Sports Medicine 42(4): 238-43.

Hamer M, Stamatakis E, Mishra G., 2009 *Psychological Distress, Television Viewing, and Physical Activity in Children Aged 4 to 12 Years*. Pediatrics 123(5): 1263-1268.

Handy S, Cao X, Mokhtarian P., 2005 *Correlation or causality between the built environment and travel behavior? Evidence from Northern California*. Transportation Research Part D: Transport and Environment 10(6): 427-444.

Hart J., 2008 *Driven to excess: impacts of motor vehicle traffic on residential quality of life in Bristol, UK*. MSc in Transport Planning at the University of the West of England, Bristol.

Hass-Klau, C., 1993, *"Impact of pedestrianisation and traffic calming on retailing, A review of the evidence from Germany and the UK"* in Transport Policy, Vol. 1, No. 1, pp. 21-31

Heesch KC, Garrard J, Sahlqvist S., 2010 *Correlates of cyclist injuries in Queensland: What factors are associated with cyclists getting injured?* 2010 Australasian Road Safety Research, Policing and Education Conference, 31 August - 3 September 2010, Canberra, Australian Capital Territory.

Helmrich S, Ragland D, Leung R, Paffenbarger R., 1991 *Physical activity and reduced occurrence of noninsulin-dependent diabetes mellitus*. New England Journal of Medicine 325(3): 147-52.

Hemmingsson E, Uddén J, Neovius M, Ekelund U, Rössner S., 2009 *Increased physical activity in abdominally obese women through support for changed commuting habits: a randomized clinical trial*. International Journal of Obesity 33(6): 645-52.

Hendriksen I., 1996 *The effect of commuter cycling on physical performance and on coronary heart disease risk factors*. Free University: Amsterdam, Holland.

Hendriksen IJM, Zuiderveld B, Kemper HCG, Bezemer PD., 2000 *Effect of commuter cycling on physical performance of male and female employees.* Medicine and Science in Sports and Exercise 32(2): 504-510.

Hendriksen I, Simons M, Garre F, Hildebrandt V 2010 *The association between commuter cycling and sickness absence*, Preventive Medicine 51: 132-135.

Higgins P, Higgins M., 2005 *A Healthy Reduction in Oil Consumption and Carbon Emissions*. Energy Policy, Vol. 33, Issue 3, February, Pages 425-425; at: www.citeulike.org/user/mokgand/article/1029150.

Higgins TJ, Johnson WL., 1999 *Evaluating transportation programs: Neglected principles, in Transportation*, 26(4), pp. 323–336

Hillier B, Sahbaz O., 2006 *High resolution analysis of crime patterns in urban street networks: an initial statistical sketch from an ongoing study of a London Borough*. University College: London, UK.

Hillman M., 1997 *Health Promotion and Non-Motorised Transport*, IN Tony Fletcher and Anthony J McMichael (Eds), Transport Policy and Urban Health. John Wiley and Sons. Chichester, England.

Hinkson E, Duncan S, Kearns R, Badland H., 2008 *School Travel Plan Evaluation: 2007 School Year*, FOR Auckland Regional Transport Authority: Auckland, New Zealand.

Hopkinson P, Wardman M., 1996 *Evaluating the demand for cycling facilities*, Transport Policy, Vol 3 No 4, pp 241-249.

Horton D, Rosen P, Cox P., 2007 *Fear of cycling*, Cycling and society. Ashgate Publishing: Hampshire, 133-52.

Hosking J, Macmillan A, Connor J, Bullen C, Ameratunga S,. 2010 *Organisational travel plans for improving health*, Cochrane Database of Systematic Reviews Mar 17;3:CD005575.

Hou L, Ji BT et al., 2004 *Commuting physical activity and risk of colon cancer in Shanghai, China*. American Journal of Epidemiology 160(9): 860-7.

Hu G, Qiao Q, Silventoinen K, Eriksson J, Jousilahti P, Lindstrom J, Valle TT, Nissinen A, Tuomilehto J., 2003 *Occupational, commuting, and leisure-time physical activity in relation to risk for Type 2 diabetes in middle-aged Finnish men and women*. Diabetologia 46(3): 322-29.

ICLEI, 2003 Active Transport Quantification Tool. (http://att.ccp.iclei.org) by the Cities for Climate Protection, International Council for Local Environmental Initiatives and The Victorian Health Promotion Foundation (VicHealth).

Infrastructure Australia, 2010 *Better Infrastructure Decision-Making: Guidelines for making submissions to Infrastructure Australia's infrastructure planning process, through Infrastructure Australia's Reform and Investment Framework*. Infrastructure Australia: Canberra, ACT.
http://www.infrastructureaustralia.gov.au/files/Better_Infrastructure_Decision_Making_Guidelines.pdf

Infrastructure Australia, 2010a *Templates for Stage 7: Better Infrastructure Decision-Making: Guidelines for making submissions to Infrastructure Australia's infrastructure planning process, through Infrastructure Australia's Reform and Investment Framework*. Infrastructure Australia: Canberra, ACT.
http://www.infrastructureaustralia.gov.au/files/Better_Infrastructure_Decision_Making_Template_Stage7_Appraisal_and_Deliverability2.pdf

International Obesity TaskForce, 2009 *Global childhood overweight*.
http://www.iotf.org/database/documents/Global_Children_JUNE_09_v2_to_go_on_24th_June.pdf

Ising H, Lange-Asschenfeldt H, Moriske H, Born J, Eilts M., 2004 *Low frequency noise and stress: bronchitis and cortisol in children exposed chronically to traffic noise and exhaust fumes*. Noise Health 6(23): 21-28.

Jacobsen PL., 2003 *Safety In Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling* Injury Prevention (http://ip.bmjjournals.com), Vol. 9, 2003, pp. 205-209; at www.tsc.berkeley.edu/newsletter/Spring04/JacobsenPaper.pdf.

Jacobsen PL, Racioppi F, Rutter H., 2009 *Who Owns The Roads? How Motorised Traffic Discourages Walking And Bicycling*. Injury Prevention, Vol. 15, Issue 6, pp. 369-373; http://injuryprevention.bmj.com/content/15/6/369.full.html.

Jensen SU, Hummer CH., 2003 *Safer routes to Danish schools. Sustainable transport: planning for walking and cycling in urban environments*. Tolley R, Woodhead Publishing Limited: Cambridge, England 588-598.

Janssen I, Katzmarzyk P, Boyce WF, Vereecken C, Mulvihill C, Roberts C, Currie PC., & the Health Behaviour in School-Aged Children Obesity Working Group 2005 *Comparison of overweight and obesity prevalence in school-aged youth from 34 countries and their relationships with physical activity and dietary patterns*, Obesity Reviews, 6: p. 123-132.

Kahlmeier S, Racioppi F, Cavill N, Rutter H, Oja P., 2010 *Health in All Policies' in Practice: Guidance and Tools to Quantifying the Health Effects of Cycling and Walking*. Journal of Physical Activity and Health, Vol. 7, Supplement 1, pp. S120-S125; at
www.euro.who.int/document/E93592.pdf.

Karadeniz D., 2008 *Impact of the Little Miami Scenic Trail on Single Family Residential Property Values*. Masters Thesis, University of Cincinnati. http://atfiles.org/files/pdf/LittleMiamiPropValue.pdf

Kavanagh A, Thornton L, Tattam A, Thomas L, Jolley D, Turrell G., 2007 *Place does matter for your health*. Key Centre for Women's Health in Society, The University of Melbourne: Melbourne, Australia.

Kelty SF, Giles-Corti B, Zubrick SR., 2008 *Physical activity and young people: the impact of the built environment in encouraging play, fun, and being active. Physical activity and children: new research*. N. P. Beaulieu. Nova Science Publishers Inc: New York, USA. 7-33.

Kenworthy J, Laube F., 2000 *Millennium Cities Database For Sustainable Transport*, Institute for Sustainability and Technology Policy, Distributed by the International Union of Public Transport (www.uitp.com).

Ker IR., 2001 *Deconstructing the Future: Assessing new initiatives in transport, including demand management and walking*, World Transport Policy and Practice, 7 (4), 55-60.

Ker IR., 2002 *Preliminary Evaluation of the Financial Impacts and Outcomes of the TravelSmart Individualised Marketing Program*. ARRB Transport Research FOR WA Planning and Infrastructure: Perth, Australia. http://www.transport.wa.gov.au/14974.asp#household

Ker IR., 2003 *Travel Demand Management: Public Transport Business Case*. ARRB Transport Research FOR Department of Infrastructure: Melbourne, Australia.

Ker IR., 2003 *External Costs of Transport*. ARRB Consulting FOR Department for Planning and Infrastructure: Perth, Australia.

Ker IR., 2004 *TravelSmart Individualised Marketing: Evaluation*. ARRB Transport Research FOR Department for Planning and Infrastructure: Perth, Australia.

Ker IR., 2004a *Perth Bicycle Network Stage 3: Evaluation*, ARRB Transport Research for Bikewest, Department of Planning and Infrastructure: Perth, WA.

Ker IR., 2007 *North Brisbane Household TravelSmart: Peer Review and Evaluation*. CATALYST FOR Brisbane City Council: Brisbane, Australia.

Ker IR., 2008 *North Brisbane Household TravelSmart: Peer Review and Evaluation*. CATALYST FOR Brisbane City Council: Brisbane, Australia.

Ker IR., 2008a *Active School Travel Program: Evaluation and Assessment*. Brisbane City Council: Brisbane, Australia.

Ker IR., 2009 *Review of the Western Australia Walking School Bus Program*. CATALYST FOR Department for Planning and Infrastructure: Perth, Australia.

Ker IR., 2009a *Causeway Principal Shared Path Benefit-Cost Evaluation*, CATALYST FOR Main Roads WA: Perth, Western Australia.

Ker IR., 2010a *A practical approach to multi-sectoral outcomes and uncertainty in evaluation: active transport and voluntary travel behaviour change*. Paper for presentation at the 9th European Evaluation Society Conference: Prague, Czech Republic.

Ker IR., 2010b *Assessing the Cost and Health Benefit of Active Transport in Queensland: Evaluation and Public Policy*. CATALYST FOR Health Promotion Queensland, Queensland Department of Health: Brisbane, Australia.

Ker IR, James B., 2000 *The Benefits of Driving Less: Evaluation of the TravelSmart pilot program in South Perth*. Report 396, Transport WA: Perth, Australia.

Ker IR, Ringvall K., 2006 *Toowong-Indooroopilly Active Travel Evaluation*. ARRB Consulting FOR Brisbane City Council: Brisbane, Australia.

Ker IR, Sidebottom AJ., 2004 *Victorian TravelSmart Business Case Toolkit – Final Report*. ARRB Transport Research FOR Department of Infrastructure: Melbourne, Australia. Toolkit available online at: http://www.transport.vic.gov.au/DOI/Internet/ICT.nsf/AllDocs/D28C68582CD4D6D2CA25761000105A6C?OpenDocument

Ker I., 2008 *Active School Travel Program: Evaluation and Assessment*. Brisbane City Council: Brisbane, Australia.

Killingsworth R, De Nazelle A, Bell R., 2003 *Building A New Paradigm: Improving Public Health Through Transportation*, ITE Journal, Vol. 73, No. 6 (www.ite.org), June 2003, pp. 28-32.

Kingham S, Ussher S., 2007 *An assessment of the benefits of the walking school bus in Christchurch, New Zealand*. Transportation Research A, 41, 502-510.

Knowles J, Adams S, Cuerden R, Savill T, Reid S, Tight M., 2009 *Collisions involving pedal cyclists on Britain's roads: establishing the causes*, United Kingdom, Transport Research Laboratory.

Knox EG., 2006 *Roads, railways, and childhood cancers*. J Epidemiol Community Health 60(2): 136-141.

Kokoski M., 2010 *Getting Real: Price Deflation of Nominal Values*, Journal of Benefit-Cost Analysis: Vol 1 (1), Article 7. http://www.bepress.com/jbca/vol1/iss1/7

Komanoff C, Roelofs C., 1993 *The Environmental Benefits of Bicycling and Walking*, In National Bicycling and Walking Study, Case Study 15, FHWA, U.S. Department of Transportation.

Krizek K, Forsyth A, Baum L., 2009 *Walking and cycling international literature review*. Victorian Department of Transport: Melbourne, Australia.

Krizek KJ., 2006 *Two Approaches to Valuing Some of Bicycle Facilities' Presumed Benefits*. Journal of the American Planning Association, Vol. 72. No. 3, Summer 2006, pp. 309-319; at: http://carbon.ucdenver.edu/~kkrizek/pdfs/Two%20approaches%20valuing%20bike.pdf

Lachapelle U, Frank LD., 2008 *Mode Of Transport, Employer-Sponsored Public Transit Pass, And Physical Activity*. Journal Of Public Health Policy. www.palgrave-journals.com/jphp

Land Transport New Zealand (LTNZ), 2006 *Economic Evaluation Manual* (EEM) - Volume 1, LTNZ (www.landtransport.govt.nz).

Lane B., 2001, *The Impact of Pedestrianisation on Retail Economic Activity*, Transport & Environment Consultancy (Bristol)

Lawton KT., 2001 *The Urban Structure and Personal Travel: an Analysis of Portland, Oregon Data and Some National and International Data*. E-Vision 2000 Conference (www.rand.org/scitech/stpi/Evision/Supplement/lawton.pdf).

Lawrence Frank & Company, 2008 *The Built Environment and Health: A Review*. Plan-It Calgary, City of Calgary (www.calgary.ca); at www.calgary.ca/docgallery/BU/planning/pdf/plan_it/health_and_wellness_reports.pdf.

Lawryk NJ, Weisel CP., 1996 *Concentrations of volatile organic compounds in the passenger compartments of automobiles*. Environ Sci Technol 30:810- 16.

League of American Bicyclists, 2009 *Economic Benefits of Bicycle Infrastructure Investments*, League of American Bicyclists (www.bikeleague.org) and the Alliance for Biking & Walking (www.peoplepoweredmovement.org); at www.bikeleague.org/resources/reports/pdfs/economic_benefits_bicycle_infrastructure_report.pdf

Learning Theories, 2008 *Social Learning Theory (Bandura)*. http://www.learning-theories.com/social-learning-theory-bandura.html

Lee A., 2009 *Can reallocated car parking to bike parking be good for a retail economy? A Lygon Street Case Study*. Booz & Company, Melbourne.

Lindsay G, Woodward A, Macmillan A., 2008 *Effects On Health And The Environment Of Increasing The Proportion Of Short Urban Trips Made By Bicycle Instead Of Motor Vehicle*, School of Population Health, University of Auckland (www.fmhs.auckland.ac.nz).

Litman T., 2002 *Evaluating Transportation Equity*. World Transport Policy & Practice (http://ecoplan.org/wtpp/wt_index.htm), Volume 8, No. 2, Summer, pp. 50-65. www.vtpi.org/equity.pdf.

Litman T., 2004 *If Health Matters: Integrating Public Health Objectives into Transportation Decision-Making*. Victoria Transport Policy Institute (www.vtpi.org); at: www.vtpi.org/health.pdf; previously published as, "Integrating Public Health Objectives in Transportation Decision-Making," American Journal of Health Promotion, Vol. 18, No. 1 (www.healthpromotionjournal.com), Sept./Oct. 2003, pp. 103-108; at www.vtpi.org/AJHP-litman.pdf.

Litman T., 2003 *Economic Value of Walkability*. Transportation Research Record 1828, Transportation Research Board (www.trb.org), pp. 3-11; at www.vtpi.org/walkability.pdf.

Litman, T., 2005, *Evaluating Transportation Land Use Impacts*, Victoria Transport Policy Institute (www.vtpi.org); at: www.vtpi.org/landuse.pdf; originally published in World Transport Policy & Practice, Vol. 1, No. 4, pp. 9-16 (www.eco-logica.co.uk/worldtransport.html)

Litman T., 2007 *Land Use Impacts on Transport: How Land Use Factors Affect Travel Behavior*. VTPI (www.vtpi.org); at www.vtpi.org/landtravel.pdf.

Litman T., 2006 *The Future Isn't What It Used To Be: Changing Trends And Their Implications For Transport Planning*. Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/future.pdf; originally published as "Changing Travel Demand: Implications for Transport Planning," ITE Journal, Vol. 76, No. 9, (www.ite.org), September, pp. 27-33.

Litman T., 2006 *Guide to Calculating Mobility Management Benefits*. Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/tdmben.pdf.

Litman T., 2007 *Smart Congestion Reductions II: Reevaluating The Role Of Public Transit For Improving Urban Transportation*. VTPI (www.vtpi.org); at www.vtpi.org/cong_reliefII.pdf.

Litman T., 2008 *Quantifying the Benefits of Non-Motorised Transport for Achieving TDM Objectives*. Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/nmt-tdm.pdf.

Litman T., 2009 *Transportation Cost and Benefit Analysis*. Victoria Transport Policy Institute (www.vtpi.org/tca).

Litman T., 2010 *Transportation Cost and Benefit Analysis II – Parking Costs*, Victoria Transport Policy Institute. (http://www.vtpi.org/tca/tca0504.pdf).

Litman T., 2010 *Evaluating Non-Motorized Transportation Benefits and Costs (previously, "Quantifying the Benefits of Non-Motorised Transport for Achieving TDM Objectives."* Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/nmt-tdm.pdf.

Litman T., 2010 *Evaluating Public Transportation Health Benefits*. American Public Transportation Association (www.apta.com); at: www.apta.com/mediacenter/pressreleases/2010/Pages/100811_Public%20Health%20Benefits.aspx.

Litman T, Fitzroy S., 2006 *Safe Travels: Evaluating Mobility Management Traffic Safety Benefits*. Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/safetrav.pdf.

Litman, T., 2009 *Community cohesion as a transport planning objective*. Victoria Transport Policy Institute.

Litman T, Doherty E., 2009 *Transportation cost and benefit analysis: techniques, estimates and implications*. Victorian Transport Policy Institute: Canada.

Litman T. Laube F., 1998 *Automobile Dependency and Economic Development*, VTPI (www.vtpi.org); at www.vtpi.org/ecodev.pdf

Local Government Commission, 2001 *The Economic benefits of walkable communities*. Center for Livable Communities, Sacramento, United States. http://www.lgc.org/freepub/docs/community_design/focus/walk_to_money.pdf

Lucy W., 2002 *Danger in Exurbia: Outer Suburbs More Dangerous Than Cities*. University of Virginia (www.virginia.edu); summarised in www.virginia.edu/topnews/releases2002/lucy-april-30-2002.html.

Lucy WH., 2003 *Mortality Risk Associated With Leaving Home: Recognizing the Relevance of the Built Environment*. American Journal of Public Health, Vol 93, No. 9, September 2003, pp. 1564-1569; at www.ajph.org/cgi/content/full/93/9/1564.

Mackett RL., 2005 *The therapeutic value of children's everyday travel*. Transportation Research: Part A: Policy and Practice 39(2-3): p. 205 – 219.

Mago R, Mahajan R., 2009 *Exercise in the treatment of depressive disorders*, In Monti DA, Beitman BD (Eds.), *Integrative Psychiatry* (pp. 22-31) Oxford University Press: USA.

Mason C., 2000 *Transport, Environment & Health: En Route to a Healthier Australia. Medical Journal of Australia*, Vol., 172, No. 5, March 2000, pp. 230-232; available at the Institute for Sustainable Futures (www.isf.uts.edu.au).

Mason C, Lake R., 2000 *Transport Access for Job Seeking: A Pilot Program*, GROW Employment Council (Sydney's Area Consultative Committee), Commonwealth Department of Employment, Workplace Relations and Small Business, Canberra, ACT.

Matthews C, Jurj A, Shu X, Li H, Yang G, Li Q, Gao Y, Zheng W., 2007 *Influence of exercise, walking, cycling, and overall nonexercise physical activity on mortality in Chinese women*. American Journal of Epidemiology 165(12): 1343-1350.

Matthews CE, Shu XO et al., 2001 *Lifetime physical activity and breast cancer risk in the Shanghai Breast Cancer Study*. British Journal of Cancer 84(7): 994-1001.

May M, Tranter PJ, Warn JR., 2008 *Towards A Holistic Framework For Road Safety In Australia*. Journal of Transport Geography, Vol. 16 (www.elsevier.com/locate/jtrangeo), pp. 395–405. More comprehensive report published by the NMRA Road Safety Trust (www.roadsafetytrust.org.au).

McDonald N, Deakin E, Aalborg A., 2010 *Influence of the social environment on children's school travel*. Preventive Medicine 50: S65-S68.

McKenzie-Mohr D, Smith W., 1999 *Fostering Sustainable Behavior: An Introduction to Community-Based Social Marketing*. New Society Publishers: Canada.

Maunsell Australia, 2004 *Travel Behaviour Change Evaluation Procedures*. Wellington, New Zealand. Maunsell Australia Pty Ltd, Pinnacle Research and Booz Allen Hamilton FOR Transfund New Zealand: Wellington, New Zealand

Mead G, Morley W, Campbell P, Greig C, McMurdo M, Lawlor D., 2009 *Exercise for depression*. Cochrane Database of Systematic Reviews Issue 3. Art. No.: CD004366. DOI: 10.1002/14651858.CD004366.pub4.

Mechling H., 2008 *Dementia and physical activity*. European Review of Aging and Physical Activity 5(1): 1-3.

Merom D, vanderPloeg H, Corpuz G, Bauman A., 2010 *Public health perspectives on household travel surveys active travel between 1997 and 2007*. American Journal of Preventive Medicine 39(2): 113-121.

Miller J, Robison H, Lahr M., 1999 *Estimating Important Transportation-Related Regional Economic Relationships in Bexar County, Texas*, VIA Transit (San Antonio; www.viainfo.net).

Ministry of Transport Public Works and Water Management, 2007 *Cycling in the Netherlands*. The Hague.

Mishan EJ., 1971 *Cost-Benefit Analysis*, George Allen and Unwin: London, England.

Moayyeri A., 2008 *The association between physical activity and osteoporotic fractures: a review of the evidence and implications for future research*. Annals of Epidemiology 18: 827-35.

Moayyeri A, Besson H, Luben RN, Wareham NJ, Khaw KT., 2010 *The association between physical activity in different domains of life and risk of osteoporotic fractures*. Bone 47(3): 693-700.

Moodie M, Haby M, Galvin L, Swinburn B, Carter R., 2009 *Cost-effectiveness of active transport for primary school children - Walking School Bus program*. Int J Behav Nutr Phys Act; 6: 63.

Morris J., 2007 *What's driving policy: Government's response to a new wave of older drivers?*, Transport Policy Branch, Policy and Intergovernmental Relations Division, Department of Infrastructure, Victorian Government: Melbourne, Australia.
www.monash.edu.au/cmo/Transport2007/JennyMorris.ppt

Möser G, Bamberg S., 2008 *The effectiveness of soft transport policy measures: A critical assessment and meta-analysis of empirical evidence*. Journal of Environmental Psychology 28(1): 10-26.

Mummery K, Schofield G, Caperchione C., 2004 *Physical activity: Physical activity dose-response effects on mental health status in older adults*. Australian and New Zealand Journal of Public Health 28(2): 188-92.

NAR and NAHB, 2002, *Joint Survey: Survey Suggests Market-Based Vision of Smart Growth*, National Association of Realtors & National Association of Home Builders; at: www.realtor.org/SG3.nsf/Pages/NARNHAB02Survey?OpenDocument

National Bicycle and Pedestrian Clearinghouse, 2005, *The Economic and Social Benefits of Off-Road Bicycle and Pedestrian Facilities*, Technical Brief, National Bicycle and Pedestrian Clearinghouse, No. 2 (www.bikefed.org); at http://greenway.org/pdf/econ_social_benefits.pdf

National Center for Safe Routes to Schools, 2010 *Safe Routes to Schools Travel Data: A Look at baseline results parent surveys and student travel tallies*, Chapel Hill, North Carolina, USA.

National Heart Foundation of Australia, 2009 *Blueprint for an active Australia*, National Heart Foundation.

New Economics Foundation, 2008, *Five Ways to Well-Being: The Evidence*. New Economics Foundation: London, England. http://www.neweconomics.org/gen/z_sys_PublicationDetail.aspx?pid=265

Nellthorp J, Mackie PJ., 2000 *The UK Roads Review - a hedonic model of decision-making*. Transport Policy, 7(1), pp 127-138.

New Zealand Transport Agency, 2010 *Economic Evaluation Manual*. New Zealand Transport Agency: Wellington, New Zealand. www.nzta.govt.nz/resources/economic-evaluation-manual

New Zealand Transport Agency, 2010a *Economic Evaluation Manual – Volume 1*. New Zealand Transport Agency: Wellington, New Zealand. www.nzta.govt.nz/resources/economic-evaluation-manual/volume-1

New Zealand Transport Agency, 2010b *Economic Evaluation Manual – Volume 2* New Zealand Transport Agency: Wellington, New Zealand. www.nzta.govt.nz/resources/economic-evaluation-manual/volume-2

Newman P, Beatley T, Boyer H., 2009 *Resilient Cities: Responding to Peak Oil and Climate Change*. Island Press: United States.

Newman P, Kenworthy JR., 1999 *Sustainability and Cities: overcoming automobile dependence*, Island Press, Washington DC

New York City, 2010 *Active Design Guidelines: Promoting Physical Activity and Health Through Design*. New York City Department of Design + Construction (http://ddcftp.nyc.gov); at www.nyc.gov/html/ddc/html/design/active_design.shtml.

NICE, 2007 *Management of depression in primary and secondary care*. National Institute for Health and Clinical Excellence. http://www.nice.org.uk/nicemedia/pdf/CG023fullguideline.pdf 2007.

Niemann H, Bonnefoy X, Braubach M., 2006 *Noise-induced annoyance and morbidity results from the pan-European LARES study*. Noise Health 8(31): 63-79.

Ontario College of Family Physicians (OCFP), 2005 *The Health Impacts Of Urban Sprawl Information Series: Volume Four Social & Mental Health*. OCFP (www.ocfp.on.ca); at www.ocfp.on.ca/local/files/Urban%20Sprawl/UrbanSpraw-Soc-MentalHlth.pdf.

Ogilvie, D., et al., 2007 *Interventions to promote walking: systematic review*. BMJ, 334(7605): p. 1204

Orsini N, Mantzoros C, Wolk A., 2008 *Association of physical activity with cancer incidence, mortality,and survival: a population-based study of men*. British Journal of Cancer 98: 1864-1869.

Owen N et al., 2007 *Neighborhood Walkability and the Walking Behavior of Australian Adults*. American Journal of Preventive Medicine, Vol. 33, Issue 5, Pages 387-395; at www.ajpm-online.net/article/S0749-3797(07)00468-0/abstract.

Panis LI, de Geus B, Vandenbulcke G, Willems H, Degraeuwe B, Bleux N, Mishra V, Thomas I, Meeusen R., 2010 *Exposure to particulate matter in traffic: A comparison of cyclists and car passengers*. Atmospheric Environment 44: 2263-70.

Parker L, Burns AC, Sanchez E., 2006 *Local Government Actions to Prevent Childhood Obesity*. Committee on Childhood Obesity Prevention Actions for Local Governments, National Institute of Medicine, National Research Council (www.nap.edu); at
www.nap.edu/catalog.php?record_id=12674#description.

Parks KM, Steelman LA., 2008 *Organizational wellness programs: A meta-analysis*. Journal of Occupational Health Psychology 13(1): 58-68.

Pate, R., 2005 *Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine*, in Journal of the American Medical Association, 1995. 273: p. 402-7.

The PEP Toolbox, 2009 The PEP Toolbox Promising Practices [Factsheet on the Stockholm Trial]; at: http://www.healthytransport.com/athena/site/file_database/factsheet_149banner.pdf

Petridou ET, Manti EG, Ntinapogias AG, Negri E, SzczerbiÅska K., 2009 *What Works Better for Community-Dwelling Older People at Risk to Fall?* Journal of Aging and Health 21(5): 713-729.

Petritsch T et al., 2008 *Health Benefits of Bicycle Facilities*. Transportation Research Board 87th Annual Meeting (www.trb.org).

Pivo G, Fisher JD., 2010 *The Walkability Premium In Commercial Real Estate Investments*. forthcoming Real Estate Economics. www.wiley.com/bw/journal.asp?ref=10808620); www.u.arizona.edu/~gpivo/Walkability%20Paper%20February%2010.pdf.

Planning Institute of Australia, 2009 *Healthy Spaces and Places*, Planning Institute of Australia, Canberra; at: http://www.healthyplaces.org.au/userfiles/file/HS&P%20An%20overview.pdf

Pucher J, Dijkstra L., 2003 *Promoting Safe Walking and Cycling to Improve Public Health: Lessons from the Netherlands and Germany*. American Journal of Public Health, Vol. 93, No. 9: Washington, USA.

Pucher J, Buehler R., 2007 *At the Frontiers of Cycling: Policy Innovations in the Netherlands, Denmark, and Germany*. World Transport Policy & Practice, Vol. 13, No. 3; at www.eco-logica.co.uk/pdf/wtpp13.3.pdf.

Pucher J, Buehler R., 2008 *Making Cycling Irresistible: Lessons from the Netherlands, Denmark, and Germany*. Transport Reviews, Vol. 28, No. 4, July 2008; at www.vtpi.org/irresistible.pdf.

Pucher J, Buehler R, Bassett DR, Dannenberg AL., 2010 *Walking and Cycling to Health: A Comparative Analysis of City, State, and International Data*. American Journal of Public Health, at http://ajph.aphapublications.org/cgi/reprint/AJPH.2009.189324v1.

Pucher J, Dill J, Handy S., 2010 *Infrastructure, programs and policies to increase bicycling: an international review*, Preventive Medicine 50 (Jan Suppl 1): S106-25.

Puget Sound Regional Council (PSRC), 2008 Transportation 2040 (long-range transport plan) and Transportation Improvement Program (three-year transportation plan), PSRC (http://psrc.org/projects/tip/index.htm).

Queensland Government, 2003 *Queensland Cycle Strategy*, Queensland Government, Brisbane.

Queensland Government (not dated) *Eat well, be active – healthy kids for life: The Queensland Government's first action plan 2005 – 2008*.

Queensland Health, 2008 *The Health of Queenslanders 2008: Prevention of Chronic Disease*, Second Report of the Chief Health Officer Queensland, Queensland Health: Brisbane, Australia.

Queensland Health, 2010 *The Health of Queenslanders 2010*, Third Report of the Chief Health Officer Queensland. Brisbane.

Queensland Government, 2008 *Toward Q2: Tomorrow's Queensland*. Department of Premier and Cabinet: Brisbane, Australia.

Queensland Government, 2009 *South East Queensland Regional Plan 2009 – 2031*, Department of Infrastructure and Planning: Brisbane, Australia.

Queensland Government, 2010 *Active, healthy communities: A resource package for Local Government to create supportive environments for physical activity and healthy eating*, State of Queensland and National Heart Foundation of Australia (Queensland Division).

Queensland Transport, 1999 *Cycle South East. Integrated Cycle Strategy for South East Queensland*, Brisbane, Queensland Government.

Racca DP, Dhanju A., 2006 *Property Value/Desirability Effects of Bike Paths Adjacent to Residential Areas*. Delaware Center For Transportation and The State of Delaware Department of Transportation, University of Delaware (www.udel.edu).
http://128.175.63.72/projects/DOCUMENTS/bikepathfinal.pdf.

Rashad I., 2007 *Cycling: An Increasingly Untouched Source of Physical and Mental Health*, Working Paper No. 12929, National Bureau Of Economic Research (www.nber.org); at www.nber.org/papers/w12929.

Reserve Bank of Australia, 2009 *Interest Rates Chart Pack*, Reserve Bank of Australia: Canberra, ACT
www.rba.gov.au/ChartPack/interest_rates_australia.pdf

Rietveld P., 2000 *Nonmotorized Modes in Transport Systems: A Multimodal Chain Perspective for The Netherlands*, in Transportation Research D, Vol. 5, No. 1, January, pp. 31-36

Rissel C, New C, Wen L, Merom D, Bauman A, Garrard J., 2010 *The effectiveness of community-based cycling promotion: findings from the Cycling Connecting Communities project in Sydney*. International Journal of Behavioral Nutrition and Physical Activity 7: 8.

Roberts I, Owen H, Lumb P, MacDougall C., 1996 *Pedalling health: health benefits of a modal transport shift*. University of Adelaide: Adelaide, Australia.

Robinson D., 2005 *Safety in Numbers in Australia: More Walkers and Bicyclists, Safer Walking and Bicycling*. Health Promotion Journal of Australia, Vol. 16, No. 1 (www.healthpromotion.org.au), April 2005, pp. 47-51.

Rose G, Marfurt H., 2007 *Travel behaviour change impacts of a major ride to work day event*, Transp. Res. Part A 41, 351–364

Roth M, Ker I, James B, Brög W, Ashton-Graham C, Ryle J, Goulias K, Richardson E., 2003 *A Dialogue on Individualised Marketing: Addressing Misperceptions*, in *Proc. 26th Australasian Transport Research Forum*: Wellington, New Zealand

Royal Automobile Club of Queensland, 2010 *Vehicle Running Costs*, Royal Automobile Club of Queensland: Brisbane, Australia. http://www.racq.com.au/motoring/cars/car_economy/vehicle_running_costs

Sælensminde K., 2004 *Cost-Benefit Analysis of Walking and Cycling Track Networks Taking Into Account Insecurity, Health Effects and External Costs of Motor Vehicle Traffic*, Transportation Research A, Vol. 38, No. 8

Sallis JF, Frank LD, Saelens BE, Kraft MK., 2004 *Active Transportation and Physical Activity: Opportunities For Collaboration On Transportation and Public Health Research*. Transportation Research A, Vol. 38, Issue 4 (www.elsevier.com/locate/tra), May 2004, pp. 249-268.

San Francisco Department of Public Health, 2008 *Pedestrian Injury Forecasting Model*, San Francisco Department of Public Health. www.dph.sf.ca.us/phes/HIA_Tools_Ped_Injury_Model.htm.

Scarmeas N, Luchsinger J, Schupf N, Brickman A, Cosentino S, Tang M, Stern Y., 2009 *Physical activity, diet, and risk of Alzheimer disease*. Journal of the American Medical Association 302(6): 627-37.

Sevick MA. et al., 2000 *Cost-Effectiveness Of Lifestyle And Structured Exercise Interventions In Sedentary Adults: Results Of Project ACTIVE*, in American Journal of Preventive Medicine, Vol. 19, No. 1.

Shephard R., 2008 *Is active commuting the answer to population health?* Sports Medicine 38(9): 751-758.

Shiel A., 2007 *In search of social value. International Journal of Public Health*, 52,333-334.

Shoup D., 2005 *The High Cost of Free Parking*, American Planning Association.

Sibley B, Etnier J., 2003 *The relationship between physical activity and cognition in children: a meta-analysis*, Pediatric Exercise Science 15: 243-256.

Sidebottom A., 2005 *National TravelSmart Business Case Toolkit*. ARRB Transport Research FOR Department of Infrastructure: Melbourne, Victoria.

Singh AS, Chinapaw MJM, Brug J, Kremers SPJ, Visscher TLS, vanMechelen W., 2009 *Ethnic differences in BMI among Dutch adolescents: what is the role of screen-viewing, active commuting to school, and consumption of soft drinks and high-caloric snacks?* International Journal of Behavioral Nutrition and Physical Activity 6(23): doi:10.1186/1479-5868-6-23.

Sloman L, Cavill N, Cope A, Muller L, Kennedy A., 2009 *Analysis and synthesis of evidence on the effects of investment in six Cycling Demonstration Towns*. Department for Transport and Cycling England.

Smith A, McKenna J, Duncan R, Jonathan L., 2008 *The impact of additional weekdays of active commuting on children achieving a criterion of 300+ minutes of moderate-to-vigorous physical activity*. Australasian Association for Exercise and Sports Science Conference (March 2008): Melbourne, Australia.

Social Exclusion Unit, 2003 *Making the Connections: Final Report on Transport and Social Exclusion*. Office of the Deputy Prime Minister: London, England. www.cabinetoffice.gov.uk/...to.../making_transport_2003.pdf

Socialdata Australia Pty Ltd., 2007 *Brisbane North TravelSmart Communities Project: Final Report*. Kelvin Grove, Queensland.

Socialdata, 2000 *Potential for Change in Different Suburbs (Summary)*. Department of Transport: Perth, Western Australia. http://www.transport.wa.gov.au/tsmart_potentialtochange.pdf

Social Exclusion Unit, 2003, *Making the connections: final report on transport and social exclusion*, London, Office of the Deputy Prime Minister

Song Y, Knaap G-J., 2003 *The Effects of New Urbanism on Housing Values: A Quantitative Assessment. National Center for Smart Growth Research and Education*, University of Maryland (www.smartgrowth.umd.edu/research/POSTSongKnaap2.htm).

Spinks AB, Macpherson AK, Bain C, McClure RJ., 2007 *Compliance with the Australian national physical activity guidelines for children: relationship to overweight status*. Journal of Science and Medicine in Sport 10(3): 156-63.

SQW, 2007 *Valuing the Benefits of Cycling: A Report to Cycling England*. Cycling England, Department for Transport (www.dft.gov.uk); at www.dft.gov.uk/cyclingengland/site/wp-content/uploads/2008/08/valuing-the-benefits-of-cycling-full.pdf.

Standing Committee on Environment and Heritage, 2005 *Sustainable Cities*. House of Representatives, The Parliament of the Commonwealth of Australia: Canberra, Australia. http://www.aph.gov.au/House/committee/environ/cities/report.htm

Steindorf K, Schmidt M, Kropp S, Chang-Claude J., 2003 *Case-control study of physical activity and breast cancer risk among premenopausal women in Germany*. American Journal of Epidemiology 157(2): 121-130.

Stokes RJ, MacDonald J, Ridgeway G., 2008 *Estimating The Effects Of Light Rail Transit On Health Care Costs*. Health & Place, Volume 14, Issue 1, March, pp. 45-58.

Stopher PR, Greaves SP., 2007 *Household Travel Surveys: Where Are We Going?*, in Transportation Research A, Vol. 41, Issue 5 (www.elsevier.com/locate/tra), June 2007, pp. 367-381

Strong W, Malma R, Bumke C, Danels S, et al., 2005 *Evidence-based physical activity for school-age youth*, Journal of Pediatrics 146: 732-7.

Sugiyama T, Merom D, Reaves M, Leslie E, Owen N., 2010 *Habitual active transport moderates the association of TV viewing time with body mass index*, Journal of Physical Activity and Health 7: 11-16.

Sullivan P, Percy A., 2008 *Evaluating changes associated with workplace and school travel plans - something old, something borrowed, something new*. From www.patrec.org/atrf/index.php?forum

Sung H, Park J, Kim H., 2009 *A Study on the Impact of the Green Transport Mode on Public Health Improvement*. KOTI World-Brief, Vol. 1, No. 1, Korea Transport Institute (www.koti.re.kr), May 2009, pp. 6-8; http://english.koti.re.kr/upload/eng_publication_regular/world-brief01.pdf.

Surface Transportation Policy Project (STPP), *Americans Attitudes Toward Walking and Creating More Walkable Communities*, STPP (www.transact.org), April 2003.

Sustrans, 1996 *Safety on the streets for children*. Bristol, England. (Information sheet FF10).

Sustrans, 2009 *TravelSmart Project Review*. Sustrans: Bristol, England. http://www.sustrans.org.uk/assets/files/travelsmart/TravelSmart%20Project%20Review.pdf

Sustrans (undated a). *Economic Appraisal of local walking and cycling routes: Summary*. Sustrans: Bristol, England. http://www.sustrans.org.uk/assets/files/general/Economic%20appraisal%20of%20local%20walking%20and%20cycling%20routes%20-%20summary.pdf

Sustrans (undated b). *Economic Appraisal of local walking and cycling routes: Methodology*. Sustrans: Bristol, England. http://www.sustrans.org.uk/assets/files/general/Economic%20appraisal%20of%20local%20walking%20and%20cycling%20routes%20-%20methodology.pdf

Sustrans, 2010 *London Borough of Lewisham – Local Development Framework Core Strategy*, Sustrans response, 1st April. http://www.lewisham.gov.uk/NR/rdonlyres/69EA3D75-3225-4C0A-8CE4-52C8C1CDC617/0/Sustrans.pdf

Swedish National Road Administration (SNRA), 1986 *Investment in Roads and Streets*, Document 1986:15E, SNRA (www.vv.se).

Sztabinski, F., 2009, Bike Lanes, *On-Street Parking and Business A Study of Bloor Street in Toronto's Annex Neighbourhood*, The Clean Air Partnership (www.cleanairpartnership.org); at: www.cleanairpartnership.org/pdf/bike-lanes-parking.pdf

Taylor D, Fergusson M., 1998 *The comparative pollution exposure of road users – a summary*. World Transp Pol Pract 4(2):22-6.

Texas Transportation Institute, 2007 *Urban Mobility Study and Mobility Measures*. Texas Transportation Institute: Texas, USA. (http://mobility.tamu.edu/ums).

The Obesity Society (nd). *Obesity in Australian Children*. http://www.asso.org.au/freestyler/gui/files//factsheet_children_cons_causes_prev_mment.pdf

Transportation Alternatives & Schaller Consulting, 2006, *Curbing Cars: Shopping, Parking and Pedestrian Space in SoHo*, Transportation Alternatives (www.transalt.org); at: www.transalt.org/files/newsroom/reports/soho_curbing_cars.pdf

Transportation Research Board, 2006 *Guidelines for Analysis of Investments in Bicycle Facilities*. NCH Report 552, TRB (www.trb.org); at http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_552.pdf.

Transport Strategy Committee on Future Perth, 1992 *Transporting Perth into the 21st Century: people, plans and posterity: final report of the Transport Strategy Committee on Future Perth*, Department of Transport: Perth, Western Australia

Transport WA, 1996 *Bike Ahead: Bicycle Strategy for the 21st Century*, Department of Transport: Perth, Western Australia.

Tranter PJ., 2004 *Effective Speeds: Car Costs are Slowing Us Down*, A report for the Australian Greenhouse Office, Department of the Environment and Heritage; at: http://www.environment.gov.au/settlements/transport/publications/effectivespeeds.html

Turner SA, Roozenburg AP, Francis T., 2006 *Predicting Accident Rates for Cyclists and Pedestrians*. Land Transport New Zealand Research Report 289 (www.ltsa.govt.nz); at www.ltsa.govt.nz/research/reports/289.pdf.

Turner S, Wood G, Luo Q, Singh R, Allatt T., 2010 *Crash prediction models and the factors that influence cycle safety*, Journal of the Australasian College of Road Safety 21(3): 26-36.

Untermann R., Vernez Moudon A., 1989 *Street Design; Reassessing the Safety, Sociability, and Economics of Streets*, University of Washington, Urban Planning (Seattle)

UrbanTrans ANZ, 2008 *School Travel Plans: International Research Summary* FOR Australian Government Department of the Environment, Water, Heritage and the Arts: Canberra, ACT.

USA Interagency Working Group on Climate Change and Health, 2009 *A human health perspective on climate change*. http://www.niehs.nih.gov/health/docs/cchh-congress-reprint-6-2-508.pdf

US Office of Management and Budget, 1992 *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*. Circular A94. Office of Management and Budget: Washington DC, USA; at: http://www.whitehouse.gov/omb/asset.aspx?AssetId=2160

US Office of Management and Budget, 2003 *Regulatory Analysis*. Circular A4. Office of Management and Budget: Washington DC, USA; at: http://www.whitehouse.gov/omb/assets/omb/circulars/a004/a-4.pdf

US Office of Management and Budget, 2009a 2010 *Discount Rates for OMB Circular No. A-94*, Office of Management and Budget: Washington DC, USA; at: http://www.whitehouse.gov/omb/asset.aspx?AssetId=2161

US Office of Management and Budget, 2009b *Table of Past Years Discount Rates from Appendix C of OMB Circular No. A-94*, Office of Management and Budget: Washington DC, USA; at: http://www.whitehouse.gov/omb/asset.aspx?AssetId=2159

Van Dyck D, Cardon G, Deforche B, Bourdeaudhuij ID., 2009 *Lower neighbourhood walkability and longer distance to school are related to physical activity in Belgian adolescents*. Preventive Medicine 48: 516-518.

Van Kemenade S, Paridis S, Jenkins E., 2003 *Can Public Policy Address Capital*. Horizons, 6 (3) 31-34. Policy Research Initiative: Ottawa, Canada. http://www.policyresearch.gc.ca/doclib/HOR_v6n3_200311_e.pdf

Van Lenthe F, Brug J, Mackenbach J., 2005 *Neighbourhood inequalities in physical inactivity: the role of neighbourhood attractiveness, proximity to local facilities and safety in the Netherlands*. Social Science and Medicine 60(4): 763-775.

Van Wijnen JH, Verhoeff AP, Jans H, van Bruggen M., 1995 *The exposure of cyclists, car drivers and pedestrians to traffic-related air pollutants*. Int Arch Occup Environ Health 67:187-93.

Vedung E., 2010 *Four Waves of Evaluation Diffusion, in Evaluation*, 16 (3), 263-277, July 2010; at: http://evi.sagepub.com/content/16/3/263

Victoria Transport Policy Institute (VTPI), 2010 *Online TDM Encyclopedia*, VTPI, (www.vtpi.org/tdm).

Voss C, Sandercock G., 2010 *Aerobic fitness and mode of travel to school in English school children*. Medicine and Science in Sports and Exercise 42(2): 281-287.

VTPI, 2004 "Land Use Evaluation", *Online TDM Encyclopedia* (www.vtpi.org/tdm)

Wall R, Brög W, Erl E, Ryle J, Barta F., 2008 A response to Möser G., Bamberg S., 2008 *The effectiveness of soft transport policy measures: A critical assessment and meta-analysis of empirical evidence*. Unpublished. Available from Ian Ker (catalystian@netscape.net) or Socialdata (socialdata@socialdata.de).

Wardlaw M., 2001 *Stepping Stones to a Better Cycling Future*. British CTC/CCN Conference, Chesterfield, England, 13th October 2001; at: www.bicyclinglife.com/library/steppingstones.htm.

Wen LM, Orr N, Millett C, Rissel C., 2006 *Driving to work and overweight and obesity: findings from the 2003 New South Wales Health Survey. International Journal Of Obesity* 30(5): 782-786: Australia.

Wen LM, Fry D, Merom D, Rissel C, Dirkis H, Balafas A., 2008 Increasing active travel to school: Are we on the right track? A cluster randomised controlled trial from Sydney, Australia. Preventive Medicine 47(6): 612-618.

Wen LM, Rissel C., 2008 *Inverse associations between cycling to work, public transport, and overweight and obesity: Findings from a population based study in Australia*. Preventive Medicine 46(1): 29-32.

Western Australian Government, 2003 *Hope for the future: The Western Australian State Sustainability Strategy*. Government of Western Australia: Perth, Australia. http://www.dec.wa.gov.au/content/view/3523/2066

Weuve J, Kang J, Manson J, Breteler M, Ware J, Grodstein F., 2004 *Physical activity, including walking, and cognitive function in older women*. Journal of the American Medical Association 292(12): 1454-61.

Whitelegg J., 1997 *Critical mass: transport environment and society in the Twenty-first century*. Pluto Press: London, UK.

Wilkinson RG, Pickett K., 2009 *The Spirit Level*, Allen Lane

Wittink R., 2003 *Planning for cycling supports road safety*, In R Tolley (ed). Sustainable transport: planning for walking and cycling in urban environments. Cambridge England, Woodhead Publishing Limited.

Woodcock J, Franco O, Orsini N, Roberts I., 2010 *Non-vigorous physical activity and all-cause mortality: systematic review and meta-analysis of cohort studies*. International Journal of Epidemiology July 14.

World Health Organisation, 2010 *Transport and health*, Regional Office for Europe, Website. http://www.euro.who.int/en/what-we-do/health-topics/environmental-health/Transport-and-health/activities/promotion-of-safe-walking-and-cycling-in-urban-areas/quantifying-the-positive-health-effects-of-cycling-and-walking/health-economic-assessment-tool-heat-for-cycling/examples-of-applications-of-heat-for-cycling

World Health Organisation, 1948 *WHO definition of health*. WHO: Geneva, Switzerland.

World Health Organisation, 2000 *Air Quality Guidelines for Europe* (2nd ed). WHO Regional Office for Europe. WHO Regional Publications European Series No.: 91: Copenhagen (DK)

World Health Organisation (WHO), 2006 *Promoting physical activity for health: A framework for action in the WHO European Region*.

World Health Organisation, 2009 *Global status report on road safety*. World Health Organisation: Geneva, Switzerland.

WHO (Adrian Davis Editor), 2003 *A Physically Active Life Through Everyday Transport: With A Special Focus On Children And Older People And Examples And Approaches From Europe*. World Health Organisation, Regional Office for Europe
(www.euro.who.int/document/e75662.pdf).

World Health Organisation, 2008 *Health Economic Assessment Tool for Cycling* (HEAT for Cycling), World Health Organisation Region Office Europe (www.euro.who.int); at www.euro.who.int/transport/policy/20070503_1.

Woodcock J, Franco OH, Orsini N, Roberts I., 2010 *Non-Vigorous Physical Activity And All-Cause Mortality: Systematic Review And Meta-Analysis Of Cohort Studies*. International Journal of Epidemiology, doi:10.1093/ije/dyq104
(http://ije.oxfordjournals.org/cgi/content/abstract/dyq104).

Young HP., 2007 *Innovation Diffusion in Heterogeneous Populations: Contagion, Social Influence, and Social Learning*. Center on Social and Economic Dynamics Working Paper No. 51, Center on Social and Economic Dynamics at Brookings, Brookings Institution: Washington DC, USA. http://www.brookings.edu/papers/2007/10_diffusion_young.aspx#_ftn1

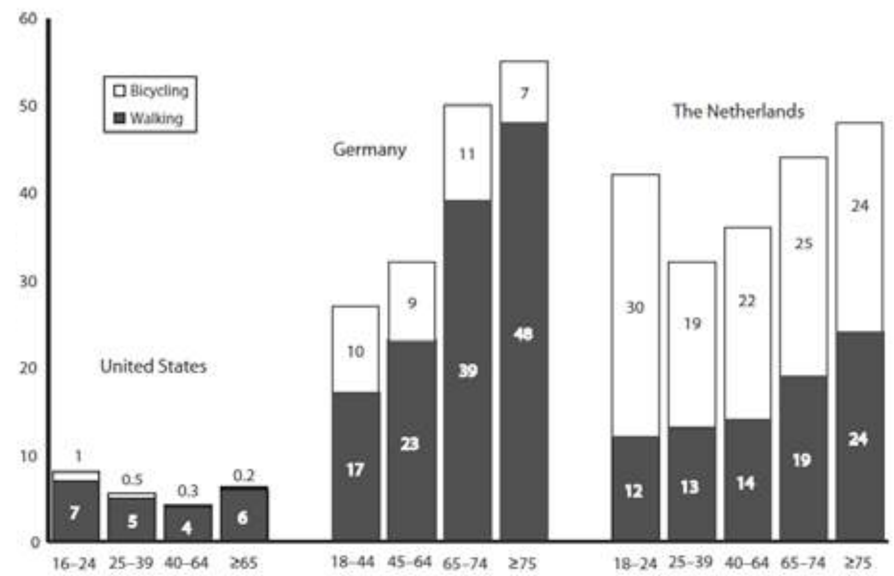
Yang L, Sahlqvist S, McMinn A, Griffin SJ, Ogilvie D., 2010 *Interventions to promote cycling: systematic review*, British Medical Journal, 2010, 341c5293.

Young W., 2010 *Email correspondence*, 26th November 2010.

Appendix A: Physical activity promotion through active transport: priority population groups

The following studies indicate that physical activity through active transport has the potential to increase physical activity levels among population groups in Australia that are less likely to be adequately active; namely, older adults, women, adolescent girls and disadvantaged population groups.

Older Adults:

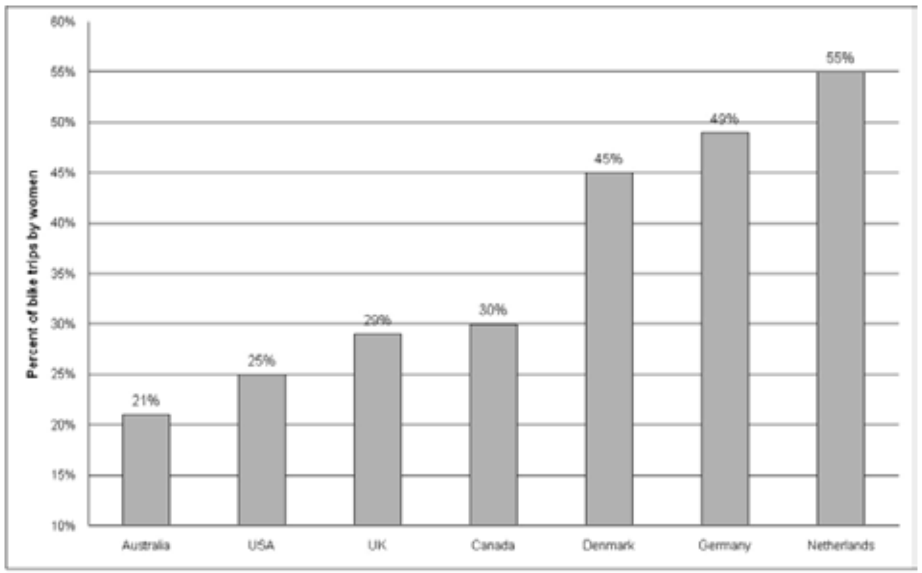


Walking and Bicycling Shares of Urban Travel by Age Group in the USA, Germany and The Netherlands, 1995
Source: Pucher & Dijkstra, 2003

Adolescent Girls:

Year 10 females are 6.45 times more likely to meet recommended levels of physical activity if they actively commute to school (Smith et al, 2008).

Women:



Sources: German Federal Ministry of Transport (2003); U.S. Department of Transportation (2003); Danish Ministry of Transport (2005); Statistics Netherlands (2005); Australian Bureau of Statistics (2007); Department for Transport (2007) and information provided directly by bike planners in Canadian provinces and cities

Percentage of bicycle trips undertaken by women
Source: Pucher & Buehler, 2008

Disadvantaged Population Groups:

Social gradient for leisure-time physical activity not apparent in active commuting in diverse population groups in USA (Berrigan et al, 2006).

Appendix B: Modelling of reduction in BMI for a single 'average' individual new to active transport (Victorian Walking School Bus program)

	PREP TO GRADE 2		COMMENTS
	BOYS	GIRLS	
Height (m)	1.20	1.19	Mean height for 5-7 year age group
Weight (kg)	23.50	23.48	Mean weight for 5-7 year age group
Body mass index BMI (kg/m2)	16.24	16.47	Mean BMI for 5-7 year age group
Estimated total energy expenditure (MJ/day)	6.43	6.64	Total energy expenditure (MJ/day) = [.107 × weight (kg)] + [2.91 × height (metres)] +.417
Estimated total energy expenditure (kJ/day)	6433	6404	Conversion to kilojoules - multiply by 1000
Increased METS -- walking versus sitting	2.5	2.5	Metabolic equivalents for sitting = 1.0, walking 3.5. Therefore, additional energy expenditure of active transport to school = 2.5 METS
Extra time spent on walking to and from school (min)	28.30	28.30	Mean travel time for Victorian children participating both in morning and afternoon WSB
Energy expenditure increase from WSB participation(kJ per day)	116	116	Increase in individual energy expenditure from walking (kJ/school day) = weight (kg) × increased METs × time (hrs) × factor to convert kcal to kJ (4.2)
Average number of days of WSB participation to and from school per week	1	1	Based on Victorian WSB experience 2004, where 1,675 enrolled children engaged in 3,049 sessions of active transport per week. This translates to 1.82 sessions per week/child, or about equivalent of walking to and from school one day per week.
Number of potential weeks of WSB participation per year	40	40	Number of weeks in the school year.
Total number of days of WSB participation per year	40	40	Number of WSB days per week × number of school weeks
Energy expenditure increase from WSB participation (kJ)	13	13	Total increase in individual energy expenditure × number of WSB days per year divided by 365
Relative increase in energy expenditure with WSB participation (%)	0.20	0.20	Average individual energy expenditure from WSB as % of estimated total energy expenditure per day: (13/6433) × 100 and (13/6404) ×100 for boys and girls respectively
Conversion factor	0.45	0.45	Factor for conversion of relative change in energy balance to relative change in weight
Relative lower weight with WSB participation (%)	0.09	0.09	$[1-(\text{energy expenditure1}/\text{energy expenditure}_2)^{0.45}]*100$
Absolute lower weight with WSB participation (kg)	0.02	0.02	0.09% of original weight
New weight (kg)	23.48	23.46	Original mean weight minus decrease in weight as a result of WSB participation
New BMI (kg/m2)	16.23	16.45	New weight divided by square of height
Reduction in BMI (kg/m2)a	0.014	0.015	Original BMI minus new BMI for new participants

Modelling of reduction in BMI for a single 'average' individual new to active transport
Source: Moodie et al, 2009

Appendix C: Health outcomes considered in selected walking/cycling studies

	HEALTH OUTCOME CONSIDERED (WHERE STATED)					
STUDY REFERENCE	Coronary heart disease	Stroke	Cancer	Diabetes (Type II)	Injuries	Other
Buis (2000)					Injuries	Absenteeism; reduced medical costs
DfT (2007)	Mortality	Mortality	Mortality		'possible decrease in accidents'	
Ege et al, 2005						Reduced use of health service
Foltynova et al (no date)	Mortality Morbidity		Colon cancer morbidity	Morbidity	Cost of accidents	Reduced medical costs. Air pollution
Jones & Eaton (1994)	Mortality				Risk of injury	
Krag (2005)	'Heart attacks'	Mortality	Colo-rectal and breast and cancer mortality	Mortality	Accidents	Osteoporosis High blood pressure; depression; back pain
Lind (2005)					Injuries	Obesity; 'excess morbidity'
Macdonald (2006)	Mortality	Mortality	Colon cancer mortality		Discussed but not included in calculations	
Rutter (2006)	All cause mortality				Increased risk of death (adjusted for safety in numbers hypothesis)	
Saari (2005)					Accidents	
Saelensminde (2004)	Mortality		Mortality	Mortality		Hypertension; Musculo-skeletal
Sustrans (2006)	Mortality	Mortality	Mortality			
Transport for London (2004)	Mortality	Mortality	Colon cancer; mortality			
Thaler (2006)						
Troelsen et al (2004)	All cause mortality					Reduced medial costs
Wang (2005)						Reduced medial costs

Source: Cavill & Kahlmeier (2007)

Appendix D: Glossary of terms

Accessibility
The ability to reach desired services and activities, such as work, school, shops and friends. Accessibility may be related to mobility but is also a function of proximity.

Active Transport (or Active Travel)
Human powered transport, including walking, cycling and their variants (wheelchair use, skating, scooters, etc.), either in their own right or in conjunction with public transport.

Adequately active (to obtain health benefits from physical activity)
For adults – recommendation is for 150 minutes per week of at least moderate-intensity physical activity, comprising ≥ 30 minutes per day (which can be accumulated in 3 x 10 minute sessions) on most days of the week (widely interpreted as five days a week). For children the recommendation is for at least 60 minutes of moderate-to-vigorous physical activity daily.

All-cause mortality
Death from all causes.

Benefit-Cost Analysis (BCA)
Measurement of the economic, environmental and social benefits of a proposed project in monetary terms and comparison with its costs. Sometimes called Cost-Benefit Analysis (CBA).

Benefits
In benefit-cost analysis, the stream of effects flowing from the creation of an asset. Usually includes operating and maintenance costs as a negative benefit.

Bottom Line
The consolidated effect of an action on a defined area of concern (e.g., economic, environmental, social).

Capital Expenditure
Expenditures that create durable assets and generate benefits over an extended period of time. Usually limited to physical assets but can extend to social capital.

Community Cohesion
The quantity and quality of positive interactions among people in a community, particularly neighbours.

Congestion
A condition of road networks (and other transport systems) that occurs as use increases, and is characterised by slower speeds, longer trip times, and increased queuing.

Costs
In benefit-cost analysis, the expenditure necessary to create an asset – usually the 'capital cost'.

Cross-sectional studies
The study variables (e.g. physical activity and psychological health) are measured at one point in time in a sample (usually) taken from a 'naturally-occurring' population that is not participating in a specific intervention related to the study variables. This is in contrast to 'intervention' studies described below.

Discount Rate
A value applied to future benefits and costs that reflect a combination of community time-preference (for having something now rather than later – sometimes called the social time-preference rate) and opportunity cost (what else could be done with the resources).

Discounting
A means of making costs and benefits at different times comparable by reference to the community value of the future relative to the present by applying a discount rate to future values.

Durability
The extent to which effects are maintained beyond the initial impact.

Ecological study
An epidemiological study in which the unit of analysis is a population group rather than an individual. For instance, an ecological study may look at the association between active transport and obesity in different countries or cities. Ecological studies are susceptible to the 'ecological fallacy'; that is, assuming that what applies as the aggregate level is valid for individuals.

Economic analysis
The process of valuing a policy or project. Common economic analysis methods include benefit/cost analysis, lifecycle analysis, and net present value.

Evaluation
The systematic collection and analysis of data needed to make decisions.

Equity impacts
Impacts related to the distribution of costs and benefits.

External impact
Impacts that consumption of a good or use of a facility imposes on other people.

Generated traffic
Additional vehicle travel that results from highway expansion or other policies that reduce motor vehicle travel costs.

Inputs
The resources required to create specified outputs.

Internal impacts
Direct impacts on the consumer of a good or user of a facility.

Intervention studies
Usually involve conducting a program (i.e. intervention) and measuring the effects; for example, conducting an exercise program with a sample of adults and measuring their psychological health before and after the program.

Inverse or negative association
As one variable increases (e.g. physical activity) the other variable of interest decreases (e.g. obesity).

Median
The median is the numeric value separating the higher half of a sample or population from the lower half. For example, a median walking time to school of 10 minutes means that half the children in the sample spent less than 10 minutes walking to school and half spent more than 10 minutes.

Meta-analysis
A mathematical (statistical) synthesis of the results of two or more primary studies that addressed the same hypothesis in the same way.

Moderate-intensity physical activity
Defined as that between 3 - 6 Metabolic Equivalent of Task (MET) (i.e. 3 - 6 times the energy expenditure at rest), with walking at the lower end of the range and cycling at the top end of the range. The MET expresses the energy expenditure of physical activities as multiples of the resting metabolic rate; with 1 MET defined as the metabolic rate at rest.

Monetisation
Measuring non-market impacts using monetary units, such as dollars per death, or cents per kilo of pollution emissions.

Morbidity
Relating to the incidence of ill health in the population – the opposite of well-being, from a health perspective.

Mortality
Relating to the incidence of death in the population, including all causes (e.g. road trauma as well as disease).

Multi-Criteria Analysis (MCA)
Assessment against a range of criteria to assess the extent to which they are achieved by a project, often involves judgment as well as quantitative analysis.

Narrative review
An overview of research evidence from primary studies that are usually selected and synthesized using less rigorous methods than a systematic review (see below).

Outcomes
What the assets or activities deliver to the community.

Odds ratio (OR)
The odds ratio is the ratio of the odds of an event occurring in one group (e.g. being classified as 'fit' in the 'walking to school' group) to the odds of it occurring in another group (e.g. being classified as 'fit' in the 'travel to school by car' group). An odds ratio of 1 indicates that the condition or event under study (e.g. children classified as 'fit') is equally likely to occur in both groups. An odds ratio greater than 1 indicates that the condition or event is more likely to occur in the first group. An odds ratio less than 1 indicates that the condition or event is less likely to occur in the first group.

Odds ratio (adjusted)
Statistical methods (also called multivariate analyses) are used to adjust the OR for potentially confounding variables (also termed covariates). In the example above, the association between 'walking to school' and being 'fit' might be confounded by children's participation in leisure-time physical activity. If adjusting the OR for children's levels of leisure-time physical activity still leads to an OR that is significantly greater than one, then it is likely that walking to school is contributing to being 'fit', and not just due to already fit children being more likely to walk to school than 'unfit' children.

Positive Association
As one variable increases (e.g. physical activity) the other variable of interest also increases (e.g. cardiovascular fitness).

Public Policy
The course of action (or inaction) taken by government (whether federal, state or local) with regard to a particular issue, including courses of action, regulatory measures, laws, and funding priorities.

Recurrent Expenditure
Expenditure for the operation and maintenance (or consumption, where maintenance does not restore the asset to original condition) of capital assets.

Resource Cost
The real value of resources used in or by a project, including both costs and benefits. Distinguished from financial cost by:

- using prices that exclude the effects of inflation over time
- excluding indirect tax (Excise on fuel; Goods and Services Tax) from financial costs.

Risk Ratios and Hazard Ratios
Similar to Odds Ratios but use different units as a basis for comparing 'exposed' (e.g. to walking to school) and 'unexposed' groups.

Social Capital
The ability of individuals to achieve desired outcomes (e.g. access to employment, education, recreation or better health) with fewer resources (e.g. cost of driving a car or use of medical services).

Smart growth
Compact, mixed, multi-modal land use development patterns.

Sprawl
Lower-density, single-use, automobile-dependent land use development patterns.

Systematic review
An overview of research evidence from all available primary studies using explicit and reproducible methods.

Sustainable Transport
A sustainable transport system is one that:

- meets the basic access and equity needs of individuals and societies
- societies can afford to construct, access and maintain
- offers choice, convenience and supports economic activity
- limits pollution and waste and consumption of resources to sustainable levels
- is resilient and capable of being continued with minimal long-term effect on the environment.

Sustainability Assessment
A way of working through the social, environmental and economic issues in a transparent way to find integrated solutions where trade-offs are minimised or non-existent.

Travel Demand Management
Strategies to affect the level of demand and use of transport, especially where transport systems are congested and capacity increases are not feasible or desirable.

Travel Plan
A systematic way of identifying, with the relevant community, ways of reducing reliance on the private car – usually in a school or workplace context.

TravelSmart
A collective term for travel behaviour change initiatives in Australia. Originally applied to community/household programs, but now including schools and workplaces.

Walking School Bus
A group of children walking to school with one or more adults, usually on a formal basis, using a defined route with meeting points, a timetable and a regularly rotated schedule of trained volunteers.

Utilitarian walking and cycling
Walking and cycling for transport (i.e. to get to places) rather than primarily for sport, recreation or fitness.

Triple Bottom Line
Consideration of economic, social and environmental impacts in planning and evaluation.

Randomised controlled trial
An experimental design in which participants are randomly assigned to receive or not receive a program (e.g. TravelSmart program in schools) and the post-program levels of the variable of interest (e.g. walking or cycling to school) are compared for the program group and the control group.