Walking and Cycling International Literature Review

Final Report

PREPARED FOR

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The Place To Be

Walking and Cycling Literature Review

This literature review was commissioned by the then Department of Infrastructure in 2007 and undertaken by:

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At the time this report was commissioned, Dr Krizek was Associate Professor, Urban Planning and Civil Engineering, University of Minnesota and Dr Forsyth was Professor, Dayton Hudson Chair of Urban Design and Director, Metropolitan Design Center, University of Minnesota.

Please note that this report uses American spellings and some American terms. For those unfamiliar with American terms, please note the following.

AMERICAN TERM	AUSTRALIAN EQUIVALENT
Sidewalk	Footpath
Transit	Public Transport
Downtown	CBD or Central Business District
L.R.T.	Light Rapid Transit
Airline distance	“As the crow flies” distance
U.S.	United States of America
U.K.	United Kingdom

Outline of report

Glossary

Adequate pedestrian infrastructure and design: By adequate levels of pedestrian infrastructure and design we mean development is intense enough so that distances between destinations are not too great, the street system allows fairly direct pedestrian routes, and there are enough sidewalks or low traffic streets to provide options for getting to major destinations.

Bicycle box: Also called an advanced stop bar, is a right angle extension of a bicycle lane at an intersection, which allows cyclists to get ahead of automobiles after being stopped at a traffic light.

Bicycle loan programs: Provide free (or nearly free) access to bicycles for local transportation needs.

Carrots: Colloquial term used to describe the range of policy options serving to make something (NMT) extremely attractive, appealing or sometimes even irresistible.

Class A cyclists: Are experienced and are happy to operate on collector or arterial streets.

Class B cyclists: Include adults or teenagers who ride more occasionally and have less confidence in traffic than Class A cyclists.

Class C cyclists: Include children, the elderly, or other inexperienced populations who either do not ride on roads or where such activity is monitored by parents

Derived travel: Travel individuals do to engage in activities in other places—work, recreation, shopping, health services.

Hard measures: Physical factors directly affected by policy changes. May include development patterns, street layout, bicycle lanes, foot paths, intersections, bicycle parking, etc.

High quality pedestrian infrastructure: E.G., wide, tree-lined sidewalks with attractive paving, artistic street lamps, etc.

LOS: Level of Service models aim to provide a common rating system for facilities used by cyclists and/or pedestrians.

NMT: Non-Motorized Travel, including pedestrian and walking travel that is derived.

PMT: Person Miles Travel, used to refer to the distance for all travel, regardless of mode.

Programming: Educational initiatives or schedules of activities, procedures, etc., to be followed to encourage walking and/or cycling.

Rail-trail: Multi- or single-use trails running through former railroad corridors. Often grade separated from the adjacent road system.

Recreational travel: Travel individuals do for the sake of travel such as a walk around the park.

Self-selection: The phenomenon in which people choose a neighbourhood or employment area based partially on the amenities that area provides for their given travel preferences.

Soft measures: Non-physical factors directly affected by policy changes. Includes pricing of alternative modes, education, complex information exchanges, etc.

SBF: Separated Bicycle Facility, also referred to as a cycle track (mostly in the U.K.), sidepath, off-street bicycle paths, and sometimes Copenhagen bicycle lanes. For purposes of this report, SBFs are used in a general sense to include all of the above.

Sticks: Colloquial term used to describe the range of policy options serving to make something (NMT) very unattractive and/or expensive.

VMT: Vehicle Miles Travel, usually to reference the distance for all travel via motorized means (e.g., auto, motorcycle, or transit).

Voluntary Travel Behaviour Change (TBC): Changes in the travel choices people make, done of their own free will, without outside coercion or regulation.

SUMMARY OF FINDINGS

Why don’t people walk or cycle more for day-to-day trip purposes? What can a government do to increase such walking and cycling? This report presents the findings from an extensive literature review aiming to help professionals and researchers in the State of Victoria understand barriers to walking and cycling as well as infrastructure and policy supports for non-motorized transportation. The research team located almost 500 articles, papers, and reports assessing walking and cycling infrastructure, policies, programs, and models. We reviewed over 300 of them—those judged to be most relevant to the questions raised by the Walking and Cycling Branch of the Department of Infrastructure and rigorous in terms of their analysis and ability to draw robust conclusions.

WALKING AND CYCLING COMMON THEMES

- *Combined factors:* Urban environments with high levels of walking and cycling typically represent a combination of many factors that help promote these modes of travel. The most compelling argument, particularly for cycling, is that only via an integrated range of environmental features (including infrastructure and facility improvements), pricing policies, or education programs will substantive changes result. This is what has been occurring in the Netherlands, Denmark, and parts of Germany for decades (Pucher and Buehler 2008).
- *Small interventions and perceptions:* The conclusion common to most studies is that small infrastructure interventions (micro-factors) have small or little effect on overall levels of walking and cycling. An exception to this finding is where gaps in the existing system are being remedied. However, small interventions often affect people's perception of pleasant walking or cycling environments which has positive outcomes. It should be emphasized, however, that it is an open question whether these positive perceptions about small interventions increase levels of walking and cycling at a population level. This is particularly the case for walking.
- *Focusing on robust results:* There are many studies that have significant findings not backed up by other studies. If researchers study enough variables, run enough regressions, and have enough observations they will uncover significant findings. At the 95 percent confidence level, 5 percent of findings will be significant by chance. Some findings are significant but the effects are very small. We addressed this issue by carefully attending to the specific type of Non-Motorized Travel (NMT), the population, and the context, and paying most regard to variables found to be significant across multiple studies, detailing this in Appendix A.

WALKING SPECIFIC FINDINGS

- *Walking vs. physical activity:* Recent U.S. literature from public health has focused on the built environment, walking, and total physical activity. The results are mixed or weak in terms of increasing total physical activity through environmental interventions. The results for travel walking, the focus of the walking part of this literature review, are stronger and more positive.
- *Perceptions:* Some studies find perceptions of the environment are important associations with walking for transportation; however, there is frequently little association between perception and reality (objective environment). That is, increasing infrastructure provision may not affect the perception of that provision. In areas where infrastructure and community design reach adequate levels, education and programming to change how people think and feel about the environment may be important. By adequate levels of pedestrian infrastructure and design, we mean development is intense enough so that distances between destinations are not too great, the street system allows fairly direct pedestrian routes, and there are enough sidewalks or low traffic streets to provide options for getting to major destinations. The bottom line then is, once environments are adequate it may be better to spend funds on programming around perceptions rather than greatly improving the environment, however, much more research is needed and we only state this to show the complexity of the tradeoffs and factors involved. The perceptions of parents about the safety of children is an important issue that has not been adequately dealt with in the literature; but it may well be that fear of stranger danger outweighs fear of traffic safety related to infrastructure.
- *Distance:* People will walk further than the 400 meters or one quarter mile that had been proposed anecdotally as a maximum walking distance, e.g., average distances over 600 meters to transit in Singapore (Olszewski and Wibowo 2005), and 40 percent of transit users living more than 300 meters airline distance from a stop in Toronto (Alshalalfah and Shalaby. 2007). Distance, however, is a real barrier for travel walking.
- *Carrots:* The U.S. literature is interested in carrots—can one make environments so attractive that people walk or cycle? Here studies have mixed findings but

community design features such as density and street pattern, or linkages to transit, may have more effect on travel walking than pedestrian infrastructure, amenities, and general aesthetics. Findings about sidewalks are mixed.

- *Sticks:* Sticks approaches seem to be effective in increasing overall levels of walking—making alternatives to walking very unattractive and/or expensive. These sticks include increasing the price and difficulty of driving and parking.
- *Populations:* Certain populations may be more sensitive to issues of high pricing of driving or parking or more positive about the incidental benefits of walking for exercise, social interaction, mental health, and such. They may also be more likely to live close to jobs, educational institutions, shops, and other transportation destinations. They value convenience and accessibility. These populations include: students, low-income people, and households without children.
- *Transit:* In the U.S and likely in Australia, a major reason for walking in urban areas, is walking to and from transit (Besser and Dannenberg 2005; Agrawal and Schimek 2007). Besser and Dannenberg (2005, 273) find that "Americans who use transit spend a median of 19 minutes daily walking to and from transit." Better transit, including community or urban design to support such transit, can likely increase walking.

CYCLING SPECIFIC FINDINGS

- *Distance:* Cyclists are willing to travel longer distances than pedestrians, though there remains a decline in cycling, generally, after four kilometers or so. This distance varies dramatically depending on trip purpose. Entertainment, recreation, and fitness trips can reach 30 to 40 kilometers, while work and shopping trips typically fall within 10 kilometers. Based on findings from other successful cycling environments, there is a strong market for trips less than 2.5 kilometers.
- *Separated Bicycle Facilities (SBFs):* separated bicycle facilities such as off-road paths are not necessarily safer, particularly at intersections with vehicular traffic. However, they are perceived as being safer which may help less confident cyclists make the decision to ride a bicycle and may ultimately lead to higher levels of ridership.
- *On-street facilities:* On-street bicycle lanes, wide curb lanes, and other non-intersection specific treatments may be safer in high trafficked areas and intersections than separated bicycle facilities and are also much cheaper to install. Within this category of facilities, it is case specific over which facility is best. For example, bicycle lanes are typically not recommended on residential streets, where they cannot be maintained, or where "no parking" regulations are frequently violated.
- *Populations:* Those who stand to benefit most from the low-cost aspects of cycling are the young, the elderly, and the economically disadvantaged. These groups may also be most in need of separated bicycle facilities and other measures to increase sense of safety. Yet, the primary groups of cyclists in Australia and the U.S. do not fit into these categories.
- *Bicycle loan programs:* Research on these programs is scant and has shown few successes. However, a crop of new, technologically-advanced systems has received much attention in the popular press and may prove successful at increasing cycling and/or reducing Vehicle Miles Travel (VMT).
- *Transit:* Many bus, tram, and train systems allow bicycles on-board or provide attached bicycle racks. However, when integrating these two modes, the emphasis is often placed on improving access and safe parking at transit stops and stations. This is due to findings that suggest destinations are usually within walking distance of the egress point and bicycles are therefore less necessary for this segment of the trip.

The findings of the report are gleaned from and supported by a literature matrix in Appendix A, distilling the literature reviewed in terms of the following topics:

- Mode: bicycle, pedestrian, or both
- Type of intervention or environmental feature addresses: community design, infrastructure, mode choice, modelling, programming
- Literature type: peer reviewed, conference paper, report by agency, book, or other
- Approach: intervention, cross-sectional, etc.
- Place or density: big city, suburban, ex-urban, rural, etc.
- Sample: who, where, when, how collected, how many
- Outcome variables, that is type of walking and/or cycling examined

KEY SUMMARY POINTS AND RECOMMENDATIONS

We summarize the general findings by breaking down the range of strategies or policy levers that were studied into a handful of categories, along with a category labelled, "combined." Based on convergence of findings from the literature, we summarize the efficacy of various strategies for the two modes differently in Table 1. Dark shading represents features that are very important, lighter grey represents those of lesser importance, and no shading represents no reliable evaluations. For walking, community design and the use of multiple strategies is paramount. For cycling, the presence of mode specific infrastructure is most important, combined with the use of multiple strategies.

Table 1: Schematic showing the efficacy of different categories of policy levels

Strategy	Walking	Cycling
Community design		
Infrastructure presence	Matters more for children	
Infrastructure of high quality (e.g., wide, tree-lined sidewalks throughout)		
Programming		
Pricing and convenience		
Combined strategies		

Implications for each broad topic are listed at the end of each section and also summarised below. They are numbered by section e.g. point 1.1 is the first point in section 1.

1.1 Interventions for walking and cycling need to be considered separately as the modes have distinctly different characteristics and infrastructure needs.

1.2 Fully understanding NMT 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.

2.1 Pricing factors are tremendously important for spurring NMT. Auto and fuel taxation and parking are two factors that stand out. If motorized transportation is more expensive, people may well shift to non-motorized modes though they may also merely travel less or take transit.

2.2 The effect of education or other programs could be important, but more detailed and longer-term follow up evaluation is required in order to fully ascertain the benefits of such, particularly as it relates to NMT.

3.1 Community or urban design including gross population density, street pattern, and accessible destinations are important in creating a walkable environment.

3.2 While distance is very important for pedestrians, on average they will walk further than the anecdotal rule of thumb of 400 meters used in many planning applications.

3.3 The relationship between pedestrian infrastructure (particularly sidewalks) and walking is complicated. There are many reasons to provide such facilities and, if designed to be adequate for such motorized equipment as gophers and Segways, they will likely be adequate for pedestrians.

3.4 Perception of infrastructure is important in walking but it is not clearly related to actual provision. That is, providing more infrastructure may not in itself change perceptions. It is important to understand better how marketing and educational programs can be used to to modify people's perceptions of walkability.

3.5 Separated bicycle facilities are particularly troublesome in intersections involving automobile traffic and do not necessarily appear to be safer.

3.6 Separated bicycle facilities and related treatments lead to the perception of increased safety on behalf of the many cyclists.

3.7 Intersections are critical pinch points for cyclists and detailed treatments increase cyclists' comfort in navigating them.

3.8 Bicycle loan programs may have an impact in or close to urban core areas, where they are usually available, though scant evaluation precludes any conclusions at this point.

4.1 Planners should not underestimate the important role that predetermined preferences and lifestyles play in understanding rates of NMT. In some environments and for some populations, preferences may undermine the role that other initiatives—programming or infrastructure—may have.

5.1 NMT planning efforts could be substantially enhanced with greater information about NMT travel; this includes data collection efforts specifically geared toward better understanding the range, purpose, and impediments for walking and bicycling.

5.2 To best understand NMT travel, analysts require relatively small geographical units of analysis and detailed data about such environments (e.g., destinations as well as networks).

SECTION 1: INTRODUCTION

POLICY MOTIVATIONS AND CENTRAL QUESTIONS

The State of Victoria, much like other areas across the globe, has been wresting with concerns of increasing traffic congestion, depleting non-renewable resources, the threat of global warming, increasing obesity, and decreasing quality of life. The automobile is often targeted as a primary culprit for such problems (Forsyth *et al.* 2007a). Many fields are grappling with these issues. Non-motorized travel (NMT), particularly walking and cycling, seem to provide potential solutions.

Some professions, such as traffic engineering and urban design, have been planning for various forms of NMT for some time. Others are relative newcomers, for example, the recent interest in active transportation from the area of public health. Some see NMT as creating problems that must be addressed; for example, safety conflicts between motorists, cyclists, and pedestrians. Others see NMT as a potential solution to environmental and public health problems. Urban designers and many activists regard NMT as part of a vibrant, vital, and human-scaled public realm. Trails advocates, those from parks and recreation fields, and proponents of traffic calming and complete streets see NMT as either a central component, or at least an additional justification, for their favoured designs (Forsyth *et al.* 2007a).

There remain however, many questions about which factors lead to walking and cycling at the individual, interpersonal, environmental, and policy levels. This report examines existing literature to better understand how specific soft (non-physical) or hard (physical) measures influence walking or cycling travel behaviour. It is prepared for the Department of Transport (formerly the Department of Infrastructure) in Victoria, Australia, and is to be used by infrastructure professionals and researchers for three purposes:

(a) to wade through the existing knowledge base related to NMT,

(b) to identify plausible interventions, and

(c) to target future research directions.

While walking and cycling for recreation are important activities, the focus in this report is on active and derived travel, that is, the travel individuals do by walking or cycling to engage in activities in other places—work, recreation, shopping, health services (as opposed to travel for the sake of travel such as a walk around the park). The focus on derived travel (sometimes referred to as utilitarian travel) suggests there are different emphases or findings than if we were to focus on recreational travel as well.

In the main report we synthesize findings from available literature in a thematic manner that is more easily understood than simply recounting batteries of studies. The main body of this report is therefore a higher level assessment, focusing on findings that converge from a number of studies and placing the literature in context. The companion literature matrix in Appendix A provides an overview of the literature on walking and cycling, summarizing over 300 specific studies out of almost 500 relevant studies that we located addressing dimensions of NMT that are relevant to the concerns of the Department of Transport. In order to conduct the literature review we searched several major transportation, urban planning, and health databases including TRIS online and Medline. We conducted an internet search for reports published by government, advocacy or other organizations. Krizek and Forsyth then classified the entire list into two tiers of studies.

Articles that are summarized in Appendix A are classified as Tier 1 and those we list in the bibliography but do not summarize are called Tier 2. Tier 1 studies have the following characteristics.

- Studies that demonstrate high quality with refereed articles preferred.
- Such works typically comprise empirical studies with strong data and research methods or systematic reviews of such studies.

Tier 2 studies are relevant to concerns of the Department of Transport and have characteristics that demonstrate quality and/or relevance. They include reports from reputable organizations and some conference papers. These may include work based on an assessment of a significant infrastructure design, other development experience or best practices. While some Tier 2 studies are referred to in the report (and are included in the bibliography at the end), only Tier 1 studies appear in Appendix A.

The literature review is international but includes only literature in English. In addition, there are many parts of the world with interesting interventions—for example parts of Europe and Latin America—but little rigorous evaluation of such. As this review is of studies that included evaluation rather than description, these interventions are under-represented.

STUDYING MUDDIED WATER

The body of research on walking and bicycling, while relatively new, can be nuanced and complex. Consider for example, the multiple ways in which one particular study could measure walking for transportation: number of trips, total distance of trips, minutes spent walking, trips over 10 minutes, percentage of total trips, purpose of trips, etc. And this is just a few of the ways that walking for transportation has been measured! What happens when cycling is also thrown into the fray? The waters become muddied very quickly, resulting in situations where findings from one study appear to contradict the results from another.

Similarly, there is enormous variety of potential pedestrian and bicycle improvements that may be used alone or in combination with each other and with urban design strategies. These include infrastructure: paths (sidewalks or sidewalks, bicycle or multi-use trails, on-street bicycle lanes), crossings (signalised, striped, coloured, underpasses, overpasses, refuges), specialized streets (pedestrian malls, shared streets), intermodal connections (bus shelters, train stations, bicycle parking areas), and destination level facilities (change areas, bicycle repair). However they also include more general community or urban design, policies, programs, marketing, and information.

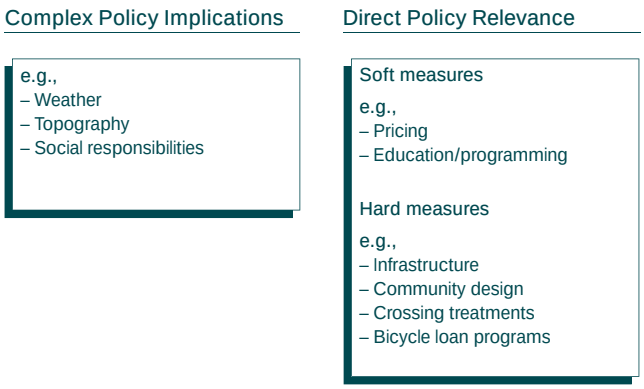
In addition, even if studies are examining similar behaviours (outcome measures, dependant variables), they might differ radically in the population studied (the sample), the environment or context (central city versus suburban versus rural), the number of control variables employed, the devices or survey instrument used to measure the outcome measure, the analysis strategies employed, the emphasis on discerning "transportation" related travel versus "recreational" related travel, etc. This report focuses primarily on walking and cycling for transportation, however, a non-motorized "trip" may combine travel with exercise or leisure (Forsyth *et al.* 2007a).

DECISION TO WALK OR BIKE: MOTIVATIONS AND BARRIERS

The decision to walk or bicycle is ultimately a behavioural one. Individuals only engage in the activity once several criteria are satisfied. For NMT, a typical thought process for such can be broken down into three parts: initial considerations, route considerations, and destination related considerations. To satisfy each of these, several factors stand in the way. In most developed communities across the globe (outside select areas in Northern Europe), there are more reasons not to walk or bicycle than there are to walk or bicycle. Like many aspects of human behaviour, pinning down reasons to explain NMT travel behaviour is fraught with difficulty.[1]

Impediments to NMT generally divide themselves along two tracks: complex policy relevant factors and direct policy relevant factors. Each is briefly described in turn below and examined in more detail later in the report.

Figure 1: Factors Affecting NMT Use



NMT is susceptible to several factors that are easily overcome by motorized travel but that require complicated policy and infrastructure responses to make non-motorized transportation attractive:

- *Climate and topography:* Rain, cold, and slopes pose challenges for NMT; the latter is particularly an issue for cycling (Bergstrom and Magnusson 2003). Scarf and Grehan (2005, 919) analysed the role of hilliness in cycle travel time and found that "1 m of vertical travel on a bicycle can be considered to be equivalent to approximately 8 m of horizontal travel." Rainy (or dark) conditions affect users' perceptions of the safety of travel. Cold or wet conditions affect one's personal comfort level while travelling. Clothing and umbrellas can moderate these effects, programming and education may alter perceptions of these features, some physical infrastructure such as up-hill cycle lanes can lessen the burden, and transit can provide a means of avoiding them temporarily through motorized transportation without using personal vehicles. However, they are complex issues to address.
- *Speed and distance:* NMT is also limited in speed and distance—an issue in rural areas and for those wishing to access many parts of a metropolitan area.
- *Carrying things:* Carrying parcels or passengers is also more difficult for pedestrians and cyclists. While children can walk or cycle, they are even slower than adults and need more attention than when strapped into a car seat (Forsyth *et al.* 2007a).

For example, "Although well-connected streets, small city blocks, mixed land uses, and close proximity to retail activities were shown to induce non-motorized transport, various exogenous factors, such as topography, darkness and rainfall, had far stronger influences" (Cervero and Duncan 2003, 1482). Factors that are more directly affected by

[1]There is a reason, after all, that in most studies aiming to predict various dimensions of travel behaviour, more than 70 percent of the variation in the data goes unexplained (e.g., that is, an R^2 of less than 3).

policy changes in areas of relevance in planning and engineering come in two forms—soft and hard measures. Research examining the efficacy of these factors is reviewed for this report. Soft measures are non-physical such as pricing of alternative modes and education. Some involve relatively complex information exchanges between peers, for example sharing information with a co-worker about bicycle routes to work (Krizek *et al.* 2007b). Hard measures are physical—development patterns, street layout, bicycle lanes, foot paths, intersections, bicycle parking, and so on.

DIFFERENCES BETWEEN WALKING AND CYCLING

While both walking and cycling are non-motorized—along with such modes as animal-powered carts—they are significantly different. It is useful to consider them together when advocating for additional attention to non-motorized travel. However, when designing policy responses, the differences between them are important as is explained in Figure 2 (Krizek *et al.* 2007b; Forsyth *et al.* 2007a). Future research and practice are likely to consider walking and cycling independently; the initial charge for this literature review separately outlined the learning outcomes for walking and cycling and we underscore this as important (Forsyth *et al.* 2007a).

Figure 2: Key Differences Between Walking and Cycling

Dimension	Specific to walking	Specific to cycling	Key differences
Participants	Almost everyone except some with mobility impairments.	There are at least 3 different types of cyclists: A (Advanced), B (Basic), and C (Children)	Cyclists demand more specific environments, depending on participants or purpose; also require more physical skills (e.g., balance).
Range/scale	Mostly up to a mile (1.6 km) in length. The average trip length in the U.S. is 1.2 miles (1.93 km); between 47% and 60% of walking trips are less than 0.5 miles (0.8 km). Recreation/ work trips tend to be longer.	Local and regional cycling. The average trip length is 4 miles (6.44 km) and 57% of cycling trips are less than 2 miles (3.22 km).	Cyclists travel much further.
Speed	Depends on the purpose of trip; ranging from 1 mph (1.6 km/h) (dawdling) to top speeds around 4-5 mph (6.44-8 km/h) for more active walking.	Usually range from 8 mph (12.9 km/h) to 20 mph (32 km/h).	Cyclists travel much faster.
Infrastructure	Infrastructure requirements for safe use include sidewalks (or paths, esp. for children). However, exemplary pedestrian environments may also contain attractive streetscaping.	Can share roads with cars though with safety issues; lanes and paths are options; need infrastructure at destinations (parking, showers)	Cyclists require more infrastructure at destinations
Infrastructure planning responsibility	Local land use planners, and transportation planners; also considered in subdivision layout and urban design.	Engineers and transportation planners responsible for on-road infrastructure; parks and recreation planners for off-road.	Responsibility does not always coincide, making coordination more difficult.
Trip purpose	Transportation (including accessing other modes, e.g., parked cars, transit) and for recreation travel	In the U.S., a clear majority of bicycle trips are related to exercise, health or recreation; cycling for transportation often plays a stronger role in many other cultural settings.	Cycling primarily viewed as a recreational activity, at least predominantly in the U.S.
Safety concerns	Crime (real and perceived); safety from traffic at crossings and on streets without sidewalks.	Safety from traffic, particularly in narrow streets and at intersections with roads.	Pedestrians are concerned about avoiding areas of high crime; bicyclists' prominent safety concern often stems from automobile traffic.
Key barriers	Distance or perceived distance? Safety from crime or traffic.	Distance. Safety from traffic. Cost of equipment?	
Interface with automobiles	Mainly at intersections, but also any locale without sidewalks.	Bicycles are often perceived as unwanted distractions in existing roadway space; conflicts also occur where trails intersect with streets.	Cyclists often perceived to be competing for limited roadway space with automobile drivers.
Interface with transit	Focus on the area around bus or LRT stops to make them pedestrian accessible and attractive for walkers.	Require front racks or other means to accommodate bicycles. Requires parking at transit stops.	Cyclists are more cost prohibitive to account for.

Table source: Adapted from Forsyth et al., 2007a. Original sources for table: Oregon Department of Transportation (1995); Forester (1994); Zegeer (1998); Statistics from U.S. National Highway Traffic Safety Administration and U.S. Bureau of Transportation. (2002); Bureau of Transportation Statistics (2003). Note: Distances and speeds in blue converted by DOT.

As is explained in Figure 2, most people walk, and most are sensitive to distance. Route choice options serve to enhance safety, interest, and the ability to stop off at multiple destinations on the same route (Hess *et al.* 1999; Humpel *et al.* 2004a, 2004b; Forsyth *et al.* 2007b). For many years urban designers dominated this literature with transportation planners only addressing the pedestrian environment in passing (Gehl 1987; Jacobs 1993; Zegeer 1995).

By contrast, far fewer people cycle than walk. Cyclists can move further and at greater speeds than pedestrians, resulting in the need for cycling facilities to be longer. Cycles are legally considered vehicles in many areas and cycling requires equipment to conduct the activity and to park at the beginning and end of each trip (Forsyth *et al.* 2007a). While there are different types of pedestrians, cyclists have been commonly classified into three classes—a critically important point if one is to fully understand the merits of different infrastructure treatments.

Class A cyclists are experienced and are happy to operate on collector or arterial streets. Class B cyclists include adults or teenagers who ride more occasionally and have less confidence in traffic. Class C cyclists include children, the elderly, or other inexperienced populations who either do not ride on roads or where such activity is monitored by parents (Krizek *et al.* 2007b). In each case the presence of cars provides safety concerns and/or causes cyclists to avoid roads. But, it is critical to understand that, relative to pedestrians, there is much wider variation in how different types of cyclists respond to different types of infrastructure treatments.

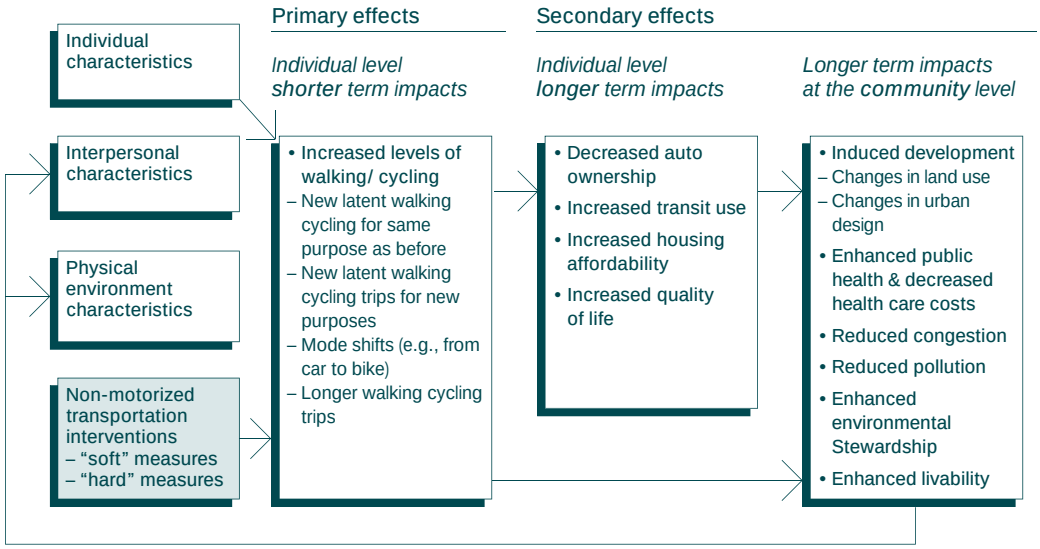
When directly comparing the differences between walking and cycling, it becomes apparent that the two modes are often more different than they are similar. Therefore, efforts to account for NMT in future planning applications often need to use different strategies as the infrastructure requirements and environmental supports for each vary too much.

CONCEPTUAL FRAMEWORK FOR INCREASED WALKING OR CYCLING

Increased use of NMT requires behavioural change—change that theoretically results from a combination of soft and/or hard measures, in addition to complex policy relevant factors. The interventions from hard measures mostly require changes to the built environment—changes that would increase the access, attractiveness, safety, comfort, and security of NMT. Additionally, they may stimulate changes in perceptions, attitudes, and other psychological factors similar to those anticipated by soft measures (Krizek *et al.* 2007b).

Increased walking and cycling may (a) replace motorized trips, (b) be new, or (c) be longer. In the longer term this may lead to secondary effects such as changed individual car ownership or community-scale reductions in traffic congestion (Krizek *et al.* 2007b). Many such secondary effects have been identified and include better air quality, improved health, and liveable cities (Figure 3). Some of these secondary benefits have complex causes and the exact contribution of non-motorized transportation is difficult to assess. Such complexity is also the case for issues like traffic congestion and obesity (Krizek *et al.* 2007b). Overall, it is crucial to assess actual effects rather than assuming that effects are significant and in the expected direction.

Figure 3. Typical Conceptual Framework



Source: Krizek et al. 2007b.

Summary

1.1 Interventions for walking and cycling need to be considered separately as the modes have distinctly different characteristics and infrastructure needs.

1.2 Fully understanding NMT 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.

What Victoria has done

The Victorian Government has a number of strategic documents that provide a future vision, information and resources for NMT. Three key documents articulate the future of transport planning and policy in Victoria. *Melbourne 2030* is a land use and transport plan for the metropolitan area which focuses on growth and sustainability (Department of Infrastructure 2002). The *Linking Melbourne: Metropolitan Transport Plan* integrates the principles of *Melbourne 2030* and focuses on four key issues as they relate to transport: safety, congestion, population growth and economic growth (Department of Infrastructure 2004). In 2006, *Meeting our Transport Challenges* was released, providing a 25-year framework designed to shape transport planning across Victoria, integrating strategies from the two plans (Department of Premier and Cabinet 2006).

In addition there are a number of surveys and programs. These include:

Surveys

- Victorian Activities and Travel Survey (VATS) – travel surveys were conducted throughout Melbourne from 1994 to 1999 (ABS, 2000).
- Victorian Integrated Survey of Travel and Activities (VISTA) – travel survey results to be released in 2009 (Department of Transport).

Programs

- TravelSmart – a travel behaviour change (TBC) program that operates through grants, policy support and programs targeting municipal governments, workplaces, schools, and communities (Department of Infrastructure 2007b; 2007c).
- Local Area Access Program (LAAP) – grants that support a range of small-scale infrastructure projects aimed at demonstrating the benefits of improved access at the local level.
- Walking and Cycling Infrastructure Program, delivered by VicRoads.

SECTION 2: SOFT MEASURES: PRICING, PROGRAMMING, AND EDUCATION

PRICING: THE LOW COST OF DRIVING/PARKING

In any effort to learn about NMT, it is critically important to understand the broader context of relative pricing in choices among different modes and, for cycling, the availability of vehicles (i.e., bicycles). Furthermore, pricing considerations are not limited to the strict monetary costs but are also related to the convenience, parking, and duration of a trip.

In many developed countries—especially the U.S. and Australia—it is well documented that auto users, on average, pay less for mobility privileges than other modes of transport. The most notable examples of car use subsidization come in the form of the financing for roadways, parking, and extremely low fuel taxes. Leveraging policies to affect these dimensions promotes a more level playing field where auto users assume a larger share of the costs for the externalities (e.g., pollutants) they generate.

Two pricing factors that are extremely influential, large scale, and directly affected by policy include the costs or taxes assessed for auto travel (in the form of petrol) and the costs associated with parking. For the former, it is well documented that variations in travel behaviour arise largely from public policy differences, especially from differences in automobile taxation (see Pucher 1988, for example, for differences between Western Europe and North America). Furthermore, increases in gas taxes are seen as an equitable and cost efficient strategy in striving for a more balanced transportation system (Wachs 2003).

For the latter, the strongest—and most direct—policy lever to spur NMT comes in the form of parking policies for automobiles. In the U.S., it is estimated that 99 percent of all car trips begin and end at a parking space that is free to the driver (Shoup 2005)—a factor that goes a long way when one considers the overall costs and benefits of a walking or cycling trip. Not only does ample and free parking provide an easy excuse for auto travel, vast parking areas are also the bane of pedestrian travel. Various examples are well documented where the marginal cost of parking has been internalized to the users, thereby resulting in higher rates of non-auto use (Shoup 2005). A pooled study of almost 900 people in Minnesota and Maryland, controlling for a variety of socioeconomic factors, found the perception of parking difficulty was the strongest association with weekly travel walking and total walking measured by survey (Rodriguez *et al.* 2007). Other factors with either no or very weak associations included several measures of transit access (perceived and measured): sidewalks (perceived and measured), bicycle paths, and crosswalks, perceived traffic, and perceptions of many destinations. Other instances come from the urban design experiments correlating gradual decreases in parking availability, such as in Copenhagen, with a general upturn in pedestrian activity.

Finally, as we report below, many studies find that people with low incomes walk more for transportation indicating that pricing considerations are likely at work. For example, Van Lenthe *et al.* (2005, 763) drew on a survey of 8,767 adults in the Netherlands and found that "compared to those living in the most advantaged neighbourhoods, residents living in the quartile of socioeconomically most disadvantaged neighbourhoods were more likely to walk or cycle to shops or work, but less likely to walk, cycle or garden in leisure time and less likely to participate in sports activities (adjusted for age, sex and individual educational level)." Agrawal and Schimek's (2007) work with a nationwide survey of 26,000 people in the U.S. arrived at similar conclusions.

While this literature review was not tasked with the responsibility of focusing on these dimensions, it is necessary to understand the strong influence pricing factors—broadly defined—have in affecting mode choice.

PROGRAMS AND EDUCATION OR SOCIAL MARKETING EFFORTS

Programs and education efforts come in many different forms, ranging from formal to informal, personalized journey planning to blanket promotional material. Many programs focus on the concept of voluntary travel behaviour change (TBC), which involves people making choices to change their travel behaviour of their own free will without outside coercion or regulation. Examples include: marketing programs, walking clubs, or school-based programs. Some efforts work with individuals or households to understand their personal travel needs and make them aware of feasible or even attractive NMT travel options of which they were previously unaware. General efforts of these sorts go by various names such as travel blending, travel smart, or personalized travel planning. The central theme in these efforts is that certain populations could benefit from either additional motivation or support or the appropriate information to engage in higher levels of NMT.

The direct effect of such programs on NMT, however, is relatively unclear because many of these efforts are also geared toward less auto travel (in terms of distance) and more transit use, and are not centred on walking or cycling. Other programs focus on increasing transportation walking for the health benefits it provides. These programs typically come from the public health field and often target specific populations, such as school children or rural populations.

Nonetheless, *some* evaluation work has been completed. The little research conducted on non-infrastructure-based school programs has found some positive results, though methodological and other factors may temper some of these findings (Staunton *et al.* 2003). Oliver *et al.* (2006) reported on an intervention that included a four-week elementary school curriculum in New Zealand; there was no significant effect on the whole sample but the most sedentary children did increase their number of steps.

Research on adults is more mixed and has tended to focus on walking rather than cycling. These programs are typically designed by the researchers for a specific set of participants and use informational materials, phone calls, and in-person meetings to encourage increased physical activity. Most of these programs do not distinguish between trip purposes, meaning transportation trips are not explicitly identified. Some find modest but significant behaviour changes although follow-up periods are typically months rather than years (e.g., Ball *et al.* 2005; Goulias *et al.* 2002). Some merely measure at the end of the intervention (Clarke *et al.* 2007; Dinger *et al.* 2005; Haines *et al.* 2007). Others find no significant changes compared with controls (e.g., Brownson *et al.* 2005) or comparing minimal versus more sophisticated interventions (Chen *et al.* 1998).

In terms of cycling, Merom *et al.* (2003) surveyed 450 adults who owned bicycles, interviewing them by phone both before and after a promotional campaign advertising the opening of a bicycle trail in western Sydney. They found a slight increase in awareness and an increase in cycling time for those close to the trail (within 1.5 kilometers), but in terms of overall physical activity this was more than offset by a decrease in walking. Overall cycling did not increase because of the trail although one subgroup—those from a non-English speaking background living close to the trail—did increase cycling time mainly due to a few participants using the trail to commute to work (p. 239).

However, Mutrie *et al.* (2002) found a significant change in the numbers of participants actively commuting to work by walking 12 months after receiving an information packet in a work-based program aimed at people who had irregularly commuted; cycling did not change. Reger *et al.* (2002) in a paid media and public-relations based intervention focused on sedentary older people and reported a significant increase in people observed walking. Ogilvie *et al.* (2004), based on a literature review, estimate such targeted campaigns can shift 5 percent of trips though it is not clear over what period.

Ultimately, more research is needed to determine how useful "soft" programs are in the long term. We imagine they may be most successful when combined with other strategies such as increased transit services, and increased pricing of driving and parking.

Summary

2.1 Pricing factors are tremendously important for spurring NMT. Auto and fuel taxation and parking are two factors that stand out. If motorized transportation is more expensive, people may well shift to non-motorized modes though they may also merely travel less or take transit.

2.2 The effect of education or other programs could be important, but more detailed and longer-term follow-up evaluation is required in order to fully ascertain the benefits of such, particularly as it relates to NMT.

SECTION 3: HARD MEASURES: COMMUNITY AND INFRASTRUCTURE DESIGN

COMMUNITY DESIGN

Community design refers to the location and type of different land uses, the overall street pattern (grid versus cul-de-sac), and the intensity of development. Nearly all literature from this line of research focuses on the extent to which such characteristics result in less auto use. However, heightened levels of NMT may not always be accompanied by lower auto use; NMT may complement auto travel rather than substitute. Or, lower levels of auto use may be consumed by transit trips. In addition, most studies combine walking and cycling, thereby masking the true impact for any one mode.

Where research has explicitly studied walking and/or cycling, it has typically aimed to tease out the impact of one or more specific factors, such as the distance to various establishments (such as retail) or measures of density (which are basically proxies for one another).

Walking findings

Adults: Many studies show community design is important for adult travel walking including street pattern, density, and mixed use or destinations (infrastructure is dealt with in the next section). However, studies contradict each other. For example, an early study by Cervero and Duncan using two-day travel diaries and a number of GIS-based measures focused on the built environment found only land use mix at the origin was statistically significant in a model predicting walk trips under five miles (2003, 1401).

More recently, Lee and Moudon (2006b) asked 438 respondents in Seattle about the last week of walking "(a) to work, (b) to school, (c) to grocery stores, (d) to other retail or service facilities, and (e) for recreation or exercise" (2006b, S81). After analyzing dozens of environmental variables using GIS they proposed several variables that facilitate walking, for leisure or travel. Travel walking, measured as any walking vs. non-walking or frequent walking versus non-walking, was associated with distances to office and mixed use center, restaurants, bank, post office, and grocery store; along with slope, parcel density, and area density (Lee and Moudon 2006b, s88, s93). Sidewalks were not significant. In another study, Forsyth *et al.* (2007b, 2008) measured dozens of density, land use, street pattern, and infrastructure characteristics in a study of 715 people in Minnesota. They found associations between travel walking, measured via survey and travel diary, and various measures of population density and connected street patterns, sidewalks, social land uses (such as libraries, day care, clinics, theaters, sports areas, recreational facilities, and houses of worship), and litter and graffiti measured via observations. It should be noted however, that these and other similar studies measure dozens of variables and find only a few to be significant.

Overall, density, street pattern, and destinations seem to be identified in many studies. These relate closely to distance as they are measures of the closeness of things and directness of routes. A review of national data based on a one day travel diary filled out by 26,000 households, found 8.7 percent of trips were walk-only and almost all the 2 percent of transit trips started with a walk trip. However, 35 percent of respondents did not report walking at all that day. For those that did, the median trip was only 0.25 miles (402 meters) but the average walk trip was 0.62 miles (998 meters) and 23 percent of walk trips were over one mile or 1609 meters. Approximately 20 percent of trips were to and from recreation or for recreation and those with higher educations were much more likely to take such trips, confirming other research (Agrawal and Schimek 2007). Agrawal and Schimek found utilitarian walking increased with very high population densities (25,000 people per square mile measured at the census block group level, or 97/ha), zero ownership, the lowest incomes, and higher educational levels.

These findings are echoed by those such as Olszewski and Wibowo (2005) who found similar average walking distances of over 600 meters to transit in Singapore and Alshalalfah and Shalaby (2007) who found more than 40 percent of transit-riders in Toronto lived more than 300 meters airline distance from transit (likely at least 400 meters on the street network). It is apparent that some people will walk far further than the anecdotal cut off of 400 meters often cited in planning studies. The issue is, are these walkers already doing it, or is there a market for increasing walking? Can accessible destinations be increased by increasing development intensity and if that is done, will more people walk to them?

For children, the perceptions of their parents about such issues as traffic safety and stranger danger are such strong mediators that the relationship between overall community or urban design and their walking is a complicated one. However perceived distance, which is related to community design, emerges as the key barrier to children walking to school in several studies (Black *et al.* 2001; CDC 2005). More work, however, has focused on infrastructure and education interventions and we deal with that below.

Cycling findings

Tenets of community design are often implicit in many bicycling related initiatives because cycling has been shown to be highly attractive for short distance trips. After all, unless common and attractive origins and destinations are brought together within feasible distances—a feature of community design—such trips would likely not be realized. Two outstanding questions are: (1) is there currently a large enough market of relatively short haul trips between common origins and destinations to make a difference (i.e., is the existing urban form/ community design compatible for such), and (2) how close is close enough for people to want to walk or cycle?

Bicyclists are willing to travel much longer distances than pedestrians, largely due to higher average

speeds attainable by bicycle. At the same time, however, distance remains an important constraint in terms of bicycling use and the distance between common origins and destinations is a critical dimension of community design. For example, part of the reason European cities have higher rates of NMT use than the U.S. is that average trip distances, regardless of mode, are shorter, presumably due to denser development patterns than many other settings. A relatively high percentage of all trips in European cities are shorter than 2.5 kilometers: 44 percent in the Netherlands, 37 percent in Denmark, and 41 percent in Germany, compared to 27 percent in the U.S. (Pucher and Buehler 2008). These general transportation facts yield a strong market for cycling trips. However, as is reported below, Melbourne also has short trips but not the same number of cyclists.

Other and more detailed dimensions of community design are also important in understanding specific types of trip purpose. For example, using detailed findings from analysis of the Twin Cities (U.S.) metropolitan area, we find that entertainment, recreation and fitness trips appear to cover the greatest average distances with some trips reaching 30 to 40 kilometers (18.6 to 24.8 miles). Work trips by bicycle are the next longest type of trip, with most trips falling within a range of about 20 kilometers. Bike trips for work, shopping, or access to bicycle trail facility tend to be shorter on average, with the majority of trips falling within 10 kilometers (6.2 miles). Trip purpose is an important factor in determining the length individuals are willing to travel by bicycle (Iacono *et al.* 2007). In a review of studies from the Netherlands, Germany and the U.K., Martens (2004, 281) found that the majority of cyclists riding to transit "travel between 2 and 5 kilometers to a transit stop, with longer access distances reported for faster modes of transit." That is, people will cycle further for a regional train than an ordinary city bus.

INFRASTRUCTURE

When most people consider efforts to induce NMT, their thoughts turn to matters of infrastructure, specifically infrastructure required for walking or cycling. Relative to overall community layout, infrastructure for pedestrians can be retrofitted in many cases with modest expense. Infrastructure for cyclists is often more expensive. Overall, NMT is unique in terms of more general transportation infrastructure because of the varied types of facilities on which it occurs and the need to consider varied types of users. Outside of freeways, almost all roadways and neighbourhood streets are NMT facilities (of course some are safer than others). There are NMT mode specific facilities—sidewalks for walking and bicycle lanes for cycling. There are also combined facilities for NMT movement. Because of the specific nature of each of these types of infrastructure, the literature on each type is discussed in turn.

Walking findings

The big picture findings can be divided by population group.

Given basic provision of infrastructure, **adults** walking for transportation can do so if given fairly basic sidewalks or low traffic streets to provide options for getting to major destinations (Hoehner *et al.* 2005; Forsyth *et al.* 2008). A number of studies of **adults** have not found general sidewalk provisions to be associated with travel walking (e.g., Lee and Moudon 2006b, s77); others do find them significant (Forsyth *et al.* 2008) but the findings are mixed. Sidewalks are likely most critical on major roads as compared to residential streets. As is noted below, if pedestrian infrastructure is made adequate in network coverage, size, smoothness for motorized wheelchairs and such, as legal requirements and equity concerns often dictate, it will likely be wide and even and continuous enough for pedestrians.

For example, Hoehner *et al.* (2005, 105) found that after adjusting for age, sex, and education, walking for transportation was negatively associated with (measured) sidewalk levelness but positively associated with a number of community design features such as "perceived and objectively measured access to destinations and transit" as well as "perceived access to bike lanes, and objective counts of active people in the neighbourhood." Perhaps older neighbourhoods with less level sidewalks had community design and socio-demographic features supportive of walking. Other studies have examined provision of street trees, lighting, buffering for pedestrians, crosswalks, and such and have mixed findings. Forsyth *et al.* (2008) found lighting but not street trees increased travel walking in Minnesota. Community design features such as high densities, connected street patterns, and some types of land uses are typically more important as are social and economic factors.

Perception is also important; some find more important than the objective environment (McGinn *et al.* 2007) but it is not clearly related to actual provision. That is, increasing provision of features such as sidewalks may not increase perception of that provision. Studies that examine the correlation between perceptions of the environment and the actual environment show little relation (McGinn *et al.* 2007).

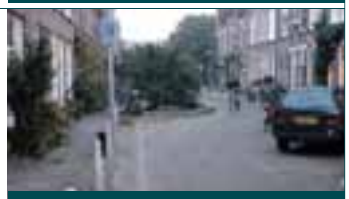
However, **children** are less confident dealing with cars and their parents may be less willing to let them walk in areas without infrastructure such as sidewalks. Ewing *et al.* (2004) using travel diary data found distance and sidewalks on main roads were associated with walking to school although as in other studies they found high income and access to cars decreased active transportation. For example, Boarnet *et al.* (2005a, 2005b) found parents reported more children walked to school after relatively simple but publicized sidewalk gap closure projects in California's Safe Routes to Schools program.

A review by Dumbaugh and Frank (2007) found that while there are gaps in the literature, sidewalks and raised medians do decrease incidence of pedestrian crashes (but crosswalks did not). Low traffic speed has been found in numerous studies to decrease accidents, or at least their severity, so traffic calming mechanisms may also be useful.

Overall, children walking to school are affected both by the distance to school and by their parents' perceptions of safety (which may be affected by physical improvements such as sidewalks but also traffic volumes, the media, etc.). While some perceptions are based in important realities, others may be altered by education and programming—this includes education for parents, for children, and for motorists

Figure 4: Facility types

SHARED FACILITIES WITH AUTOMOBILES

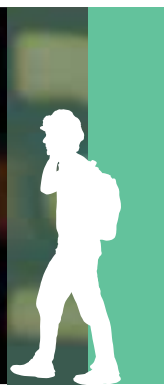
Type of facility	Representative photograph	
Roadways and neighbourhood streets	 Sendai, Japan	 Canberra, Australia
Traffic calming	 Taree, Australia	 Utrecht, Netherlands
Shared streets and bicycle boulevards	 Stockholm, Sweden	 Berkeley, U.S.
Wide curb lanes	 Tsukuba, Japan	 Vallingby, Sweden
On-street bicycle lanes—same direction as traffic	 Davis, U.S.	 Atlanta, U.S.

Type of facility	Representative photograph	
On-street bicycle lanes–counterflow	 London, U.K.	 Boulder, U.S.
Combined (shared) off-road facilities for NMT	 Izumi Park Town, Japan	 Minneapolis, U.S.
NMT MODE SPECIFIC FACILITIES		
Separated bicycle facilities	 Almere, Netherlands	 Kista, Sweden
Copenhagen bicycle lanes	 Copenhagen, Denmark	 Amsterdam, Netherlands

Type of facility	Representative photograph	
Bike boxes	 Utrecht, Netherlands	 Portland, U.S.
Footpaths or sidewalks exclusively for walking	 New York, U.S.	 Dubbo, Australia
Pedestrian only streets/paths	 San Antonio, U.S.	 Sydney, Australia
Bicycle parking/lockers	 Amsterdam, Netherlands	 Minneapolis, U.S.
Trip end facilities/stations for cycling (parking plus gear changing facilities, etc.)	 Himeji, Japan	 Milton Keynes, U.K.

Photographers: Ann Forsyth, Kevin Krizek, and Laura Baum.



CYCLING FINDINGS: A FOCUS ON SEPARATED BICYCLE FACILITIES (SBFs)

Given the range of populations (children and inexperienced to highly skilled) and infrastructure treatments (bicycle boulevard to on-street facilities to bicycle only off-street paths, see Figure 4 above), it is extremely difficult to arrive at similarly big picture conclusions, particularly regarding the impact of cycling-specific infrastructure treatments. Generally, discussions often turn to the merits of physically separating bicycle travel from other modes of travel versus right-of-way facilities that separate them via painting or striping or right-of-ways with little separation. We therefore broadly discuss the literature amidst various considerations, draw conclusions where able, and then turn to discussing other related matters and infrastructure treatments.

Figure 5: Cyclist on a "Copenhagen bike lane" on Swanston Street, Melbourne.

Separated bicycle facilities (SBFs) (also referred to as cycle tracks, mostly in the U.K.), including sidepaths, off-street bicycle paths, and sometimes Copenhagen bicycle lanes (named after the first known city to install one), are often used to reduce interactions between cyclists, pedestrians, and motor vehicles. Part of the difficulty in understanding the merits of SBFs stems from the varying definitions; generally speaking, they are defined as a path within the right-of-way designed specifically for cyclists and separated physically from motor vehicles. But even within this definition there is considerable variation. Physical separation may be in the form of bollards, raised paving, medians, vehicle parking or a completely different path, several meters from the road. The best known and widespread examples of SBFs come from the Netherlands and Denmark where such facilities are commonplace throughout many urban core areas as well as other environments.

Generally speaking, SBFs are usually installed with two key rationales: increased safety (preventing conflicts and collisions between modes) and increased use. The literature related to each is introduced in turn.

SEPARATED BICYCLING FACILITIES AND SAFETY

The most common argument in favour of SBFs stems from increased safety, which is ironic since SBFs as a safety measure is highly controversial and has even drawn point/counter-point arguments in leading transportation journals (Forester 2001; Pucher 2001).

Arguments opposed to cycling specific infrastructure cover several points, mostly relying on specific empirics. First among them stems from the cost required for their installation—a cost that research cannot reliably demonstrate is worth it. The cost figures to support such assertions are not always convincing, mainly because the benefits are so difficult to quantify.

A second argument against SBFs are empirics demonstrating how they are *not* necessarily safer, when considered vis-à-vis actual crash data. Opponents point to the fact that the majority of bicycle-auto conflicts are not from cars and bicycles travelling in the same direction. As information in Figure 6 suggests, the bulk of all bicycling oriented crashes are derived from intersections or turning movements. Separating the modes via infrastructure, many argue, exacerbates the complexity of intersections and hence leads to additional crashes and conflicts. A good number of studies suggest this.

For example, studying driver scanning behaviour in Helsinki, Summala *et al.* (1996) found that drivers making right turns looked to their left more often than their right, thus failing to notice cyclists on the adjacent bicycle path. Alternatively Räsänen and Summala (1998) in a study of bicycle-motor vehicle accidents in Finland, found that the most common accident type involved drivers turning right and a cyclist coming from the driver's right along a separated bicycle facility, a manoeuvre that has the cyclist coming from an unexpected direction. Furthermore, others suggest that cyclists in streets have fewer crashes. Pedler and Davies (2000) found that those cyclists who bicycled on the road had fewer interactions with motor vehicles at intersections than those who rode on the cycle tracks. However, this finding must be taken lightly, as the skill and confidence level of cycle track cyclists was probably lower than that of on-road riders. In a study of facility safety in Ottawa and Toronto, Canada, Aultman-Hall (2000, 10) found that "the rates of injuries indicates it is safest per kilometer for travel on the road, followed by off-road paths/trails and then least safe on sidewalks." Similarly, Wachtel and Lewiston (1994), in a study of bicycle-motor vehicle accidents in Palo Alto, California found that cyclists on sidewalks or bicycle paths incur a risk of collision with motor vehicles that is 1.8 times as great as that for roadway travel.

Figure 6: Bicycle Crashes

Most frequent car-bicycle crashes by age and urban versus rural

Urban	
CHILD	ADULT
1-Cyclist running stop sign	1-Motorist turning left
2-Cyclist exiting residential driveway	2-Traffic light changed too quickly
3-Cyclist riding on sidewalk turning to exit driveway	3-Motorist turning right
4-Cyclist on sidewalk hit by motorist exiting driveway	4-Motorist restarting from stop sign
5-Cyclist swerving left from curb lane	5-Motorist exiting commercial drive
Rural	
CHILD	ADULT
1-Cyclist exiting residential driveway	1-Motorist overtaking unseen cyclist
2-Cyclist swerving about on road	2-Motorist overtaking too closely
3-Cyclist swerving left	3-Motorist turning left
4-Cyclist entering road from sidewalk or shoulder	4-Motorist restarting from stop sign
5-Cyclist running stop sign	5-Cyclist swerving around obstruction

Source: adapted from Forester 1993, p. 269 (each category limited to top 5 frequencies)

Where safety research does not focus specifically on SBFs, it often addresses issues related to on-street bicycle lanes or wide curb lanes. In these cases, the available literature suggests the following. Harkey and Stewart (1997), in a study of 1,583 bicycle-motor vehicle interactions in 13 locations in six metropolitan areas in the U.S., found that bicycle lanes had the following advantages over wide curb lanes: (1) Motorists were less likely to encroach on the adjacent lane, (2) Motorists had less variation in their lane placement when passing, and (3) Cyclists were more likely to ride further away from the edge of the roadway. In addition, they found that bicycle lanes as narrow as 0.92 meters (3 ft) provide enough space for motorists and cyclists to interact safely, while bicycle lanes of 1.22 meters (4 ft) optimize safety conditions. Other research has supported the findings that vehicle encroachment into the adjacent lane is reduced (Hunter *et al.* 1999a, 2005; Hallett *et al.* 2006) and cyclist distance from the curb is increased (Hunter *et al.* 2005) on streets with bicycle lanes, as compared to wide curb lanes. Research focusing on the riding position of the cyclist found that cyclists rode, on average, further away from moving traffic where bicycle lanes were present and/or wider (Hallett *et al.* 2006). More general trends related to safety are discussed in the section, "Separated Bicycle Facilities: The Big Picture", below.

SEPARATED BICYCLING FACILITIES AND INCREASED USE

The other argument for SBFs stems from increased bicycle use, a claim equally as difficult to reliably document. We quickly review a sample of studies—from the specific to the more general. An inherent difficulty of this research comes when one examines detailed studies, particularly coming from the U.S., suggesting the relationships are highly nuanced. For example, research analysing 2000 census and other data from 43 large cities across the U.S. (Dill and Carr 2003) found that the number of bicycle lanes per square mile explains a large share of the variation in bicycle

commuting rates. Interestingly enough, however, the study differentiated between on-street and off-street facilities and the model with only on-street facilities was considerably more robust, suggesting that off-street facilities have a small (but still significant) role. Examining city specific studies, additional factors are accounted for in the explanatory models and thus, the reliability of these findings decreases.

Moudon *et al.* (2005) surveyed 608 randomly sampled respondents in urbanized King County, Washington (U.S.) and found that proximity to trails (separate bicycle facilities) and the presence of agglomerations of offices, clinics/hospitals, and fast food restaurants were significant environmental variables in respondents cycling at least once per week. Conversely, variables that were theorized to be significant, but were not, included the presence of (on-street) bicycle lanes, traffic speed and volume, slope, block size, and the presence of parks. These findings somewhat comport with Krizek and Johnson (2006) who found that only close distances to SBFs were statistically significant predictors of choosing cycling, though the relationship was not found to be linear nor even statistically significant at further distances. A key point from this sampling of studies is that most conclusions are drawn from cross-sectional studies that control for a minimum number of factors. The more disaggregate the unit of analysis, the muddier the water becomes. Additional confounding issues stemming from self-selection trouble the ability to arrive at reliable conclusions regarding the merits of such facilities.

But rather than simply approach the issue as one correlating use with proximity to facilities, the causal mechanism may be less direct. Increased use may be related to the dimension discussed above, safety, but more at a perceptual level for the user (rather than actual level). A logical stream of thought emerging from the literature runs along the following lines. It is asking a lot for all cyclists, particularly young, old, or inexperienced, to ride amidst vehicular traffic (even with law abiding and highly educated motorists). SBFs provide increased choice. This choice may be attractive for select populations and others, particularly from a safety standpoint. Whereas the above section focused on safety empirics, an equally compelling argument is how they relate to perceived safety (whether such safety is real or perceived, however, is another question).

For many, perception is reality and in this case, SBFs usually win out. For example, on-street facilities elicit varying reactions from cyclists. In a survey of members of the Texas Bicycle Coalition, Taylor and Mahmassani (1996) found that bicycle lanes were a stronger incentive for casual and inexperienced cyclists to ride than wide curb lanes, but for experienced cyclists there was no preference for either facility. Landis *et al.* (1997) found that, all else being equal, cyclists perceive streets with bicycle lane striping or paved shoulders as safer than those without. Many psychologists and researchers argue that perceived safety is all that matters and this has been supported in some applications.

The closest stream of research that addresses perceived safety comes under the banner of bicycle level of service (LOS) models which aim to provide a common rating system for facilities used by cyclists. Models are typically developed using data from cyclists on their perceived safety and comfort when riding in different environments. Landis and colleagues have conducted a number of studies on bicycle LOS for different facilities—often SBFs are addressed in such applications. Where SBFs are not directly addressed, many of the tenets that SBFs aim to shield cyclists from (e.g., autos, fast moving traffic) are considered.

In a study describing a generalized urban bicycle LOS model, Landis *et al.* (1997) highlight the significance of bicycle lane striping and road condition on cyclists' perceptions of safety. Landis *et al.* (2003) later found that traffic volume, width of the outside through lane, and intersection crossing distance are the key elements affecting intersection LOS for cyclists. In another study, the following factors were found to be significant for urban arterials: traffic volume, number of through lanes, speed limit, percentage of heavy vehicles, surface condition, width of outside lane, and the number of unsignalised intersections (Landis *et al.* 2006). For off-street shared-use paths, Hummer *et al.* (2005) found that path width, presence of other users, and presence of a centreline significantly affected ratings of trail experience, with both centrelines and other users lowering ratings, while path width raised them. Studying a variety of intersections where cycling facilities end (discontinuities), Krizek and Roland (2005) show that cyclists' discomfort is related to increased distance of crossing intersections, having parking after the discontinuities, and wider width of the curb lane. Given that some research indicates that SBFs lead to increased perception of safety by a variety of users, an expected outcome is increased cycling.

The most convincing evidence showing that SBFs result in heightened use comes from relatively large scale studies focusing on the Netherlands, Denmark, and parts of Germany. Reportedly, from the mid-1970s to the mid-1990s, SBFs expanded greatly in all three countries. In Germany, the bikeway network more than doubled in length, from 12,911 kilometers in 1976 to 31,236 kilometers in 1996 (German Federal Ministry of Transport 1998). In the Netherlands, the bikeway network doubled in length, from 9,282 kilometers in 1978 to 18,948 kilometers in 1996 (Pucher and Dijkstra 2000; Statistics Netherlands 1999). The onset of facilities was accompanied by a general upturn in the amount of cycling as well—though these rates were already notoriously high relative to most other cities in the world. These claims and

observations hold much value, though at the same time, one must take into account the power of complementing SBFs with more general and widespread adoption in cycling-oriented policies (Pucher and Buehler 2006; Ministerie van Verkeer en Waterstaat 2007).

SEPARATED BICYCLING FACILITIES: THE BIG PICTURE

Clearly there are a number of factors to consider in planning for both SBFs and other on-street facilities. A poorly designed separated facility (e.g., next to a sidewalk or with inadequate attention devoted to intersections) is indeed likely to be more dangerous than riding on the roadway. Equally, a rail-trail with grade-separated intersections, easy grades and a 12-foot paved surface is likely going to be a great alternative to a parallel busy arterial street with no space for bicyclists.

The available literature, unfortunately, does not allow one to draw direct correlations between SBFs and increased safety. Nor can we draw direct correlations between SBFs and increased use. It is extremely difficult to make more definite conclusions because studies have too seldom controlled sufficiently for confounding factors. For example, some studies have considered off-street facilities to include bicycle facilities and sidewalks. Alternatively, other studies have not controlled for skill and confidence level of the cyclist.

Figure 7: Example of bicycle boxes in downtown Melbourne. A discussion about these facilities is found below.

There is, however, general consensus on the following. The belief that SBFs reduce the risk of accident is a common reason SBFs lead to increased perception of safety for cyclists across different types of users. With increased perception of safety comes increased ridership. And, in locations with higher levels of ridership, there is convincing evidence that, per capita, the cycling is safer because of a concept referred to as *safety in numbers*.

Conventional wisdom suggests that the number of collisions varies directly with the amount of walking and bicycling. However, upon examining detailed data from a variety of settings—68 cities in California (U.S.), 14 cities in Europe, 47 towns in Denmark, and eight European counties—findings revealed the same picture: a non-linear relationship, such that collision rates declined with increases in the numbers of people walking or bicycling (Jacobsen 2003). This means that motorists are less likely to collide with a cyclist bicycling if more people walk or bicycle and initiatives to encourage increased rates of cycling may be an appropriate strategy to increase overall safety as well.

The most reliable conclusion, therefore, drawn from the available literature about the efficacy of SBFs and related bicycle treatments requires roundabout, though sound, reasoning. SBFs, however they are defined or implemented, usually lead to increased perception of safety across a wider array of users which helps induce bicycle use. Communities with higher rates of bicycle use have fewer crashes with motorists on a per capita basis and are therefore considered safer.

INNOVATIVE CROSSING TREATMENTS

In any environment for bicycle movement, intersections are particularly problematic. Clearly delineated SBFs fail to improve such problems. This draws our attention to various intersection treatments and we highlight below some themes where, unfortunately, only minimal study has been completed.

Bicycle boxes

The bicycle box (or advanced stop bar) is a treatment aimed to reduce conflicts between turning vehicles, forward moving vehicles, and forward moving cyclists (see Figure 7). The box is a right angle extension of a bicycle lane that allows cyclists to get ahead of automobiles stopped at a traffic light. When the light turns green, cyclists are able to move more safely through the intersection ahead of the autos. In more

Figure 8: Innovative Crossing Treatments in Muenster

Figure 9: Coloured treatment for a bicycle lane outside of Flinders St. Station, leading into downtown Melbourne.

progressive environments, cyclists have their own signal, which turns green prior to the autos' signal to give a further head start.

Little research has been done on the usage or safety of bicycle boxes, though one study by Hunter (2000b) examined the effects of the installation of a bicycle box in Eugene, Oregon (U.S.). The author found that 22 percent of cyclists with the opportunity to do so used the bicycle box. While conflicts between cyclists and vehicles in the intersection did not change following installation, no conflicts were observed involving cyclists who used the bicycle box as intended.

These kinds of innovative crossing treatments may well take some getting used to on the part of cyclists and motorists before definitive results on their effectiveness can be seen. Considering the safety issues that exist, intersections are an important focal point in planning for cyclists and pedestrians. However, by themselves, they have limited capacity without regard to the larger network of facilities.

Many European countries use coloured treatments to demarcate space for bicyclists (and sometimes pedestrians) and to draw motorists' attention to various facilities (Denmark – blue; the Netherlands and Germany - red, U.K. - red or green, France, Australia, New Zealand – green). Such applications are usually at intersections but may often parallel heavily travelled routes leading up to high trafficked areas.

The most notable application of the use of coloured treatments by a municipality formerly with no coloured treatments comes from Portland, Oregon (U.S.). The city striped select conflict points (usually heavy right turning traffic crossing the path of straight-ahead bicyclists) with blue markings and appropriate signing. The few studies that evaluated the impacts of the colour striping found that motorists were more likely to yield to cyclists after installation; however, the change also resulted in fewer cyclists scanning for motorists or using hand signals to indicate intent (Hunter *et al.* 2000). While the majority of cyclists and a near majority of motorists reported that the lanes enhanced safety, there is some question as to whether the increased comfort level of cyclists could lead to additional conflicts or collisions. Gårder *et al.* (1998) studied the effects of installing raised and painted bicycle crossings through intersections in Gothenburg, Sweden. They found an overall cyclist risk reduction of approximately 30 percent, due to both the new crossing and the increase in total cyclists using the crossing. However, the authors point out that cyclist speed plays a large role in collisions and that changes that increase cyclist speed (such as safer crossings) may pose a significant safety danger for all users.

Other than the facilities on which NMT takes place (trails, roads, intersections), there are other infrastructure important to consider—particularly for cycling—such as the availability of parking facilities, showers, and lighting. However, there is too little study of this infrastructure to allow for a robust account to understand the importance of each.

BICYCLE LOAN PROGRAMS

A final form of hard infrastructure strategy—in the sense that it involves metering equipment, parking areas and such—is a bicycle loan program. Bicycle loan programs appear in all shapes and sizes in cities throughout the world and more recently, are the latest fad in this line of work. The central concept of these programs is making available free (or nearly free) access to bicycles for local transportation needs. Variables at play include primary audience (tourists or locals or both), length of rental, to charge or not to charge, membership requirements, etc. Several variations of this concept have been explored over the past dozen or so years—few with any notable success. Theft and maintenance are consistent issues.

The latest fashion of these efforts include several European cities (the French cities of Lyon and Paris as well as London, Barcelona, and Stockholm), which have signed contracts with private advertising agencies that supply the city with thousands of bicycles free of charge. In return, the agencies advertise both on the bicycles themselves and on other select locations in the city. These programs also prevent theft by requiring users to pre-purchase user cards with credit cards and by equipping the bicycle with complex anti-theft and bicycle maintenance sensors. In the case of not returning the bicycle within a day, the bicycle sharing operator is allowed to withdraw money from the given credit card account.

Detailed, systematic, and robust studies of community bicycle programs are difficult to come by. Recent reports optimistically suggest positive impacts. For example, the programs instituted on grand scales in Lyon and Paris have received rave reviews in the popular press; anecdotal evidence suggests the "loaner" bicycles are widely used. The little research that exists on these programs is less optimistic regarding the potential impact of bicycle sharing on reducing auto trips, though findings may be highly case-specific. One study by Noland and Ishaque (2006) surveyed users of the OYBike program in London and found that bicycles were primarily used for leisure and recreation trips and that repeat usage of bicycles was not high. Results suggest that the primary barriers to usage were uncertainty about bicycle condition, difficulty with the locking system, and the need to use a mobile phone to check out a bicycle, factors which need not be inherent to bicycle sharing programs generally. In a case study report without empirical validation, DiDonato *et al.* (2002) report that the majority of trips made using bicycle-share bicycles replace walking or transit trips, and therefore do not contribute to a reduction in overall auto use.

MOTORIZED TRANSPORTATION USING PEDESTRIAN AND CYCLING FACILITIES

Finally, while not a focus of this review, intended to focus on existing research related to non-motorized transportation, we note that in addition to cyclists and pedestrians a variety of motorized modes of transportation also use pedestrian and cycling facilities (e.g., Segways, gophers, motorized wheelchairs, electric bicycles, and even small motor scooters). Use of such machinery does not likely affect travel walking; however, as numerous guidelines and prescriptions related to width of path indicate, such modes may well require wider and more level sidewalks, and possibly better lighting, than pedestrians alone.

If pedestrian infrastructure is provided that is adequate for such machinery, as equity reasons suggest it should, such infrastructure will be more than adequate for pedestrians in terms of width, evenness, and texture. That is, a more than adequate level of pedestrian infrastructure is likely to be provided for equity reasons to support such modes (though this will not necessarily lead to pedestrian-supportive community design). Of course, pedestrians are likely to appreciate such features as shade as well but shade trees may well be provided for other environmental reasons. Overall, pedestrians can benefit from infrastructure provided at a quality needed for other purposes. We deal with this issue of the benefits of redundant provision later in the report.

While off-street cycling facilities will likely have adequate size and grade, these motorized modes may move more slowly than Class A cyclists, thus creating issues related to compatibility. However, in terms of this potential for conflict with cyclists, there is not a great deal of literature specific to these motorized modes.

SUMMARY

3.1 Community or urban design including gross population density, street pattern, and accessible destinations are important in creating a walkable environment.

3.2 While distance is very important for pedestrians, on average they will walk further than the anecdotal rule of thumb of 400 meters used in many planning applications.

3.3. The relationship between pedestrian infrastructure (particularly sidewalks) and walking is complicated. There are many reasons to provide such facilities and, if designed to be adequate for such motorized equipment as gophers and Segways, they will likely be adequate for pedestrians.

3.4 Perception of infrastructure is important in walking but it is not clearly related to actual provision. That is providing more infrastructure may not in itself change perceptions. It is important to understand better how marketing and educational programs can be used to modify people's perceptions of walkability.

3.5 Separated bicycle facilities are particularly troublesome in intersections involving automobile traffic and do not necessarily appear to be safer.

3.6 Separated bicycle facilities and related treatments lead to the perception of increased safety on behalf of the many cyclists.

3.7 Intersections are critical pinch points for cyclists and detailed treatments increase cyclists' comfort in navigating them.

3.8 Bicycle loan programs may have an impact in or close to urban core areas, where they are usually available, though scant evaluation precludes any conclusions at this point.

SECTION 4: ROLE OF PREFERENCES

SELF-SELECTION

The bulk of existing research on NMT—if not all of it—responds to research questions using cross sectional data (i.e. data at one point in time). The urban planning community is learning, not surprisingly, that things are not as simple as some of these cross sectional studies might indicate. Analysing a single policy or environmental change without fully capturing other important influences may lead to errant conclusions. Such factors hold particularly true for matters related to understanding the factors leading to people's decision to cycle. Trying to unravel such decision-making by isolating the specific role of various facilities, for example, is a complex endeavour.

Put another way—as any reliable textbook on statistics suggests—correlation does not mean causation. It is important to distinguish between the following: (a) documenting correlations between bicycle facilities and use, versus (b) claiming that bicycle facilities will induce use. The majority of previous work on the subject has not adequately differentiated between the two. For example, residents (or families) often select locations to match their desires for certain behaviours, such as walking or cycling. This is an option they prioritize in their home and work location. This suggests that differences in rates of NMT between households in different areas of the city with different access to NMT facilities should not be credited to facility alone; the differences may well reflect self-selection. In other words, people who are likely to cycle, choose to locate in a given neighbourhood or employment area where they have a better chance of cycling.

The above considerations are particularly vexing for researchers aiming to shed light on debates and discussions around causality. Proving statistical association is not the same as proving causality. Two phenomena can move together due to chance, or there could be bi-directional causality. There is no statistical test for causality. What is the researcher of cycling and walking behaviour left to do? How can one reliably say that cycling facilities will increase levels of cycling and walking? It is difficult.

These considerations suggest that differences in travel between households with different neighbourhood design should *not* be solely credited to various interventions that apply to the community. In other words, people who are likely to walk anywhere, choose the choice to locate in a given neighbourhood where they have a better chance of walking or cycling. Alternatively, populations might be engaging in walking or cycling behaviour—if for no other reason—than the willingness to advance health. It may have little to do with hard or soft measures. This makes incorporating walking into models of transportation more complex, as a walk "trip" may also be a recreational activity.

Suburban residents also tend to express more dependence on their cars and also to think travelling by car is safer than walking, biking, or taking transit. Most significantly, in some studies suburban residents put more importance on safety than do residents of traditional neighbourhoods, who put somewhat more importance on sociability and attractiveness (Handy *et al.* 2006). Are these differences in attitudes and preferences more important in explaining travel behaviour than differences in the built environment, thus supporting the self-selection hypothesis? This is the million dollar question that much research is aiming to answer (e.g., Cao *et al.* 2006b).

SUMMARY

4.1 Planners should not underestimate the important role that predetermined preferences and lifestyles play in understanding rates of NMT. In some environments and for some populations, preferences may undermine the role that other initiatives—programming or infrastructure—may have.

SECTION 5: ACCOUNTING FOR AND MODELLING NON-MOTORIZED TRAVEL (NMT)

Accounting for and modelling NMT proves to be very difficult because of a range of factors related to data availability: learning of behaviours, representing them along networks, and using units of analysis and simulation strategies precise enough to detect noticeable differences. We comment on each below.

A basic foundation of NMT research—knowing the various behaviours of individuals—continues to be a major hurdle. Most available information on NMT addresses the number of people who walk or cycle, as opposed to number of trips or miles travelled. The existing surveys and other sources that address the frequency of NMT produce a wide variety of results. Each source asks about a different time frame; the number of people who complete the behaviour on a bicycle in a week will be larger than the number who ride in a day.

In terms of measurement, NMT behaviour can be ascertained by (a) self report (e.g., diary, survey), (b) observation (in person, using sensors) or (c) via various motion detectors (accelerometers, pedometers, global position systems, etc.) (Troiano 2005). There is significant work testing the relative reliability and validity of these approaches. Figure 10 captures some of the differences across these measures (Troped 2001; Krizek *et al.* 2007b).

Figure 10. Measurement Strategies and How Well the Behaviour is Captured

Measurement strategies	Phenomena / Behaviour to Measure: Who does and does not walk or cycle	Number of trips	Distance	Purpose or destination	Intensity
Self-report	+	✓	–	+	–
Observation	–	+	–	–	✓
Instrumentation	+	✓	+	–	+*

\+ = is good at capturing this phenomenon/behaviour
✓ = fair
— = poor
* the ability to measure intensity differs from accelerometers (good) to GPS units (poor)

Source: Krizek et al. 2007b.

More specifically self-report has problems with definitions (what is a trip—does it include walking to the bus, walking the dog) and, because NMT is a virtuous behaviour, people want to win the researchers' approval by showing that they engage in these activities. However, because many walk trips are short and chained with other trips they are easy to forget e.g., walking to transit or from a parked car around a shopping centre. Furthermore, a key issue for walking is that one trip can serve multiple purposes—e.g., travel and health—which is difficult to deal with in models.

These are difficult problems to address. The data necessary to reliably build such models is in short supply for walking and cycling. User and trip characteristics at a suitable level of aggregation, along with user preferences for facility design characteristics are currently of limited quality and are considered a high priority for improvement (USDOT 2000). These data items are not adequately covered in most large scale survey instruments, such as metropolitan travel surveys or the Nationwide Personal Transportation Survey (NPTS) in the U.S. and where they do, there are problems. As Krizek

et al. (2007b) explain:

> For this reason, the recent version of the U.S. National Household Travel Survey (NHTS) made a special effort to prompt respondents about walking and bicycle trips using a follow-up telephone questionnaire. Interviewers asked, "Did [you] use any other type of transportation during [your] stay in [city here], including bicycling and walking?" So far, I have recorded [N] trip(s). Before we continue, did [you] take any other walks, bicycle rides, or drives on [trip date]? Please include any other trips where [you] started and ended in the same place." Walking trips increased significantly between the 1995 NPTS and the 2001 NHTS, and survey administrators believe this increase is attributable to the improved prompts rather than a true increase. Also of concern is the period of time covered by the diary: a one-day diary may miss occasional use of walking and bicycling as a mode of transportation and as a form of exercise or recreation (Krizek *et al.* 2007b).

While at first blush it may seem that instrumentation would be more accurate, in fact such methods do have weaknesses – e.g., motion detectors do not indicate purpose and people forget to wear them; GPS units do not work in some locations and do not measure intensity of activity; sensors only count people using facilities, ignoring those who are not active. Many of these detectors are also expensive and/or bulky and the fields lack standard protocols for processing information.

Such issues often result in analysts borrowing assumptions from analysis usually slated for other purposes. A common example is an analysis that borrows impedance values (relative time, distance, or cost) from a locally calibrated travel model. The values extracted from these data may be sensitive to the environment in which they were collected. Ideally, travel survey data would be collected year round and cover all seasons (Ortuzar and Willumsen 2001). More commonly, data are collected over a period of several months and reflect weather conditions prevailing at the time the survey data were collected.

This is especially important in the case of non-motorized modes and in locations where significant seasonal climate variations exist. For example, if survey data are collected during warmer, drier months it is possible that changes in travel behaviour during colder or more precipitous months might be missed. These changes might include mode shifts, in which case the number of pedestrians and bicyclists might be overestimated during cold weather periods, and changes in destination choice for discretionary trips, which would affect the length or distance of travel, and hence the relevant impedance values.

Furthermore, a key distinction related to cycling that has to be tracked is that adults are considerably less likely to ride a bicycle than are children, regardless of the time frame being considered. These two groups must be studied separately to avoid confusion or ambiguity. This is generally not an issue with most bicycling surveys, which tend to focus on adults. It is, however, a factor in deriving numbers from general travel data collection surveys that deal with the entire household.

But NMT research is more than about just learning of the behaviours. It also requires data on the context, requiring multiple data sets relating to travel behaviour and land use, each of which presents unique challenges for analysts addressing NMT.

LAND USE/URBAN FORM DATA

The quality of land use and urban form data directly affects the accuracy of NMT research. Extending the range of desired destinations beyond employment and improving the accuracy or robustness of accessibility calculations requires data at a spatial resolution that is not typically available in most research applications. There are sources of establishment-level data on attributes such as employment, sales and other variables that could potentially serve as good proxy variables for attractiveness and be easily scaled to different levels of geographic aggregation. However, these sources are typically private financial organisations or highly confidential. The data can be costly to acquire and require significant effort in terms of cleaning and preparation for spatial analytical use (Forsyth *et al.* 2006). Alternate, low-cost sources of data such as business directory telephone listings have been employed elsewhere (Handy and Clifton 2001) in the context of the calculation of measures of "neighbourhood" accessibility, though these data sets typically contain limited information on size or quality of establishments. While there have been few standard approaches to constructing NMT related environmental variables, recent work in public health has developed protocols for environmental measurement that can provide models for such work (Forsyth 2007a 2007b).

ZONAL STRUCTURE AND NETWORKS

In addition, other efforts often use zones as units of analysis that do little justice to the detailed nature of pedestrian travel. For example, they may aggregate information to census tracts (in the United States, approximately 5,000-6,000 people), zip or postal code areas, or transportation analysis zones (TAZs). An ecological fallacy arises because average demographic or urban form characteristics are assumed to apply to any given individual neighbourhood resident. When measures of commercial intensity are aggregated, for example, each zone reveals the same measure despite each zone exhibiting considerably different development patterns. The heart of the problem—and the ability to detect such subtle geographical differences—lies with the size of the units of analysis that are employed (Iacono *et al.* 2007).

Networks employed for purposes of regional travel models typically

replicate roadways. Networks for walking and cycling are often different and need to be drawn at a finer scale. Specifically, the network structure is too coarse to trace the paths chosen by pedestrians and cyclists, and the zones are too large to differentiate many of the shorter trips made by bicycle and on foot. Also, few networks contain links with specialized facilities for non-motorized travel, such as sidewalks or SBFs, and on-street bicycle lanes.

One way around these problems, as will be described in greater detail in a later section, is to use street network layers encoded as geographic information system (GIS) files as the basis for calculations of a minimum-cost path (with distance as a proxy measure for cost) between an origin and destination point. These networks can be manually modified to include certain types of special facilities. However, few cities or regional authorities have complete inventories of NMT systems, making the construction of a complete pedestrian and bicycle network a resource-intensive task. If time is the desired impedance measure, then assumptions need to be made about the relationship between distance and time in terms of an average speed. While this may be acceptable for pedestrian travel, the availability of bicycle facilities may alter bicyclists' travel time, necessitating special treatment of these facilities (El-Geneidy *et al.* 2007).

INADEQUATE MODELS

Related to the issue of inadequate networks and data is the applicability of model components (most commonly the well-used four-step transportation planning models) to appropriately represent NMT. Most relevant to several components of any urban modelling system is how accessibility is represented and the specific impedance function used, representing the influence of travel time, money and other costs on the willingness of individuals to travel longer distances. In transportation planning practice, it has been common to use gravity or other synthetic models to forecast the spatial distribution of trips, from which an impedance value can be estimated. While this approach works reasonably well for motorized modes, which tend to have a more regional distribution, there are often a large number of origin-destination pairs with zero observations. This problem, known as the sparse matrix problem, is exacerbated by the application of such models to origin-destination data for non-motorized modes, which tend to have a more concentrated spatial distribution (Iacono *et al.* 2007).

It is only the combination of the above and detailed efforts—measuring patterns of use, networks, attractors—that will allow robust modelling efforts that can then be used to more reliably predict induced demand (see for example, Lindsey *et al.* 2006).

SUMMARY

5.1 NMT planning efforts could be substantially enhanced with greater information about NMT travel; this includes data collection efforts specifically geared toward better understanding the range, purpose, and impediments for walking and bicycling.

5.2 To best understand NMT travel analysts require relatively small geographical units of analysis and detailed data about such environments (e.g., destinations as well as networks).

SECTION 6: CONCLUSIONS AND FURTHER RESEARCH

Available literature on NMT is in ample supply. It would therefore seem that we could say more with certainty. Unfortunately, this is not the case; several complex factors interfere with our ability to draw general conclusions about the impact of various interventions, be they hard or soft.

This concluding section summarizes and synthesizes the above review into several take away points. The section is divided into three parts:

- Conclusions derived from a close reading of available literature,
- Conclusions informed by both the literature but also based on professional experience, and
- Fruitful areas for future research.

CONCLUSIONS BASED EXCLUSIVELY ON AVAILABLE LITERATURE

Learning about walking and cycling is extremely difficult

Walking and cycling remain understudied phenomena, particularly when researched in a rigorous manner. To increase the knowledge of how users respond to various interventions, more data must be systematically collected in a variety of environments and credibly analysed. Research needs to do the best it can to isolate confounding factors such as psychological, social, and economic factors. Because of these limitations in fully understanding NMT and how it is affected by various policy and infrastructure investments, planners and politicians must be careful not to overestimate the likely impacts of various treatments.

There is no silver bullet

It needs to be recognized that no single infrastructure investment will have dramatic changes; there is no silver bullet, especially when considering the complexity of NMT. Yearning for such will only lead to frustrating dialogue; time and resources should best be spend in a more constructive manner.

Necessary versus sufficient conditions

Understanding that there is no single bullet, it is important to recognize that there are instances where certain pieces of the puzzle must be in place to even allow NMT to occur. We refer to these as necessary conditions. For walking, for instance, good community design stands out. Lacking tolerable distances for walking between common origins and destinations, few people will walk, regardless of how attractive the environment is. In some specialized environments, a similar assertion could be made about the role of SBFs—e.g., in corridors with high levels of fast moving auto traffic.

Combined strategies work

It is only natural—and expected—for policy makers and infrastructure professionals to want to know the measurable impact a given infrastructure investment will have (what will be the effect of various intersection treatments, how many more cyclists will be induced by constructing a path, will an on-street bicycle path make a difference?).

However, several factors combine to produce a successful walking or cycling environment and ultimately make it attractive for people to bicycle or walk. For example, consider the age-old question: what factors best explain the variation among municipalities in NMT use and what role does policy and (wider) traffic policy play? The most robust studies suggest it may well be that any particular feature contributes only a little, and then only for those with some psychological, social, or economic predisposition to walk or cycle. Communities with notably high rates of cycling use many different strategies—programming, policy, environmental design, and other. Walking is not so dependent on unusual infrastructure but still significantly benefits from a multi-pronged approach that reflects the needs of different user groups.

More specifically, non-infrastructure modifications may include traffic calming of residential neighbourhoods, restrictions on motor vehicle use, better traffic education of both motorists and non-motorists, and enforcement of traffic regulations protecting cyclists. Coordinated implementation of multi-faceted and mutually reinforcing policies and programs is needed in order to create successful pedestrian and cycling environments.

Role of key destinations and design features in walking

Walkers are sensitive to distance, so the location of destinations would seem to matter a great deal to this group. However, findings from recent research on destinations or mixed use have not been as clear as many assumed it might be, as is explained in Section 3.

The following findings can be synthesised:

- Overall density, which is related to the clustering of destinations including other housing units, is associated with travel walking in most, but not all, studies.
- Specific destinations are seen as important in various studies but the destinations differ between studies.
- Street patterns are important in some studies and not others—this may be a measurement issue or it may be due to the use of space (for instance in suburban areas pedestrians may cut through large blocks on paths not identified in the data collection nor known in most network measures).
- Infrastructure has some importance in travel walking—sidewalks, lighting—but merely building a sidewalk will not make an environment walkable.

However, these features do combine to create a walkable environment.

Target specific populations

Assessing the effect of different treatments is on surer footing when specific populations are targeted; certain populations comprise low hanging fruit because they are likely to be more receptive than other populations. We describe several populations and how and why their behaviour may be more responsive to walking or cycling improvements or interventions.

- Recent movers: These populations are seen as open to changing travel mode. However, studies of soft measures such as education and counselling have found them difficult to recruit (Department of Transport 2005; Ampt *et al.* 2006).
- Low income people including students: People with low incomes have been consistently found to be more sensitive to pricing of modes. For those without constraints such as complex trip chaining to reach child care or distant work, non-motorized travel can be cost effective.
- Others with lower proportions of driver's licenses (youth, seniors) are also potential targets for both hard and soft interventions.

Given these factors, cycling prompts a conundrum of sorts. Bicycles are relatively inexpensive modes of transport (though not quite as cheap as walking). In this respect, getting people on bicycles opens up both mobility and accessibility to populations; and, enhanced bicycle facilities may play an important role in such.

As pointed out, primary populations who stand to benefit are those who may be at a disadvantage in terms of auto-ownership or operation, such as the young, the elderly, the economically disadvantaged or more generally, unlicensed populations. In areas rich with these populations, the provision of free bicycles or enhanced facilities may have greater impact. For example, student populations and university towns (Baltes 1996) are notoriously associated with high levels of cycling (e.g., Stuttgart, Germany; Muenster, Germany; Gronigen, the Netherlands, Davis, California (U.S.); Boulder, Colorado (U.S.)). Enhanced facilities in these environments will be heavily used because there are more people engaged in the activity.

Outside of college towns, however, at least in the U.S., the predominant cyclist appears to have few of the aforementioned characteristics. The average cyclist is male, white, higher income, and between the ages of 18 and 44. While in Europe and Asia cyclists are more diverse, the environment and policy context in Australia has enough similarities with the U.S. to require close consideration. Data from a supplemental survey in Queensland by the Australian Bureau of Statistics showed that three quarters of cyclists (people who had cycled in the last year) were aged 15-44, 60 percent were males, male cyclists were more likely to ride each day than females (almost 11 percent versus 4.5 percent) and most cycled for recreation or exercise (Australian Bureau of Statistics 2004).

What does this mean and what are the planning implications based on some of the above described conclusions? First, where there are real needs and concerns to address young, old or sometimes female populations, it suggests that SBFs have a pronounced role because they are perceived as safer. For the young, limited experience and unpredictable movements put children at special risk on streets. Cycling specific infrastructure is more important for those with slower reflexes, frailty, and deteriorating hearing and eyesight. Furthermore, women have been shown to be more risk averse than men when it comes to cycling facilities (Krizek *et al.* 2005). For pedestrians, this indicates populations where marketing may be useful.

Policy levers or strategies

The above conclusions can best be summarized by Table 1 in the summary at the beginning of this report showing five different classes of policy levers or strategies used to promote NMT (we also include a fifth category: combined strategies). Dark shading indicates more important; lighter shading indicates less important. Based on a close reading of the literature, the efficacy of each policy lever differs by mode and some strategies, such as programming, have extremely little evaluation (thus the absence of any shading). Digesting the available literature, it is clear that tenets of community design (e.g., having origins and destinations close to one another, street design) is paramount for transportation related walking. For cycling, ensuring a higher level of perceived safety is important because this leads to more use and thereafter, lower levels of cycling-auto crashes per capita.

The hope of many infrastructure agencies is that specific infrastructure investments will

Figure 11: Facilities along St. Kilda Road, Melbourne showing redundancy is fine and sometimes necessary

increase NMT. For walking, infrastructure is less important and overall design more crucial given the sensitivity of pedestrians to distance. Sidewalks are significant in some studies and not in others. Perhaps, basic provision on major roads provides a basis for walking and improvements to quality do not improve that. However, it can be said that the sidewalk to nowhere will be little travelled. Findings are even less strong for such features as street lamps and street trees although this may be due to lack of variation in provision—if there is lighting and some street trees along almost every sidewalk small variations such as providing decorative fixtures may not make much measurable difference (Forsyth *et al.* 2008).

CONCLUSIONS INFORMED BY LITERATURE BUT ALSO BASED ON PROFESSIONAL EXPERIENCE

The walkable place

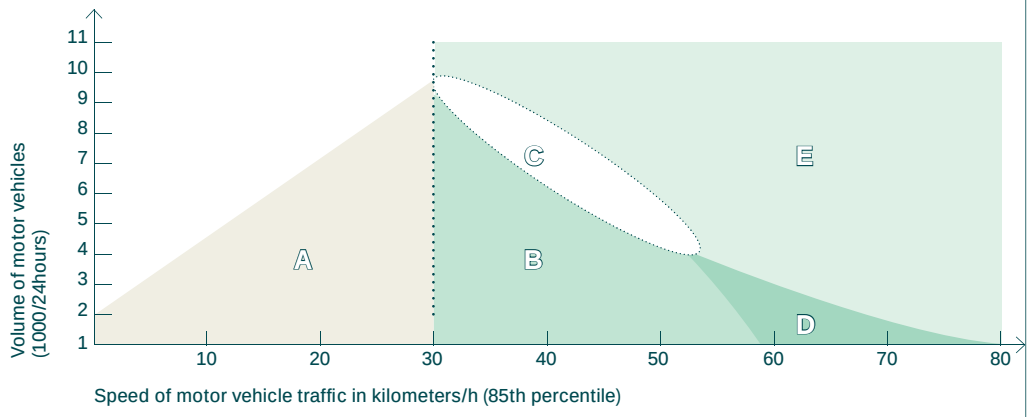
Creating a convenient environment where people have the option to walk is a good thing—at the very least it provides choices. While overall community or urban design is vital in creating walkable distances, pedestrian infrastructure has many benefits. Increased numbers of street trees can be justified for reasons of shade, temperature control, aesthetics, habitat, and so on. Continuous pedestrian routes are useful for providing choices for those who choose not to drive or cannot.

What type of cycling facilities where?

Given the range of infrastructure options, an outstanding question in many discussions is how one can best know what treatment should be applied to different environments. Available research can provide only broad suggestions regarding the applicability of various treatments and their merits. Synthesizing central themes from various studies and scenarios, professionals concerned with bicycle infrastructure have struggled with such general guidelines. Practice in the Netherlands is reportedly informed by using a schematic from which Figure 12 below is adapted; it prescribes different suggested treatments depending on traffic volumes and vehicle speeds.

Of course, not all treatments are possible in each desired circumstance due to limitations of funding, available space or other issues. For this reason, corridors might require a range of treatments, sometimes a handful of different facility types along a short stretch. A key point in Figure 12 is that it is important to acknowledge that there are environments where SBFs may be unnecessary. These conditions include (1) residential streets, (2) where there is an incapacity to maintain them (e.g., sweeping), and (3) where a municipality cannot commit to "no parking" regulations. Notwithstanding the above mentioned generalities, the effects of various treatments on other and more specific populations are mentioned below.

Figure 12.



Area A: All modes can be mixed. The only reason to consider bicycle tracks or bicycle lanes is for the sake of continuity of design on connecting bicycle routes.

Area B: In general, a profile without segregation is acceptable, but depending on circumstances bicycle tracks or bicycle lanes can be desirable.

Area C: Some form of separation is needed, but visual separation (bicycle lanes) can be acceptable as well.

Area D: Bicycle tracks are desirable, but as densities are low, a mixed profile is acceptable. However, bicycle lanes are not advisable.

Area E: Speed and/or density of traffic flow make it an absolute necessity to segregate bicycles and motor traffic. Separate bicycle tracks are the only option.

Note: above figure and text modified from http://strans.org/graph.html

Small distances, big hurdles

The market for NMT is strongest where distances are relatively short; this applies more to walking than cycling but still for cycling nonetheless. The central question is what distance defines a short distance and who defines it—a matter obviously related to the population travelling and the purpose. It is widely acknowledged that 70 percent of all trips in the Netherlands, for example, are less than 7.5 kilometers and that half of these trips (35 percent) are cycling (Ministerie van Verkeer en Waterstaat 2007). As expected, the percentage of cycling trips increases with shorter distances (44 percent of all trips in the Netherlands are less than 2.5 kilometers and, reportedly, 37 percent of them are cycling (Pucher and Buehler 2008, Figure 4)). Such startling statistics draw sharp focus to the potential of short trips.

According to the recent travel survey for the Melbourne Metropolitan Area, 40 percent of all trips are less than 2 kilometers—a surprisingly similar statistic to the Netherlands (less than 27 percent of trips in the U.S. are less than 2.5 kilometers (Pucher and Buehler 2008)). However, the mode share for cycling for these 40 percent of trips in Melbourne is nowhere near the 44 percent in the Netherlands.

This suggests that other impediments, are getting in the way—possibly related to culture, parking, lack of equipment (to carry goods), etc.—impediments which, if overcome, could go a long way towards increasing the mode split for cycling. Unfortunately, there are big hurdles to overcome and additional research could shed useful light on such matters (see section below).

The network is king

Given existing land use and transportation patterns in most communities, it is a lot to expect a comprehensive and seamless pedestrian and/or cycling network. It is also unrealistic to expect a city to realize such in short order time (e.g., a few years). This realization requires communities to creatively conceive of prioritized routes for frequented origins and destinations and to better improve conditions for existing routes with modest resources.

Doing so requires one to consider the larger network of bicycle facilities, map common origins and destinations, available routes, and to seize opportunities to amplify or improve the existing network. An overall network, after all, is what many users cherish (Lawlow *et al.* 2003), not just spot improvements here or there. Automobile transportation networks typically consist of neighbourhood streets, collectors, arterials, and freeways. A similar analogue could be considered for cycling routes, though not necessarily on the same routes as automobiles.

For example, in Boulder, Colorado, largely considered a leading city for bicycle transportation, the Bicycle System Plan identifies a network of primary and secondary corridors. Primary corridors (routes clearly demarcated for high levels of cycling) are spaced roughly one per 1.5 kilometers, with higher density and trafficked areas having less spacing between corridors. Secondary corridors are equally identified routes and generally rely on residential streets to further amplify the primary routes and to serve finer levels of geography.

Figure 13: Confusion between trams, cyclists, and pedestrians along one of the existing primary bicycle corridors in downtown Melbourne, Swanston Street.

In other words, primary bicycle routes need not be facilities clearly separated from all other modes of travel, or facilities that require exorbitant resources. They merely require clearly identified and targeted routes with attention devoted to avoiding high levels of competition with other modes, particularly autos. In less travelled routes, multiple types of facilities could combine to provide users with strong wayfinding that is welcome and safe.

Furthermore, planned network and corridor designations are used to prioritize enhancements and the maintenance of existing facilities. They are used to identify target opportunities for completion as redevelopment opportunities arise. A central philosophy of a bicycle network plan is that the sum is more valuable than the parts. Rather than investing in spot improvements, a network philosophy stresses that improvements should be targeted, prioritized, and integrated within the larger system.

Redundancy of facilities is OK

There is often considerable concern expressed when SBFs—especially facilities clearly separated from auto traffic—are planned for corridors parallel to popular street bicycle routes. Such concerns are understandable

because efficiency is paramount and redundancy is often seen as a threat to such. In many instances, however, it is important to recognize that different types of facilities serve different users and that one size bicycle facility does not fit all. SBFs are particularly appealing for Class B and/or C users (more inexperienced); Class A users often prefer to be on the road amidst traffic because of higher travel speeds. In the right contexts, redundancy is all right and should not necessarily be avoided.

Intersections, crossings, and 'pinch points' are key

The decision to cycle is complex and multi-faceted. Sometimes a single element along the trip—a dangerous intersection, a troublesome bridge, a hairy road crossing—may be the single factor preventing people from cycling along a route. The merits of select intersection treatments were addressed above. However, the literature is non-existent in addressing crossing treatments in the form of under/overpasses. While these facilities are always more costly than at-grade crossings, they often go a long way towards accommodating timid cyclists and well-designed facilities with good sight lines should be strongly pursued, whenever possible, in discreet and strategic locations.

Figure 14: Examples of underpasses and overpasses

EXAMPLES OF UNDERPASSES AND OVERPASSES WITH PROBLEMS

Underpass without clear sight lines; Cumbernauld, Scotland.

Bicycle and pedestrian bridge with adequate but uninspired design and curvature that limits sight lines; Minneapolis, (U.S.).

BETTER EXAMPLES OF UNDERPASSES AND OVERPASSES

Underpass that is only partially below grade below raised roadway; Vallingby, Sweden. Sight lines are adequate.

Paired bicycle and pedestrian bridges; Amsterdam, Netherlands. Sight lines are good.

Bicycle (and pedestrian) underpass with clear sight lines; Canberra, Australia.

Pedestrian overpass; Millennium Park, Chicago (U.S.). Note, the metal railings do cut off views so the park is fairly heavily staffed with security.

Crossings and intersections may also be important for pedestrians—particularly when children or seniors need to cross busy streets or any pedestrian needs to wait a long time for a crossing signal. While there is little research on the effects of such crossings on overall levels of walking, it is logical that very slow or dangerous crossings would be a deterrent. The literature addressing crime prevention through environmental design has long been critical of underpasses as representing entrapment points, and this is true in many cases. However, if at-grade crossings are impossible or cost prohibitive, European experience demonstrates that such underpasses can be well designed with good sight lines although it is recognized that this comes at some expense.

AVENUES FOR VALUABLE FURTHER RESEARCH

Safety and measures of exposure

Discussions of NMT and safety usually focus on the number of crashes independent of amount of NMT travel crossing the area. This can sometimes lead to errant diagnoses because routes generally considered safe attract higher rates of use and thus more accidents. Thus, any discussions and research examining the safety of NMT needs to control for measures of exposure—that is, how much NMT there is in the area.

Detailed barriers for shorter trips

A reported 40 percent of all trips in Melbourne are less than 2 kilometers—a statistic relatively similar to the Netherlands. Yet Melbourne does not reach close to the 35 percent mode split for cycling in the Netherlands. This suggests a strong need to better understand the myriad reasons why residents choose not to cycle for these short trips. Is it culture, pricing, the lack of facilities or the inability to carry goods? In reality, it is probably a combination of each, but more in depth survey research is necessary to understand the detailed role of hypothesized impediments for these shorter trips.

TravelSmart and long-term follow up

As mentioned, initiatives such as TravelSmart and other education programs hold potential for shifting attitudes and use of NMT. A major shortcoming in understanding the strength of such programs is that there is a dearth of analysis that assesses the merits of these programs over longer term horizons (e.g., more than a few months or a year after the conclusion of the program).

Detailed accounting for NMT

In almost all dimensions, there is a dearth of reliable data about various dimensions of NMT (and accompanying urban form and network data). Data collection efforts, and subsequent analysis, need to be deliberate, focused, and aimed to address relatively specific questions. Notable areas of improvement include: measurement of short trips, attitudes/impediments toward short trips, purposes for all trips, the linking with other modes, etc.

Using walking/cycling to increase the transit-shed

Bicycling and walking are most appropriate for relatively shorter trips. But one should not dismiss how the shorter trips enabled by NMT can directly advance longer trips enabled by transit. Considerably more research is needed to build on the existing knowledge base to understand the conditions under which the transit-shed can be significantly broadened to include longer NMT trips. Some research has been completed looking at various dimensions of this puzzle (see for example, Martens 2004; 2007; Besser and Dannenberg 2005; Rietveld 2000b), but it is all very case dependent. More analysis is required to learn, for example: the distances residents are willing to travel to access multimodal trips, the convenience/impediments involved in bicycle on transit, how NMT distances differ for different ends of transit trips, bicycle parking requirements at transit stops, and the role of NMT signage outside of transit stops.

Substituting cycling for walking trips

Much research assumes that cycling trips will replace motorized modes. However, due to the significant effect of preferences and lifestyles of individuals, there is increasing evidence to suggest that pedestrians are most likely to be attracted to cycling. More systematic research is needed to assess whether NMT as a whole increases when cycling increases.

No “silver bullet” but how much of each type of program?

The strongest message contained in this report is that combined approaches are most successful to promote NMT. Available research, however, has underperformed in allowing users to learn more about the relative impact of each approach, that is, how important are education, infrastructure, community design, signage or other interventions. Teasing out the relative contributions of each is difficult. However, further research pursued within the rubric of combined measures will help planners better understand the relative impact of each and discern where to devote additional resources, all matters considered

Figure 15: Bicycle facility along Beach Road (south of Melbourne) with the skyline in the background.

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Note: * Indicates article is in Appendix A.

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Appendix A

LEGEND FOR APPENDIX

Issue	
Community design	Comm. des.
Infrastructure	Infra.
Programming, Education, Marketing	Prog.

Study (Type)	
Cross-sectional study	Cross-sec.
Literature review	Lit. rev.
Case study	Case st.
Before and after	B-and-a
Quasi-experimental	Q-exp.
Pretest-Posttest	Pre-Post
Longitudinal	Longit.
Quasi-longitudinal	Quasi-Longit.
Randomised control trial	R.C. trial
Review	Review
Modeling	Modeling
Behaviour observation	B. observ.
Discussion	Discussion
Best practices	Best prac.
Case control study	Case-cont.
Audit	Audit
Experiment	Exper.
Simulated scenario analysis	S.S. anal.

Literature Type	
Conference paper	Conf. p.
Report	Report
Report by reputable agency	Report r.a.
Peer reviewed	Peer rev.

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Abraham et al. (2002)	Bicycle	Infra.	Conf. p.	Cross-sec.	Big city	934 downtown commuter cyclists in Calgary, Canada, were sent surveys, most by email; 547 responded (out of 975 who provided contact information on a previous intercept survey).	Attractiveness of cycling	• "Cyclists are attracted to shorter journeys, but are also willing to travel substantially further to ride on specific types of routes; and/or to destinations with specific destination facilities" (pg. 1). • "An 'individual bike locker' was valued as highly as saving the respondent 8.5 minutes of their travel time along arterial roadways or 18.8 minutes along a residential roadway" (pg. 9).
Allan (2001)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city, Suburban	Data from 1996 census of population and housing for Adelaide, Australia and surrounding areas.	Commute mode; walking permeability indices	• "No statistically significant correlation was found between the workforce density of a particular LGA [local government area] and the propensity to walk to work" pg. 46. • "The analysis of the Distance and Time indices demonstrates that while the Adelaide city centre performs reasonably well in terms of actual walking distances required in order to reach many of the city's key attractions on foot, in terms of the actual time required, its performance could be improved significantly" pg. 49.
Alshalalfah et al. (2007)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city	15,830 individual records of transit trips in a regular work day in Toronto, Canada from the 2001 Transportation Tomorrow Survey (TTS).	Median distance from home to transit stop	• "It was found that around 60% of transit users in Toronto live within the transit service area of 300 m airline distance assumed by the transit service provider. These results indicate that people in Toronto are willing to walk further to access transit than assumed existing standards for transit service areas" (pg. 114).
Ampt et al. (1998)	Both	Prog.	Conf. p.	Longit.	Not specified	100 households in Adelaide, Australia. Households that had recently moved or were soon to move.	Car driver trips; car driver miles; total hours in car	• Car driver trips among all people approached dropped 3.3% in Nottingham and 13.6% in Adelaide. Car driver miles dropped 6.2% in Nottingham and 11.2% in Adelaide. Total hours in car dropped 4.8% in Nottingham and 19.3% in Adelaide. • In Adelaide "about 80% of the changes occurred from the simplest tenet of travel blending -- thinking about travel in advance and trip chaining" (pg. 68).
Ampt et al. (2006)	Both	Prog.	Peer rev.	Pre-Post	Metro area	102 "households on the move" in Canberra, Australia participated in the program. Intervention included phone conversation, journey plans, a GPS, and other information.	Program participation	• "Once people were contacted, the use of the conversation as a way of understanding the needs of new movers proved to be very successful with the uptake of the TravelSmart tools through a conversation at 54%" (pg. 105). • The best sources for contacting households on the move "were lists of households that were sold and areas of new development. Even better are likely to be agencies that are relocating large numbers of staff or clients" (pg. 105).
An and Chen (2007)	Both	Model	Conf. p.	Cross-sec.	Big city	1,616 households from Lexington, KY participated in the 2001 National Household Travel Survey (NHTS).	Non-motorized commute mode share	• "Employment density, percentage of student population, median household income, and average sidewalk length altogether provide the strongest predicative power over the prediction of non-motorized mode share" (pg. 1)
Antonakos (1994)	Bicycle	Infra.	Peer rev.	Cross-sec.	Not specified	Surveyed 552 cyclists at four recreational bicycle tours in Michigan during the summer of 1992, a 95% response rate.	Cycling facility preferences; bicycle commuting	• "Age was positively correlated with preference for on-road facilities (striped bike lanes, wide curb lanes), with importance placed on surface quality, scenery, and bike safety education. Age was negatively correlated with preference for bike paths separated from the roadway" (pg. 25). • The author found that significantly more people cycle for errands than for commuting" (pg. 31).
Audirac (1999)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city, Suburban, Exurban	The data were collected in August 1991 as a subset of the University of Florida, Bureau of Economic and Business Research (BEBR) monthly consumer attitude survey. Sample size was 558 out of 1,000 people contacted, a response rate of 56%.	Willingness to trade off lot size for walking access to various destinations	• "(1) about 30 percent of the total sample is sympathetic to each trade-off, with the exception of proximity to entertainment; (2) there is contradicting evidence for many of the new urbanist assumptions about suburbanites' preferences; and (3) the preferences of respondents living in single-family homes and mobile homes (lot-size consumers) differ from those of apartment or condo residents" (pg. 53).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Aultman-Hall (2000)	Bicycle	Infra.	Report	Cross-sec.	Big city, Suburban	Bicycle and route safety data sets for 2,963 commuter cyclists in Ottawa and Toronto, Canada. From Aultman-Hall and Adams (1998).	Rate of cyclist injuries	• "The rate of major injuries (an injury requiring medical attention) was greatest on sidewalks and the difference between paths and sidewalks was negligible" (pg. 56). • "The rates of injuries indicates it is safest per kilometer for travel on the road, followed by off-road paths/trails and then least safe on sidewalks" (pg. 10).
Aultman-Hall and Adams (1998)	Bicycle	Infra.	Peer rev.	Cross-sec.	Big city, Suburban	Bicycle and route safety data sets for 2,963 commuter cyclists in Ottawa and Toronto, Canada (represent response rates of 45.3% in Toronto and 52.5% in Ottawa).	Sidewalk cyclist status (dichotomous); Sidewalk cycling accident rates	• "6.7 percent of sidewalk travel occurred on roads with bike lanes" (pg. 73). "This suggests that, for some cyclists, even the bicycle lane or designation as a bicycle route is not sufficient for them to feel safe on the road with motorized traffic" (pg. 73). • "Even on paths, sidewalk cyclists have higher rates for falls, injuries, and major injuries" ... "It is possible, based on the results in Table 4, that sidewalk cycling is not inherently more dangerous, but that those who use sidewalks are less skilled cyclists" (pg. 74).
Aultman-Hall and Hall (1998)	Bicycle	Model	Peer rev.	Cross-sec.	Big city, Suburban	Bicycle and route safety data sets for 2,963 commuter cyclists in Ottawa and Toronto, Canada. From Aultman-Hall and Adams (1998).	n/a	• Results suggest recall bias may be present for Ottawa but not for Toronto. "Perhaps some minor collisions are underreported farther into the past" (pg. 27). • "It is concluded that the instrument could not adequately measure the travel patterns of cyclists in the very near past or on particular days" (pg. 28).
Aultman-Hall et al. (1997a)	Bicycle	Comm. des.	Peer rev.	Cross-sec.	Big city	1993 Guelph Community Bicycle Survey and 1993 Guelph Bicycler User Survey, covering Guelph, Ontario, Canada.	Average one way trip length	• "Individuals who cycle in January do not have a mean commuting length different from those who do not cycle in the winter (not significant at the 0.05 level)" pg. 105. • 5 percent of travel is on off-road paths, and 7 percent of available network is off-road paths. The authors state that this suggests "that cyclists find the off-road routes unappealing or they are inappropriately located for the work or school origin and destination locations" (pg. 106). • "On average, the actual routes contain more traffic signals than the shortest paths" (pg. 109).
Aultman-Hall et al. (1997b)	Ped	Comm. des.	Peer rev.	S.S. anal.	Suburban	Three site plans for a real site of 23.3 ha in the Regional Municipality of Hamilton-Wentworth, Ontario, Canada.	Shortest walking distance from residence to amenity (school, transit, park)	• "The inclusion of walkways in the neighbourhood designs analysed here provided a measurable decrease in the percentage of residences above the 400-m distance level. This suggests that provision of pedestrian walkways is worth considering during the retrofitting of existing suburban areas" (pg. 16).
Badland and Schofield (2005)	Both	Comm. des.	Peer rev.	Lit. rev.	Not specified	24 physical activity/urban design/transport peer-reviewed, published articles.	n/a	• "Further investigation is needed first however, to understand perceived and real environmental barriers for different user groups, particularly low SES groups and those with limited vehicular accessibility" (pg. 193). • "The majority of existing research is based on country-specific, self-report cross-sectional designs, which have led to inherent flaws and no establishment of causality" (pg. 192).
Ball et al. (2005)	Both	Prog.	Peer rev.	B-and-a	Not specified	66 adults aged 45-78, who identified themselves as under-active, were recruited at two sites (Melbourne and Brisbane) in 2002. Interventions were printed information and print + telephone.	Self-reported global PA; Self-reported moderate-vigorous intensity activity; Self-reported walking	• "Both groups significantly increased their overall physical activity between baseline and week 12...these increases were maintained by week 16 (pg. 139). • "Only the print-plus-telephone group significantly increased walking between weeks 1 and 12...and also between weeks 1 and 16" (pg. 139).
Baltes (1996)	Bicycle	Comm. des.	Peer rev.	Cross-sec.	Metro areas	1990 US Census data for 100 per cent of the Metropolitan Statistical Areas in the United States.	Percentage of mode split captured by bicycle for work trips in the MSA	• "MSAs with relatively high levels of nondiscretionary bicycling appear to have urban densities that promote shorter trips, relatively temperate year-round climates, and a large proportion of students, particularly college students" (pg. 96).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Barnes et al. (2006)	Bicycle	Infra.	Conf. p.	Longit.	Big city	Seven bicycle facilities in Minneapolis and St. Paul, MN were analysed. Facilities includes on-street bicycle lanes and off-street bicycle paths.	Bicycle mode share	• "It does hint at the possibility that one effect of facilities is to make longer commutes more viable, while the impact may be less significant on shorter commutes" (pg. 8). • "Trips within the facilities buffers show a larger increase in bicycle mode share than do trips that leave the buffers; however, all trips in the central city show an increase" (pg. 9). • "The bridge improvements did seem to have a considerable effect on commuters' willingness to use bicycles to cross the river" (pg. 11).
Baudains et al. (2001)	Ped	Prog.	Peer rev.	Longit.	Big city	Approximately 316 employees from six workplaces filled out before and after questionnaires in 1999 in Perth, Australia. The two interventions were TravelSmart Workplace initiatives, which involved speakers, workshops, publications, posters, and volunteer leaders.	Walking trips	• "The overall result of the interventions (type 1 and 2 together) was an increase in walking trips of 1.36%, with changes in each workplace ranging from -0.82% to 3.59%" (pg. 30). • "The type two (Environmental leadership) intervention achieved much more change overall (2.96%) than the type 1 intervention (-0.13%)" (pg. 30).
Beckwith et al. (1998)	Ped	Infra.	Peer rev.	Exper.	Big city	Passive Pedestrian Sensors: a passive infrared, microwave radar, and two ultrasonic sensors were tested.	Pedestrian detection rate; Detection reliability	• "The infrared and Doppler radar censors that passed the preliminary testing discussed in this report have shown encouraging initial secondary test results" (pg. 102).
Beltz and Huang (1998)	Both	Model	Report r.a.	Model-ling	Not specified	n/a	n/a	• What is needed to move forward: Data collection; better understanding/use of GIS; regional analysis; improvement to ITE trip generation model; prioritization among projects; validity testing of existing methodologies; quantification of response to a facility.
Bergstrom and Magnusson (2003)	Bicycle	Mode Choice	Peer rev.	Cross-sec.	Big city	Two surveys: (1) 1998 survey of employees at four major companies in Lulea and Linkoping, Sweden (N= 433, response rate 72%); (2) 2000 survey of employees from one of the companies surveyed in 1998 (N=572, response rate 69%).	Mode of transport to work	• "There was a clear difference in mode choice between seasons. The number of car trips increased by 27% from summer to winter while the number of bicycle trips decreased by 47%." (pg. 649). • "The comparatively low car access rate among winter cyclists indicates that restrictions for the use of cars is likely the measure that would lead to the largest increase in cycling frequency, although this might be an undesired course of action" (pg. 664).
Besser and Dannenberg (2005)	Ped	Comm. des.	Peer rev.	Cross-sec.	Not specified	2001 National Household Travel Survey of 3,312 adult transit users (out of 105,942 total surveyed).	Minutes spent walking to transit	• "Americans who use transit spend a median of 19 minutes daily walking to and from transit; 29% achieve >= 30 minutes of physical activity a day solely by walking to and from transit. In multivariate analysis, rail users, minorities, people in households earning <15,000 a year, and people in high-density urban areas were more likely to spend >= 30 minutes walking to and from transit daily" (pg. 273.).
Biddulph (2002)	Ped	Infra.	Peer rev.	Lit. rev.	Not specified	n/a	n/a	• Lessons from pilot projects: establish a consistent definition of home zones; engage in dialog with local people; use visualisations and 'mock-ups' of the scheme; be creative but realistic; learn from others; have dedicated staff committed to the project; use facilitators; manage expectations.
Birk and Geller (2006)	Bicycle	Infra.	Conf. p.	Longit.	Big city	24-tube counts and hand counts over 20-year period.	Average daily bicycle counts	• "Between 1992 and 2005 Portland increased its developed bikeway network by 215%, from 83 miles to 260 miles. During this same period, bicycle use in Portland soared. A comparison of 1990 and 2000 census data shows a doubling of bicycle commute trips citywide, with more dramatic increases in close-in neighbourhoods" (abstract).
Black et al. (2001)	Ped	Mode Choice	Peer rev.	Cross-sec.	Not specified	4,214 surveys were completed by parents/ guardians of children in 51 infant schools in England in 1996.	Mode choice	• "Regarding travel distances, it seems that promotion of walking has greater prospect if school catchment is explicitly considered. Hence, such an approach renders even more important efforts by schools to have a presumption in favour of children living nearby" (1138).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Boarnet et al. (2005a)	Both	Infra.	Peer rev.	Cross-sec.	Not specified	Survey of 1,244 parents of children (grades 3-5) in ten California Safe Routes to School (SR2S) schools from spring 2002 through autumn 2003.	Percentage of parents reporting their children walked/ cycled more to school	• "Children who passed completed SR2S projects were more likely to show increases in walking or bicycle travel than were children who would not pass by projects (15% vs. 4%)" (pg. 134). • "More parents stated that their child walked or bicycled less (18% [155 of 862]) after construction of the SR2S project, than said their child walked or bicycled more (10.6% [91 of 862])" (pg. 137). "This finding was unexpected and could be due to several factors" including, a highly publicized abduction around the time of the SR2S changes; disruptions caused by construction of the projects may have caused those who use to walk or bike to change modes.
Boarnet et al. (2005b)	Both	Infra.	Peer rev.	B-and-a	Not specified	Survey of parents of children in ten California Safe Routes to School (SR2S) schools from spring 2002 through fall 2003 (see Boarnet et al 2005a).	Amount of reported child walking to school; Observed child pedestrians walking in street or shoulder; Vehicle yielding; Vehicle speed	• "For each of the three sidewalk gap closure projects, observed walking increased from before construction" to "after construction" (pg. 307). • At all three of the schools with gap closure projects, "children who would pass the project on their way to school were significantly more likely to have reported increases in walking, compared to children who would not have passed the project on their way to school" (pg. 307).
Boer et al. (2007)	Ped	Comm. des.	Peer rev.	Cross-sec.	Metro area	30,025 individuals in 13,012 households were surveyed by the 1995 National Personal Transportation Survey in the ten largest CMSAs.	At least one walk trip during 24-hour period (binary)	• "Higher levels of business diversity and higher percentages of four-way intersections were associated with more walking" (pg. 298).
Brög and Barta (2007)	Both	Prog.	Conf. p.	B-and-a	Big city, Suburban	3,900 people from four U.S. cities chosen to be test cities for the FTA's Individualized Marketing Demonstration Program.	Trips per person per year	• "With the Individualized Marketing Intervention, car (as driver) trips decreased by 5%, while the car (as passenger) mode increased by 6%. Car (as driver) trips were replaced by environmentally friendly modes -- walking increased by 20%, bicycling by 25%, and transitation by 25%, representing statistically significant changes" (pg. 12). • "All activities showed increases [in environmentally friendly modes] however the biggest ones were connected with leisure activities 41% (from 22 to 31) and other activities 62% (from 13 to 21)" (pg. 14).
Brownson et al. (2000)	Ped	Infra.	Peer rev.	Cross-sec.	Rural	Population based sample of 1269 residents >18 years in 12 rural counties in Missouri surveyed via telephone from April-December 1998.	Walking behaviour in past month	• "Although not statistically different, persons who were not regular walkers (57.7%) were more likely to report increased activity due to trail use than were regular walkers (47.5%). This suggests that a "ceiling" effect may exist in which regular walkers may be using the trails to maintain but not increase an already adequate level of walking activity" (pg. 240).
Brownson et al. (2004)	Ped	Prog.	Peer rev.	Q-exp.	Rural	Six intervention communities in the Missouri 'bootheel' region and six comparison communities in Arkansas and Tennessee. Interventions included newsletters, counselling, and events 'such as fun walks' (p.837).	Walking trail use; Total minutes walked in the past week; Total minutes walked for exercise	• "Among persons who used trails at baseline (16.9% of the total population), 32.1% reported increases in physical activity since they began using the trail. From community-wide samples, two subgroups indicated a positive net change in rates of 7-day total walking: people with high school degrees or less and people living in households with annual incomes of <= $20,000. However, no studied group showed a statistically significant net intervention effect" (pg. 28).
Brownson et al. (2005)	Ped	Prog.	Peer rev.	Q-exp.	Rural	Six intervention communities in the Missouri Ozark region and six comparison communities in Arkansas and Tennessee. Data collection occurred between 2002 and 2004.	Minutes walked per week; Moderate physical activity in past week	• "At follow-up, the percentage of respondents who met the recommendation for walking was the same across the intervention and comparison areas. Among the dependent variables, walking showed some evidence of a positive linear trend across dose categories. After adjusting for covariates and baseline rates, intervention participants in the moderate and high dose categories were about three times more likely to meet recommended guidelines for walking" (pg. 837).
Byrd and Sisiopiku (2006)	Ped	Model	Conf. p.	Lit. rev.	Not specified	Geometric and traffic control data from two intersections in Birmingham, Alabama on January 5, and March 2, 2005.	Level of service (LOS)	• "The results show that all study sidewalks operate under acceptable conditions. However, the selection of the assessment method appears to have a major impact on the LOS value obtained" (pg. 9). • "Among the methods studied, the HCM 2000 method consistently provided the highest LOS estimates, whereas the trip quality method resulted in the lowest LOS ratings" (pg. 9).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Cao et al. (2006a)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city	1,368 respondents to a 1995 survey conducted in six neighbourhoods in Austin, TX.	Frequencies of strolling and walking to the store in the last 30 days	• "Findings suggest that although residential self-selection impacts both types of trips, it is the most important factor explaining walking to a destination, i.e. for shopping" (pg. 1). • "Distance to the nearest store is highly significant in predicting frequency of walking to the store, consistent with the findings of others" (pg. 16).
Cao et al. (2006b)	Both	Comm. des.	Conf. p.	Cross-sec.	Not specified	688 "movers" and 994 "nonmovers" from eight neighbourhoods in Northern California filled out a twelve-page survey in late 2003.	Frequencies of home-based nonwork trip by auto, walking/ biking, and transit	• "We found that having mixed land uses tends to discourage auto travel and facilitate the use of transit and non-motorized modes; the availability of transit service and walking/biking infrastructures are important predictors for transit and non-motorized travel; and walking/biking behaviour is also affected by the aesthetic quality and social context of the built environment. All these associations are present even after a accounting for the influences of residential preferences and travel attitudes" (pg. 12).
Cao et al. (2007a)	Both	Comm. des.	Conf. p.	Quasi-Longit.	Not specified	Data collected from 547 movers in 8 neighbourhoods in Northern California.	Changes in travel modes (walk, drive, etc.) before move	• "After controlling for socio-demographics and attitudes, various measurements for changes in the built environment - attractiveness, safety, physical activity options, and socializing - have positive influences on changes in walking" (pg. 19). • "Further, the current number of business types within 400 meters is positively associated with changes in walking" (pg. 20).
Cao et al. (2007b)	Both	Comm. des.	Conf. p.	Lit. rev.	Not specified	28 empirical studies.	Travel walking	• "Virtually all of the 28 empirical studies reviewed found a statistically significant influence of the built environment remaining after self-selection was accounted for" (pg. 1).
Carnegie et al. (2002)	Ped	Comm. des.	Peer rev.	Cross-sec.	Not specified	1,200 adults aged 40-60 years from the Illawarra region of New South Wales, Australia were surveyed in 1995	Average minutes walked per week; average kcal per week	• "Those who did little walking (20 min or less per week) reported more negative perceptions of their aesthetic environment than those who reported walking for between 20 min and 2 hr and those who reported walking for more than 2 hr" (pg. 151).
CDC (2002)	Both	Comm. des.	Report r.a.	Cross-sec.	Not specified	611 respondents to the 1999 HealthStyles Survey answered questions about their child's trips to school.	At least one walk or cycle trip to school/ week during the previous month (binary)	• "Children whose parents reported no barriers to them walking or biking to school were six times more likely to use nonmotorized means to get to school 'than the rest of their peers aged 5-18 years with one or more barriers'" (pg. 702).
CDC (2005)	Ped	Mode Choice	Report r.a.	Cross-sec.	Not specified	1,588 respondents to the 2004 ConsumerStyles survey answered questions about their child's trips to school.	Walk trips to school per week during the previous month	• "The most commonly reported barrier [to walking or bicycling to school] was distance to school (61.5%), followed by traffic-related danger (30.%), the weather (18.6). Fifteen percent of parents cited another barrier, "11.7% reported crime as a barrier, and 6.0% reported school policy as a barrier" (pg. 1).
Cerin et al. (2007)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city	Physical Activity in Localities and Community Environments (PLACE) study in Adelaide, Australia. 2,650 participants were recruited from 32 neighbourhoods. Response rate 11.5%.	Weekly minutes of walking for transport; monthly frequency of walking to specified destinations	• "Workplace proximity was the most significant contributor to transport-related walking, especially among women" (pg. 713). • "No significant relationships were found between walking and proximity of home/ car commercial destinations, schools, bus/train stops, beach/river, and recreational destinations" (pg. 718).
Cervero (2001)	Ped	Comm. des.	Peer rev.	Cross-sec.	Not specified	Bay Area Rapid Transit (BART) passenger survey from 1992 of 35,000 passengers. 1994 Household Travel Survey compiled by Metropolitan Washington Council of Government (MWCOG) region with trip records for 177 Montgomery County residents.	Percentage of access trips to and from BART stations by walking	• "The share of BART access trips by foot increased sharply with densities (especially residential densities) and mixed-land uses around stations and fell as substitutes to walking (i.e., lots of parking and good transit connections) were more plentiful" (pg. 6). • "The results suggest that BART stations situated in freeway medians averaged around 7 percent fewer egress trips by foot, controlling for densities and other factors. This finding buttresses the argument that quality of walking environment matters" (pg. 9). • "In contrast to the aggregate analysis from the Bay Area, densities at either trip end [in Washington DC] exerted no discernible influences on the likelihood of walking-and-riding in the disaggregate analyses" (pg. 17).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Cervero and Duncan (2003)	Both	Comm. des.	Peer rev.	Cross-sec.	Big city, Suburban	2000 Bay Area Travel Survey (BATS) which has data for members of 15,066 randomly selected households in the 9 county San Francisco Bay Area.	Non-work trip mode choice	• "Even after controlling for a socioeconomic factor like vehicle ownership levels, African Americans were more likely to walk than were Whites or Asian Americans" (pg. 1481). • "The only built environment factor significant at the 5% probability level was land-use diversity at the trip origin" (pg. 1481). • "Although well-connected streets, small city blocks, mixed land uses, and close proximity to retail activities were shown to induce nonmotorized transport, various exogenous factors, such as topography, darkness and rainfall, had far stronger influences" (pg. 1482).
Cervero and Gorham (1995)	Both	Comm. des.	Peer rev.	Q-exp.	Big city, Suburban	Matched pair analyses of transit- and auto-oriented neighbourhoods in San Francisco, CA (7) and Los Angeles-Orange County, CA (6).	Pedestrian and bicycle modal shares; Trip generation rates	• Bay Area Results: "Controlling for income and, to the extent possible, transit service levels, Transit neighbourhoods average far less solo commuting than do nearby Auto neighbourhoods" (pg. 7). • LA results: "With the exception of LaVerne, Transit neighbourhoods had the higher walking rates and the lower drive-alone rates for work trips, in terms of both the modal-share and trip-generation variables. However, impacts on transit commuting were less straightforward" (pg. 7).
Cervero and Kockelman (1997)	Both	Comm. des.	Peer rev.	Cross-sec.	Big city, Suburban	1990-1991 BATS survey for 50 sampled neighbourhoods in the San Francisco Bay Area.	Daily personal VMT; Mode choice per trip	• "The research finds that density, land-use diversity, and pedestrian-oriented designs generally reduce trip rates and encourage non-auto travel in statistically significant ways, though their influences appear to be fairly marginal" (pg. 199). • "Compact development was found to exert the strongest influence on personal business trips" (pg. 199).
Cervero and Radisch (1996)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city, Suburban	8,000 questionnaires on non-work travel were sent to households in 12 Census tracts in the Rockridge and Layfayette areas of the San Francisco Bay Area in the spring of 1994; 1,420 were returned.	Commute mode share; Mode choice for non-work home-based trips	• "Rockridge residents averaged around a 10 percentage point higher share of non-work trips by non-automobile modes than did residents of Lafayette... The greatest differences were for shop trips under one mile" (pg. 127). • "Modal splits were more similar for work trips, confirming the proposition that neighbourhood design practices exert their greatest influence on local shopping trips and other non-work purposes. For work trips, compact, mixed-use, and pedestrian-oriented development appears to have the strongest effect on access trips to rail stations, in particular inducing higher shares of access trips by foot and bicycle" (pg. 127).
Chen et al. (1998)	Ped	Prog.	Peer rev.	R.C. trial	Not specified	125 women aged 23-54 years were randomly assigned to one of two interventions: print materials plus six counselling sessions vs. print materials and one brief phone call.	Self-reported minutes walked per week; Informant-reported minutes walked per week; Total physical activity (subset of participants)	• "Both groups reported significantly increased walking at a 2-month posttest (M change = 86 and 81 min per week for behavioural and educational groups, respectively) and 5-month follow-up (M change = 40 and 52 min per week). A 30-month follow-up of 50 participants indicated both groups continued to report more walking than at baseline" (pg. 20).
Clarke et al. (2007)	Ped	Prog.	Peer rev.	R.C. trial	Not specified	93 intervention women, and 31 comparison women were recruited. All participants were low income mothers aged 18 - 45 years: interventions included eight weekly classes including information, interaction, menu planning, and 30 mins of exercise per class.	Motivational readiness to exercise; Exercise self-efficacy; Pedometer steps; Weight loss	• "Mothers enhanced their motivational readiness to exercise, exercise self-efficacy, pedometer steps, and pedometer kilocalories. Reductions in body weight, percent body fat, and waist circumference also were observed. Significant correlations were found between exercise self-efficacy and exercise readiness ($r=0.28$, $P<0.01$), pedometer steps ($r=0.30$, $P<0.01$), and pedometer kilocalories ($r=0.28$, $P<0.05$)" (pg. 962).
Clayden et al. (2006)	Ped	Infra.	Peer rev.	Cross-sec.	Not specified	91 surveys from residents of Northmoor and Kennington in England were completed. Two Sheffield case studies are also discussed.	Perception of safety	• Safety: 50% of respondents from Northmoor felt safer after construction compared to before. While in Kennington, there was no evidence of an improvement in perceptions of safety (pg. 64). • "Kennington [as compared to Northmoor] was not able to attract funding for complimentary initiatives and was not therefore subject to the same co-coordinated approach to tackling social issues" (pg. 68).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Clifton and Livi (2005)	Ped	Comm. des.	Conf. p.	Cross-sec.	Suburban, Big city	Door-to-door survey of 274 men and 384 women in three Maryland communities (College Park, Bel Air, and Turner Station) from 2003 to 2004; response rate by neighbourhood ranged from 36-74%.	Total distance walked per day; Number of days walked per week	• "Destinations such as churches and stores were also accessed more on foot by women" (pg. 83). • "When asked if improvements to the environment would change their walking behaviour, women were less likely to respond in the negative...This finding suggests that women are more aware of and more strongly influenced by their environment than men are" (pg. 83). • "Walking as a means of transport and walking for relaxation were significant and positive for women but not for men in both models" (pg. 84).
Coates (1999)	Bicycle	Infra	Conf. p.	Longit.	Big city	Cycle accidents from 1979 to 1992 in Oxford, England at various sites.	Junction accidents	• "The numbers of junction accidents have increased at virtually all sites of the phase 1 lanes and at all but two of the phase 2 sites. It would therefore appear that introducing cycle lanes but not marking them across junctions could increase cycle accidents at junctions" (pg. 219). • In April 1992, cycle lanes through a number of junctions were marked and painted a light brown colour. "The introduction of cycle lane markings across junctions in 1992 has been successful in reducing accidents at these sites" (pg. 220).
Coogen et al. (2007)	Ped	Comm. des.	Peer rev.	Cross-sec.	Metro area	865 adults who had recently made or were contemplating making a residential move in 11 U.S. Metropolitan areas. 81% of the sample were white and 69% had a college degree.	Self-reported walk mode share for nine trip purposes	• "All three variables were associated with walking, and all three variables interacted. The standardized coefficients were 0.23 for neighbourhood form, 0.21 for autos per person, and 0.18 for personal values" (pg. 363). • "Participants in households with less than one car per adult have a walk mode share of 19%; those from households with at least one car per adult have a walk share of 8%" (pg. 365).
Cooper (2007)	Both	Prog.	Conf. p.	Longit.	Big city	Travel diaries of participants in IndiMark social marketing intervention—primarily involving highly personalised information. Telephone survey of Madison-Miller neighbourhood in King County, WA; survey of awareness in general population.	Self-reported mode share	• "The pre- and post-participant reported mode shares for each In Motion program indicate a 24 to over 50% decrease in driving alone, and a 20 to almost 50% increase in transit usage. These self-reported numbers are supported by bus stop counts and analysis of overall transit ridership" (pg. 1).
Dannenberg et al. (2005)	Ped	Infra.	Peer rev.	Audit	Campus	Walkability was evaluated on seven agency campuses in the headquarter city of the Federal agency. Three other agency campuses were also audited.	Walking route segment assessments	• "Of 79 walking route segments surveyed on 10 agency campuses, 34% were rated poor, 32% fair, and 34% good. Repeat assessment of 20 walking route segments by three independent observers yielded similar scores" (pg. 39).
Day (2006)	Both	Comm. des.	Peer rev.	Lit. rev.	Not specified	n/a	Physical activity	• "It may be that for low-income Black and Latino populations, extra gains in physical activity for travel and work are insufficient to offset reduced levels of participation in recreational physical activity and other risk factors for overweight and obesity" (pg. 92).
Day et al. (2007)	Ped	Infra.	Peer rev.	B-and-a	Big city	163 and 129 adults, before and after respectively, participated in the before-and-after survey on Minnie Street in Santa Ana, CA.	Reported walking to grocery store; Observed pedestrian counts	• Vehicle speeds and counts declined significantly from before to after observations (pg. 322). • The number of pedestrians on Minnie Street and perceptions of safety from crime both declined after renovation. • Respondents "reported that they walked to the grocery store more often (P<.001), compared to respondents in before surveys" (pg. 323).
De Bourdeaudhuij et al. (2003)	Both	Comm. des.	Peer rev.	Cross-sec.	Big city, Suburban, Rural	Random sample of 1,000 adults in Ghent, Belgium received a seven-page mailed questionnaire. 521 adults responded.	Minutes of sitting, walking, moderate-intensity, and vigorous-intensity activities per week	• "Minutes of walking and of moderate-intensity activity were related to quality of sidewalks and accessibility of shopping and transitation" (pg. 83). • "Other environmental variables expected to be related to walking or moderate activity were not, such as residential density, availability of bike lanes, neighbourhood aesthetics, perceived safety from crime and traffic, and street connectivity" (pg. 90).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
DeMaio and Gifford (2004)	Bicycle	Prog.	Peer rev.	Best prac.	Not specified	n/a	Success of bicycle sharing programs	• "Factors critical to success include: customer demand; bike facilities and safety; profitability; theft and vandalism; and multimodal connectivity" (pg. 5). • "No smart bike program has made a profit to date" (pg. 9).
Dept. of Transport (2005)	Both	Prog.	Report	Lit. rev.	Not specified	Seven residential programs, six workplace programs and two school-based programs. Interventions were varied and included individualised marketing and TravelSmart.	Success of personalised travel planning	• "The pilots that targeted residential populations were consistently the most effective at reducing car kilometers and increasing use of sustainable modes of transport…The effectiveness of the residential pilots appeared to be largely due to well chosen target populations, sizeable intervention groups, and well orchestrated individualised marketing and personalised travel planning" (pg. 3).
DiDonato et al. (2002)	Bicycle	Prog.	Report	Case st.	Big city	n/a	Bicycle availability in shared bike programs	• "The bikes are most often used instead of walking or other forms of transitation, neither of which significantly add to automobile congestion inside a city" (pg. 5). • Necessary features of a smart-bike program include: Dual locking system; Per-minute charge; Booking service; Ability to accept bank cards; Comfortable bikes; Ability to personally lock bikes; Durability.
Dill (2004)	Both	Comm. des.	Conf. p.	Cross-sec.	Suburban	210 people completed surveys from Fairview Village near Portland, OR and two control developments in May 2003.	Total weekly VMT; Walk trips during 7-day period	• "residents in Fairview Village drove significantly fewer miles in private vehicles. Some of this difference is explained by lower vehicle ownership rates and smaller households. The adults in Fairview Village also made significantly fewer vehicle trips and more walking and bicycling trips during the week before the survey" (pg. 1).
Dill and Carr (2003)	Bicycle	Infra.	Peer rev.	Cross-sec.	Metro area	Primary data source was the Census 2000 Supplemental Survey (C2SS).	Percentage of workers commuting by bicycle	• "The most significant variable in the model is the infrastructure variable--miles of Class II lanes per square mile--which is positively associated with bicycle commuting. The results also indicate that vehicle ownership and the number of days of rain are negatively related to bicycle commuting, as expected" (pg. 120). • The model is stronger using just Class II bikeways per square mile (as opposed to Class II and Class I). "This indicates that Class I facilities (separated bike paths) are not as strongly associated with commuting as are Class II facilities." (pg. 121.)
Dill and Voros (2007)	Bicycle	Comm. des.	Conf. p.	Cross-sec.	Metro area	November 2005 phone survey of 566 adults in the Portland metro area.	Cyclist status (non, irregular, regular); Utilitarian cyclist (binary)	• "Objective measures of proximity to off-street trails and bike lanes was not associated with higher levels of cycling. However, positive perceptions of the availability of bike lanes was associated with more cycling and the desire to cycle more. Higher levels of street connectivity were associated with more cycling for utilitarian trips" (pg. 2).
Dinger et al. (2005)	Ped	Prog.	Peer rev.	Pre-Post	Not specified	36 adult women associated with the University of Oklahoma aged 25 to 54 years in Norman, OK September-November 2003. Interventions included brochures, pedometers, and emails.	Time spent walking; use of the 10 processes of change; self-efficacy	• "Participants significantly increased their total walking minutes ($p = .001$) and use of counterconditioning, dramatic relief reinforcement management, self-liberation, stimulus control, and social liberation ($p < .05$)" (pg. 2). • "Participants significantly increased the number of minutes they spent walking while at work, for transportation, and during leisure time" (pg. 5).
Doolittle and Porter (1994)	Bicycle	Prog.	Report	Lit. rev. and Case st.	Not specified	Information was collected from over 20 transit agencies, supplemented by site visits and a literature review.	n/a	• "Market research and promotional activities are very important for introducing a new service...Comprehensive regulations, user and staff training, and regular enforcement promote safety and serve to protect the agency from lawsuits claiming negligence" (pg. 33).
Douglas and Evans (1997)	Both	Comm. des.	Conf. p.	Cross-sec.	Big city, Suburban	Approximately 3000 employees from four different employment centres in the Washington DC metro area recorded travel patterns in a one-day diary.	Commute travel mode; Midday trips per employee	• For midday trips: "Employees in the suburban office/research park generate nearly 15 times the VMT per employee as those in the downtown CBD while making less than 65% as many trips" (pg. 302).
Dumbaugh and Frank (2007)	Both	Infra.	Conf. p.	Lit. rev.	Not Specified	n/a	Traffic safety of safe routes to school	• "Despite the potential benefits many of the countermeasures are perceived to have, these benefits are largely presumed rather than known, and in two cases (motorist education programs and marked crosswalks at unsignalised locations), they were found to have no effect, or even a negative effect, on pedestrian safety" (pg. 12). • "Of the strategies reviewed, only sidewalks and raised medians were demonstrably shown to reduce the incidence of pedestrian crashes" (pg. 12). However strategies to lower speeds decrease severity of accidents.

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Evenson et al. (2003)	Both	Mode Choice	Peer rev.	Cross-sec.	Not Specified	Students in 6th-8th grades (N=2151) and 9th-12th grades (N=2297) in 60 middle schools and 62 high schools in North Carolina during the spring of 2001.	Travel mode to school	• "Among middle school students, 9.4% usually walked to school and 4.1% usually bicycled to school at least 1 day per week. Among high school students, 4.9% usually walked to school and 2.8% usually bicycled to school at least 1 day per week." (pg. 887).
Evenson et al. (2005)	Both	Infra.	Peer rev.	Q-exp.	Not Specified	366 adults living within two miles of the evaluated trail in Durham, North Carolina were interviewed via telephone before and after construction of the trail from July 2000-April 2001 and again in November 2002.	Change in time spent in leisure activity; Leisure activity near home; Moderate and vigorous activity; Walking; Walking for transportation	• "At follow-up, of the 366 adults living within 2 miles of the trail, 11.0% had not heard of the trail, and 23.1% had heard of the trail and had used it at least once. In multivariate logistic models, leisure activity, leisure activity near home, moderate activity, vigorous activity, and walking for transportation did not significantly change for those who used the trail compared to those not using the trail" (pg. 177).
Ewing (2005)	Ped	Comm. des.	Peer rev.	Lit. rev.	Not Specified	n/a	Travel walking, total physical activity	• "There is relatively strong evidence of association between metropolitan development patterns and use of active travel modes such as walking and transit, and between neighbourhood design and active travel choices" (pg. 75).
Ewing et al. (2004)	Both	Infra.	Conf. p.	Cross-sec.	City	15,980 trips were recorded by two travel diary surveys conducted in Gainesville, FL in 2000 and 2001. This paper focuses on 709 K-12 school trips.	Mode choice to school	• "Students with shorter walk or bike times to school proved significantly more likely to walk or bike" (pg. 1). • "Students travelling through areas with sidewalks on main roads were also more likely to walk" (pg. 1). • "Land use variables such as density and mix also were not significant" (pg. 1).
Fallon et al. (2004)	Both	Pricing	Peer rev.	Cross-sec.	Metro area	732 questionnaires from adults in the metropolitan areas of Auckland, Wellington and Christchurch, New Zealand.	Stated mode preference	• "In all three cities, the primary alternative mode chosen was walk and catch transit. Beyond this, however, there was no consistent pattern of mode choice, reflecting the differing nature of the alternatives to car driving available in the three cities" (pg. 21). • Employer practices, such as free parking, employee owned vehicles, etc. significantly constrain mode choice changes in drivers (pg. 28).
FHWA (1992a)	Both	Infra.	Report r.a.	Lit. rev.	Not Specified	n/a	Cycling and walking for travel	• Recommendations: -- "Focus should be on creating a linked network of bicycle facilities so that access to all areas of a city are enhanced" (pg. 85). • "More bike lanes and wide curb lanes along arterials are the preferred investment strategy for raising the level of bicycle commuting in the short term: they should be a standard feature for all new roads and be a required component of roadway rehabilitation" (pg. 85).
FHWA (1992b)	Both	Prog.	Report r.a.	Case st.	Big city	Portland, OR.	Cycling and walking for travel	• Strategies of bicycling and walking promotion: build network of paths; create auto-free areas; provide secure parking; provide showers and changing rooms; design safe and pleasant facilities; use signs and pavement markings; give incentives; increase enforcement; educate and inform; integrate with transportation, land-use and environmental planning; and fund long-term programs (pg. ii).
FHWA (1992e)	Both	Prog.	Report r.a.	Case st.	Not Specified	Examples in Asia, Australia, and New Zealand.	Cycling and walking for travel	• Key strategies include: Intermodal cycle-and-ride systems; traffic calming; pedestrian and bicycle priority areas; pedestrian and bicycle supportive land use planning; commuter subsidies and pricing; bicycle helmet encouragement laws.
FHWA (1992d)	Both	Infra.	Report r.a.	Lit. rev. and Case st.	Not Specified	Transit linkages.	Cycling and walking for travel	• Recommendations include: Need for a clearinghouse of information; development guidelines for nonmotorized transit access development; additional research and pilot projects.
FHWA (1993a)	Both	Prog.	Report r.a.	Lit. rev. and Case st.	Not Specified	Various cities and states in Canada and the US.	Cycling and walking for travel	• Common elements of successful bicycle/ped programs include: full-time cycle and ped staff positions; citizen advocates and support, advisory committees; and the importance of integrating bicycling and walking programs into the everyday operations of Government.

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Fitzpatrick et al. (2006)	Ped	Infra.	Report r.a.	Cross-sec.	Not Specified	Multiple surveys were conducted: focus groups, phone meetings, on-site interviews, on-street interviews. Field data was collected at 42 study sites in seven different states.	Motorist yielding; Pedestrian crossing behaviour	• Recommendations: "3.5 ft/s walking speed for the general population; and If older pedestrians are a concern, use a 3.0 ft/s walking speed" (pg. 46). • Motorist yielding: "Red signal or beacon treatments consistently perform well, with compliance rates above 94 percent...pedestrian crossing flags and in-street crossing signs also were effective in prompting motorist yielding, achieving 65 and 87 percent compliance, respectively" (pg. 48). • "Median refuge islands were the only treatment with statistically different compliance values based on the number of lanes" (pg. 49).
Forsyth et al. (2007b)	Ped	Comm. des.	Peer rev.	Cross.-sec.	Metro area	715 people from 36 focus areas in the Twin Cities metropolitan area participated in the Twin Cities Walking Study.	MET min/week of total PA, leisure walking, transport walking; Total walking miles/week, Mean/ median accelerometer counts	• Higher density places had more travel walking; lower density more leisure walking: "density is associated with the purpose of walking (travel, leisure) but not the amount of overall walking or overall physical activity, although there are sub-group differences by race/ethnicity" (pg. 679).
Forsyth et al. (2008)	Ped	Comm. des.	Peer rev.	Cross.-sec.	Metro area	715 people from 36 focus areas in the Twin Cities metropolitan area participated in the Twin Cities Walking Study.	MET min/week of total PA, leisure walking, transport walking; Total walking miles/week, Mean/ median accelerometer counts/day	• "Travel walking measured both by survey and diary was positively correlated with social land uses, sidewalks, transit, litter/graffiti, and connected street patterns. Leisure walking was negatively correlated with some of the same features: transit, sidewalks, street lights, connected street patterns, social land uses, as well as tax exempt land uses" (P.9). • "This study looked at many measures of design and destinations at many geographies and there were no strong positive correlations between the built environment measures and overall physical activity" [PA] (pg. 18).
Foster et al. (2004)	Ped	Comm. des.	Peer rev.	Cross-sec.	Not Specified	A national sample of 4,265 English adults aged 16-74 years, surveyed in 1996.	Any reported walking in past 4 weeks; Reported walking >=150 min/week in past 4 weeks	• "In women, perceived safety of walking during the day, and no shop within walking distance were associated with any reported walking occasions. Perceptions of the environment were not related to women walking >= 150 mm/week. In men, having a park within walking distance was associated with walking >=150 mm/week (OR = 2.22; 95% CI: 1.18 to 4.35). No other significant associations were found" (pg. 924).
Frank and Pivo (1994)	Ped	Comm. des.	Peer rev.	Cross-sec.	Metro area	Puget Sound Transportation Panel data from 1989, with approximately 28,955 valid trips by 1,680 households.	Work trips by SOV, transit, and walking	• "Population density had the greatest effect on walking trips for both work and shopping. Employment density was found to be significantly related to SOV use, transit use, and walking trips for both work and shopping. Mixing of uses had the weakest relationship with mode choice, having the greatest effect on walking for work trips" (pg. 50). • "A significant decrease in SOV travel occurs at relatively low densities (between 20 and 50 employees per acre)" (pg. 51).
Frank et al. (2005)	Ped	Comm. des.	Peer rev.	Cross-sec.	Metro area	357 adults aged 20-70 years were recruited as part of the SMARTRAQ study between 2001 and 2003 in the 13-county Atlanta Metropolitan Area.	Moderate-intensity physical activity min/ day	• "Measures of land-use mix, residential density, and intersection density were positively related with number of minutes of moderate physical activity per day. A combined walkability index of these urban form factors was significant (p =0.002) and explained additional variation in the number of minutes of moderate activity per day over sociodemographic covariates" (pg. 117).
Frank et al. (2006)	Both	Comm. des.	Peer rev.	Cross-sec.	Metro area	Data was collected in 2002-2003 from approximately 75 adults aged 20-65 years in each of the 16 neighbourhoods in King Co., WA (1,228 adults total).	Weekly minutes of active transportation (walking/biking); BMI	• "We found a 5% increase in walkability to be associated with a per capita 32.1% increase in time spent in physically active travel, a 0.23-point reduction in body mass index, 6.5% fewer vehicle miles travelled, 5.6% fewer grams of oxides of nitrogen (NOx) emitted, and 5.5% fewer grams of volatile organic compounds (VOC) emitted" (pg. 75). • "Walkability is a better predictor of active transportation than of overall physical activity" (pg. 85).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Frank et al. (2007)	Ped	Comm. des.	Peer rev.	Cross-sec.	Metro area	2,161 participants aged 5-20 years completed two day travel diaries in the Atlanta, GA region.	At least one walk trip over 2 days (binary); Walked at least 0.5 mile/day (binary)	• "In the analysis of the full sample, number of cars, recreation space, and residential density were most strongly related to walking" (pg. 305).
Fulton et al. (2005)	Both	Comm. des.	Peer rev.	Cross-sec.	Not Specified	1,458 parent-child pairs (with children aged 4-12 years) were surveyed by telephone nationwide in 1996.	Active transportation mode to school	• "14% of children and adolescents reported ATS [active transportation to school]. ATS was more frequent among boys (16.6%) than girls (11.1%), and among children in lower than upper grades" (pg. 353). • "Hispanic race/ethnicity, living with one parent, and perceiving a safe neighbourhood were associated with ATS in the unadjusted but not the adjusted logistic model" (pg. 353).
Gårder et al. (1994)	Bicycle	Infra.	Peer rev.	Lit. rev.	Not Specified	n/a	Safety for cyclists at signalised intersections	• "The conclusion that can be drawn so far from combining results shows that the most likely effect of introducing a cycle path is that the risk will increase by about 40% for a passing cyclist" (pg. 429).
Gårder et al. (1998)	Bicycle	Infra.	Peer rev.	B-and-a	Big city	13 bicycle experts filled out surveys. 44 intersections in Gothenburg, Sweden were studied, with crash data from 1988 to 1996. Interventions occurred in 1993.	Motor vehicle speeds; Bicycle/vehicle accidents	• "The results show that the paths with raised crossings attracted more than 50% more bicyclists and that the safety per bicyclist was improved by approximately 20% due to the increase in bicycle flow, and with an additional 10% to 50% due to the improved layout. However, the increased bicyclist volume means that the total number of bicycle accidents is expected to increase...Using a Bayesian approach for combining the results shows that the most likely effect of raising the bicycle crossing is a risk reduction of around 30%, compared with the before situation with a conventional bicycle crossing" (pg. 64).
Giles-Corti and Donovan (2003)	Ped	Comm. des.	Peer rev.	Cross-sec.	Metro area	1,803 adults aged 18-59 years in metropolitan Perth, Australia were interviewed in their homes using a 255-item survey (1995-1996).	Walking at recommended levels	• "In the 2 weeks preceding the survey, 72.1% of respondents had walked for transport, and 68.5% had walked for recreation. However, only 17.2% did a sufficient amount of walking to be classified as walking at recommended levels" (pg. 1585). • "Of those who engaged in a combination of activities, 78.2% achieved recommended levels of physical activity, as compared with 13.6% of those who walked for transport only and 31.7% of those who walked for recreation only" (pg. 1585).
Giles-Corti et al. (2005)	Ped	Comm. des.	Peer rev.	Cross-sec.	Metro area	516 public open spaces (POS) in metropolitan Perth, Australia (1995-1996). 1,803 adults aged 18-59 years in metropolitan Perth, Australia were interviewed.	Use of open space in previous 2 weeks; sufficient PA; walking as recommended; six or more walking sessions/week	• "Overall, 28.8% of respondents reported using POS for physical activity. The likelihood of using POS increased with increasing levels of access, but the effect was greater in the model that adjusted for distance, attractiveness, and size" (pg. 169).
Gill (2006)	Ped	Infra.	Peer rev.	Discu-ssion	Not Specified	Cases from the United Kingdom.	Home zone evolution	• "Five out of the seven TRL evaluations suggest a positive impact on play opportunities and independent mobility of children and young people" (pg. 98).
Gomez et al. (2004)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city	177 Mexican-American 7th graders enrolled in Project Physical Activity Changes in Teenagers (PACT) in San Antonio, TX.	Outdoor physical activity away from school in bouts per week	• "Multiple regression analysis showed that distance to nearest open play space was inversely and significantly associated with boys' OPA, while density of violent crime within 1/2 mi of home was inversely and significantly associated with girls' OPA. Girls' perceptions that their neighbourhood was safe for physical activity were also associated with higher levels of OPA, while boys' assessments of neighbourhood safety were not significantly related to OPA" (pg. 876).
Gomez et al. (2005)	Both	Mode Choice	Peer rev.	Cross-sec.	Metro area	1,464 adults aged 18-29 years from two locations in metropolitan Bogota, Columbia were surveyed in 2002.	Frequency of bicycling and walking as means of transport in last 7 days for 10 minutes or more	• "16.7% reported bicycling for at least 10 min during the last week and 71.7% reported walking for at least 90 min during the last week" (pg. 445). • "Approximately 1 out of 6 young adults reported using the bicycle for transport and two out of three young adults reported walking specifically for transport" (pg. 455). • The authors found a "positive association between utilitarian physical activity with leisure physical activity" (pg. 456).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Goulias et al. (2002)	Both	Prog.	Peer rev.	Cross-sec.	Metro area	1,831 households participated in the study (998 in before group, 621 in after group, and 212 in control group). Intervention included individualised marketing.	Mode choice	• "The IndiMark intervention appears to be a very good soft policy action in decreasing car driving. Every method used to assess its effect...indicates significant differences in the number of trips by car as driver for the group receiving information. In parallel, a significant increase is observed in the use of nonmotorized modes (mainly walking) and smaller increases in transitation and bicycle use" (pg. 85).
Guo et al. (2007)	Both	Comm. des.	Conf. p.	Cross-sec.	Metro area	19,437 individuals from the San Francisco Bay Area who participated in the 2000 BATS, had travelled information analysed covering a two-day period.	Person trips by purpose and by mode (home-based: maintenance and discretionary trips)	• "few built environment factors lead to the substitution of motorized mode use by non-motorized mode use. Rather, factors such as increased bike way density and street network connectivity have the potential of promoting more non-motorized travel to supplement individuals' existing motorized trips" (pg. 1). • "Rain and temperature also show no statistically significant association with maintenance trip rates by motorized and non-motorized modes" (pg. 14).
Guttenplan et al. (2001)	Ped	Model	Peer rev.	B. observ.	Not Specified	1,315 real-time observations of pedestrians were collected.	Pedestrian ratings of safety/comfort	• "recommends that the arterial be viewed as a transportation facility that serves all those modes and that an arterial analysis should involve calculation of the LOS of each of the modes" (pg. 158).
Hagelin (2007)	Bicycle	Infra.	Conf. p.	Cross-sec.	Not Specified	14 transit agencies participated in the survey. 220 users from three Florida jurisdictions completed surveys as well.	"Bike-to-bus" programs	• Of the 220 respondents to the Bicycles-on-Bus user survey almost one in four indicated that they were new transit riders or had only used transit a few times in their lifetime. Of those new users, approximately 80 percent indicated that the ability to integrate bicycling and transit was the reason for the mode switch.
Haines et al. (2007)	Ped	Prog.	Peer rev.	Pre-post	Not Specified	125 faculty/staff from mid-western college were involved in the study from June-October 2004. Intervention included pedometer and email messages.	Mean steps recorded; BMI; Hypertension status; Blood glucose	• "The authors observed differences between baseline and follow-up in BMI ($p = .024$), blood glucose ($p = .06$), and total cholesterol ($p = .09$). The program had a moderate effect on fitness, mood, health awareness, nutrition, and health" (pg. 219).
Hallett et al. (2006)	Bicycle	Infra.	Report	B. observ.	Big city	Behavioural observations of motorists passing cyclists were recorded for 60 half-hour segments, total, from 24 sites in three Texas cities.	Lateral position of the bicyclist; change in lateral position of the motorist; encroachment	• "The only variables found to have a statistically reliable effect on the lateral position of the bicyclist were the presence of residential development, whether cyclist was a casual recreationalist, the presence of a bike lane, and the width of the bike lane, if present" (pg. 23). • "In the case of the motorist, the change in lateral position and probability of an encroachment is much higher on a roadway without a bike lane, even when total outside width is held constant" (pg. 26).
Ham et al. (2005)	Ped	Mode Choice	Peer rev.	Cross-sec.	Not specified	Data from the 1995 Nationwide Personal Transportation Survey and the 2001 National Household Travel Survey.	Mode choice	• "Of trips of 1 mile or less, adults reported more walking in 2001 (21.2%) than in 1995 (16.7%). For trips to school of 1 mile or less, youths also increased walking from 1995 (31.3%) to 2001 (35.9)" (pg. 1). Nevertheless, both groups fell short of meeting the Healthy People 2010 walking goals.
Handy (1996a)	Both	Comm. des.	Peer rev.	Cross-sec.	Metro area	Metropolitan Transportation Commission's (MTC) database with travel data from MTC's 1981 travel survey of 7,235 Bay Area households.	Average person kilometers travelled	• "The results show that higher levels of both local and regional accessibility are associated with lower average shopping distances but are not associated with differences in shopping frequency. As a result, higher levels of both local and regional accessibility are associated with less total shopping travel" (pg. 58). • "The effect of each type of accessibility [regional and local] was most significant in those communities in which the other type of accessibility was low" (pg. 66).
Handy et al. (2006)	Both	Comm. des.	Peer rev.	Quasi-Longit.	Not Specified	A survey was sent to 6,746 movers and nonmovers in 8 neighbourhoods in Northern California in 2003.	Frequency of walk trips to the store in the previous 30 days; Frequency of strolls in the neighbourhood in the previous 30 days	• "After accounting for these effects, changes in several perceptions of the built environment had a positive impact on walking change (led to smaller decreases or larger increases): accessibility, physical activity options, safety, and socializing. Three objective measures were also positively significant: minimum distance to a bank, number of banks within 800m, and number of types of businesses within 1600m" (pg. 68). • "It would take a tremendous increase in the accessibility factor (4 points, equal to 4 standard deviations) to make an average person more likely to walk more (a little or a lot) than to walk the same amount" (pg. 69).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Harkey and Stewart (1997)	Bicycle	Infra.	Peer rev.	Field study	Big city, Rural	13 locations in six metro areas. 1,583 bicycle-motor vehicle interactions were recorded.	Distance btw. bicycle & road; Distance btw. car & bicycle; % of interaction in which car encroached into left lane; Change in lateral position of car	• "The type of facility (wide curb lane versus bicycle lane versus paved shoulder) does have a significant effect on the separation distance between bicyclists and motor vehicles...The results also indicated that bicycle lanes as narrow as 0.92 m (3 ft) provide sufficient space for motorists and bicyclists to interact safely. At the same time, a 1.22-m (4-ft) wide bicycle lane tended to optimize operating conditions because there were very few differences in the measures of effectiveness when 1.22-m lanes were compared with wider lanes" (pg. 111).
Heath et al. (2006)	Both	Prog.	Peer rev.	Lit. rev.	Not Specified	n/a	Physical activity	• "Two interventions were effective in promoting physical activity (community-scale and street-scale urban design and land use policies and practices)...Evidence is insufficient to assess transportation policy and practices to promote physical activity" (pg. S55). Educational campaigns alone or in combination with environmental changes had stronger evidence.
Herrstedt (1998)	Bicycle	Infra.	Report	Lit. rev.	Big city	Information from Denmark.	Bicycle safety	• "The aim of recessing the vehicle stopline by 5 meters is to reduce the number of accidents involving vehicles turning right and cyclists travelling straight ahead" (pg. 11). • "Extended cycle tracks appear to be a particular source of problem in some cases. Experiences indicate that cycle lanes or truncated tracks might be preferable for cyclists entering the intersection area" (pg. 10).
Herrstedt et al. (1993)	Bicycle	Infra.	Conf. p.	Discu-ssion	Not Specified	Information from Denmark.	Bicycle safety in urban areas	• Proposed solution to deal with the fact that cycle tracks are safer on segments, but less safe in intersections: "The cycle track is truncated 20-30 meters before the junction and continued in a cycle lane instead of mixing cyclists and motor vehicles in a shared area. The cycle lane is separated from the vehicle lane with a 30 cm white painted rumble pavement in the separation area between the lane and the footway" (pg. 228).
Hess et al. (1999a)	Ped	Comm. des.	Peer rev.	Q-exp.	Not specified	Pedestrian volume measurements into 12 neighbourhood commercial centres in the Puget Sound region.	Observed pedestrians/hour; Pedestrians/ hour/1,000 residents; Pedestrians/hour	• "The majority of suburban pedestrians use streets with sidewalks where available. Also, suburban pedestrians are more likely both to jaywalk and to use crosswalks than their urban counterparts. People under age 18 and people of colour were overrepresented in suburban pedestrian populations compared with their makeup in the local residential population" (pg. 9).
Hoehner et al. (2005)	Both	Comm. des.	Peer rev.	Cross-sec.	Big city	Telephone survey of 1,068 adults in St. Louis, MO and Savannah, GA between February and June 2003.	Engaged in any transportation activity (walking or cycling); Met guidelines through transport. activities; Met guidelines through leisure-time activity	• "After adjusting for age, gender, and education, transportation activity was negatively associated with objective measures of sidewalk levelness and perceived and objective neighbourhood aesthetics. It was positively associated with perceived and objectively measured number of destinations and public transit, perceived access to bike lanes, and objective counts of active people in the neighbourhood" (pg. 105). • "Overall, the results suggested that the physical environment may affect transportation activity more so than recreational activity" (pg. 115).
Huang and Cynecki (2000)	Ped	Infra.	Peer rev.	B-and-a	Big city	Video of 10 intersections in four cities (Cambridge, MA; Corvallis, OR; Seattle, WA; and Sacramento, CA) before and after installation were collected.	Percentage of motor vehicle yielding; Pedestrian wait time; Frequency of pedestrians crossing in crosswalk	• "none of the treatments had a significant effect on the percentage of pedestrians for whom motorists yielded, the treatments usually did not have a significant effect on average pedestrian waiting time, and refuge islands often served to channelise pedestrians into marked crosswalks" (pg. 26). • "The effect of the bulbouts in Seattle was statistically significant, but in the undesired direction--that is, the wait times at the bulbouts were longer in the after period than in the before period" (pg. 28).
Huang et al. (2000)	Ped	Infra.	Peer rev.	B-and-a	Big city, Suburban	Evaluation of signs in 11 intersections in Troy, NY; Tucson, AZ; Portland, OR and Seattle, WA.	Motorist yielding; Pedestrian crossing behaviour; Frequency of pedestrians crossing in crosswalk	• "Of the treatments that were evaluated, pedestrian safety cones most consistently allowed pedestrians to cross with the benefit of a motorist yielding" (pg. 47).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Hui et al. (2007)	Ped	Model	Conf. p.	Field study		1,882 sidewalk pedestrian samples recorded in areas of Beijing, China.	Pedestrian walking speed; Step size; Step frequency	• "Results showed that walking speed, step size and step frequency followed normal distribution. At the significance level of 0.05, gender and age significantly affected walking speed, step size and step frequency, except walking speed and step size of child and old pedestrians" (pg. 1).
Hummel et al. (2002)	Both	Infra.	Unpub-lished report	Lit. rev.	Not Specified	n/a	Traffic calming effects	• "Before and after studies in a number of towns revealed that traffic calming schemes had a positive effect on retailing" (pg. 35). Also reduce traffic speeds.
Hummer et al. (2005)	Both	Model	Peer rev.	Cross-sec.	Not Specified	105 volunteers viewed 36 video clips from 10 paths.	Overall quality of trail experience	• "Analysis showed that variables related to path operations and the path width had the strongest relationships to the overall quality of the trail experience" (pg. 28).
Humpel et al. (2002)	Both	Comm. des.	Peer rev.	Lit. rev.	Not Specified	19 quantitative studies were identified.	Physical activity in many forms—total, walking etc.	"Accessibility, opportunities, and aesthetic attributes had significant associations with physical activity. Weather and safety showed less-strong relationships" (pg. 188).
Humpel et al. (2004a)	Ped	Comm. des.	Peer rev.	Cross-sec.	Not Specified	982 adults over age 40 from a coastal Australia metropolitan area participated.	Minutes per week of walking (1) in neighbourhood for any purpose; (2) for exercise; (3) for pleasure; (4) to get to and from places	• "Men with the most positive perceptions of neighbourhood aesthetics were significantly more likely to be in the highest category of neighbourhood walking... Women who perceived the weather as not inhibiting their walking were significantly more likely to be high neighbourhood walkers" (pg. 119). • "No significant differences in proportions were found for walking to get from place to place" (pg. 121).
Humpel et al. (2004b)	Ped	Comm. des.	Peer rev.	Cross-sec.	Not Specified	Telephone interviews with 800 faculty and staff of an Australian university.	Reported min. of walking in the n'hood/ week; Total walking/ week; Total physical activity/week	• "Men were significantly more likely to walk in their neighbourhood if they lived in a coastal location, and they highly rated "environmental aesthetics", "convenience" of facilities, and "access" to facilities. For women, neighbourhood walking was associated with high ratings of "convenience" but was significantly less likely if they had high ratings for "access". For total walking and total physical activity, few significant associations emerged" (pg. 239).
Hunter (2000a)	Bicycle	Infra.	Report r.a.	Q-exp.	Small city	Two intersections in Eugene, OR were videotaped to assess cyclists and motor vehicle behaviour.	Perception of safety; Operational behaviours of cyclists and motorists	• More than 17 percent of the surveyed bicyclists using the narrow lane intersection felt that it was safer than the comparison location with a standard-width right-turn lane, and another 55 percent felt that the narrow-lane site was no different safety-wise than the standard-width location.
Hunter (2000b)	Bicycle	Infra.	Peer rev.	B-and-a	Big city	Video was taken of the intersection of High St and Seventh Ave in Eugene, OR in the summer of 1998.	Operational behaviours of cyclists, pedestrians and motorists	• "Twenty-two percent of the bicyclists who approached in the left side [bike lane] and then crossed to the BL on the right side of the street (the bicyclists for whom the box was most intended) used the box" (pg. 99). • Conflicts between motor vehicles and bicyclists did not change following installation of the bike box (pg. 104).
Hunter et al. (2005)	Bicycle	Infra.	Report	B-and-a	Suburban	Videotapes were taken of cyclists riding through seven midblock and intersection locations in 2000/2001 and again in 2003.	Position of bicycle on the roadway; Position of motor vehicle on the roadway; Position of each mode as a bicycle was passed by a motor vehicle	• "After the new striping: (1) bicycles were ridden, on average, 7 to 9 inches farther away from the gutter pan seam, (2) motor vehicles were driven, on average, 6 to 12 inches farther away from the gutter pan seam, (3) passing motor vehicles were driven, on average, 3 to 5 inches closer to bicycles at curb and gutter sites; conversely, passing motor vehicles were driven, on average, 4 to 6 inches further away from bicycles at the sites where the stripe was already in place, (4) the addition of the stripe at new locations had the effect of reducing the amount of motor vehicle encroachment into the adjacent lane on these multi-lane roadways" (pg. i).
Hunter and Stewart (1999)	Bicycle	Infra.	Report	Q-exp.	Not Specified	Data on 628 cyclists on sections of two roadways in Ft. Lauderdale and Hollywood, FL were videotaped during the spring of 1999.	Bicycle/motorist conflicts; Lateral positioning of cyclists; Bicycle-to-passing-vehicle distance	• "Bicyclists tended to centre themselves in the middle of the BL in the presence of a parked motor vehicle in both locations. There was a slight tendency for the bicyclists to ride a bit farther away from the edge of the BL stripe when the parked motor vehicle was closer to the curb" (pg. 16). • "Bicyclists in both locations tended to ride farther away from the outside BL edge stripe in the presence of a passing motor vehicle, regardless of the position of the parked vehicle" (pg. 16).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Hunter et al. (1999a)	Bicycle	Infra.	Peer rev.	B. observ.	Not Specified	Videotapes of 4,600 bicyclists from 48 sites in Santa Barbara, CA; Gainesville, FL; and Austin, TX.	Operational behaviours and conflicts	• Midblock: "significantly more motor vehicles passing bicycles on the left encroached into the adjacent motor-vehicle traffic lane from WCL situations (17 percent) compared to BL situations (7 percent)" (pg. 71).
Hunter et al. (2000)	Bicycle	Infra.	Peer rev.	B-and-a	Big city	Ten intersections in Portland, OR were videotaped before and after installation of blue paint in the bicycle lanes from 1997 to 1998.	Motorist yielding; Cyclist safety behaviour; Perception of safety	• "Significantly higher numbers of motorists yielded to cyclists and slowed or stopped before entering the blue pavement areas, and more cyclists followed the coloured bike-lane path. However, the blue pavement also resulted in fewer cyclists turning their heads to scan for traffic or using hand signals, perhaps signifying an increased comfort level" (pg. 107).
Hyden et al. (1999)	Both	Prog.	Report	Discus-sion	Not Specified	Swedish experience.	Replacing car trips with walking and cycling	• Regarding users: "We have learned that women, elderly people and children/ youngsters are more often users in this sense, than other citizens are" (pg. 107). • "To consider the characteristics of different user-group segments will be necessary in order to efficiently enhance walking" (walking and cycling) (pg. 107).
ITE (1998)	Ped	Infra.	Other	Discus-sion	Not Specified	n/a	Context sensitive solutions	• Design guidelines relate to thoroughfares, roadsides, crossings, parking, medians, lanes, bicycle lanes, bus stops, curb extensions and snow removal systems.
Jackson and Ruehr (1998)	Bicycle	Prog.	Peer rev.	Cross-sec.	Metro area	3,800 interviews with San Diego County, CA adults during February-March 1994; 41,571 calls were made to complete these interviews.	Mode choice; Facility preferences	• "Only 15% of respondents who rode a bicycle at least once within the past year reported riding for transportation purposes" (pg. 9). • "Preference for a separated paved path that excludes cars was highest among those who cycled least often (75 percent among those cycling less than once per week or once per week). By comparison, 60 percent of frequent cyclists (those cycling from one to seven times weekly on average) preferred a separate paved path that excludes cars" (pg. 10).
Jacobsen (2003)	Both	Mode Choice	Peer rev.	Longit.; Cross-sec.	Not Specified	68 cities in California (US), 14 cities in Europe, 47 towns in Denmark, and eight European counties.	Injuries/capita; Fatalities/capita	• "The likelihood that a given person walking or bicycling will be struck by a motorist varies inversely with the amount of walking or bicycling. This pattern is consistent across communities of varying size, from specific intersections to cities and countries, and across time periods" (pg. 205).
Jagannathan and Bared (2005)	Ped	Infra.	Peer rev.	Model-ling	Rural	Three typical continuous flow intersection (CFI) configurations were modelled.	Average delay per stop experienced by pedestrians	• "The results indicate an acceptable pedestrian level of service of B or C on the basis of the average delay per stop experienced by any pedestrian for pedestrian crossings at the typical CFI geometries modelled. All pedestrians served at the CFIs are accommodated within two cycles for a typical signal cycle length ranging from 60 to 100 s" (pg. 133).
Jago et al. (2005)	Both	Comm. des.	Peer rev.	Cross-sec.	Metro area	210 10 to 14 year old Boy Scouts in Houston, TX during 2003/2004.	Minutes of sedentary, light, and moderate-to-vigorous intensity activity per day, avg. over 3-day period	• "Four factors were obtained: walking/cycling ease, tidiness, sidewalk characteristics, and street access and condition. Sidewalk characteristics were negatively associated with minutes of sedentary behaviour while age was positively associated. Sidewalk characteristics were positively associated with minutes of light-intensity physical activity and age negatively associated" (pg. 98)
Jago et al. (2006a)	Both	Comm. des.	Peer rev.	Cross-sec.	Metro area	210 10 to 14 year old Boy Scouts in Houston, TX.	Minutes of sedentary, light, and moderate-to-vigorous intensity activity per day	• "Only observed sidewalk characteristics were correlated with physical activity and were retained in the regression models" (pg. 422). • Food establishments did not have a statistically significant relationship to physical activity. • "We found no evidence of associations between objectively recorded physical activity and either crime (safety), destinations, or residential density" (pg. 426).
Jago et al. (2006b)	Both	Comm. des.	Peer rev.	Cross-sec.	Metro area	210 10- to 14-year old Boy Scouts in Houston, TX in 2003/2004.	Minutes of sedentary, light, and moderate-to-vigorous intensity activity per day	• "Park, crime, and gym variables were associated with physical activity, but relationships varied according to whether a 400 m, 1 mile, or nearest criteria was used" (pg. 230).
Jensen (1999)	Ped	Infra.	Peer rev.	Lit. rev.	Not Specified	Travel behaviour of 16 to 74 year-old inhabitants of 47 Danish cities with more than 10,000 inhabitants.	Urban road injuries per inhabitant	• "A result from the study is that modal choice of the urban population does not correlate with the number of urban road injuries per inhabitant" (pg. 61).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Jensen and Nielsen (1997)	Bicycle	Infra.	Peer rev.	B-and-a	Not Specified	248 recorded accidents at 47 signalised intersections from 1989-1994.	Bicycle accidents; Cyclist injuries; Cyclist deaths	• "At the intersections where the blue surfaces were applied, the number of bicycle accidents was reduced by 38%, and the number of killed and severely injured cyclists decreased by 71%. The accidents related to bicycle crossings marked only with broad white lines and bicycle symbols are too few to make an accurate statement about their safety effect" (pg. 27).
Jensen et al. (2006)	Bicycle	Infra.	Report	B-and-a	Big city	Data for more than 8,500 accidents, 1,500 traffic counts, and 1,000 interviews.	Accidents and injuries in junctions and in between	• "The construction of cycle tracks has resulted in a slight drop in the total number of accidents and injuries on the road sections between junctions of 10% and 4% respectively. At junctions on the other hand, the number of accidents and injuries has risen significantly, by 18%" (pg. 2). • "The radical effects on traffic volumes resulting from the construction of cycle tracks will undoubtedly result in gains in health from increased physical activity. These gains are much, much greater than the losses in health resulting from a slight decline in road safety" (pg. 8).
Johansson and Leden (2007)	Both	Infra.	Peer rev.	Q-exp.	Not Specified	Data collected using video filming, speed measurements, surveys, and crash data on driver behaviour at four sites in Boras, Sweden from 1999 to 2002.	Vehicle speed	• "The goal of traffic calming of a 90 percentile driving speed below 30 km/h was not fulfilled at any of the test sites. A conclusion is that the height of a speed cushion is important" (pg. 500). • Where changes were implemented, vehicle speeds did go down considerably.
Jones and Sloman (2003)	Ped	Prog.	Conf. p.	Lit. rev.	Not Specified	n/a	Marketing and management strategies to reduce car travel	• "(1) Marketing and management measures acting together may address the multiple reasons for making linked trips by car...(2) The 'snowball effect': long-term effects may be greater than short-term ones...(3) Marketing and management measures may amplify the impact of 'hard' measures...(4) Marketing and management may increase the elasticity of response to restraint measures" (pg. 25).
Jordon (1998)	Ped	Infra.	Peer rev.	Cross-sec.	Big city	2,167 pedestrian crash reports for Philadelphia, PA for the year 1994.	Child pedestrian injuries	• "The data indicate that few children are injured by cars near schools during opening, recess, and closing times. More children are injured en route to or from school, but not near the school" (pg. 132).
Kerr et al. (2007)	Both	Comm. des.	Peer rev.	Cross-sec.	Metro area	3,161 respondents aged 5-18 years to the SMARTRAQ travel survey in the Atlanta, GA region in 2001-2002 are analysed.	Walked at least once over two days (dichotomous)	• "Residential density, intersection density, and mixed land use were all significantly related to walking in both males and females. Greater density and greater numbers of land use were related to higher walking rates" (pg 180). • Living in mixed use-areas and having access to recreational space were related to youth walking for transport in 11 of 13 population subgroups studied" (abstract).
King et al. (2003)	Ped	Comm. des.	Peer rev.	Cross-sec.	Metro area	149 postmenopausal women in SW Pennsylvania participated in 1999.	Avg. steps/day; KCal expended/week from walking and from all leisure-time activities	• "Living within walking distance (defined as within a 20-minute walk of home) of a park; biking or walking trail; or department, discount, or hardware store was related to higher pedometer readings ($p < .01$)" (pg. 74).
King et al. (2005)	Both	Comm. des.	Peer rev.	Cross-sec.	Metro area	158 overweight postmenopausal women from SW Pennsylvania participated in 2002/03.	Average steps per day	• "After controlling for individual age, race/ethnicity, education, smoking status, and body mass index, indicators of low neighbourhood SES, living in a neighbourhood with homes built between 1950 and 1969 (representing an urban form that is more pedestrian-friendly than after 1969), and living within walking distance (1500 m) of specific types of businesses and facilities were positively associated with individuals' physical activity level measured by pedometer ($p < 0.05$)" (pg. 461).
Kingham et al. (2001)	Both	Mode Choice	Peer rev.	Cross-sec.	Suburban	962 employees of two large corporations in Hertfordshire, England in 1998/1999.	Mode choice	• "While only 2 and 7% of respondents cycled to work, real potential for cycling was identified, given improvements in the cycling infrastructure. Similarly, while only 0 and 3% currently use transit for the journey to work, improved services could see a significant modal shift" (pg. 153).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Kirtland et al. (2003)	Both	Comm. des.	Peer rev.	Cross-sec.	Not Specified	1,112 Sumter County, SC adults were surveyed in Jan/Feb 2001.	Activity status: (1) Meets recommendations, (2) insufficiently active, (3) inactive	• "those meeting national physical activity guidelines or reporting some physical activity demonstrated greatest agreement with access to recreation facilities, while those not meeting the guidelines demonstrated greater agreement with safety of recreation facilities" (pg. 323).
Kitamura et al. (1997)	Both	Comm. des.	Peer rev.	Cross-sec.	Big city	San Francisco residents of five selected neighbourhoods were surveyed.	Total, transit and nonmotorized trips over 3 days; Fraction of trips by mode	• Attitudes explain a greater proportion of the variation in travel behaviour and mode than socioeconomic or environmental variables. • "Measures of residential density, public transit accessibility, mixed land use, and the presence of sidewalks are significantly associated with trip generation by mode and modal split" (pg. 126).
Knoblauch et al. (2001)	Ped	Infra.	Report	B-and-a	Big city, Small city	Eleven intersections from four cities were examined before and after the installation of crosswalks in 1996 and 1997.	Vehicle volumes and speed; Ped . volumes; Motorist yielding; Aggressive ped. behaviour; % of crossing peds. in crosswalk	• "It was found that drivers approach a pedestrian in a crosswalk somewhat slower, and that crosswalk usage increases after markings are installed. No evidence was found indicating that pedestrians are less vigilant in a marked crosswalk. No changes were found in driver yielding or pedestrian assertiveness" (abstract).
Kockelman (1997)	Both	Comm. des.	Peer rev.	Cross-sec.	Metro area	More than 9,000 responses from the 1990 San Francisco Bay Area travel surveys were analysed.	Total VKT/hshld; Total nonwork home-based VKT/hshld.; Automobile ownership; Mode choice	• "After demographic characteristics were controlled for, the measures of accessibility, land use mixing, and land use balance--computed for trip-makers' home neighbourhoods and at trip ends--proved to be highly statistically significant and influential in their impact on all measures of travel behaviour...In contrast, under all but the vehicle ownership models, the impact of density was negligible after accessibility was controlled" (pg. 116).
Kolt et al. (2006)	Ped	Prog.	Peer rev.	R.C. trial	Not Specified	186 adults aged 65 and older from the Auckland, New Zealand area were recruited.	Participant evaluations	• "All respondents (100%) agreed or strongly agreed that a good overall level of service and support was provided, and that the counsellor was understanding and supportive...Most (87%) agreed or strongly agreed that the telephone calls encouraged them to be physically active. Among the participants who received printed material, most agreed or strongly agreed that these encouraged them to become or remain active" (pg. 201).
Konheim and Ketcham (2000)	Ped	Comm. des.	Peer rev.	Case st.	Big city	The transportation systems of four metropolitan areas (London, Paris, New York, Tokyo) were compared.	Mode choice	• "It appears that the more that daily trip needs can be met by walking, the more likely that longer trips will be made by transit than by automobile" (pg. 56). • "On a per-capita basis, the number of motorized trips per person per day in Tokyo's exurbs is less than a third of that in New York's suburbs, and there are more than three times more walking trips per capita in Tokyo's outer zone than in New York suburbs."
Krizek (2000)	Both	Comm. des.	Peer rev.	Q-exp.	Metro area	Puget Sound Travel Panel data were used. Almost 550 households changed residential location over the seven waves of data.	Numerous measures related to trips per household and tours per household; Percentage of total trips by transit, bicycle, or foot	• "Most surprising is that the change in the percentage of walking and transit trips for all relocation pairs appears insignificant except for high to medium levels of access. Also, the number of trips per tour does not appear to change for any relocation pair. However, substantial differences in travel distance and time occur in the medium to low accessibility and low to medium accessibility. As expected, locating from a medium to a low accessibility neighbourhood increases trip and tour distance at a statistically significant level, and vice versa" (pg. 53).
Krizek (2003b)	Both	Comm. des.	Peer rev.	Q-exp.	Metro area	Puget Sound Travel Panel data were used. Almost 430 households changed residential location over the seven waves of data.	Vehicle miles travelled; Number of trips; Person miles travelled; Number of trips per tour	• "The largest influence in each of the models comes from the baseline travel behaviour variable, showing that the greater the baseline value, the greater the propensity to decrease it (i.e., the more a household travels, the more they want to reduce their amount of travel). NA [neighbourhood accessibility] in each of the models is also statistically significant" (pg. 274). • "The positive coefficient indicates that increases in NA result in an increase in number of tours" (pg. 275).
Krizek (2006a)	Ped	Comm. des.	Peer rev.	Cross-sec.	Metro area	Over 10,000 individuals participated in the Travel Behaviour Inventory (TBI) Home Interview Survey in 2001.	Lifestyle classifications	• Seven lifestyle classifications are identified, which can be used by policy makers to develop better-informed policies regarding urban form, land use, and transportation.

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Krizek (2006b)	Bicycle	Infra.	Peer rev.	Cross-sec.	Big city, Suburban	90 Univ. of Minn. Employees participated in the winter survey and 91 in the summer.	Home value; Travel time commuters were willing to spend in order to travel on particular facilities	• "These findings indicate that bicycle commuters in Minneapolis and St. Paul prefer bicycle lanes on existing streets over off-street bicycle trails, and also prefer them over streets that have no on street parking but lack designated bicycle lanes" (pg. 309). • "Though proximity to bicycle facilities is valued different for different types, it actually significantly reduced home value in suburban locations" (pg. 309).
Krizek and Johnson (2006)	Both	Comm. des.	Peer rev.	Cross-sec.	Metro area	2000 Twin Cities Metropolitan Area Travel Behaviour Inventory (TBI) for 1,653 residents aged 20 years or older.	Bicycle and walking trips from home per day	• "We found that distances to retail and bicycle facilities are statistically significant predictors of choosing active modes of transport at close distances, but the relationships do not appear to be linear" (pg. 33).
Krizek and Roland (2005)	Bicycle	Infra.	Peer rev.	Cross-sec.	Big city	Case study of 30 bicycle facilities in Minneapolis, Minnesota. Survey of 28 cyclists in the Twin Cities metro area in 2003.	Cyclist perceptions of comfort	• "The findings suggest that discontinuities ending on the left side of the street, with increased distance of crossing intersections, having parking after the discontinuities, and wider width of the curb lanes are statistical elements that contribute to higher levels of discomfort" (pg. 56).
Krizek et al. (2005)	Bicycle	Mode Choice	Conf. p.	Cross-sec.	Metro area	Secondary data from five surveys.	Desired amenities; Perceptions of safety; Commute mode choice; Travel time willing to spend for certain facilities	• "Men are more than twice as likely to complete their trip by bicycle than women (0.66% versus 0.25%). Men are more likely to bicycle to work than women...and to bicycle for rest and relaxation...Conversely, however, women are more likely than men to ride a bicycle to school as a student...to do shopping and errands...and to visit friends and relatives" (pg. 33). • "Women are willing to travel more additional minutes than men for a preferred facility" (pg. 36).
Krizek et al. (2007)	Bicycle	Infra.	Peer rev.	Cross-sec.	Big city, Suburban	1,966 individuals completed a survey given at 13 locations along a bicycle/ped. trail in the Minneapolis/St. Paul metropolitan area.	Distance of route travelled; Distance between chosen route and shortest route	• "The analysis demonstrates that a cogent distance decay pattern exists and that the decay function varies by trip purpose. Furthermore, we find that bicyclists travel, on average, 67% longer in order to include the trail facility on their route" (pg. 611). • "Meanwhile, the difference in the number of intersections between the two routes has a positive effect on the difference in route length...Consequently, this model suggests that bicyclists are willing to endure a route with more intersections that also incorporates a trail segment" (pg. 620).
Kweon et al. (2006)	Both	Infra.	Report	Cross-sec.	Not Specified	186 parents from four school walk zones in College Station, TX participated.	Reported child travel mode to school	• Results indicate that children walk more in older neighbourhoods with mature trees while they cycle more in newer neighbourhoods with more sidewalks. Also children who live on cul-de-sacs walk to school less than those who live on grid streets. • "Contrary to the popular 2 mi walk zone guidelines, the mean distance for walking in this study is .71 mi while the mean distance of cycling is .93 mi." (abstract).
Landis (1996)	Bicycle	Model	Peer rev.	Model-ling	Not Specified	Review of the Interaction Hazard Score (IHS) and Latent Demand Score (LDS) models.	Level of service	• The IHS Model rates the on-road bicycling environment and interprets the rating as a level-of-service classification. The model uses existing roadway and traffic variables to estimate perceived hazards from the bicyclists' perspective.
Landis et al. (1997)	Bicycle	Model	Peer rev.	Cross-sec.	Big city	150 cyclists completed the 17 mile course in Tampa, FL.	Cyclists' assessment of roadway environment	• "This study proves conclusively that there is a statistically significant inverse mathematical relationship between pavement condition and the dependent variable BLOS" (pg. 125). • "segments with striped bike lanes or paved shoulders were perceived as being better (i.e., safer or less hazardous) than those without, all other traffic and roadway geometrics being the same" (pg. 124).
Landis et al. (2001a)	Ped	Model	Report	Cross-sec.	Big city	75 people participated in the 'FunWalk for Science' event in Pensacola, FL.	Pedestrian ratings of safety/comfort	• "In general, as the lateral separation [between pedestrian and motor vehicles] increases, the pedestrian's comfort or sense of safety also increases" (pg. 55). • "Similarly, the speed of motor vehicle traffic was confirmed as significantly affecting pedestrians' sense of safety. As speed increases, pedestrian discomfort increases" (pg. 59).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Landis et al. (2003)	Bicycle	Model	Peer rev.	Cross-sec.	Big city	Nearly 60 cyclists aged 14 to 71 years from the Orlando, FL area completed the 17 mi roadway course.	Cyclist sense of safety in intersection	• "The study reveals that roadway traffic volume, total width of the outside through lane, and the intersection (cross street) crossing distance are primary factors in the Intersection LOS for the bicycle through movement" (pg. 101).
Landis et al. (2004a)	Both	Infra.	Peer rev.	B. observ.	Not Specified	Data from three "Ride for Science" events in 2003 in Florida, Maryland, and California.	Trail user sweep width; Trail user length	• "With respect to sweep width (Table 3), the critical user is the inline skater (pg. 138). Refuge islands: "Recumbent bicycles, bicycles with trailers, and hand cycles all have 85th percentile lengths greater than 6 ft. The longest likely users, bicycles with trailers, exceeded 8 ft in length and should be considered the critical users" (pg. 138).
Landis et al. (2005)	Ped	Model	Peer rev.	Cross-sec.	Big city	Data from video simulation, walking course, and 2004 "Walk for Science" event in Sarasota, FL (approx. 50 participants).	LOS rating	• Authors found a statistically significant difference between LOS ratings in the controlled (video simulation) environment compared to real-time experiences.
Landis et al. (2006)	Bicycle	Model	Report	Cross-sec.	Suburban	700 perceptions from bicyclists riding a course in 2005 and viewing a video simulation were collected.	User perceptions of roadway environment	• "Statistical analyses comparing data using the video simulation and during the field event indicated no significant difference [in user perceptions]. Therefore, researchers can present the bicyclists view of riding environments without exposing them to potentially hazardous traffic/roadway conditions" (pg. v).
Larsen (1994)	Bicycle	Infra.	Peer rev.	Cross-sec.; Longit.	Big city	1,021 bicyclists injured in collision accidents and treated at Odense Univ. Hospital and 1,502 bicyclists injured in single accidents.	Bicycle-motor vehicle collisions	• "To decrease the number of collision accidents with motor vehicles it is necessary to separate the bicyclists from the "hard road traffic" especially at crossings" (pg. 27). • 42% of the collisions were localized at normal roadways, 44% at bicycle tracks and 9% at paths or at the pavement" (pg. 30).
Lawlow et al. (2003)	Bicycle	Infra.	Peer rev.	Lit. rev.	Not Specified	UK National Cycle network is reviewed.	n/a	• "We suggest that evaluation should be undertaken combining evidence from network user surveys, routine transport surveys and linking details of development of the network with routine surveys to compare modes of transport and levels of activity between areas close to the network and those more distant from a network path" (pg. 100).
Leden (1989)	Bicycle	Infra.	Peer rev.	Cross-sec.	Not Specified	Approximately 14,000 children in some 40 schools in Sweden, Finland, and Norway were surveyed.	Risk of collision	• "The average collision risk when children cycle through an intersection on the carriageway is about 0.5 collisions involving a motor vehicle per hundred thousand cycling children. To avoid an increase in the total collision risk if a cycle-path is built, the intersections must be designed so that the collision risk is at most 0.8 collisions per hundred thousand cycling children" (pg. 14).
Leden et al. (2005)	Both	Infra.	Peer rev.	B-and-a	Small town	Video was taken of five treated locations along the E12 highway. About 100 children were surveyed before and after the changes.	Driver yielding	• "Behaviour of motor vehicle drivers changed significantly. Before, 32% of children crossing as pedestrians were given way to by car drivers compared to 72% after. For cycling children, the different was even greater, though the code change only concerned pedestrians, 6% were given way to before compared to 84% after" (pg. 459).
Lee (2007)	Ped	Comm. des.	Conf. p.	Cross-sec.	Big city	438 adult respondents from Seattle, WA to a telephone survey in 2002.	Odds of walking to four utilitarian destinations; Odds of 'using' and odds of 'walking to' three recreational destinations	• "Over 52% reported walking to grocery stores at least once per week, 37% to parks, 29% to restaurants, 24% to trails, 19% to banks and 18% to convenience stores. Walkers to grocery stores accumulated 209 minutes of walking and nine walking trips in total per week, contrasting to only 101 minutes and 3.3 trips for non-walkers. For all utilitarian destinations, increased accessibility was positively associated with the odds of walking to the destinations. One additional destination within 1 km from home was associated with about 30% increase in the odds of walking to that destination type" (pg. 2).
Lee and Moudon (2004)	Both	Comm. des.	Peer rev.	Lit. rev.	Not Specified	20 published empirical studies on links between various forms of physical activity and the built environment.	Physical activity, walking, cycling, etc.	• "The studies help advance environment-behaviour research related to urban and transportation planning. They identify behavioural and environmental determinants of physical activity and employ rigorous data collection methods and theoretical frameworks that are new to the planning field" (pg. 147).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Lee and Moudon (2006a)	Ped	Model	Peer rev.	Cross-sec.	Not Specified	Telephone survey of 608 adults in King County, WA, sampled using a spatial sampling strategy.	Frequency and duration of weekly walking; Frequency and duration of walking for: commuting, shopping, and recreation	• "Distance measures to routine daily destinations are shown to be simple and effective alternatives to complicated composite measures often used to capture land use mix and street connectivity" (pg. 204). • Destinations, distance, density, and route... "Together, these environmental variables captured slightly over 10% of the variations in explaining walking in both final models. This is significant because the 10% is an independent contribution after controlling for the socio-demographic confounders and even the perceived environmental variables" (pg. 212).
Lee and Moudon (2006b)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city	438 adult respondents from Seattle, WA to a telephone survey in 2002.	Walker status; Transportation walk trips/week; Recreation walk trips/ week	• "Utilitarian destinations were positively associated with transportation walking, but recreational destinations were not associated with any walking. Residential density was correlated with both purposes of walking, and sidewalks with recreation walking only. Hills were positively associated with recreation walking and negatively with transportation walking" (pg. S77). • "Route-related variables, such as block size, traffic volume, sidewalk and street trees, did not show a statistically significant association with transportation walking; but longer sidewalks was positively associated with recreation walking" (pg. S90).
Levine and Frank (2007)	Both	Comm. des.	Peer rev.	Cross-sec.	Metro area	1,455 randomly selected households of metro Atlanta participated in a stated-preference survey in 2001/2002.	Index of desired degree of neighbourhood change	• "The study provides evidence that the segment of the housing market that is interested in these alternatives is underserved--that is, there is unmet demand for alternative development in the Atlanta region" (pg. 272).
Li et al. (2005a)	Ped	Comm. des.	Peer rev.	Longit.	Big city	582 senior residents in 56 Portland, OR neighbourhoods were surveyed in 2001.	Neighbourhood walking in last 12 months as self-reported on likert scale	• "Results indicated a significant neighbourhood effect, with neighbourhood-level walking characterized by a downward trajectory over time" (pg. 145). • "neighbourhoods with safety of neighbourhood walking and greater access to physical activity facilities tended to show less decline (i.e., smaller rates of decline) in walking activity over the four assessment points" (pg. 155).
Li et al. (2005b)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city	577 older adults in 56 Portland, OR neighbourhoods participated in the survey.	Neighbourhood walking in last 12 months as self-reported on likert scale	• "A positive relation was found between built environment factors (density of places of employment, household density, green and open spaces for recreation, number of street intersections) and walking activity at the neighbourhood level. At the resident level, perceptions of safety for walking and number of nearby recreational facilities were positively related to high levels of walking activity. A significant interaction was observed between number of street intersections and perceptions of safety from traffic" (pg. 558).
Lindsey and Nguyen (2004)	Both	Infra.	Peer rev.	Cross-sec.	Not Specified	Data were collected on five Indiana trails in 2000 and at five locations along an Indianapolis trail in 2001.	Bicycle traffic counts: monthly, average daily, weekday, weekend, average hourly, and peak hour traffic	• "Trail traffic was higher in municipalities with larger populations and higher on weekend days than on weekdays. Peak hour traffic accounted for higher proportions of traffic on weekdays than on weekend days. Traffic at different locations on one trail in Indianapolis varied considerably" (pg. 213). • "The percentage of users who said they use the trails for commuting ranged from essentially zero to approximately 5%" (pg. 216).
Lindsey et al. (2006)	Both	Comm. des.	Peer rev.	Model-ling	Big city	Infrared monitors were used to measure traffic at 30 locations on five trails in Indianapolis, IN.	Daily counts of trail users	• "Trail traffic correlates positively and significantly with income, neighbourhood population density, education, percent of neighbourhood in commercial use, vegetative health, area of land in parking, and mean length of street segments in access networks" (S139).
Lovejoy et al. (2006)	Ped	Comm. des.	Conf. p.	Cross-sec.	Not Specified	1,682 people (784 from suburban neighbourhoods and 898 from traditional neighbourhoods) in Northern California were surveyed in 2003.	Avg. VMT/week; Avg. number of walks in the n'hood in 30 days; # of walks to local shopping in the last 30 days	• Four types of mismatched residents: suburban mismatched on accessibility, attractiveness, and socializing aspects; traditional mismatched on safety aspects. • "We find evidence of accessibility-unsatisfied residents driving less than other suburban residents, statistically as little as traditional residents, suggesting that people who want to drive less can, even if living in a suburban neighbourhood" (pg. 11).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Mackett (2003)	Both	Mode Choice	Peer rev.	Cross-sec.	Not Specified	Survey and travel diary of 377 residents over 10 years of age from England.	Mode choice for short trips	• Reasons for using car: heavy items, driving others, time constraints, length of trip. • "In 17% of cases a lift was being given to a family member or friend and in a further 3% of cases a lift was being given to an elderly or ill person" (pg. 335). • For 22% of trips, no viable alternative mode could be identified by the subject (pg. 341).
Martens (2004)	Bicycle	Mode Choice	Peer rev.	Cross-sec.	Big city	Data from previous studies was analysed for the three countries: the Netherlands, Germany, and the UK.	Cycle-and-ride user characteristics	• "The majority of bike-and-ride users travel between 2 and 5 km to a transitation stop, with longer access distances reported for faster modes of transit. Faster and higher quality types of transitation attract significantly more bike-and-ride users than slower and lower quality types of transitation" (pg. 281).
Martens (2007)	Bicycle	Infra.	Peer rev.	Lit. rev.; Case st.	Not Specified	Review of studies and data sets related to cycle-and-ride in the Netherlands.	Transit access mode	• "The bicycle accounts for only 6% of access trips to bus and tram stops and for as little as 2% for metro stations" (pg. 327).
McGinn et al. (2007)	Ped	Comm. des.	Peer rev.	Cross-sec.	Not Specified	Phone survey of 1,482 participants in Forsyth County, NC and Jackson, MS in 2003.	Leisure time PA; Outdoor leisure PA; Walking activity; Transportation activity (any vs. none)	• "When objective measures were compared to respondent's perceptions little agreement was found. Objective measures were not associated with any physical activity outcomes; however, several associations were seen between perceived measures and physical activity" (pg. 588).
McMahon et al. (1999)	Ped	Infra.	Peer rev.	Case-cont.	Not Specified	47 crash sites and 94 comparison sites in Wake County, NC, with crash data from 1993-1996.	Likelihood that a site is a crash site	• "Physical design factors found to be associated with a significantly higher likelihood of being a crash site are a higher speed limit; the lack of wide, grassy walkable areas; and the absence of sidewalks" (pg. 43).
McMillan (2005)	Both	Infra.	Peer rev.	Lit. rev.	Not Specified	n/a	Child trip to school	• The author identifies Mediating Factors (neighbourhood safety, traffic safety, and household transportation options) and Moderating Factors (social/cultural norms, parental attitudes, and sociodemographics) on the mode of school trips and highlights the fact that, for children up to a certain age, it is the parents, primarily, who are making the mode decision for their child.
McMillan (2007)	Both	Infra.	Peer rev.	Cross-sec.	Not Specified	Caregivers of children from 16 different schools in California were brought home surveys by their children in grades 3-5.	Reported child travel mode to school	• "The results of the analysis support the hypothesis that urban form is important but not the sole factor that influences school travel mode choice. Other factors may be equally important such as perceptions of neighbourhood safety and traffic safety, household transportation options, and social/cultural norms. Odds ratios indicate that the magnitude of influence of these latter factors is greater than that of urban form; however, model improvement tests found that urban form contributed significantly to model fit" (pg. 69).
McMillan et al. (2006)	Ped	Mode Choice	Peer rev.	Cross-sec.	Not Specified	1,244 caregivers of children in grades 3-5 at 10 CA Safe Routes to School schools were surveyed.	Odds of walking/ biking to school	• "Being a female child reduced the likelihood of walking/bicycling to school when controlling for variables such as child age, perception of neighbourhood safety, and household socioeconomics" (pg. 83). • Results showed that caregivers who are active themselves are more likely to have children who walk or bike to school. • "Caregivers' feelings about neighbourhood safety were not significant factors, contradicting popular opinion and prior research" (McMillan 2005).
Merom et al. (2003)	Both	Prog.	Peer rev.	Q-exp.	Not Specified	Survey of 450 adult bicycle owners, aged 18-55 years, completed pre- and post-test telephone interviews in western Sydney, Australia in 2000-2001. Intervention was promotional campaign around rail trail.	Mean daily bike counts; Mean cycling time; Trail awareness	• "A significant increase (+2.9%, McNemar P< 0.05) in unprompted Trail awareness was detected but post-campaign awareness was low (34%)...Mean daily bike counts in the monitored areas increased significantly after the Trail launch (OR=1.35, P=0.0001, and OR =1.23, P=0.0004)" (pg. 235).
Merom et al. (2005a)	Ped	Prog.	Peer rev.	Cross-sec.	Metro area	1,100 adults aged 18 to 65 from Australia's metropolitan areas were surveyed in 1993.	Total time walking; Moderate physical activity; Mode choice	• "Among participants who did not usually actively commute to work was a significant decrease in car only use and an increase in walking combined with transit. Among those who were employed was a significant increase in total time walking and in other moderate physical activity, resulting in a significant decrease in the proportion who were "inactive"" (pg. 159).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Merom et al. (2005b)	Ped	Prog.	Peer rev.	Cross-sec.	Not Specified	812 parents were interviewed following a Walk Safely to School Day in 2002.	Mode choice to school	• "The children of 24% of parents (n=197) surveyed participated in some way in WSTSD, with 177 of these children (90%) walking all or part of the way to school... There was a relative increase of 31% (n=55) of children walking attributed to the event" (pg. 103). • "at a population level, Walk Safely to School Day increased the prevalence of walking to school by 6.8%" (pg. 104).
Merom et al. (2007)	Ped	Prog.	Peer rev.	R.C. trial	Not Specified	369 inactive adults were recruited for the study, which was conducted in 2005 in New South Wales, Australia.	All-purpose walking for exercise, recreation and travel; Moderate-vigorous PA in past week; Leisure time in sports/ recreation in last 3 months	• "the WPP group increased significantly participation in other sports/recreations and was more likely than the control group to meet physical activity recommendations by all leisure-time physical activity, by all-purpose walking (APW), and all physical activity in the last week" (pg. 290).
Michael et al. (2006)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city	582 older adults in 56 Portland, OR neighbourhoods participated in the survey in 2002/2003.	Neighbourhood walking in last 12 months as self-reported on likert scale	• "Perceived and objective measurements of the built environment exhibited a low degree of agreement (kappas: <.20). After adjustment for education, age, and gender, presence of a mall was positively associated with neighbourhood walking in both the objective and perceived models" (pg. 302).
Miles and Panton (2006)	Ped	Prog.	Peer rev.	Q-exp.	Not Specified	46 overweight and obese women aged 30-65 years participated in the study.	Steps per day; Body weight; BMI	• "Most of the increase in walking was for leisure or exercise, with only one of the ten reporting occasionally walking for errands and one showing a substantial increase in steps when she began working at Goodwill" (pg. 387). • "Perceiving that they have places to walk to in the neighbourhood was associated with increases in physical activity" (pg. 387).
Montufar et al. (2007)	Ped	Infra.	Conf. p.	Field study	Big city	8 signalized intersections in Winnipeg, Canada. 1,792 pedestrians were observed (1,104 in summer and 688 in winter) in the 8 intersections.	Walking speed	• "The research found that in all cases the normal is lower than the crossing walking speed. It also found that younger pedestrians walk faster than older pedestrians, regardless of season and gender, and females walk slower than males regardless of season and age. Furthermore, both younger and older pedestrians have a greater normal walking speed in summer than in winter but lower crossing speed in winter than in summer" (pg. 2).
Moudon et al. (1997)	Ped	Comm. des.	Peer rev.	Q-exp.	Big city, Suburban	12 sites in the Puget Sound area were measured for pedestrian trip volume.	Volume of walking trips into cordon area	• "The average urban pedestrian volume is 37.7 pedestrians per hour per 1,000 residents, which is 3 times higher than the 12.5 pedestrians per hour per 1,000 residents in suburban sites. These results strongly support the hypothesis that, when holding other variables constant, the urban versus suburban difference in route directness and completeness of pedestrian facilities (namely, block size and sidewalk length) affects pedestrian volumes" (pg. 48).
Moudon et al. (2005)	Bicycle	Comm. des.	Peer rev.	Cross-sec.	Metro area	608 randomly sampled respondents in King County, WA.	Cycled at least once per week (dichotomous)	• "Both perceived and objective environmental conditions contribute to the likelihood of cycling. Proximity to trails and the presence of agglomerations of offices, clinics/ hospitals, and fast food restaurants, measured objectively, are significant environmental variables. Previously researched correlates of cycling, such as the presence of bicycle lanes, traffic speed and volume, slope, block size, and the presence of parks, are found insignificant when objectively measured" (pg. 245).
Moudon et al. (2007)	Ped	Comm. des.	Peer rev.	Cross-sec.	Metro area	608 randomly sampled respondents in King County, WA were surveyed by telephone.	Total weekly minutes of walking in neighbourhood	• Measures of distance to neighbourhood destinations dominated the results: shorter distances to grocery stores/markets, restaurants, and retail stores, but longer distances to offices or mixed-use buildings ($p < .01$ or .05). The density of the respondent's parcel was also strongly associated with walking sufficiently ($p < .01$)" (pg. 448).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Muraleetharan and Hagiwara (2007)	Ped	Infra.	Conf. p.	Cross-sec.	Big city	531 respondents in Hokkaido, Japan answered a stated preference survey. 354 respondents answered a revealed preference survey.	Pedestrian route choice behaviour	• "The model results indicate that pedestrians choose routes not only for distance, but also for the overall LOS of sidewalks and crosswalks. On longer travel paths, pedestrians divert from the shortest-path route and are found to use high LOS sidewalks and crosswalks. On shorter routes, pedestrians tend not to avoid low LOS sidewalks or crosswalks" (pg. 2).
Mutrie et al. (2002)	Both	Prog.	Peer rev.	R.C. trial	Big city	295 employees at three workplaces in Glasgow, Scotland. Intervention was an information packet.	Stage of change for active commuting; Seven day recall of PA; Perceived physical and mental functioning	• "The intervention group was almost twice as likely to increase walking to work as the control group at six months. The intervention was not successful at increasing cycling. There were no distance travelled to work, gender, or age influences on the results. Twenty five per cent of the intervention group, who received the pack at baseline, were regularly actively commuting at the 12 month follow up" (pg. 407).
MvVW (2007)	Bicycle	Prog.	Report	Discus-sion	Big city	Experience from the Netherlands.	Cycling in general	• The report is divided into four sections with examples and case studies to illustrate principles: an overview with statistics; policy background; facilities for all target groups; and practical measures, which includes parking, theft, and road infrastructure.
Nabti and Ridgway (2002)	Bicycle	Infra.	Report r.a.	Case st.	Not Specified	Innovative bicycle treatments examined.	n/a	• "Approximately 50 treatments are summarized in this report. These treatments include on-street innovations such as contra-flow bike lanes, shared bike/bus lanes, bike boulevards, raised bike lanes and coloured bike lanes. There is information on trail facilities including one-way trails and median trails" (pg. ix).
Nelson and Allen (1997)	Bicycle	Infra.	Peer rev.	Cross-sec.	Big city	Data from 18 U.S. cities, originally collected by Goldsmith.	Commuter mode choice	• "After considering such factors as weather, terrain, and number of college students, a positive association was found between miles of bicycle pathways per 100,000 residents and the percentage of commuters using bicycles" (pg. 79).
NHTSA (2003)	Both	Mode Choice	Report r.a.	Cross-sec.	Not Specified	9,616 adults over age 16 were interviewed from all 50 states and the District of Columbia in 2002.	Mode choice; Trip purpose	• "About 27.3% of the driving age public reported they rode a bicycle at least once during the summer of 2002" (pg. 2). • "The most common purposes of trips were for recreation (26.0%) and for exercise or health reasons (23.6%)" (pg. 5).
NICHES (2006)	Bicycle	Prog.	Report	Lit. rev.	Big city	n/a	Public bicycle programs	• "Benefits of public bicycle programs may include: increasing modal share; encouraging intermodality; wise use of inner urban space; health benefits; increasing traffic safety; strengthened local identity" (pg. 4).
Noland (1995)	Both	Mode Choice	Peer rev.	Cross-sec.	Metro area	Adult residents of the counties of the Philadelphia metropolitan area.	Mode choice; Simple risk perception score; Enhanced severity risk perception score	• "This study also shows that perceived safety improvements in bicycle transportation have an aggregate elasticity value that is greater than one. This means that bicycle safety improvements attract proportionately more people to bicycle commuting (i.e. a 10% increase in safety results in a greater than 10% increase in the share of people bicycle commuting)" (pg. 503).
Noland and Ishaque (2006)	Bicycle	Prog.	Peer rev.	Cross-sec.	Big city	46 customers of the OYBike program in London were surveyed in early September 2005.	Trip purpose; Usage statistics	• "Leisure and recreational trips account for the major uses. Commuting and other utilitarian trips represent about one-quarter of all trip purposes" (pg. 77). • Repeat usage is not high, which may suggest some dissatisfaction with the system after initial usage or which may be due to some users trying out the system for its novelty" (pg. 88). • "Key impediments to use are the uncertainty of the condition of the bicycles when they are checked out, the difficulty of the locking system, and the need to use a mobile phone" (pg. 93).
OECD (2000)	Both	Infra.	Report	Lit. rev.	Not specified	n/a	Safety for cyclists, pedestrians, moped riders, and motorcyclists	• Ways to improve cyclist safety: "turning lanes on the approach arms to junctions controlled by traffic signals; marking-out of cycle lanes at junctions to make the cycle route more readily visible to other road users; on open stretches of road between junctions, maintenance of cycle tracks and lanes and their verges to avoid projections of water and dirt; and ensuring that road surfaces are level" (pg. 28).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Ogilvie et al. (2004)	Both	Prog.	Peer rev.	Lit. rev.	Not Specified	Systematic literature review.	Mode choice; Health measures	• "We found some evidence that targeted behaviour change programmes can change the behaviour of motivated subgroups, resulting (in the largest study) in a shift of around 5% of all trips at a population level...Participants in trials of active commuting experienced short term improvements in certain measures of health and fitness, but we found no good evidence on effects on health of any effective intervention at population level" (pg. 1).
Ogilvie et al. (2005)	Both	Prog.	Peer rev.	Lit. rev.	Not Specified	Sensitivity analysis of literature.	Mode choice	• "The distribution of available evidence was skewed. Population level interventions were less likely than individual level interventions to have been studied using the most rigorous study designs; nearly all of the population level evidence would have been missed if only randomised controlled trials had been included" (pg. 886).
Oja et al. (1998)	Both	Prog.	Peer rev.	Cross-sec.	Town	2,014 subjects aged 20-64 years in Tampere, Finland received surveys. 1,256 others answered a separate questionnaire.	Aerobic fitness; Blood lipid levels; Body weight; Leisure-time PA	• "The results of the questionnaire survey indicated that while about one-third of the working-age sample commuted by walking or cycling an additional one-quarter were in a position to either begin or increase physically active commuting" (pg. S87). • "Women reported more often than men that walking or cycling to work is their main form of physical activity and substitutes for other physical activity during leisure" (pg. S88).
Oliver et al. (2006)	Both	Prog.	Peer rev.	Q-exp.	Not Specified	78 children aged 8-10 years in a primary school in Auckland, New Zealand, in spring 2004. Intervention included curriculum for elementary school children and pedometer.	Daily steps	• "Results showed that more than one half of the participants were achieving >15,000 steps daily...Differences between baseline and intervention weekdays were nonsignificant for the complete sample; however, significant increases in step counts were observed when the children with low activity levels, especially females, were examined separately" (pg. 74).
Olszewski and Wibowo (2005)	Ped	Infra.	Peer rev.	Cross-sec.	Big city	1,480 interviews were conducted with passengers at MRT stations in Singapore.	Mode choice to transit	• "About 60% of MRT passengers walked to the stations, and the average walking distance was 608 m. Men were more likely to walk than women" (pg. 38). • "Besides the actual distance, factors that significantly affected the access mode choice were number of road crossings, traffic conflicts, and number of ascending steps" (pg. 38).
Osberg and Stiles (1998)	Bicycle	Mode Choice	Peer rev.	B. observ.	Big city	Data on passing cyclists in the three cities was collected in Paris, Boston, and Amsterdam between 1995 and 1997.	Helmet use (dichotomous); Light use (dichotomous)	• "According to United Nations data on passenger car- and bicycle-related deaths, transportation in the Netherlands is safer than in the U.S. or France" (pg. 25). • Factors leading to low combined death rates in the Netherlands: (1) potential car drivers are instead riding bicycles (2) better education of cyclist, driver, and pedestrian education, (3) separation of modes, (4) traffic calming, and (5) denser environment in the Netherlands leads to fewer vehicle miles travelled.
O'Sullivan and Morrall (1996)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city	1,800 peak-hour commuters were interviewed in Calgary, Canada.	Trip distances to/from LRT station	• "The research strongly indicates that people walk farther to reach an LRT station than a bus stop. Using bus walking standards would result in an underestimate of LRT walking distances by about half" (pg. 19).
Owen et al. (2004)	Ped	Comm. des.	Peer rev.	Lit. rev.	Not Specified	Review of 18 studies.	Rates of walking for transportation	• "Attributes associated with walking for exercise were different from those associated with walking to get to and from places" (pg. 67). • "Presence of sidewalks, perceptions of traffic safety, and stores within walking distance were positively associated with walking for transport (Giles Corti and Donovan 2002)" (pg. 69).
Patterson and Chapman (2004)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city, Suburban	372 females living alone over age 70 in Portland, OR.	Number of walking purposes/ resident; Distance to nearest services; Reported quality of life; Reported n'hood satisfaction	• "The study showed that new urbanism partially explained several differences in service use and activity: distance to a grocery store, number of services used within 1 mile from home, number of walking activities, number of services accessed by walking, and number of services accessed by driving" (pg. 45).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Pedler and Davies (2000)	Bicycle	Infra.	Report	B. observ.	Not Specified	Video cameras monitored the behaviour of 1,512 cyclists at five locations in England in 1999. In addition, 223 cyclists were interviewed at the sites.	Driver yielding; Vehicle speed; Cyclist-driver interactions	• "Cycle tracks with priority for cyclists across minor roads appeared to work reasonably satisfactorily in some circumstances, but some hazardous interactions were also observed" (pg. 1). • "High flows of cyclists will increase the likelihood of drivers giving way to cyclists and being alert to cyclists on the crossing" (pg. 16). • "Humped cycle track crossings seemed to be effective in slowing drivers and indicating the presence of a cycle crossing to drivers" (pg. 17).
Pein (1997)	Bicycle	Infra.	Peer rev.	Cross-sec.	Not Specified	442 bicyclists were timed crossing a trail-roadway intersection in Pinellas County, FL.	Bicycle intersection crossing time	• "a theoretical equation was derived to predict bicyclist crossing time for any distance. This derived equation is a linear function of distance, so the regression coefficients could then be used to estimate bicyclist crossing velocity and acceleration on the Pinellas Trail" (pg. 127).
Perlic and Fann (2005)	Ped	Infra.	Conf. p.	Evaluation	Big city	10 locations in Seattle, WA were evaluated using the established criteria.	Grade-separated pedestrian crossings at transit	• The following criteria categories were used to evaluate station areas: land use/ urban design considerations, perceived ease of accessibility, vehicular environment, pedestrian environment and other issues.
Perry et al. (2007)	Ped	Prog.	Peer rev.	Q-exp.	Rural	46 rural women were involved in the study (control and target) in the Pacific Northwest. Intervention included interviewing and team building.	Cardiorespiratory fitness; Self-efficacy; Social support	• "Women in HTH group had a greater improvement in cardiorespiratory fitness (P =.057) and in social support (P =.004) compared with women in the comparison group. Neither group of women experienced a change in exercise self-efficacy (P =.814)" (pg. 304).
Petritsch et al. (2005)	Ped	Model	Peer rev.	Cross-sec.	Big city	Approximately 100 people participated in the 2004 "Walk for Science" event in Sarasota, FL.	User perceptions of pedestrian intersection environment	• Pedestrians crossing with traffic did not score the intersection differently than those crossing against traffic (pg. 58). • The pedestrian LOS model for roadway segments did not adequately predict how pedestrians rated intersections. "The results…suggest that a specific pedestrian LOS model for signalised intersections needs to be developed" (pg. 58).
Petritsch et al. (2006a)	Bicycle	Infra.	Peer rev.	Cross-sec.	Not Specified	User counts of cyclists were collected for two four-hour periods throughout Florida in 2004 and 2005.	Relative crash rates for on- and off-street facilities	• "The example roadway used for this analysis is a four-lane roadway, with a separation to an 8-ft sidepath of 12 ft (3.7 m). As the speed increases, so does the relative safety of the sidepath compared with the adjacent roadway. At posted speeds greater than 40 mph (64 km/h), the sidepath has a lower crash rate than the adjacent roadway. This trend is consistent across all variable ranges" (pg. 199). • "There is an optimal operational width for this sidepath at conflict points: approximately 7 ft" (pg. 198).
Petritsch et al. (2006b)	Ped	Model	Peer rev.	Cross-sec.	Big city	Approximately 100 people participated in the 2004 "Walk for Science" event in Sarasota, FL.	User perceptions of arterial sidewalk environment	• "Although further hypothesis testing may be conducted in a future study, the resulting general model for the pedestrian LOS of urban arterials with sidewalks has a high correlation coefficient (R2 = .70) with the average observations and is transferable to a significant number of metropolitan areas in the United States" (pg. 84).
Pinjari et al. (2007)	Both	Comm. des.	Conf. p.	Cross-sec.	Metro area	1,878 individuals from 1,447 households were surveyed by the 2000 San Francisco Bay Area Travel Survey (BATS).	Residential location choice; Mode choice	• "The built environment attributes such as accessibility, density, and land use mix have significant impacts on commute mode choice even after controlling for residential sorting effects and unobserved taste variations that contribute to such effects" (pg. 12).
Plaut (2004)	Ped	Mode Choice	Peer rev.	Cross-sec.	Metro area	Israeli Census data.	Mode choice (walk to work vs. other modes) and (work at home vs. commuters)	• "It is shown that walkers to work tend to be lower-income, less-educated people with lower asset ownership rates. Females are overrepresented amongst them, while "high-status" professionals are underrepresented. Workers at home appear to be a more complex group. They tend to have higher levels of education and wealth than commuters, but earn less on average" (pg. 229).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Pronovost and Lusignan (1996)	Bicycle	Infra.	Conf. p.	B-and-a	Big city	631.5 hours of observation of cyclists, drivers and pedestrians in five intersections before and after blue markings were painted on the roads in Montreal in 1994.	Cyclist intersection crossing time; Level of conflict between cyclists & motorists and cyclists & pedestrians	• "An increase in the time cyclists took to cross intersections was noted after the crossing was colour marked…this result confirms that cyclists show greater caution after the installation of coloured markings" (pg. 50). • "The number of cyclists who respected the designated cycle path crossing rose from 4.4% to 34.3%" (pg. 50). • "Following colourization of the bicycle crossing, our research revealed a small but significant decrease in the level of conflict between cyclists and motorists" (pg. 50).
Pucher (1998)	Both	Prog.	Peer rev.	Case st.	Big city	Policies in three German cities: Munster, Freiburg, and Munich.	Mode choice	• "In each of the cities, the percentage of travel by bicycling, walking and transit has been raised over the past 20 years, while the car's share of modal split has fallen" (pg. 285).
Pucher (2001)	Bicycle	Infra.	Edito-rial	Discus-sion	Not Specified	n/a	Cycling safety on separate vs. on road facilities	• Key Arguments: "the overwhelming evidence is that cycling is much safer and more popular precisely in those countries where bikeways, bike lanes, special intersection modifications, and priority traffic signals are the key to their bicycling policies" (pg. 1).
Pucher and Buehler (2006)	Bicycle	Infra.	Peer rev.	Discus-sion	Not Specified	Comparison of the. U.S. and Canada.	Bicycling trends	• "The main reasons for this difference are Canada's higher urban densities and mixed-use development, shorter trip distances, lower incomes, higher costs of owning, driving and parking a car, safer cycling conditions, and more extensive cycling infrastructure and training programs" (pg. 265).
Pucher and Buehler (2007)	Bicycle	Prog.	Peer rev.	Case st.	Big city	Case studies of six cities in the Netherlands, Denmark, and Germany.	Cycling rates	• "In our sample of six Dutch, Danish, and German cities, the most important approach to making cycling safe, convenient, and attractive has been the provision of separate cycling facilities along heavily travelled roads and at intersections, combined with extensive traffic calming of residential neighbourhoods" (pg. 64).
Pucher and Buehler (2008)	Bicycle	Prog.	Peer rev.	Case st.	Not Specified	Comparison of the. U.S., U.K., Netherlands, Denmark, and Germany.	Cycling rates	• Key policies and measures used in the Netherlands, Denmark and Germany: extensive systems of separate cycling facilities; intersection modifications and priority traffic signals; traffic calming; bicycle parking; coordination with transit; traffic education and training; traffic laws (pg. 55).
Pucher and Dijkstra (2000)	Both	Infra.	Peer rev.	Discus-sion	Not Specified	Lessons from Europe for the U.S.	Walking and cycling safety	• "Over the past two decades, these countries have undertaken a wide range of measures to improve safety: better facilities for walking and bicycling; urban design sensitive to the needs of non-motorists; traffic calming of residential neighbourhoods; restrictions on motor vehicle use in cities; rigorous traffic education of both motorists and nonmotorists; and strict enforcement of traffic regulations protecting pedestrians and bicyclists" (pg. 1).
Pucher and Dijkstra (2003)	Both	Infra.	Peer rev.	Cross-sec.	Not Specified	Secondary data from national travel and crash surveys in the Netherlands, Germany, and the United States in 2000.	Commute mode share; Pedestrian and cyclist injury rate	• "American pedestrians and cyclists were much more likely to be killed or injured than were Dutch and German pedestrians and cyclists, both on a per-trip and on a per-kilometer basis" (pg. 1509).
Purath and Miller (2005)	Ped	Prog.	Peer rev.	R.C. trial	Not Specified	287 sedentary women were recruited for the study. Intervention included counselling and telephone contact.	Total minutes walked per day; Stage of change; Paffenbarger PA variables	• "Being assigned to the intervention group was a significant predictor in all of the regression models...Minority women showed greater improvement in stage of change of physical activity ($p = .001$) as well as week-end physical activity ($p = .042$). Women with less education were more likely to increase total minutes walked per week ($p = .038$)" (pg. 57).
Pulugurtha et al. (2006)	Ped	Model	Conf. p.	Longit.	Big city	Pedestrian volumes were collected at activity locations throughout the day in Las Vegas, NV.	Pedestrian volume during morning peak, evening peak, and evening off-peak hours	• "The results indicate that commercial area is insignificant and it is not important in estimating pedestrian trips. It was seen that the number of bus stops was not a significant factor in all the models except for the morning peak hour model…The average annual household income was significant in all four models...As expected, the peak hour pedestrian trips were a function of number of lanes and residential area" (pg. 16).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Raford et al. (2007)	Bicycle	Comm. des.	Conf. p.	Cross-sec.	Big city	Traces of routes for 423 cyclists from 50 organisations in London.	Cyclist volumes at gates	• "Total cyclist volumes corresponded strongly with the most accessible, direct streets in the urban network" (pg. 1). • "This research suggests that angular minimization is an important factor in cyclist route choice and that measurement of least angle routes in urban environments can be a useful way of predicting cyclist volumes and route choice" (pg. 1).
Räsänen and Summala (1998)	Bicycle	Infra.	Peer rev.	Longit.	Big city, Small city	188 bicycle-car accidents in four cities in Finland.	Cyclist-driver accidents	• "The distribution of cases within group 1A confirmed the earlier finding that drivers turning right, but not those turning left, hit cyclists coming from the right" (pg. 661). • "The most frequent accident type among collisions between cyclists and cars at bicycle crossings was a driver turning right and a bicycle coming from the driver's right along a cycle track" (pg. 657).
Reed et al. (2004)	Ped	Infra.	Peer rev.	Cross-sec.	Rural	1,112 adults in a south-eastern county in the U.S. were administered a telephone survey in 2001.	Use of trails; Awareness of trails	• "There was no agreement between the awareness and presence of trails. Fifty-six percent of the respondents reported having trails; however, only 33% reported using the trails" (pg. 903).
Reger et al. (2002)	Ped	Prog.	Peer rev.	Q-exp.	Small city	1,472 adults were interviewed pre- and post-intervention. Intervention included paid media, PR, and public health activities including information to physicians.	Walker counts; Self-reported PA: Meeting PA guidelines; Total minutes walked per week	• "Behaviour observation showed a 23% increase in the number of walkers in the intervention community versus no change in the comparison community. Thirty-two percent of the baseline sedentary population in the intervention community reported meeting the...recommendation for moderate-intensity physical activity by walking at least 30 min at least five times per week versus 18.0% in the comparison community" (pg. 285).
Reynolds et al. (2007)	Bicycle	Comm. des.	Peer rev.	Cross-sec.	Big city	201 trail segments from three trails in Chicago, Dallas, and Los Angeles were analysed.	Cyclist counts for each segment	• "Positive associations with trail use were observed for mixed views, streetlights, good trail conditions, and the presence of cafes and other trailside facilities. Negative associations were observed for littler, noise, higher vegetation density, drainage features, natural areas adjacent to the trail, and tunnel present" (pg. 335).
Rhodes et al. (2006)	Ped	Comm. des.	Peer rev.	Cross-sec.	Not Specified	351 adults from South Vancouver Island, British Columbia, Canada were surveyed.	Frequency of walking trips greater than 20 minutes during a typical week	• "Results using structural equation modelling indicated that the Theory of Planned Behaviour mediated the environment-walking relationship. Specifically, retail land-mix use and neighbourhood aesthetics were associated with walking through affective and instrumental attitudes" (pg. 110). • "Walking correlated with neighbourhood aesthetics and land-mix use for retail but no other significant correlations were identified" (pg. 115).
Rietveld (2000a)	Bicycle	Infra.	Other	Discus-sion	Not specified	Discussion from the Netherlands.	Bicycle access to rail	• "Especially at the home end, the bicycle appears to play a large role as an access mode with a user share of 35%" (pg. 71).
Rietveld (2000b)	Both	Infra.	Peer rev.	Discus-sion	Not Specified	Data on non-motorized modes from The Netherlands.	Non-motorized mode share	• "For transit chains where some segments have low frequencies the non-motorized access modes of walking and biking may greatly improve the overall quality of the chain. This underlies that transit companies should not only bother about the speed and frequency of their own service, but also the accessibility of their transit nodes for non-motorized transport, including adequate parking facilities for bicycles" (pg. 36).
Rietveld and Daniel (2004)	Bicycle	Comm. des.	Peer rev.	Cross-sec.	Not Specified	Data for 103 Dutch municipalities collected from a variety of sources.	Bicycle mode share	• "It appears that most of the inter-municipality variation in bicycle use is related to physical aspects such as altitude differences and city size, and features of the population (share of youngsters). Differences in ethnic composition also appear to matter" (pg. 531).
Rissel and Garrard (2006)	Bicycle	Prog.	Peer rev.	Lit. rev.	Not Specified	n/a	Cycling	• Recommendations based on literature review: implement strategies to increase political commitment to support cycling; regular national cycling/travel surveys; document the effects of different types of infrastructure on cycling; better understanding of safety issues associated with cycling; research role of cycling in overall levels of physical activity; better documentation of successful strategies.

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Road Directorate (1998)	Both	Infra.	Report	Best prac.	Not Specified	Experience from the Netherlands.	Walking and cycling	• "In countries with a high cyclist share, different factors played a role in order to achieve this status: a long tradition in the use of this transport mode, a flat landscape and the implementation of a long list of measures both infrastructural and non-infrastructural. What seems to be important is a continued network, such as some special attention in crossing points between different types of road users" (pg. 288).
Robinson et al. (1980)	Both	Pricing	Peer rev.	Cross-sec.	Suburban, Big city	6,900 questionnaires were distributed to randomly selected households in five cities.	Stated mode preference	• "80 percent of automobile trips for shopping or personal business were 4 miles or less" (which the authors considered the maximum biking distance for such trips). "This suggests a significant potential for future competition between automobile modes and nonmotorized modes within these trip distances." (pg. 41). • The order of strategies based on their ability to increase walking and biking: (1) Compact land use; (2) Pedestrian or bicycle facilities; (3) Congestion fee; (4) Fuel price increase; and (5) Bicycle or pedestrian facilities (pg. 47).
Rodriguez and Joo (2004)	Both	Comm. des.	Peer rev.	Cross-sec.	Metro area	In 1997, 509 students, faculty and staff at the University of North Carolina, Chapel Hill, NC completed surveys.	Preferred mode choice to campus	• "Results suggest that the four attributes of the local physical environment jointly make significant marginal contributions in explaining travel mode choice. In particular, the estimates reveal that local topography and sidewalk availability are significantly associated with the attractiveness of bicycling and walking modes, respectively" (pg. 151).
Rodriguez et al. (2006)	Ped	Comm. des.	Peer rev.	Q-exp.	Suburban	Heads of households in the new urbanist community and the control communities received surveys.	Weekly total moderate or vigorous PA hours; Location of PA; Daily trips involving PA	• Between a New Urbanist and a suburban neighbourhood, the authors identified "differences in where people were physically active. Residents of the new urbanist neighbourhood were more likely to be physically active in their neighbourhood than were residents of conventional suburbs. This difference was due to their walking more for utilitarian purposes, as distinct from walking for leisure" (pg. 43).
Roemmich et al. (2006)	Ped	Comm. des.	Peer rev.	Cross-sec.	Not Specified	32 boys and 27 girls aged 4-7 years from Erie County, NY participated in the study in 2003.	Average accelerometer counts per minute over all 4 days	• "Greater housing density predicted increased physical activity of boys, but not girls" (pg. 437). • "Street connectivity was not independently related to physical activity" (pg. 440).
Rooney et al. (2003)	Ped	Prog.	Peer rev.	Q-exp.	Not Specified	510 female employees at a health care organisation in a three-state area participated in the study in 2000.	Awareness of daily activity; Total physical activity	• "Setting daily step goals, keeping a log of steps walked, and wearing the pedometer all the time were the indicators most likely to predict significant improvements in level of awareness and amount of physical activity, self-efficacy, and other physical improvements (increased energy, ill less often, and weight loss)" (pg. 31).
Rose (2007)	Bicycle	Infra.	Conf. p.	Cross-sec.	Big city	4,342 cyclists were tallied using an off-road path in Melbourne, Australia.	Cyclist use of off-road paths	• "the vast majority of trips (85%) were for commuting to work with recreational use accounting for approximately an order of magnitude less (8% of all trips). On average cyclists spent over 50% of their riding time on off-road facilities. If the off-road facilities were not available, approximately one in five (20%) of riders would change modes" (pg.1)
Rose and Ampt (2001)	Both	Prog.	Peer rev.	Cross-sec.	Big city	50 individuals in a pilot study in Sydney, Australia & 100 households in a second study in Adelaide, Australia. Intervention from Travel Blending® program and involved information kits and travel diaries over a nine-week period.	Number of car driver trips; Car driver km; Total hours in car	• "Quantitative results from the Adelaide study indicate about a 10% reduction in car driver kilometers with a slightly higher percentage reductions in car driver trips and total hours spent in the car" (pg. 95).
Rose and Marfurt (2007)	Bicycle	Prog.	Peer rev.	Cross-sec.	Big city	Surveys were sent in March 2005 to participants in the 2004 Ride-to-Work event in Victoria, Australia.	Ride status in first five months after event (1=rode bicycle, 0=did not ride); Stage of engagement	• "More than one in four (27%) of those who rode to work for the first time as part of the event were still riding to work five months after the event. Over 80% of first-timers indicated that the event had a positive impact on their readiness to ride to work with 57% indicating that it influenced their decision to ride. The event was found to have a greater impact on influencing behaviour change for female than male riders" (pg. 351).
Rowley et al. (2007)	Ped	Prog.	Peer rev.	Q-exp.	Rural	165 mothers from semi-rural England took part in the program.	Self-reported physical activity; Psycho-social benefits	• "Evaluation indicated that the walking programmes provided an acceptable and supported opportunity for parents and children to participate in physical activity. Participants increased their levels of regular physical activity and reported psychological benefits" (pg. 28).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Rutherford et al. (1997)	Both	Comm. des.	Conf. p.	Cross-sec.	Big city	900 households in the greater Seattle area were surveyed.	Average daily travel mileage per person	• "The large differences among the areas reported for travel distance are not seen when considering travel time. The travel time was about 90 minutes per person regardless of where that person lived" (pg. 147). • "Residents of the two mixed-use neighbourhoods in Seattle travelled 27 percent fewer miles than the remainder of North Seattle, 72 percent fewer than the inner suburbs and 119 percent fewer than the outer suburbs" (pg. 146).
Rwebangira (2001)	Bicycle	Mode Choice	Peer rev.	Discus-sion	Big city	Review of African experience and prospects.	Cycling	• "The most important constraints to cycling were found to be lack of traffic safety for cyclists and the lack of affordability of a bicycle. Traffic safety is particularly a cycling deterrent in large cities" (pg. 7).
Ryley (2006a)	Bicycle	Infra.	Peer rev.	Q-exp.	Big city	997 households in West Edinburgh, Scotland completed a stated preference survey in July 2003.	Propensity to cycle	• "Model estimation shows that cyclist facilities, primarily at the destination but also en route, largely determine the propensity to cycle to work or study" (pg. 187). • "There was a preference among respondents for more money to be spent improving off-road (69% agreement) than on-road (49% agreement) cycle lanes" (pg. 190). • "Payments to individuals do not appear to be an effective method to induce cycling in this study" (pg. 191).
Ryley (2006b)	Both	Mode Choice	Peer rev.	Cross-sec.	Big city	2,910 households survey in the Edinburgh-based Scottish Household Survey for 1999 and 2000.	Non-motorized journeys in previous week; Commute mode; Journeys previous day	• "The life stage of having children is shown to affect individual travel behaviour. Households with children present have distinctive travel behaviour characteristics: they are particularly car dependent, tend to own but not use bicycles, and favour leisure cycling trips" (pg. 367).
Saelens et al. (2003a)	Both	Comm. des.	Peer rev.	Cross-sec.	Metro area	On 2 occasions, 107 adults from neighbourhoods in San Diego, CA were selected to complete a survey.	Minutes of moderate-intensity PA during past 7 days; Percentage of time walking for different purposes	• "Table 4 shows that residents in the high-walkability neighbourhood engaged in approximately 52 more minutes of moderate-intensity physical activity during the past 7 days than did residents of the low-walkability neighbourhood" (pg. 1555). • "After controlling for age and education, walking for errands was higher in the high-walkability neighbourhood" (pg. 1555).
Saelens et al. (2003b)	Both	Comm. des.	Peer rev.	Lit. rev.	Not Specified	Literature review.	Utilitarian walking+cycling rates	• "Neighbourhood comparison and correlational studies with nonmotorized transport outcomes are considered, with evidence suggesting that residents from communities with higher density, greater connectivity, and more land use mix report higher rates of walking/cycling for utilitarian purposes than low-density poorly connected, and single land use neighbourhoods. Environmental variables appear to add to variance accounted for beyond sociodemographic predictors of walking/cycling for transport" (pg. 80).
Saksvig et al. (2007)	Ped	Mode Choice	Peer rev.	Cross-sec.	Not Specified	1,596 6th-grade girls from 36 middle schools in six US states.	Mean min. of PA for total PA and moderate to vigorous PA	• "Travel by walking was reported by 14% of participants before school and 18% after school. Girls who reported travel by walking before and after school (combined) had 13.7 more minutes of total physical activity and 4.7 more minutes of MVPA than girls who did not report this activity" (pg. 153).
Sallis et al. (1998)	Both	Prog.	Peer rev.	Lit. rev.	Not Specified	Seven published studies were reviewed.	Physical activity	• "Two studies showed that placing signs encouraging stair use can be effective. Quasiexperimental evaluations provided limited evidence that broad environmental changes can be effective. Large-scale policy interventions are currently being conducted in several countries" (pg. 379).
Scarf and Grehan (2005)	Bicycle	Model	Peer rev.	Model-ling	Not Specified	Data from 38 tour stages from the Tour de France, the Tour de Spain and the Tour of Italy.	Route travel time	• "A simple analysis of the data suggests that 1 m of vertical travel on a bicycle can be considered to be equivalent to approximately 8 m of horizontal travel" (pg. 919). • "we argue that a distance of 1 km over good off-road terrain is equivalent to a distance of 2 km on-road, and that a distance of 1 km over poor off-road terrain is equivalent to a distance of 4 km on-road" (pg. 919).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Schlossberg et al. (2006)	Both	Comm. des.	Peer rev.	Cross-sec.	Small city	Middle school students from four middle schools in Bend and Springfield, OR.	Primary modes of travel (three or more days per week) for trips to and from school	• Five primary results emerge: (1) urban form helps predict travel mode to and from school; (2) middle school students walk further than planners expect; (3) many students use a different mode when they travel to school and when they leave school; (4) urban form measures that predict walking behaviour differ from those that predict biking behaviour; and (5) urban form is only one factor in students' transportation decisions" (pg. 337). • The authors observed no relationship between distance to school and travel by car. • "Holding distance and other urban form measures constant, intersection density was also a strong predictor of whether or not children walked to and from school" (pg. 341).
Seethaler and Rose (2006)	Both	Prog.	Conf. p.	Experi-ment	Not specified	160 households were involved in the study.	TravelSmart program participation	• "Although not statistically significant at a 95% confidence level because of limited sample size, the results indicate an increase in participation when persuasion strategies were integrated into the TravelSmart recruitment process (pg. 94).
Shafer et al. (1999)	Both	Infra.	Report	Cross-sec.	Big city	1,004 people participated in a user survey at three shared-use trails in Texas in the summer of 1998.	User satisfaction with trails	• "Adequate separation from motor vehicles was noted as a positive attribute that should be provided whenever possible on shared use trails. Trail surface quality and width was also noted as an important attribute, particularly in cases where numerous user types (e.g., bicyclists, joggers, walkers) were using the same trail" (abstract).
Shafizadeh and Niemeier (1997)	Bicycle	Mode Choice	Peer rev.	Cross-sec.	Big city	1993 bicycle-intercept survey distributed in Seattle, WA.	Bicycle commute travel times	• "This study also suggests that separated bicycle paths play an integral part in the overall bicycle transportation network. Statistical analysis also indicated that cyclists travelling primarily on separated paths tend to make significantly longer trips" (pg. 84).
Shaheen et al. (2005)	Bicycle	Prog.	Peer rev.	Lit. rev.	Small city	Preparation for field test of Segway, electric bicycle, and bicycle access to transit in California.	Low-speed mode crash rates	• "A review of the safety literature indicates that user error is the major cause of low-speed mode crashes, and significant risk factors are poor surface conditions and obstructions to drivers' vision" (pg. 189).
Shay et al. (2006)	Ped	Comm. des.	Peer rev.	Q-exp.	Suburb	348 adult residents of Southern Village, Chapel Hill, NC were administered surveys and travel diaries in 2003.	Total internal utilitarian trips; Walk internal utilitarian trips; Drive internal utilitarian trips	• "It is found that within the neotraditional neighbourhood, walk trips drop off quickly with increasing distance to destinations, whereas drive trips increase" (pg. 154). • "The variable for "shops and services nearby" is not significant for walk trips, suggesting that those valuing proximity to a destination may not necessarily change their walking habits beyond the effect that distance to the commercial centre exerts" (pg. 159).
Shriver (1997)	Ped	Comm. des.	Peer rev.	Q-exp.	Big city, Suburban	Neighbourhood-intercept survey in four Austin, TX neighbourhoods (two "traditional", two "modern").	Walk trip purpose, distance, duration, and magnitude	• "In the physically accessible neighbourhoods, walks are predominantly short and frequent utilitarian trips that involve more secondary activities. Activity in the less accessible neighbourhoods is characterized by longer, less frequent recreational walks that involve fewer secondary activities" (pg. 64).
Siddiqui et al. (2006)	Ped	Infra.	Peer rev.	Cross-sec.	Not Specified	58,202 pedestrian crashes in the state of Florida from 1986-2003 were analysed.	Pedestrian injury severity (ordinal scale)	• "In terms of crossing locations, the probability of a pedestrian dying when struck by a vehicle is higher at midblock locations than at intersections for any light condition" (pg. 141).
Sisiopiku and Akin (2003)	Ped	Infra.	Peer rev.	B. observ.	Big city	897 people responded to an e-mailed survey.	Pedestrian behaviour at crosswalks; Pedestrian perceptions of crosswalks	• "It was found that unsignalised midblock crosswalks were the treatment of preference to pedestrians (83% reported a preference to cross) and also showed high crossing compliance rate of pedestrians (71.2%). It was also evident that the crosswalk location, relative to the origin and destination of the pedestrian, was the most influential decision factor for pedestrians deciding to cross at a designated location (90% said so)" (pg. 249).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Smith and Walsh (1988)	Bicycle	Infra.	Peer rev.	B-and-a	Big city	Accident data on Johnson and Gorham Streets, where bicycle lanes were installed in 1977.	Bicycle accidents	• After the bicycle lanes were installed, "the increase in accidents (expanded before versus after) is statistically significant at the 0.03 and 0.18 levels for the total and average accidents, respectively" (pg. 52). • "The data suggest that the high level of after period accidents resulted from initial unfamiliarity with a novel situation because accidents dropped sharply after the first year of the after period" (pg. 54).
Snelson et al. (1993)	Bicycle	Prog.	Peer rev.	Cross-sec.	Not specified	Group discussions were held in Birmingham, Maidstone and Norwich in 1992. In 1993 a second sample of 1,000 motorists were sent a survey.	Potential to change modes	• Of all motorists, the following three groups might be persuaded to increase bicycle usage: non-cyclists who say they may take up cycling again; leisure-only cyclists who might cycle for commuting/shopping/personal business; cycling motorists who don't normally use a bicycle for trips. "Taking these three groups together, about a third of motorists might be persuaded to increase their use of a bicycle in place of a car" (pg. 558).
Socialdata Australia (2003)	Both	Prog.	Report	B-and-a	Small city	1,394 people participated in the 'before' survey in 2001 and 1,030 people in the 'after' survey in 2002 in the Town of Cambridge.	Mode choice	• Results reported a 7% reduction in car as driver trips, with the trips changing to: walking (+11%), cycling (+67%), and transit (+13%). "The changes that occurred in the way residents travel had little impact on their mobility....the time spent travelling increased from 55 minutes to 56 minutes" (pg. 54).
Staunton et al. (2003)	Both	Prog.	Peer rev.	Cross-sec.	Not Specified	Survey of public school students in Marin County, CA 2000-2002.	Frequency of non-motorized + carpool trips to school	• "Student surveys shows that from Fall 2000 to Spring 2002, there was a 64% increase in the number of children walking, a 114% increase in the number of students biking, a 91% increase in the number of student carpooling and a 39% decrease in the number of children arriving by private car carrying only one student" (pg. 1431).
Steiner (1994)	Ped	Comm. des.	Peer rev.	Lit. rev.	Not Specified	Literature review.	Trip length and number; Mode choice	• "Although research using aggregate data suggests that people who live in high-density developments make fewer and shorter trips and walk or use transit more frequently than residents of areas with lower densities, these studies have not separated out other factors, such as income, household size, life-cycle characteristics or household members, and other land-use characteristics for which density may be a proxy" (pg. 42).
Steiner et al. (2002)	Ped	Model	Report	Cross-sec.	Big city	Data from the "Walk for Science 2000" event in Pensacola, FL.	Users' perception of roadside conditions	• "This plot indicates that the presence of other pedestrians does have an affect on people's perception of safety at relatively low pedestrian volumes, i.e. when the volume of pedestrians is less than ten (10) for every 15-minute period, however, without having segments with a greater range of pedestrian volumes (particularly at the higher end), reliable conclusions cannot be drawn from the existing data" (pg. 3).
Stinson and Bhat (2003)	Bicycle	Infra.	Peer rev.	Cross-sec.	Big city	3,145 individuals completed a stated-preference survey.	Commuter bicyclist route choice	• The models indicate that, for commuter bicyclists, travel time is the most important factor in choosing a route. Presence of a bicycle facility (especially a bicycle lane or separate path), the level of automobile traffic, pavement or riding surface quality, and presence of a bicycle facility on a bridge are also very important determinants.
Stone and Broughton (2003)	Bicycle	Infra.	Peer rev.	Longit.	Not Specified	Bicycle-motor vehicle accidents in Great Britain from 1990-1999.	Incidence rates; Fatality rates	• "three-quarters of fatal and reported serious cycle accidents occur on 30 mph roads, but that the fatality rate rises markedly after the age of 40 years" (pg. 555). Fatality rates increased with speed limit increases: 5 percent fatality rate at 30 mph, 13 percent at 40 mph, 21 percent at 60 mph and 31 percent at 70 mph.
Stopher et al. (2004)	Both	Prog.	Conf. p.	Lit. rev.	Not Specified	n/a	Success of travel smart type programs	• The authors suggest that the use of GPS devices to be used for one week by participants is a better way to measure travel behaviour. They also suggest that panels, as opposed to repeated cross-sections, should be the only method used for evaluating TravelSmart.

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Summala et al. (1996)	Bicycle	Infra.	Peer rev.	B. observ.	Not specified	Video of drivers' scanning behaviour from two T-intersections in Helsinki, Finland in the fall of 1990.	Drivers' scanning behaviour (head movements)	• "The drivers turning right scanned the right leg of the T-intersection less frequently and later than those turning left" (pg. 147). • "The results suggested that speed-reducing countermeasures changed drivers' visual search patterns in favour of the cyclists coming from the right, presumably at least in part due to the fact that drivers were simply provided with more time to focus on each direction" (pg. 147).
Taylor and Mahmassani (1996)	Bicycle	Infra.	Peer rev.	Experi-ment	Not Specified	All members of the Texas Bicycle Coalition were sent a stated-preference survey in the mail.	Stated mode choice (auto only, park and ride, or cycle and ride)	• "The results also indicate that bike lanes are superior to wide curb lanes as an incentive for casual and inexperienced cyclists, but that bike lanes and wide curb lanes are an identical incentive for experienced cyclists" (pg. 86). • "Bicycle lockers are a relatively powerful incentive for a commuter to choose to bike and ride" (pg. 91).
Telfer et al. (2006)	Bicycle	Prog.	Peer rev.	Pre-Post	Not Specified	113 participants from 20 cycling proficiency training (CPT) courses were given questionnaires in 2003 and 2004.	Cycling frequency per week; Moderate PA per week; Cycling skills and knowledge	• "At 2-month follow-up, the course had significantly increased participants' self-reported skills and confidence for cycling. More than half of the participants (56%) said they cycled more 2 months after the course...There was also a significant increase in weekly participation in other forms of moderate intensity physical activity" (pg. 151).
Thom and Clayton (1992)	Bicycle	Infra.	Peer rev.	Field study	Big city, Suburban	Field observations of 900 cyclists at seven locations in the Canadian cities of Vancouver and Winnipeg in 1991.	Cyclist-motor vehicle accidents	• "The most frequent contributing factor on the part of the cyclist was failure to yield right of way (in 347, or 15 percent, of accidents), followed by sidewalk and/or wrong-way riding...The most frequent contributing factor on the part of the motorist was also failure to yield right of way (in 447, or 19 percent, of accidents), followed by improper right turn" (pg. 96).
Tilahun et al. (2004)	Bicycle	Infra.	Report	Cross-sec.	Big city	181 University of Minnesota employees participated in the survey.	Travel time participants are willing to expend for different facilities	• "Respondents are willing to travel up to twenty minutes more to switch from an unmarked on-road facility with side parking to an off-road bicycle trail, with smaller changes associated with less dramatic improvements" (pg. 1)
Tilt et al. (2007)	Ped	Comm. des.	Peer rev.	Cross-sec.	Big city	529 residents of Seattle, WA responded to a mail survey.	Subjective accessibility; Walk trips/month; Subjective greenness; Satisfaction with greenness; BMI	• "Objective accessibility were related to walking trips per month, as was subjective greenness, although objective measures of actual greenness were not. In areas with high accessibility, BMI was lower in areas that had high NDVI, or more greenness" (pg. 371). • "The most frequently walked types of destinations found in one's neighbourhood were parks and grocery stores" (pg. 375).
Timperio et al. (2004)	Both	Comm. des.	Peer rev.	Cross-sec.	Big city	Children aged 5-6 years (n=291) and 10-12 (n=919) were recruited from 19 Australian primary schools.	Total weekly trips walking or cycling to local destinations	• "Parental belief that there were no lights or crossings was associated with walking or cycling among 10- to 12-year-old boys. Among older girls, parent's belief that their child needed to cross several roads to reach play areas and that there is limited transit in their area, and child's belief that there were no parks or sports grounds near home were associated with a lower likelihood of walking or cycling" (pg. 39).
Timperio et al. (2006)	Both	Comm. des.	Peer rev.	Cross-sec.	Big city	235 children aged 5-6 years and 677 children aged 10-12 years from 19 elementary schools in Melbourne, Australia in 2001.	Average reported walk and cycle trips to school per week	• "Among both age groups, negative correlates of active commuting to school included parental perception of few other children in the neighbourhood and no lights or crossings for their child to use, and an objectively assessed busy road barrier en route to school" (pg. 45). • "Younger children with a steep incline en route to school, and older children with a direct route, were less likely to walk or cycle to school compared with other children" (pg. 48).
Troped et al. (2001)	Both	Comm. des.	Peer rev.	Cross-sec.	Suburb	413 randomly sampled adults in Arlington, MA in September 1998.	Use of Minuteman bikeway (binary)	• "In logistic models, age and female gender showed statistically significant inverse associations with Bikeway use over the previous 4-week period. Increases in self-reported and GIS distance were associated with decreased likelihood of Bikeway use" (pg. 191).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Ullman et al. (2004)	Ped	Infra.	Conf. p.	Cross-sec.	Big city, Suburban	Between 40 and 44 pedestrian surveys were completed at each of seven sites.	Pedestrian perceptions of safety	• "It was found through this study that as the control at a pedestrian crossing increases through the addition of signs, flashing lights, and/or signals, the pedestrians' perception of safety also increases" (pg. 1).
Unwin (1995)	Bicycle	Mode Choice	Peer rev.	Cross-sec.	Not Specified	Review of numerous surveys of Britain including, 1985-86 National Travel Survey, 1981 Census, Greater London Council surveys 1981-1984, Cyclist's Touring Club questionnaire 1978.	Miles cycled/week	• "Boys aged 11-15 years cycle the greatest number of miles per person per week, followed by men aged 16-59 years. Cycling to work is weakly associated with affluence" (pg. 41). • "Modelling cycling to work patterns suggests that hilliness, traffic danger, rainfall and longer trip lengths are important deterrents to cycling" (pg. 41).
Van Houten and Seiderman (2005)	Bicycle	Infra.	Peer rev.	B-and-a	Big city	Video of 4,500 cyclists and 4,500 moving vehicles during peak-hour periods in 2003 in Cambridge, MA. Also, before (n=117 for bicycles, n=129 for cars) and after (n=123 for bicycles, n=120 for cars) surveys of bicyclists and motorists were performed.	Parking position; Bicycle and motor vehicle road positions	• "When motorists were asked what made them most aware of cyclists on the street; the most common response in the before survey was 'nothing.' In the after survey, the most common response was 'the bicycle lane'" (pg. 3). • "Most important, cyclists who were riding the closest to parked cars in the baseline condition moved farther away, so the percentage of people riding more than 2 or 3 ft from parked cars went up significantly" (pg. 7)
van Lenthe et al. (2005)	Both	Comm. des.	Peer rev.	Cross-sec.	Not Specified	Surveyed 8,767 participants, aged 20-69 years, in the Dutch GLOBE study of Eindhoven.	Physical inactivity (three point scale)	• "Compared to those living in the most advantaged neighbourhoods, residents living in the quartile of socioeconomically most disadvantaged neighbourhoods were more likely to walk or cycle to shops or work, but less likely to walk, cycle or garden in leisure time and less likely to participate in sports activities (adjusted for age, sex and individual educational level)" (pg. 763).
Virkler (1998a)	Ped	Infra.	Peer rev.	Field study	Big city	49 signalized intersection approaches and one unsignalized in Brisbane, Australia.	Signal delay	• "Data from 49 signalised intersections within the routes indicate that upstream coordinated signals can significantly affect downstream signal delay. It was also found that, in a coordinated signal system, the standard deviation of delay at a signal can be much different from what would be expected if arrivals were random" (pg. 37).
Virkler (1998b)	Ped	Infra.	Peer rev.	Field study	Big city	10 intersection approaches in Brisbane, Australia were studied.	Signal delay	• "For low green times, the effect of pedestrian platooning on delay was found to be greater than that generally recognized for the automobile mode" (pg. 77).
Wachtel and Lewiston (1994)	Bicycle	Infra.	Peer rev.	Longit.	Small city	In May 1987 nearly 3,000 cyclists were counted and their behaviour observed.	Accident risk	• "all categories of bicyclists travelling against the direction of traffic flow are at greatly increased risk for accidents--on average 3.6 times the risk of those travelling with traffic" (pg. 5). • "The average cyclist in this study incurs a risk on the sidewalk 1.8 times as great as on the roadway, and the result is statistically significant ($p<0.01$)" (pg. 7).
Wardman et al. (1998)	Bicycle	Mode Choice	Peer rev.	Q-exp.	Small city	221 households completed a stated preference survey in 1996 in England.	Mode choice	• "The risk of accident is the most commonly cited reason for not cycling" (pg. 127).
Weinstein and Schimek (2005)	Ped	Comm. des.	Conf. p.	Cross-sec.	Not Specified	2001 National Household Travel Survey.	Trip purpose	• "The data also show that the number of walk trips people take for recreation and exercise is unrelated to population density and car ownership, whereas a relationship was found between those factors and "utility" trips taken to access a particular place" (pg. 2). • "About 20% [of walk trips] are for recreation or exercise. Walk to transit accounts for 16%, school trips are 7%, work trips are 4%, and walk-the-dog trips are 3%" (pg. 9).
Weinstein et al. (2007)	Ped	Comm. des.	Conf. p.	Cross-sec.	Big city	328 adults who walked to the transit station at five transit stations in the San Francisco Bay area and Portland, OR in 2006.	Route choice	• "(1) Pedestrians walk considerably farther to access light rail stations than commonly assumed. (2) Pedestrians believe that their primary consideration in choosing a route is minimizing time and distance. (3) Secondary factors influencing route choice are safety and, to a lesser extent, attractiveness of the route, sidewalk quality, and the absence of long waits at traffic lights" (pg. 1).

Citation	Mode	Issue	Lit. Type	Study	Density	Sample	Outcome Variable(s)	Key Findings
Wendel-Vos et al. (2004)	Both	Comm. des.	Peer rev.	Cross-sec.	Small city	13,184 former participants in a national health study from Maastricht, the Netherlands in 1998.	Hours/week of walking/biking for commuting and for leisure	• "In a neighbourhood defined as a circle with a 300-m radius, the square area of sport grounds was associated with bicycling in general and the square area of parks was associated with bicycling for commuting purposes" (pg. 725).
Wigan (1995)	Ped	Mode Choice	Peer rev.	Discus-sion	Not Specified	n/a	n/a	• "Significant gender differences are disguised by combining cycling and walking into a single nonmotorized transportation mode" (pg. 7).
Wray et al. (2005)	Ped	Prog.	Peer rev.	Cross-sec.	Not Specified	297 adults were surveyed in St. Joseph, MO in 2003.	Days/week walked >= 10 min; Participation in community walk event or fair	• "Reported exposure to the campaign was significantly associated with two of four pro-walking belief scales (social and pleasure benefits) and with one of three community-sponsored activities (participation in a community-sponsored walk) controlling for demographic, health status, and environmental factors" (pg. 1).
Yarlagadda and Srinivasan (2007)	Both	Mode Choice	Conf. p.	Cross-sec.	Metro area	Data for 3,851 children was used from the 2000 San Francisco Bay Area Travel Survey (BATS).	Travel mode to school	• "Empirical results indicate that the characteristics of child like age, gender, and ethnicity, and employment and work flexibility characteristics of the parents have strong impacts on the mode choice decisions" (abstract). • "The distance between home and school is found to strongly and negatively impact the choice of walking to and from school, with the impact being stronger for walking to school. Several land-use and built-environment variables were explored, but were found not to be statistically significant predictors" (abstract).
Yi and Zhang (2006)	Ped	Comm. des.	Conf. p.	Case st.	Suburban	Accessibility and connectivity measured using GIS on three neighbourhoods in Texas.	Connectivity and accessibility	• "Our analysis indicates that connectivity and accessibility of a cul-de-sac neighbourhood whose design concepts focus on better pedestrian access and interconnectedness with separate pedestrian trails are higher than the typical suburban neighbourhood with cul-de-sacs and comparable with the grid neighbourhood" (abstract).
Zacharias (1999)	Both	Infra.	Peer rev.	B. observ.	Big city	Sections of a street in Amsterdam, Netherlands were videotaped and the behaviours and movements of people in various modes were observed.	Distance between each individual and the three nearest individuals	• "The average peak of 4.6 persons/minute/m is below those levels found to result in reduced speed, platooning and reduced cross-movement, all of which can however be observed nearby on the Kalverstraat" (pg. 25).
Zegeer et al. (2005)	Ped	Infra.	Report	Cross. sec.	Not Specified	1,000 marked crosswalk sites and 1,000 unmarked crosswalk sites in 30 cities across the United States.	Observed pedestrian crashes	• "On two-lane roads, the presence of a marked crosswalk alone at an uncontrolled location was associated with no difference in pedestrian crash rate, compared to an unmarked crosswalk. Further, on multilane roads with traffic volumes above about 12,000 vehicles per day, having a marked crosswalk alone (without other substantial improvements) was associated with a higher pedestrian crash rate (after controlling for other site factors) compared to an unmarked crosswalk" (abstract).
Zein et al. (1997)	Both	Infra.	Peer rev.	Pre-Post	Big city, Small city	Crash data for four neighbourhood sites in Canada.	Collision frequency; Collision severity; Annual collision claim costs	• "The traffic-calming projects all achieved reductions in collision frequency, severity, and the annual collision claim costs. The magnitude of these benefits varied among the projects, with an average 40 percent reduction in collision frequency and 38 percent reduction in the annual claim costs" (pg. 6).
Zlot and Schmid (2005)	Both	Comm. des.	Peer rev.	Cross-sec.	Not Specified	Data on 34 metropolitan statistical areas or cities from three different surveys.	Utilitarian walking+ cycling rates; Recreational walking+biking rates	• "Utilitarian walking and bicycling and parkland acreage were significantly correlated. No significant relationships were observed for leisure time walking or bicycling" (pg. 314).

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