

Victoria Transport Policy Institute

1250 Rudlin Street, Victoria, BC, V8V 3R7, CANADA

www.vtpi.org info@vtpi.org

Phone & Fax 250-360-1560

"Efficiency - Equity - Clarity"

If Health Matters

Integrating Public Health Objectives in Transportation Planning

By

Todd Litman

Victoria Transport Policy Institute

13 June 2006



Abstract

This paper investigates how transport policy and planning practices would change if public health objectives received greater priority. Conventional transport decision-making focuses on some health impacts but overlook others. It gives considerable attention to per-kilometer vehicle crash risk and pollution emissions, but overlooks the safety and pollution problems that result from increased vehicle mileage, and the negative health impacts resulting from less physically active travel. As a result, transportation agencies tend to undervalue strategies that reduce total vehicle travel and create a more diverse transport system. Various mobility management strategies are described and their impacts on traffic safety, pollution emissions and physical activity are evaluated. This analysis suggests that giving greater priority to health objectives in transport planning would reduce roadway and parking capacity expansion and increase support for mobility management strategies, particularly those that increase walking and cycling.

A summary of this paper was published as, Todd Litman, "Integrating Public Health Objectives in Transportation Decision-Making," *American Journal of Health Promotion*, Vol. 18, No. 1 (www.healthpromotionjournal.com), Sept./Oct. 2003, pp. 103-108, also available at www.vtpi.org.

Todd Alexander Litman © 2001-2005

You are welcome and encouraged to copy, distribute, share and excerpt this document and its ideas, provided the author is given attribution. Please send your corrections, comments and suggestions for improving it.

Contents

Introduction	3
Transportation Health Impacts	4
Traffic Crashes	5
Vehicle Pollution	10
Physical Activity and Fitness.....	11
Comparing Transportation Objectives.....	13
Planning Practices	14
Safety and Health Impacts of Mobility Management Strategies	16
Vehicle Travel Reduction Incentives	16
Pay-As-You-Drive Vehicle Insurance.....	17
Mode Shifting	17
Mobility Substitutes	20
Travel Time and Route Shifts.....	20
Traffic Speed Reductions	21
Smart Growth	21
Health Impacts Summary.....	24
Conclusions.....	25
Information Resources	26
Endnotes.....	30

Introduction

Conventional public decision-making tends to reflect a *reductionist* model, in which individual problems are assigned to a specialized organization with narrowly defined responsibilities.¹ For example, transportation agencies are responsible for improving traffic flow, environmental agencies are responsible for reducing pollution, and health agencies are responsible for public health. This can result in an agency implementing solutions to one problem (which is within their mandate) that exacerbate other problems (which are outside their mandate), and it undervalues solutions that provide modest but multiple benefits.

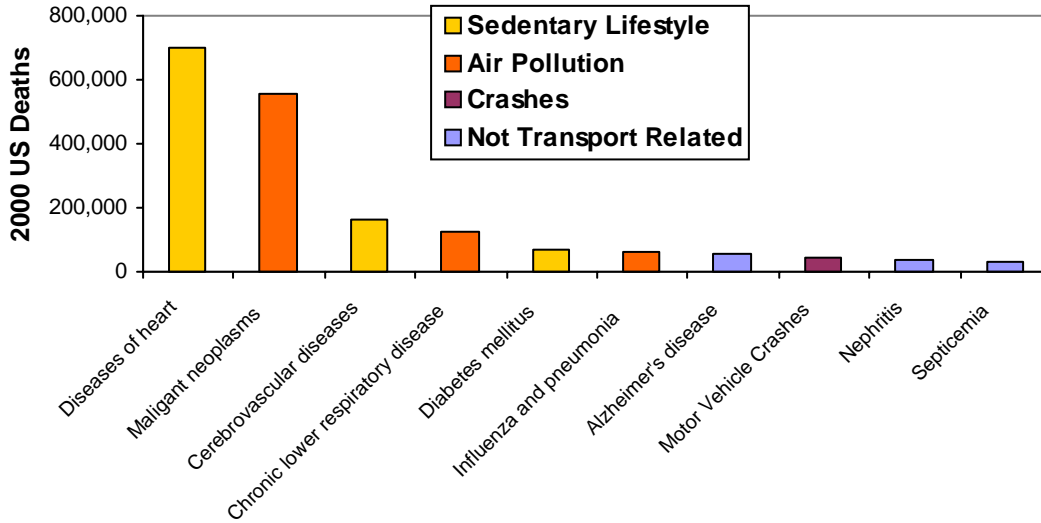
This paper examines a particular example of this sort of policy disconnect: the lack of coordination between transport and health objectives. It asks, “How would transport policy and planning practices change if transportation agencies considered public health one of their primary responsibilities?”

Many transportation professionals may be offended by this question because they do consider public health an important concern, as reflected in their efforts to reduce traffic crashes and pollution emissions. However, as this paper points out, current transport planning practices tend to focus on some health impacts but overlook others. For transportation agencies to better address public health objectives they will need to consider a wider range of health impacts and develop better tools for evaluating how particular policy and planning decisions affect public health objectives.

Transportation Health Impacts

Transport planning decisions impact public health in three main ways: through traffic crashes, vehicle pollution and physical activity.² Of the ten most common causes of death in the U.S., seven are affected by transportation, as illustrated in Figure 1.³

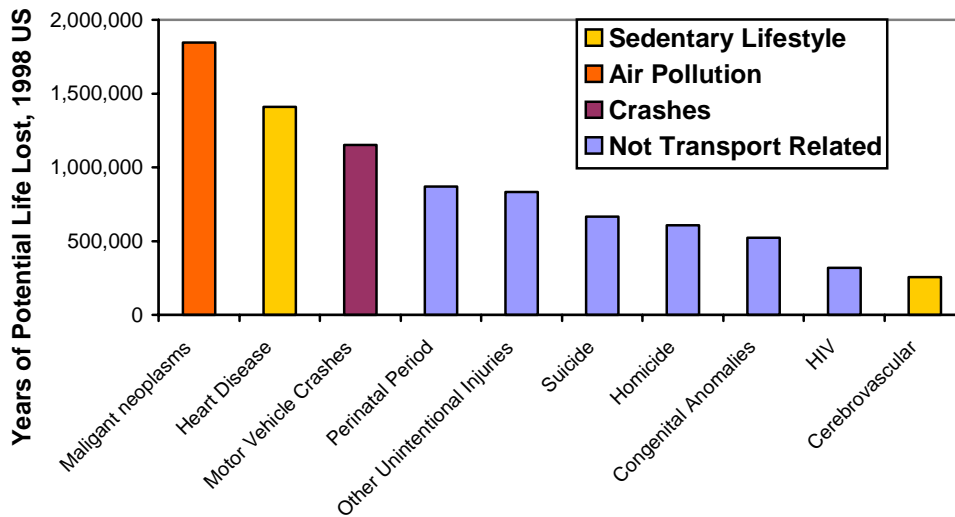
Figure 1 Ten Leading Causes of U.S. Deaths⁴



Most major causes of death are affected by physical activity, air pollution or traffic risk.

Figure 2 provides a similar comparison, showing how transportation affects the ten main causes of Years of Potential Life Lost (YPLL), which takes into account age at death, and so ranks traffic crashes higher because they tend to kill younger people than illnesses associated with sedentary lifestyle and pollution.

Figure 2 Ten Leading Causes of Years of Potential Life Lost⁵



Transportation planning decisions can affect most major causes of death and disability.

These three transportation-related health impacts are examined below.⁶

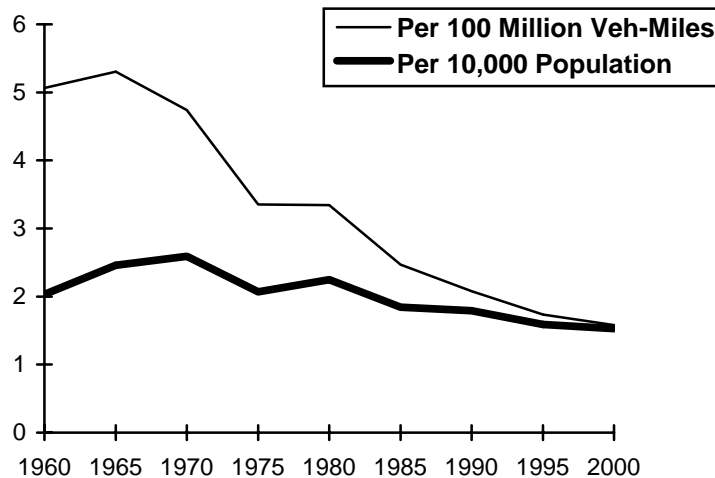
Traffic Crashes

Transport planning gives considerable attention to traffic safety. Many vehicle design features, roadway improvements and traffic safety programs are intended to prevent crashes or protect vehicle occupants when they crash.

Motor vehicle crash risk can be viewed in two different ways, giving two very different conclusions about the degree of danger and the effectiveness of various safety strategies. Transportation professionals usually measure crash rates per unit of travel (i.e., injuries and fatalities per hundred million vehicle-miles or -kilometers). Evaluated in this way, U.S. crash rates have declined by more than two thirds over the last four decades, indicating that traffic safety programs are successful and should be continued to further increase traffic safety.

But per capita vehicle mileage has more than doubled over this period, which has largely offset the decline in per-kilometer crash rates. When fatalities and injuries are measured *per capita* (e.g., per 10,000 population), as with other public health risks, there has been surprisingly little improvement over this period despite large investments in safer roads and vehicles, increases in the use of crash protection devices, reductions in drunk driving, and improvements in emergency response and trauma care. Taking these factors into account, much greater casualty reductions should have been achieved. For example, the increase in seat belt use over this period, from about 0% in 1960 up to 75% in 2002, by itself should reduce fatalities by about 33% (wearing a seatbelt reduces the chances of a crash fatality by about 45%), yet, per capita traffic deaths only declined by about 25%. Figure 3 compares these two different ways of measuring traffic crash risk.⁷

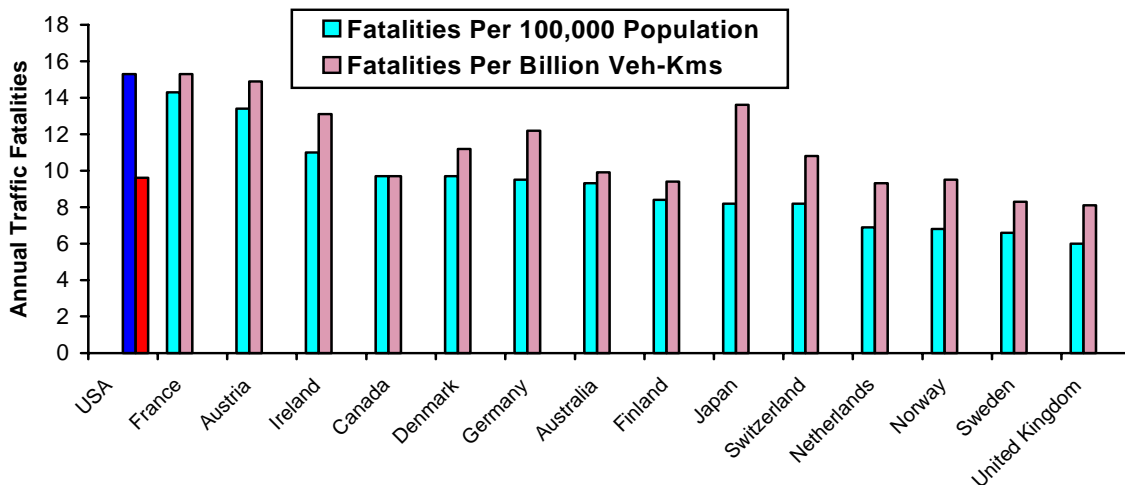
Figure 3 U.S. Traffic Fatalities⁸



This figure illustrates traffic fatality trends over four decades. Per mile crash rates declined substantially, but per capita crash rates declined little despite significant traffic safety efforts.

Traffic crashes continue to be the greatest single cause of deaths and disabilities for people in the prime of life. Although among developed countries the U.S. has one of the lowest traffic fatality rates *per vehicle-km*, it has one of the highest traffic fatality rates *per capita*, as illustrated in Figure 4. The U.S. has more than twice the per capita traffic fatality rate as in the UK, Sweden and Norway, and a 50% higher rate than in Canada. From this perspective, traffic safety continues to be a major problem, current safety efforts are ineffective, and new approaches are needed to really improve road safety.

Figure 4 International Traffic Fatality Rates⁹

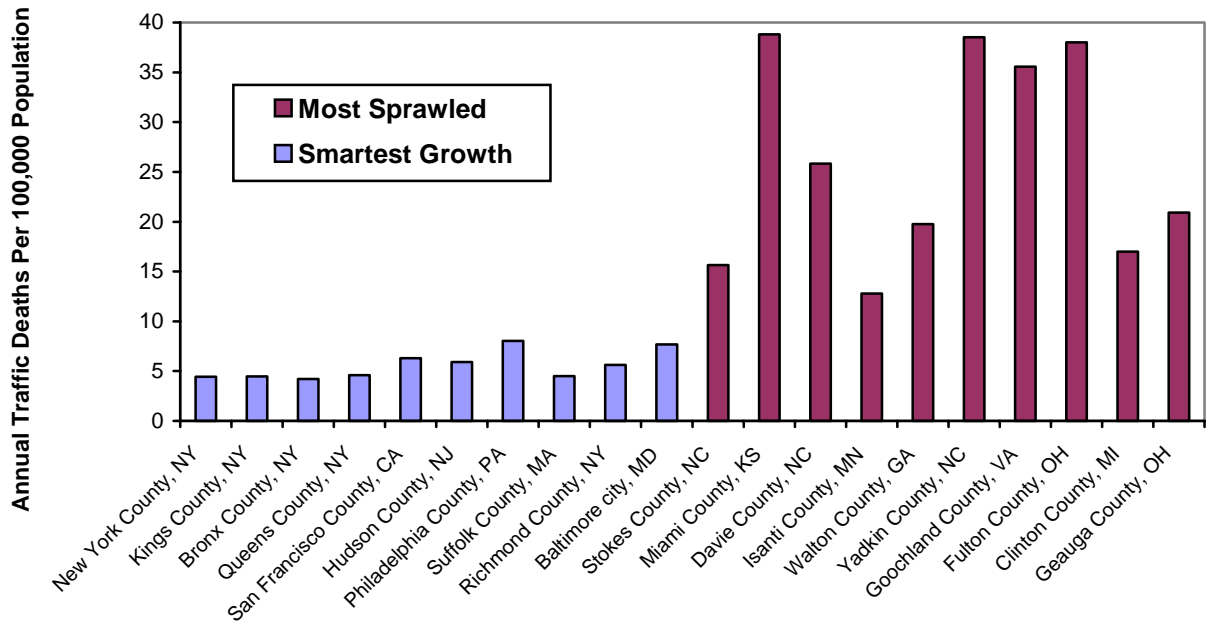


This figure compares national traffic fatality rates. Among developed countries the U.S. has one of the lowest rates per vehicle-kilometer and one of the highest rates per capita.

The relationship between mileage and traffic fatalities is quite different when compared between countries at different levels of development. Many developing countries have high per capita traffic fatality rates, despite low per capita vehicle ownership and mileage. For example, World Health Organization data show per capita traffic fatality rates are higher in Africa than in North America or Europe, although vehicle ownership is an order of magnitude lower.¹⁰ Per-kilometer traffic fatality rates decline with increased motorization, as vehicle and road quality improves, and residents take more traffic safety actions (drive and walk more cautiously, wear seatbelts and helmets, better maintain their vehicles, etc.). However, these safety trends eventually plateau, and among developed countries, traffic risk is significantly affected by transportation and land use patterns.

Higher density, clustered development patterns tend to increase traffic density (vehicles per lane-km), which tends to increase crash rates per vehicle-kilometer, but reduces per capita vehicle mileage and crash severity (due to lower traffic speeds). As a result, per capita traffic fatalities tend to increase as land use patterns become more sprawled, as illustrated in Figure 5. The least sprawled U.S. cities average 5.6 traffic fatalities per 100,000 population, while the most sprawled average 26.3, nearly five times as high. For every 1% increase in a 100-point Smart Growth index, all-mode traffic fatality rates fell by 1.5%.¹¹ All told, city residents are much safer, even taking into account other risks that increase with urban living, such as pedestrian traffic fatalities and homicides.¹²

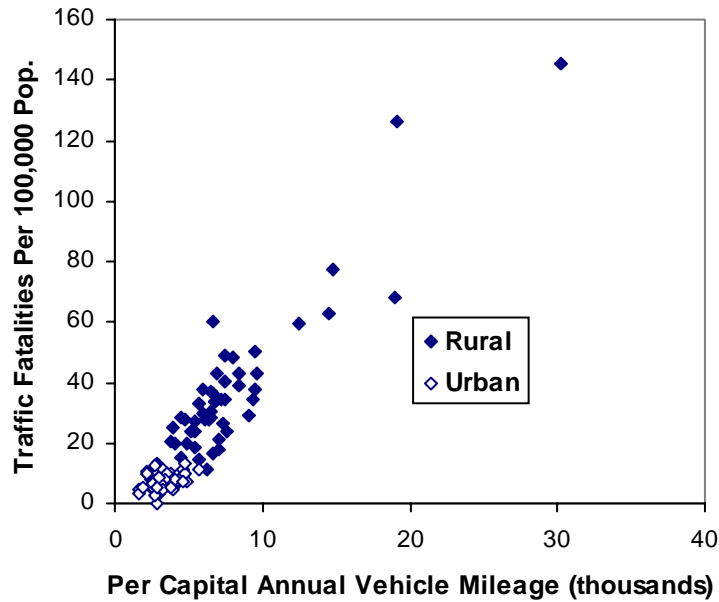
Figure 5 Annual Traffic Death Rate¹³



The ten most sprawled U.S. communities have about five times the per capita traffic fatality rate as the ten Smartest Growth communities.

Per capita traffic fatalities tend to increase with per capita annual vehicle mileage, as shown in Figure 6. High mileage cities tend to have two or three times the traffic fatality rate as low mileage cities.

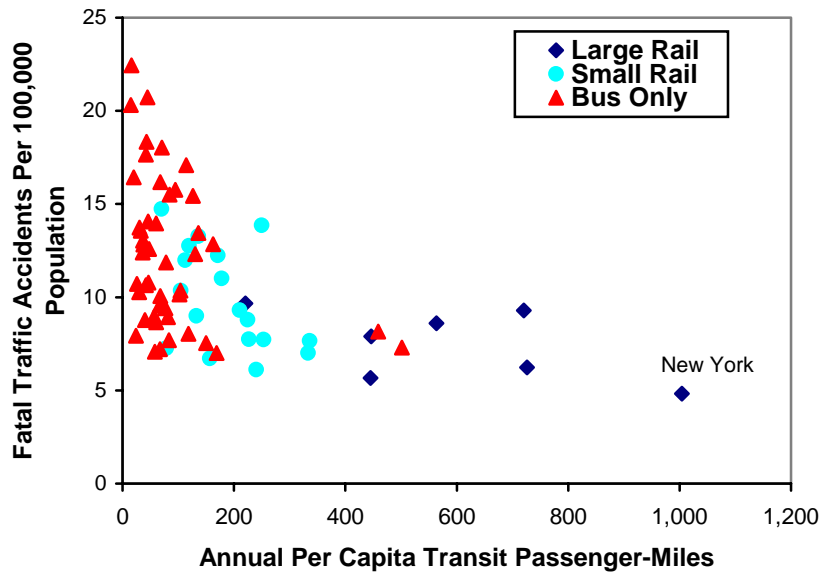
Figure 6 Fatal Traffic Accidents¹⁴



Per capita traffic fatalities tends to increase with per capita vehicle mileage.

Per capita traffic fatalities tend to decline as a city becomes more transit oriented, as illustrated in Figure 7.

Figure 7 Fatal Traffic Accidents¹⁵



Per capita traffic fatalities tends to decline with increased per capita transit ridership. Since cities with large rail systems tend to have higher transit ridership, they tend to have fewer traffic fatalities. These values include all deaths, including those in transit vehicles, deaths to automobile passengers hit by transit vehicles, and deaths to pedestrians.

When road risk is measured using a distance-based rate, such as crashes or fatalities per 100 million miles, increased vehicle mileage is not considered a risk factor and vehicle travel reductions are not considered a safety strategy. From this perspective, an increase in total crashes is not a problem provided mileage increases proportionally. For example, building grade-separated highways tends to reduce per-kilometer crash rates and increase total vehicle travel, and reduces crash rates per mile but not per capita.¹⁶ Emphasizing per-kilometer crash rates ignores the potential safety benefits of mobility management policies (i.e., strategies that change travel behavior and reduce vehicle travel). Mobility management is considered a solution to urban traffic congestion and pollution problems, but generally not as a safety strategy.

Vehicle Pollution

A second category of transport-related health impacts involve vehicle pollution emissions.¹⁷ Although tailpipe emissions tend to receive the most attention, pollution is also produced during fuel production and distribution (called “upstream” emissions), vehicle refueling, hot soak (i.e., evaporative emissions that occur after an engine is turned off), and mechanical emissions produced from road dust and wear of brake linings and tires.

Vehicle air pollution is widely recognized as health risk, and vehicle emission reduction programs are often cited as examples of technological success. It is common to hear claims that vehicle emissions have declined by 90% or more over the last few decades, but this is an exaggeration.¹⁸ Although tailpipe emission rates measured by standard tests have declined significantly, actual reductions are smaller.¹⁹ Tests do not reflect real driving conditions, and vehicles produce harmful emissions are not measured in these tests. Increased vehicle mileage has offset much of the reduction in per-kilometer emissions, so vehicle emissions continue to be a major source of air pollution.

Many factors affect the human health impacts of vehicle pollutants, including emission rates per vehicle mile, per capita mileage, and exposure (the number of people located in areas where emissions are concentrated). As with accident risk, transportation professionals have traditionally focused on reducing vehicle emissions per vehicle-kilometer, although in recent years some efforts have been made to reduce emissions by reducing vehicle travel. Per capita air pollution emissions tend to increase with per capita vehicle mileage and highway capacity.²⁰ This suggests that efforts to reduce traffic congestion and improve mobility by increasing roadway capacity may increase total pollution emissions, and that strategies that reduce per capita vehicle mileage may be effective ways to reduce emissions.

Motor vehicle air pollution probably causes a similar order of magnitude of premature deaths as traffic crashes, although air pollution deaths tend to involve older people, while traffic crashes are more likely to harm people during the prime of life and so cause greater reductions in Potential Years of Life Lost (PYLL) or Disability Adjusted Life Years (DALYs).^{21, 22, 23}

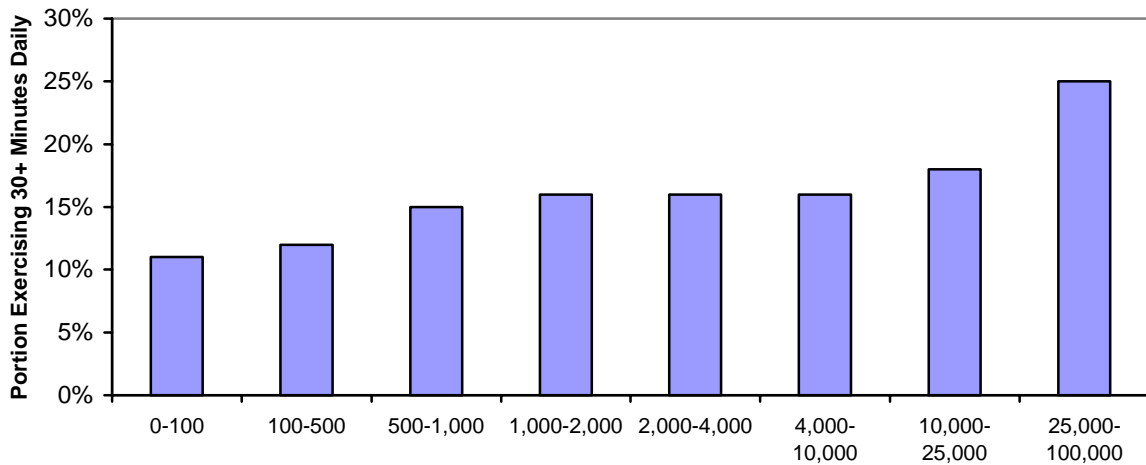
Physical Activity and Fitness

The third category of health impacts concerns the effects that transport planning can have on physical activity and fitness.²⁴ In recent years, public health officials have become increasingly alarmed at declining physical fitness, excessive body weight, and resulting increases in diseases associated with a sedentary lifestyle among the general population.²⁵

There are many ways to be physically active, but many, such as sports or exercising in a gym, require special time, money and skill, which discourages most people from participating regularly over their full lifetime. Many experts believe that more *Active Transport* (walking and cycling, and their variants such as running and skating, also called *Nonmotorized Modes* and *Human Powered Transport*) is the most practical and effective way to improve public fitness.²⁶ Residents of automobile dependent, sprawled communities are found to have health risks, including less walking, increased obesity and increased hypertension.²⁷

Residents of more walkable, multi-modal neighborhoods tend to achieve most of the minimum amount of physical activity required for health.²⁸ Unpublished analysis by transport modeler William Gehling found that the portion of residents who walk and bicycle at least 30 minutes a day increases with land use density, from 11% in low density areas (less than 1 resident per acre) up to 25% in high density (more than 40 residents per acre) areas, as illustrated in Figure 8.

Figure 8 Portion of Population Walking & Cycling 30+ Minutes Daily (Unpublished Analysis of 2001 NHTS by William Gehling)



As land use density increases the portion of the population that achieves sufficient physical activity through walking and cycling increases. Based on 2001 NHTS data.

Analysis of the National Household Travel Survey (NHTS) found that Americans who use public transit on a particular day spend a median of 19 daily minutes walking to and from transit, and 29% achieve 30 minutes of physical activity during transit access trips.²⁹

Frank, et al (2006) developed a *walkability index* that reflects the quality of walking conditions, taking into account residential density, street connectivity, land use mix and retail floor area ratio (the ratio of retail building floor area divided by retail land area).³⁰ They found that in King County, Washington a 5% increase in their walkability index is associated with a 32.1% increase in time spent in active transport (walking and cycling), a 0.23 point reduction in body mass index, a 6.5% reduction in VMT, and similar reductions in air pollution emissions.

There appears to be significant latent demand for nonmotorized travel, that is, people would walk and bicycle more frequently if they had suitable facilities and conditions. One survey found that 17% of U.S. adults claim they would sometimes bicycle commute if secure storage and changing facilities were available, 18% would if employers offered financial incentives, and 20% would if they had safer cycling facilities.³¹ Table 1 summarizes another public survey indicating high levels of interest in cycling and walking. This suggests that policies that improve walking and cycling conditions and encourage active transportation can increase public health.

Table 1 Active Transportation Survey Findings³²

	Cycle	Walk
Currently use this mode for leisure and recreation.	48%	85%
Currently use this mode for transportation.	24%	58%
Would like to use this mode more frequently.	66%	80%
Would cycle to work if there “were a dedicated bike lane which would take me to my workplace in less than 30 minutes at a comfortable pace.”	70%	
Support for additional government spending on bicycling facilities.	82%	

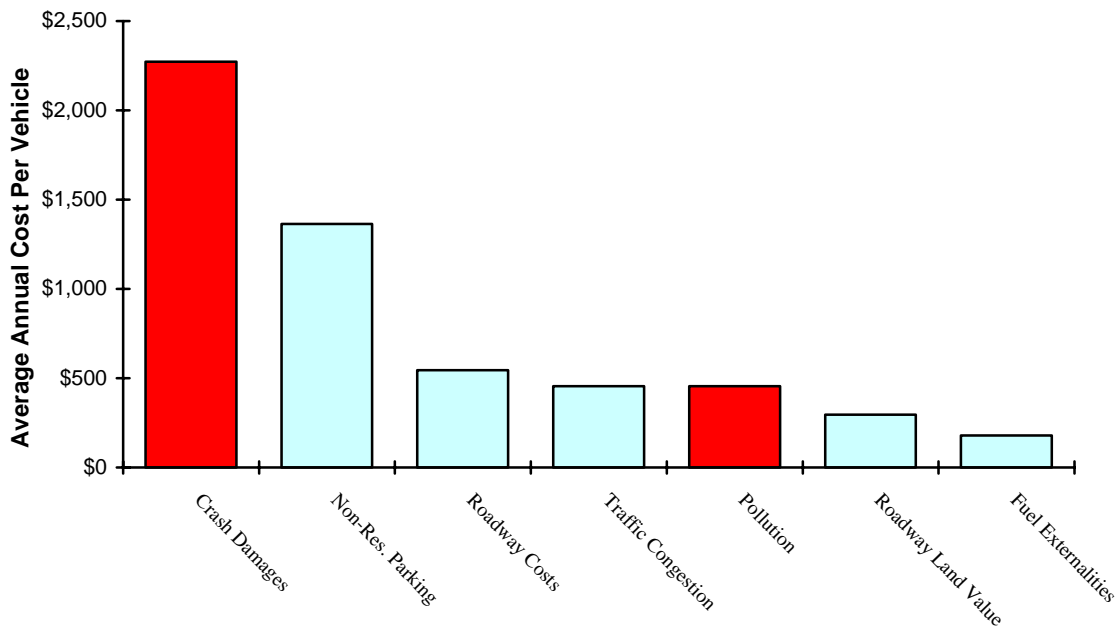
The total health costs of inadequate physical activity are far greater than those of traffic crashes. A Harvard University study found that cardiovascular diseases are the leading causes of premature death and disability in developed countries, causing ten times as many lost years of productive life as road crashes.⁸ Even modest reductions in these illnesses could provide even greater overall health benefits than large reductions in traffic crashes. However, it is difficult to determine how a particular transportation policy or planning decision will affect these diseases, since it depends on their ability to increase physical activity by people who are otherwise overly sedentary. The *Health Benefits Economic Model* by the International Council for Local Environmental Initiatives provides a methodology for valuing the health benefits of more active transportation.³³

One study found that, accounting for demographic factors such as age, race/ethnicity, educational achievement and income, the frequency of self-reported chronic medical conditions such as asthma, diabetes, hypertension and cancer increased with sprawl.³⁴ On average there are 1,260 reported chronic medical conditions per 1,000 population. A 50-point change from more to less sprawling cities is associated with 96 fewer conditions. Shifting from a very sprawled region such as San Bernardino, California to a less sprawled region such as Boston, Massachusetts would result in a reduction of 200 chronic medical conditions per 1,000 population, a 16% reduction. This effect appears to be particularly strong for the elderly and lower-income people.

Comparing Transportation Objectives

For this analysis it is interesting to compare the value of public health improvements with other transport planning objectives. Figure 9 illustrates the estimated magnitude of various transport costs. It indicates that crash damages are the largest categories of these costs, due to the large number of people killed and injured in the prime of life, and associated property damages.³⁵ As mentioned earlier, air pollution damages probably cause a similar number of premature deaths, but these generally involve older people and therefore cause smaller reductions in Disability Adjusted Life Years (DALY), and air pollution causes less property damage. The health costs of sedentary transport are even more difficult to quantify, but a plausible guess is that they are at least as great as the costs of air pollution, and may exceed the costs of crash damages.

Figure 9 Costs of Motor Vehicle Use in the U.S.³⁶



This figure illustrates the estimated magnitude of various transportation costs. Crash damages are one of the largest costs, far greater than traffic congestion or pollution costs.

This has important implications for transport planning. It indicates that a congestion reduction strategy is probably not worthwhile if it causes even small increases in crashes, pollution emissions or inactive transport. For example, if roadway capacity expansion reduces congestion by 10%, but increases crash damages by 2% due to additional vehicle travel or higher traffic speeds, its incremental costs exceed its incremental benefits. However, a congestion reduction strategy provides far greater total benefits if it causes even small reductions in crashes and pollution, or small increases in walking and cycling among people who are overly sedentary. For example, a strategy that reduces congestion by 5% provides twice the total benefit to society if it also reduces crashes by 1%.

Planning Practices

Current transport planning tends to focus on a subset of the various health impacts described above. Transportation professionals devote considerable attention to vehicle occupant safety and tailpipe emissions, measured per unit of travel, but give little consideration to the crash and environmental risks associated with increased vehicle mileage, or to the impacts their decisions have on physical activity and fitness.

Although transportation professionals do not intentionally increase vehicle mileage or reduce use of active modes, conventional transport planning practices are biased in various ways that tend to overvalue automobile-oriented improvements and undervalue alternative modes and mobility management strategies.³⁷ Individually such transport planning decisions usually appear modest and justifiable, but they tend to create automobile-dependent transport systems and land use patterns that significantly increase per capita vehicle travel and reduce active transport.³⁸

Current transport planning tends to undercount and undervalue nonmotorized transportation.³⁹ Travel surveys ignore most walking trips. For example, if a traveler takes 10 minutes to walk to a bus stop, rides on the bus for five minutes, and takes another five minute walk to their destination, this *walk-transit-walk* trip is usually counted simply as a transit trip, even though the nonmotorized links take more time than the motorized link. Similarly, a 5-minute walk from a parking space to a destination is ignored. One researcher estimates that the actual number of nonmotorized trips is six times greater than what conventional surveys indicate.⁴⁰

Current transportation and land use patterns tend to create barriers to walking and cycling.⁴¹ Widening roads, increasing traffic speeds, increasing parking supply and dispersing destinations all tend to make landscapes that are less suitable for nonmotorized transportation. Communities with suitable transportation and land use patterns have significantly higher levels of walking and cycling.^{42, 43, 44}

Are there ways to achieve both transport planning objectives such as reduced congestion, and public health objectives such as reduced per capita crash rates and improved fitness? Yes there are. The general term for these is *Mobility Management* (also called *Transportation Demand Management* or *TDM*), which refers to various strategies that encourage more efficient use of transport resources. Mobility management is the transportation component of Smart Growth and Smart Growth is the land use component of mobility management.⁴⁵ Most of these strategies can help achieve a variety of planning objectives such as infrastructure cost savings, consumer choice, community livability and equity. Table 2 lists various mobility management strategies.

Table 2 Mobility Management Strategies⁴⁶

Improve Transport Options	Incentives to Reduce Driving	Parking and Land Use Management	Programs and Policy Reforms
Alternative Work Schedules	Walking And Cycling Encouragement	Bicycle Parking	Access Management
Bicycle Improvements	Commuter Financial Incentives	Car-Free Districts and Pedestrianized Streets	Campus Transport Management
Bike/Transit Integration	Congestion Pricing	Clustered Land Use	Carfree Planning
Carsharing	Distance-Based Pricing	Location Efficient Development	Commute Trip Reduction Programs
Flextime	Fuel Taxes	New Urbanism	Market Reforms
Guaranteed Ride Home	HOV (High Occupant Vehicle) Priority	Parking Management	Context Sensitive Design
Park & Ride	Parking Pricing	Parking Solutions	Freight Transport Management
Pedestrian Improvements	Pay-As-You-Drive Vehicle Insurance	Parking Evaluation	Least Cost Planning
Ridesharing	Road Pricing	Shared Parking	Regulatory Reform
Shuttle Services	Speed Reductions	Smart Growth	School Transport Management
Small Wheeled Transport	Street Reclaiming	Smart Growth Planning and Policy Reforms	Special Event Management
Taxi Service Improvements	Vehicle Use Restrictions	Transit Oriented Development (TOD)	Mobility Management Marketing
Telework			Tourist Transport Management
Traffic Calming			Transportation Management Associations
Transit Improvements			
Universal Design			

Mobility management includes more than three dozen strategies that improve transportation options, encourage use of efficient modes, and create more accessible land use patterns.

Conventional transportation decision-making does not completely ignore mobility management, but it tends to consider it a last resort for extreme urban traffic problems, to be implemented if conventional engineering solutions are infeasible. Mobility management is not usually considered a safety strategy. When transportation agencies evaluate strategies for achieving objectives such as reducing traffic congestion, parking problems or per-km crash risk, mobility management strategies do not usually rank very high. Most individual mobility management strategies have modest impacts, typically affecting only a small portion of total vehicle travel. However, these impacts tend to be cumulative and synergetic (total impacts can be greater than the sum of their individual impacts). A comprehensive mobility management program using a complementary set of cost-effective strategies (i.e., strategies that are fully justified for their direct economic and consumer benefits) can often reduce total per capita automobile travel by 20-40% compared with conventional, automobile dependent transportation and land use policies.

Safety and Health Impacts of Mobility Management Strategies

This section describes the safety and health impacts of various mobility management strategies. For more information see specific chapters in the *Online TDM Encyclopedia*.⁴⁷

Vehicle Travel Reduction Incentives

Many mobility management strategies (road and parking pricing, marketing programs, vehicle use restrictions) give motorists incentives to reduce their vehicle mileage. Some studies indicate that given modest incentives and encouragement, many people can reduce their vehicle travel by 10-20%.⁴⁸

A given change in annual mileage tends to cause a proportional change in that vehicle's chance of causing a crash and a proportionally greater change in total crash damages. For example, if you reduce your chances of *causing* a crash by 10% (perhaps by driving more cautiously), your total crash risk declines by about 7%, since other drivers cause about 30% of the crashes you are involved in. If your annual mileage declines by 10%, your chance of causing a crash declines by 10%, and your risk of being in a collision caused by other drivers' mistakes also declines, since you are no longer a crash target for those miles. If all other motorists reduce their mileage by 10%, but you do not, you can expect a 7% reduction in crash risk, since 70% of your crashes involve another vehicle (you are no longer at risk from their mistakes, and they are no longer at risk from your mistakes for the miles not driven). If all motorists reduce mileage by 10% and other factors are held constant, total crash costs should decline by about 17% (10% + 7%). Empirical studies support this conclusion, indicating that each 1.0% vehicle mileage reduction causes a 1.4-1.8% reduction in crashes, although these impacts may vary depending on the type of mileage reduced.^{49, 50}

Reductions in per capita vehicle mileage provide air emission reduction benefits. To the degree that they result in shifts to nonmotorized modes by otherwise sedentary people, they provide fitness benefits.

Congestion Pricing Safety Impacts⁵¹

The central London congestion charging scheme was introduced on 17 February 2003, with the primary aim of reducing traffic congestion in and around the charging zone (London, 2004). First year results indicate that the program has reduced accidents:

- Total vehicle-kilometres reduced by 12%, car traffic reduced by 30%, crashes declined 28%.
- Moped and motorbike travel increased 10 –15%, with 4% fewer crashes.
- Bicycle travel increased 20%, with a 7% reduction in crashes.
- Crashes involving pedestrians declined 6%.
- Increased bus journey time reliability by up to 60%.
- No evidence of any overall increase in road traffic outside the zone.
- Subjective improvements in noise and air quality.

Pay-As-You-Drive Vehicle Insurance

Pay-As-You-Drive pricing converts vehicle insurance premiums from a fixed cost into a variable cost. It prorates existing premiums by annual mileage, so insurance is priced by the vehicle-kilometer rather than the vehicle-year. This price structure gives motorists an incentive to reduce their driving, with greater incentives for higher risk categories. For example, a low-risk motorist who currently pays \$300 annually for insurance would pay about 2.5¢ per mile, and so is predicted to reduce their mileage an average of 5%, while a higher-risk motorist who currently pays \$1,800 for insurance would pay 15¢ per mile, and so might reduce their annual mileage by 20%, since they save far more with each mile reduced. As a result this strategy can provide extra safety benefits. It also reduces pollution emissions and may cause some automobile travel to shift to nonmotorized modes.

Mode Shifting

Many mobility management strategies cause travelers to shift from driving to another transport mode, either by making alternatives more attractive or by discouraging automobile use. This can have a variety of safety impacts. Table 3 shows estimated fatality rates of different transport modes. This only reflects the direct risk to the individual who uses that mode, but does not include risks to others, or impacts of changes in total vehicle travel. Modes such as walking and cycling *bear* relatively high risks, but *impose* little risk on other road users, and when travelers shift from automobiles to other modes they often reduce their total mileage (for example, people may choose between walking to a local store or driving across town to a supermarket), and so reduce risk exposure. The safety impacts of shifts to specific modes are discussed below.

Table 3 Fatalities per 100 Million Passengers in Britain⁵²

	Per Trip	Per Hour	Per Km
Motorbike	100	300	9.7
Air	55	15	0.03
Water	25	12	0.6
Pedalcycle	12	60	4.3
Foot	5.1	20	5.3
Car	4.5	15	0.4
Van	2.7	6.6	0.2
Rail	2.7	4.8	0.1
Bus	0.3	0.1	0.04

This table compares crash rates of common travel modes.

Transit

Travel shifts from automobile to transit tend to reduce total crash costs. Transit vehicle passengers have about one-tenth the crash fatality rates of automobile occupants, and shifts to transit reduce total vehicle traffic, reducing risks to other road users. In the U.S., urban transit has a relatively high total fatality rate (including both occupants and other road users) per passenger-kilometer due to low load factors (passengers per vehicle-km),

but mobility management strategies that increase transit load factors have small marginal crash risk, and so reduce crash rates.

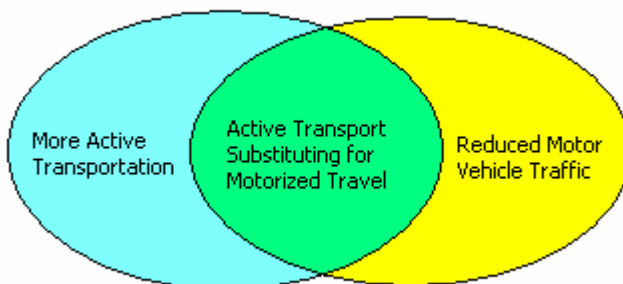
Transit can be a catalyst for more accessible land use patterns that reduce per capita automobile travel and increase walking.⁵³ Per capita traffic fatalities tend to be lower and per-capita walking trips tend to be higher in transit-oriented urban areas than in automobile-oriented cities.⁵⁴ Most transit trips involve walking or cycling links, to get to a transit stop and to travel from a transit stop to the ultimate destination. Transit oriented communities require good walking conditions. As a result, mobility management strategies that encourage transit use are likely to increase active transportation.

Ridesharing

Ridesharing refers to carpooling and vanpooling. Ridesharing reduces overall crash risk by reducing total vehicle mileage. Two people who carpool rather than drive alone bear about the same level of internal risk, but reduce risk to others by using one vehicle rather than two. It may result in somewhat safer driving, for example, because drivers may be more cautious when they have passengers, carpools may tend to rely more on their more skilled motorist or safer vehicle, and because vanpool operators are sometimes required to take special safety tests. Some High Occupant Vehicle lanes have relatively high crash rates due to awkward merging conditions, and vanpools may have a relatively high rollover rate which may increase crash severity under some conditions, but there is currently insufficient data to quantify these factors, and design changes are being implemented to reduce these risks. Ridesharing reduces air pollution emissions and may increase walking, for example, rideshare commuters are more likely to walk for errands during breaks than if they had driven to work.

Nonmotorized Transport

Walking and cycling (also called *nonmotorized*, *human powered* or *active* transport) can provide a variety of benefits to individuals, businesses and governments, particularly when it substitutes for motorized travel, as illustrated below.⁵⁵



More active transport improves physical fitness, and provides additional benefits when it reduces motor vehicle traffic, including reduced crash risk imposed on other road users, and reduced air pollution emissions.

Walking and cycling tend to have relatively high per-kilometer casualty rates, suggesting that individuals increase their risk of crash injuries and death when they shift from automobile to nonmotorized modes. However, such shifts do not necessarily increase overall health risks because:⁵⁶

- Nonmotorized travel imposes minimal crash risk to other road users.
- Nonmotorized trips tend to be shorter than motorized trips, so total per capita mileage declines. A local walking trip often substitutes for a longer automobile trip.
- High crash and casualty rates for pedestrians and cyclists result, in part, because people with particular risk factors tend to use these modes, including children, people with disabilities and elderly people. A skilled and responsible adult who shifts from driving to nonmotorized travel is likely to experience less additional risk than average values suggest.

Nonmotorized travel provides health benefits that can offset crash risk. One study found that bicycle commuters have a 40% lower mortality than people who do not cycle to work, which suggests that the incremental risks of cycling are outweighed by health benefits, at least for experienced adult cyclists riding in a bicycle-friendly community.⁵⁷

Some mobility management programs include education and marketing components that encourage safety, particularly for cycling. These can reduce per-kilometer crash rates (experienced cyclists tend to have lower per-kilometer crash rates than inexperienced, less skilled cyclists), although it is difficult to predict how much effect this has.

Empirical evidence indicates that shifts from driving to nonmotorized modes tends to reduce per capita crashes. Urban regions with high rates of walking and cycling tend to have lower per capita traffic fatalities than more automobile-dependent communities. For example, walking and cycling travel rates are high in the Netherlands, yet the per capita traffic death rate is much lower than in automobile dependent countries.⁵⁸

Residents of areas with higher rates of walking and cycling experience less obesity, diabetes and hypertension.⁵⁹ For example, residents of the Netherlands, Denmark and Sweden have obesity rates only a third of those in the U.S., and Germany's is only half as high; residents of these four European countries live an average of 2.5 to 4.4 years longer while spending half as much on health care as in the U.S.⁶⁰

Shifts from automobile to walking and cycling can provide proportionately large air pollution emission reductions because they usually replace short, cold start trips for which internal combustion engines have high emission rates. As a result, each 1% of automobile travel shifted to nonmotorized modes decreases motor vehicle air pollution emissions by 2% to 4%.⁶¹

Active Transportation as an Investment (by John Z. Wetmore)

Health researchers recommend devoting about 30 minutes, or about 2% of each day, in moderate exercise, such as walking or cycling. Is this time a worthwhile investment?

The GAM83 mortality table used by insurance actuaries gives the probability of dying within one year for an X-year-old, for X from 5 to 110 (“Qx” for short). This table indicates that the expected value of age-at-death for an 18-year-old male alive today is 77.8, or 59.8 more years. An 18-year old male would need to live 102% of 59.8 = 61.0 years, or age at death 79.0 to offset a 30 minute a day exercise investment. That is, it is worthwhile to invest 2% of each day if it reduces the probability of death by 11% for later ages.

Each Qx can be multiplied by a constant “C” that represents a reduction in the risk of dying (e.g., if $Q_{76} = 4.9\%$ and $C = 0.8$ then $Q_{76} = 4.9\% * 0.8 = 3.92\%$). The objective is to find C such that the expected age at death increases from 77.8 to 79.0. As it turns out, C is 0.89.

According to the Honolulu Heart Study (www.agenet.com/watchful_walking_adds.html), the probability of death for 61 to 81 year old males is about 50% less for those who walk two miles per day. Taking C times Q61 through Q81 and leaving alone Q5 through Q60 and Q82 through Q110. C turns out to be 0.84. That is, 30 minutes daily exercise is a worthwhile investment if the probability of death is 16% lower for ages 61 to 81 and unchanged for all other ages. The observed reduction of 50% is much better than the break-even point of 16% reduction.

Not only that, but many people consider time spent on moderate exercise enjoyable. The result is a double return on investment: health and enjoyment.

Mobility Substitutes

Mobility substitutes include telework and delivery services. They tend to reduce vehicle mileage, which reduces crashes, although there may be rebound effects, such as the tendency of telecommuters to make special trips for errands that they would otherwise perform while commuting, and to move farther from their worksite to less accessible, exurban locations. This typically offsets about a third of mileage reductions and associated safety benefits.⁶² For example, an employee who telecommutes three days a week would reduce commute mileage by 60%, but may drive additional miles for errands, resulting in a 40% net reduction in vehicle mileage and more modest safety benefits. Mobility substitutes that reduce total vehicle travel can provide significant air emission reductions, but they do not necessarily provide direct health and fitness benefits.

Travel Time and Route Shifts

Mobility management strategies that shift vehicle travel from peak to off-peak periods, or from congested highways to alternative routes, have mixed safety impacts. Per mile crash rates are lowest on moderately congested roads, and increase with lower and higher congestion levels, but fatalities decline at high levels of congestion, indicating a trade-off between congestion reduction benefits and crash fatalities.⁶³ Shifting vehicle trips to less congested roadway conditions can reduce crashes, but the crashes that occur tend to be

more severe due to higher travel speeds. As a result, the safety impacts of mobility management strategies that shift travel times and routes vary depending on specific circumstances, and are difficult to predict. Shifting travel time or route tends to do little to reduce air pollution emissions or increase health and fitness.

Traffic Speed Reductions

There has been considerable research concerning the effects of traffic speed and speed control strategies have on road safety. Some research indicates that increased speed variance (the range between the highest and lowest speed vehicles) tends to increase crash rates per vehicle-km, and higher traffic speeds tend to increase crash severity.⁶⁴ This suggests that speed control strategies that reduce average traffic speeds and speed variance on highways can reduce crash costs. Traffic calming (roadway design strategies to reduce traffic speeds on a particular roadway) and increased traffic law enforcement tend to increase safety. A meta-analysis of 33 studies concluded that area-wide traffic calming programs reduce injury accidents by about 15%, with the largest reduction is on residential streets (25%), and somewhat smaller reductions on main roads (10%).⁶⁵

Traffic speed reductions have mixed air emission impacts, depending on traffic conditions, driving conditions, vehicle type and which emissions are considered. Speed reductions can improve walking and cycling conditions, and so can improve health and fitness if applied to areas with latent demand for nonmotorized travel.

Smart Growth

Per capita traffic fatality rates tend to increase with urban sprawl, due to increased per capita vehicle mileage and traffic speeds. Previously described research indicates that regions with Smart Growth development patterns (higher density, with more balanced transportation systems) have a fifth the per capita traffic fatality rate as highly sprawled regions, and even greater differences exist at the local level.

Higher density development can increase per-kilometer emission rates (due to increased congestion) and exposure (due to more people located near roadways), but reduced per capita vehicle mileage. This tends to reduce overall pollution emissions.⁶⁶ Traditional community design is associated with increased walking and bicycling.⁶⁷ This suggests that mobility management strategies which create more accessible land use and more balanced transport systems can increase overall health, although more research is needed to quantify these impacts.⁶⁸

Below is a list of specific planning practices that help create healthier communities:

- *Strategic planning.* Is there a comprehensive community vision which individual land use and transportation decisions should support?
- *Self-contained community.* Are common services such as shops, medical services, transit service, schools and recreation facilities located within convenient walking distance of houses and each other? Is there a good jobs/housing ratio within a 2-mile radius?

- *Walkability.* Do streets have sidewalks? Are sidewalks well designed, maintained and connected, and suitable for people using wheelchairs and pushing strollers and carts? Are streets easy to cross, even by people with disabilities?
- *Cycling.* Are there adequate bike paths, lanes and routes? Are there cycling skills training and law enforcement programs? Are there bike racks and changing facilities at worksites?
- *School access.* Are most children able to walk or bicycle to school? Are walking and cycling condition around the school adequate. Are there programs to improve walking and cycling, and encourage use of alternative modes for travel to school?
- *Mixed income communities.* Are there a mix of housing types and prices, allowing lower income and disabled people to live in the community? Are there programs to insure affordable housing is located in accessible, multi-modal areas where residents can easily walk to public services such as stores, medical clinics and transit stops?
- *Sense of place.* Does the community have a strong sense of identity and pride? Does the neighborhood have a name?
- *Transit service quality.* Does the neighborhood have high quality public transit, with more than 20 buses or trains a day (less than half-hour headways) and little crowding during peak periods?
- *Parking management.* Are parking requirements flexible, so developers and building managers can reduce their parking supply in exchange for implementing a parking management program?
- *Roadway and walkway connectivity.* Are streets and paths well-connected, with short blocks and minimal cul-de-sacs. Are streets as narrow as possible, particularly in residential areas and commercial centers. Are traffic management and traffic calming to control vehicle impacts.
- *Complete streets.* Are streets designed to accommodate walking, cycling and public transit, and comfortable and convenient for activities such as strolling, playing, shopping, sightseeing, eating and special events?
- *Site design and building orientation.* Are buildings to be oriented toward city streets, rather than set back behind large parking lots?
- *Transportation demand management.* Are TDM strategies and programs implemented to the degree that they are cost effective? Do employers have incentives to implement commute trip reduction programs? Is there a local transportation management association?
- *Greenspace.* Are there efforts to preserve greenspace, particularly wild areas such as streams, shorelines and forests?

To help consumers, real estate professionals and planning practitioners apply these concepts the *Healthy Location Index* below indicates the degree to which a particular site or neighborhood reflects healthy community planning principles.

Table 5 Healthy Community Index Calculations

Feature	How to Calculate	Points
Sidewalks on block	No (0 points) Yes (10 points)	
Portion of local streets with sidewalks.	Range from 0 points for no street within ½ kilometer have sidewalks up to 10 points for all streets have sidewalks.	
Portion of local streets and paths that accommodate wheelchairs.	Range from 0 points for no street within ½ kilometer with sidewalks that accommodate wheelchairs, up to 10 points for all streets with sidewalks that accommodate wheelchairs.	
School walkability	10 minus number of minutes required for a child to walk safely to school. 0 if walking to school is not feasible for a typical child.	
Cycling conditions	Portion of streets within 1 kilometer that safely accommodate bicycles, rated from 0 to 10.	
Neighborhood service destinations	One point for each of the following located within ½ kilometer convenient walking distance, up to 10 maximum: grocery store, restaurant, video rental shop, public park, recreation center, library.	
Public transit service quantity	Number of peak period buses per hour within ½ kilometer, up to 10 maximum.	
Public transit service quality	Portion of peak-period transit vehicles that are clean and comfortable from 0 (all vehicles are dirty or crowded) up to 10 (all vehicles are clean and have seats available).	
Local traffic speeds	Portion of vehicle traffic within 1-kilometer that have speeds under 40 kilometers per hour, from 10 (100%) to 0 (virtually none).	
Air Pollution	10 minus one for each exceedance of air quality standards.	
	<i>Total</i>	

This table summarizes the calculation of the Healthy Community Index, which can range from 0 (unhealthy location) to 100 (healthy location). It reflects various neighborhood design factors that affect residents' health.

Health Impacts Summary

Table 6 summarizes the safety and public health impacts of various mobility management strategies.

Table 6 Mobility Management Safety and Health Impact Summary

Travel Change	Strategies	Safety	Pollution	Fitness
Vehicle Mileage Reductions	Pricing, marketing, mode shifting and other incentives.	Each 1% mileage reduction reduces crashes 1.2-1.8%.	Proportional reduction in emissions.	May increase walking and cycling
Distance-Based Insurance	PAYD Insurance, Distance-based pricing.	Large potential safety benefits since higher risk drivers have the greatest incentive to reduce mileage.	10% mileage and emission reduction per participating vehicle.	May increase walking and cycling
Shifts to Transit	Transit Improvements, HOV Priority, Park & Ride	Increases safety due to greater safety for transit passengers and reduced vehicle traffic.	Reduces emissions, particularly if it leverages overall reductions in per capita mileage.	Generally increases walking and cycling.
Shifts to Ridesharing	Ridesharing, HOV Priority	Modest safety benefits.	Emission reductions proportional to mileage reductions.	May encourage some additional walking.
Shifts to Nonmotorized Modes	Walking and Cycling Improvements, Traffic Calming	Increases risk to participants, but reduces risk to other road users.	Reduces emissions.	Large potential benefits.
Mobility Substitutes	Telework, Delivery Services	Increases safety by reducing vehicle mileage, but rebound effects often offset some benefits.	Reduces emissions, but rebound effects often offset a portion of benefits.	No direct benefits.
Time & Route Shifts	Flextime, Congestion Pricing	Mixed. Reducing congestion tends to reduce crashes but increases the severity of crashes that do occur.	Mixed. Reducing congestion tends to reduce some emissions but increases others.	No direct benefits.
Traffic Speed Reductions	Traffic Calming, Speed Enforcement	Significantly increases safety by reducing crash frequency and severity.	Mixed. Reducing speed reduces some emissions but increases others.	Can significantly increase walking and cycling.
Land Use & Transport System Changes	Various land use management and planning reforms	Increases safety by reducing per capita vehicle mileage and traffic speeds.	Increased density increases some emissions and exposure, but tends to reduce total emissions.	Can significantly increase walking and cycling.

This table summarizes the crash reductions, emission reductions and fitness impacts of various mobility management strategies.

Conclusions

Transportation planning decisions affect human health in three ways: through traffic risk, pollution emissions, and by affecting physical activity and fitness. Although these risks are difficult to quantify with precision, they are each significant in magnitude, affecting large numbers of deaths and physical disabilities. Put more positively, transportation planning decisions that reduce these risks can provide significant human health benefits, resulting in reduced suffering, cost savings and increased productivity.

Conventional transportation decision-making tends to use a reductionist approach in which different organizations are responsible for narrowly-defined problems. As a result, they can implement solutions to one problem that exacerbate other problems, and they tend to undervalue strategies that provide multiple benefits.

Transportation agencies tend to focus on some health impacts while overlooking others. They give considerable attention to per-kilometer crash risk and pollution emissions, but generally ignore crash risk and pollution emissions that result from increased vehicle mileage, and negative health impacts from less physical activity. As a result, they tend to overvalue roadway and parking capacity expansion, and undervalue mobility management strategies that reduce vehicle travel and increase transport system diversity.

Health impacts are often greater in magnitude than impacts given priority in transport planning, such as traffic congestion. As a result, congestion reduction strategies that cause even a small increase in per capita crashes, emissions or physical inactivity are probably harmful to society overall, while congestion reduction strategies that support safety, environment and health objectives provide far greater total benefits.

Many factors affect transportation health impacts. Less developed countries tend to have high per-kilometer crash rates and pollution emissions, which decline with increased motorization, as vehicles, roads and traffic safety behavior improve. However, at a particular level of development, traffic risk and pollution emissions are significantly affected by per capita vehicle travel.

Mobility management can provide significant public health benefits, including improved safety, air quality and fitness. Yet, transportation professionals generally overlook traffic safety benefits when evaluating mobility management programs, and traffic safety professionals generally overlook mobility management as a traffic safety strategy. This reflects, in part, their tendency to measure traffic risk per vehicle-kilometer, which ignores the potential safety benefits of reduced vehicle travel.

Raising the priority of safety and health objectives in transport planning would reduce emphasis on roadway capacity expansion and increase emphasis on mobility management strategies, particularly those that result in more walking and cycling. This could provide significant health and safety benefits. Integrating health objectives into transport planning can be one of the most cost-effective ways to improve public health, and improved public health can be among the greatest benefits of mobility management.

Information Resources

Below are various information resources concerning transportation and health.

Active Living by Design (www.activelivingbydesign.org) encourages physical activity and health through community design and public policy strategies.

Active Living Storybank (www.activeliving.org) is a searchable database of projects, programs and initiatives that promote health through changes in the built environment, public policy and education.

Active Living Website (www.icma.org) by the International City/County Management Association.

AJHP, “Special Issue: Health Promoting Community Design,” *American Journal of Health Promotion* (www.healthpromotionjournal.com), Vol. 18, No. 1, Sept./Oct. 2003.

AJPH, “Built Environment and Health,” *American Journal of Public Health* (www.ajph.org), Vol. 93, No. 9, Sept. 2003. Many of these articles are available at the *Active Living By Design* (www.activelivingbydesign.com) website.

America WALKs (www.webwalking.com/amwalks) is a coalition of walking advocacy groups.

APA, *Planning and Designing the Physically Active Community: A Resource List*, American Planning Association (www.planning.org/physicallyactive/pdf/ReferenceList.pdf), 2003.

Nick Cavill, “Walking and Health: Making the Links”, *World Transport Policy and Practice*, Vol. 7, No. 4 (www.ecoplan.org/wtpp), 2001, pp. 33-38.

CORDIS, *Best Practice to Promote Cycling and Walking and How to Substitute Short Car Trips by Cycling and Walking*, CORDIS Transport RTD Program, European Union (www.cordis.lu/transport/src/adonisrep.htm), 1999.

Committee on Physical Activity, Health, Transportation, and Land Use, *Does the Built Environment Influence Physical Activity? Examining the Evidence*, TRB Special Report 282, Transportation Research Board (www.trb.org), 2005; available at <http://trb.org/publications/sr/sr282.pdf>.

Marie Demers, *Walk For Your Life! Restoring Neighborhood Walkways To Enhance Community Life, Improve Street Safety and Reduce Obesity*, Vital Health Publishing (www.vitalhealthbooks.com/book/2414947630.html), 2006.

DCPP, *Unintentional Injuries, #39*, Disease Control Priorities Project (www.dcp2.org/main/Home.html). This website analyzes human health risks and risk prevention strategies in developing countries, including motor vehicle crashes.

Dan Emerine and Eric Feldman, *Active Living and Social Equity: Creating Healthy Communities for All Residents*, International City/County Management Association (<http://bookstore.icma.org>), 2005.

Leonard Evans, "The Dramatic Failure of U.S. Traffic Safety Policy: Engineering Is Important, Public Policy Is Critical," *TR News*, Transportation Research Board (www.trb.org), Jan/Feb. 2006, pp. 28-31.

Reid Ewing, et al., "Relationship Between Urban Sprawl and Physical Activity, Obesity, and Morbidity," *American Journal of Health Promotion*, Vol. 18, No. 1 (www.healthpromotionjournal.com), Sept/Oct. 2003, pp. 47-57, available at www.smartgrowth.umd.edu/pdf/JournalArticle.pdf.

Larry Frank, "Obesity Relationships with Community Design, Physical Activity and Time Spent in Cars," *American Journal of Preventive Medicine* (www.ajpm-online.net/home), Vol. 27, No. 2, June, 2004, pp. 87-97.

Lawrence Frank and Peter Engelke, *How Land Use and Transportation Systems Impact Public Health*, Active Community Environments, Georgia Institute of Technology and Center for Disease Control (www.cdc.gov/nccdphp/dnpa/aces.htm), 2000.

Lawrence Frank, et al, "Many Pathways From Land Use To Health: Associations Between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality," *Journal of the American Planning Association*, Vol. 72, No. 1 (www.planning.org), Winter 2006, pp. 75-87.

Lawrence Frank, Sarah Kavage and Todd Litman, *Promoting Public Health Through Smart Growth: Building Healthier Communities Through Transportation And Land Use Policies*, Smart Growth BC (www.smartgrowth.bc.ca), 2006; available at www.smartgrowth.bc.ca/downloads/SGBC_Health%20Report%20Final.pdf.

Howard Frumkin, Lawrence Frank and Richard Jackson, *Urban Sprawl and Public Health: Designing, Planning, and Building For Healthier Communities*, Island Press (www.islandpress.org), 2004.

HSF, *Heart and Stroke Foundation 2005 Report Card*, Canadian Heart and Stroke Foundation (ww2.heartandstroke.ca), 2005.

HDA, *Making The Case: Improving Health Through Transport*, Health Development Agency, UK National Health Service (www.publichealth.nice.org.uk), 2005.

Healthy Cities and Urban Governance (www.who.dk/healthy-cities) World Health Organization, Regional Office for Europe. This website describes strategies for creating healthier urban cities.

ICLEI, *Health Benefits Economic Model*, Cities for Climate Protection, International Council for Local Environmental Initiatives (www3.iclei.org/ccp-au/tdm/index.html), 2003.

ICMA, *Active Living and Social Equity: Creating Healthy Communities for All Residents – A Guide for Local Governments*, International City/County Management Association (www.icma.org), 2005.

International Association for the Study of Obesity (www.iaotf.org) performs research and public education related to obesity, its health impacts and strategies to reduce this problem.

Richard J. Jackson and Chris Kochtitzky (Center of Disease Control), *Creating A Healthy Environment: The Impact of the Built Environment on Public Health*, Sprawl Watch Clearinghouse (www.sprawlwatch.org/health.pdf), 2001.

Richard Killingsworth, Audrey De Nazelle and Richard Bell, "Building A New Paradigm: Improving Public Health Through Transportation," *ITE Journal*, Vol. 73, No. 6 (www.ite.org), June 2003, pp. 28-32.

Todd Litman, "Integrating Public Health Objectives in Transportation Decision-Making," *American Journal of Health Promotion*, Vol. 18, No. 1 (www.healthpromotionjournal.com), Sept./Oct. 2003, pp. 103-108, also available at www.vtppi.org.

Todd Litman, *Active Transportation Policy Issues: Backgrounder For the Go For Green "National Roundtable on Active Transportation,"* Victoria Transport Policy Institute (www.vtppi.org), 2003.

Bill Lyons, *Integrating Health and Physical Activity Goals Into Transportation Planning*, Volpe National Transportation Systems Center (www.volpe.dot.gov) for the Federal Highway Administration and Federal Transit Administration (www.planning.dot.gov/technical.asp), 2004.

Chloe Mason, "Transport, Environment & Health: En Route to a Healthier Australia?," *Medical Journal of Australia*, Vol., 172, No. 5, March 2000, pp. 230-232; available at the Institute for Sustainable Futures (www.isf.uts.edu.au).

Barbara A. McCann and Reid Ewing, *Measuring the Health Effects of Sprawl: A National Analysis of Physical Activity, Obesity and Chronic Disease*, Smart Growth America (www.smartgrowthamerica.org) and the Surface Transportation Policy Project, Sept. 2003.

National Center for Chronic Disease Prevention and Health Promotion (www.cdc.gov/nccdphp/dnpa) provides information on public health programs related to nutrition and exercise. The *Built Environment* section (www.niehs.nih.gov/drcpt/be/home.htm) provides information on public health and quality-of-life impacts related to community design.

Robert Noland, *Traffic Fatalities and Injuries: The Effects of Changes in Infrastructure and Other Trends*, *Journal of Accident Prevention and Analysis*, forthcoming 2004; available at www.cts.cv.ic.ac.uk/staff/wp22-noland.pdf.

PATH (Planning for Active Transportation and Health) (www.nrsrcaa.org/path/Documents.htm), describes practical measures to increase transportation efficiency, equity and health in rural regions, sponsored by the Natural Resources Services of the Redwood Community Action Agency.

Pedestrian and Bicycle Information Center (www.walkinginfo.org).

John Pucher and Lewis Dijkstra, "Promoting Safe Walking and Biking to Improve Public Health: Lessons From The Netherlands And Germany," *American Journal of Public Health*, Vol. 93, No. 9 (www.ajph.org), Sept. 2003, pp. 1509-1516.

James F. Sallis, Lawrence D. Frank, Brian E. Saelens and M. Katherine Kraft, "Active Transportation and Physical Activity: Opportunities For Collaboration On Transportation and

Public Health Research,” *Transportation Research A*, Vol. 38, Issue 4 (www.elsevier.com/locate/tra), May 2004, pp. 249-268.

Surgeon General, *Physical Activity and Health*, Center for Disease Control and Prevention (www.cdc.gov/nccdphp/sgr/sgr.htm), 1999. Defines recommended levels of physical activity.

VTPI, *Online TDM Encyclopedia*, Victoria Transport Policy Institute (www.vtppi.org), 2004.

Walkable Communities (www.walkable.org) works with communities to create more people-oriented environments.

WHO, Carlos Dora and Margaret Phillips (eds), *Transport, Environment and Health*, World Health Organization Regional Publication, European Series, No. 89 (www.euro.who.int/document/e72015.pdf), 2000.

WHO, Adrian Davis Editor, *A Physically Active Life Through Everyday Transport: With A Special Focus On Children And Older People And Examples And Approaches From Europe*, World Health Organization, Regional Office for Europe (www.euro.who.int/document/e75662.pdf), 2003.

WHO, World Report on Road Traffic Injury Prevention, World Health Organization and World Bank (www.who.int), 2004; available at www.who.int/entity/world-health-day/2004/infomaterials/world_report.

Endnotes

¹ Litman, T. “Reinventing Transportation; Exploring the Paradigm Shift Needed to Reconcile Sustainability and Transportation Objectives.” *Transportation Research Record 1670*, Transportation Research Board (www.trb.org), 1999, pp. 8-12; available at www.vtpi.org.

² WHO, Carlos Dora and Margaret Phillips (eds), *Transport, Environment and Health*, World Health Organization Regional Publication, European Series, No. 89 (www.euro.who.int/document/e72015.pdf), 2000; Lawrence Frank, Sarah Kavage and Todd Litman, *Promoting Public Health Through Smart Growth: Building Healthier Communities Through Transportation And Land Use Policies*, Smart Growth BC (www.smartgrowth.bc.ca), 2006.

³ Of course, these do not indicate the degree to which transportation affects each of the health risks: motor vehicle air pollution is only one of many contributors to respiratory illnesses, and nonmotorized travel is just one physical fitness strategy.

⁴ CDC. “Deaths: Preliminary Data for 2001.” *National Vital Statistics Reports*, Vol. 51, No 5, Center of Disease Control and Prevention, National Center of Health Statistics (www.cdc.gov/nchs), March 14, 2003.

⁵ *Web-based Injury Statistics Query and Reporting System: Years of Potential Life Lost (YPLL)*. National Center for Injury Prevention and Control, National Center of Disease Control and Prevention (www.cdc.gov/ncipc/wisqars), accessed 17 March 2003.

⁶ WHO, Carlos Dora and Margaret Phillips (eds), *Transport, Environment and Health*, World Health Organization Regional Publication, European Series, No. 89 (www.euro.who.int/document/e72015.pdf), 2000.

⁷ NHTSA, *Traffic Safety Facts 2001*, National Highway Traffic Safety Administration, DOT HS 809 474 (www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSF2001/2001occpro.pdf), 2002.

⁸ BTS. *Transportation Safety Data*. Bureau of Transportation Statistics, USDOT (www.bts.gov/publications/nts/index.html), 2000.

⁹ OECD, *IRTA Database* (www.bast.de/htdocs/fachthemen/irtad/english/we2.html), 2001

¹⁰ WHO, *World Report on Road Traffic Injury Prevention*, World Health Organization and World Bank (www.who.int), 2004.

¹¹ Ewing, Schieber, and Zegeer, 2003.

¹² Lucy, W. *Danger in Exurbia: Outer Suburbs More Dangerous Than Cities*. University of Virginia (www.virginia.edu), 2002.

¹³ Reid Ewing, Richard A. Schieber and Charles V. Zegeer, “Urban Sprawl As A Risk Factor In Motor Vehicle Occupant And Pedestrian Fatalities,” *American Journal of Public Health* (www.ajph.org), 2003.

¹⁴ David Clark and Brad M. Cushing, “Rural and Urban Traffic Fatalities, Vehicle Miles, and Population Density.” *Accident Analysis and Prevention*, Vol. 36, 2004, pp. 967-972.

¹⁵ Todd Litman, *Critique of ‘Great Rail Disasters’*, Victoria Transport Policy Institute (www.vtpi.org), 2004.

¹⁶ Noland, Robert. “Traffic Fatalities and Injuries: The Effects of Changes in Infrastructure and Other Trends.” Forthcoming in the *Journal of Accident Prevention and Analysis*. Available at www.cts.cv.ic.ac.uk/staff/wp22-noland.pdf.

¹⁷ Litman, T. “Air Pollution Costs.” *Transportation Cost and Benefit Analysis Guidebook*. Victoria Transport Policy Institute (www.vtpi.org/tca), 2002.

- ¹⁸ DeCicco, J and Delucchi, M. *Transportation, Energy and Environment; How Far Can the Technology Take Us*. American Council for an Energy-Efficient Economy (www.aceee.org), 1997.
- ¹⁹ BTS. *Mobility and Access, Transportation Statistics Annual Report 1997*. Bureau of Transportation Statistics (www.bts.gov), p. 109-110.
- ²⁰ Alison Cassady, Tony Dutzik and Emily Figdor, *More Highways, More Pollution: Road-Building and Air Pollution in American's Cities*, U.S. PIRG Education Fund (www.uspirg.org), March 2004.
- ²¹ Seethaler, R. *Health Costs Due to Road Traffic-Related Air Pollution; An Assessment Project of Austria, France and Switzerland*, Ministry Conference on Environment and Health, World Health Organization (www.who.dk), June 1999.
- ²² Murray, C. *Global Burden of Disease and Injury*. Center for Population and Development Studies, Harvard School of Public Health (www.hsph.harvard.edu/organizations/bdu), 1996.
- ²³ Litman, T. "Air Pollution." *Transportation Cost and Benefit Analysis: Techniques, Estimates and Implications*. Victoria Transport Policy Institute (www.vtppi.org/tca), 2002.
- ²⁴ WHO, Adrian Davis Editor, *A Physically Active Life Through Everyday Transport: With A Special Focus On Children And Older People And Examples And Approaches From Europe*, World Health Organization, Regional Office for Europe (www.euro.who.int/document/e75662.pdf), 2003.
- ²⁵ US Surgeon General. *Physical Activity and Health*. Center for Disease Control and Prevention (www.cdc.gov/nccdphp/sgr/sgr.htm), 1999.
- ²⁶ WHO. *Charter on Transport, Environment and Health*. World Health Organization (www.who.dk), 1999.
- ²⁷ Reid Ewing, et al., "Relationship Between Urban Sprawl and Physical Activity, Obesity, and Morbidity," *American Journal of Health Promotion*, Vol. 18, No. 1 (www.healthpromotionjournal.com), Sept/Oct. 2003, pp. 47-57, available at www.smartgrowth.umd.edu/pdf/JournalArticle.pdf.
- ²⁸ Todd Litman, *Land Use Impacts on Transport*, Victoria Transport Policy Institute (www.vtppi.org), 2005.
- ²⁹ Lilah M. Besser and Andrew L. Dannenberg, "Walking to Public Transit: Steps to Help Meet Physical Activity Recommendations," *American Journal of Preventive Medicine*, Vo. 29, No. 4 (www.acpm.org), 2005; available at www.cdc.gov/healthyplaces/articles/besser_dannenberg.pdf.
- ³⁰ Lawrence Frank, et al, "Many Pathways From Land Use To Health: Associations Between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality," *Journal of the American Planning Association*, Vol. 72, No. 1 (www.planning.org), Winter 2006, pp. 75-87.
- ³¹ "A Trend On the Move: Commuting by Bicycle." *Bicycling Magazine*. Rodale Press, April 1991.
- ³² Envirionics. *National Survey on Active Transportation*, Go for Green, (www.goforgreen.ca), 1998.
- ³³ ICLEI, *Health Benefits Economic Model*, Cities for Climate Protection, International Council for Local Environmental Initiatives (www3.iclei.org/ccp-au/tdm/index.html), 2003.
- ³⁴ Roland Sturm, *Urban Design, Lifestyle, and the Development of Chronic Conditions*, presented at the Built Environment and Childhood Obesity, National Institute of Environmental Health Sciences (www-apps.niehs.nih.gov/conferences/drcpt/oe2005/speakerdocs/strum-doc.pdf), 2005.
- ³⁵ Miller, T. *The Costs of Highway Crashes*, FHWA (Washington DC), Publ. No. FHWA-RD-055, 1991.
- ³⁶ "Transportation Costs." *Online TDM Encyclopedia*. Victoria Transport Policy Institute (www.vtppi.org/tca), 2002. Also see Litman, T. *Transportation Cost and Benefit Analysis*, Victoria Transport Policy Institute (www.vtppi.org/tca), 2002.

- ³⁷ “Comprehensive Transportation Planning.” *Online TDM Encyclopedia*. Victoria Transport Policy Institute (www.vtpi.org/tca), 2002.
- ³⁸ Litman, T. *Socially Optimal Transport Prices and Markets*. Victoria Transport Policy Institute (www.vtpi.org), 1998.
- ³⁹ Litman, T. *Economic Value of Walkability*. Victoria Transport Policy Institute (www.vtpi.org), 2002.
- ⁴⁰ Rietveld, P. “Nonmotorized Modes in Transport Systems: A Multimodal Chain Perspective for The Netherlands.” *Transportation Research D*, Vol. 5, No. 1, Jan. 2000, pp. 31-36.
- ⁴¹ Jackson R. J. and Kochtitzky, C. *Creating A Healthy Environment: The Impact of the Built Environment on Public Health*. Sprawl Watch Clearinghouse (www.sprawlwatch.org/health.pdf), 2001. Killingsworth, R., De Nazelle A., and Bell, R. “Building A New Paradigm: Improving Public Health Through Transportation,” *ITE Journal*, Vol. 73, No. 6 (www.ite.org), June 2003, pp. 28-32.
- ⁴² Ewing R. and Cervero, R. “Travel and the Built Environment – Synthesis.” *Transportation Research Record 1780* (www.trb.org), 2002.
- ⁴³ Boarnet, M. and Crane, R. “The Influence of Land Use on Travel Behavior: A Specification and Estimation Strategies.” *Transportation Research A*, Vol. 35, No. 9 (www.elsevier.com/locate/tra), November 2001, pp. 823-845.
- ⁴⁴ “Land Use Impacts on Transportation.” *Online TDM Encyclopedia*. Victoria Transport Policy Institute (www.vtpi.org/tca), 2002.
- ⁴⁵ Killingsworth, R. and Lamming, J. “Development and Public Health; Could Our Development Patterns be Affecting Our Personal Health?” *Urban Land*, Urban Land Institute (www.uli.org), July 2001, pp. 12-17.
- ⁴⁶ VTPI. *Online TDM Encyclopedia*. Victoria Transport Policy Institute (www.vtpi.org/tca), 2004.
- ⁴⁷ VTPI, 2004.
- ⁴⁸ *TravelSmart* (www.travelsmart.transport.wa.gov.au), 2001.
- ⁴⁹ Litman, T. *Distance-Based Vehicle Insurance: Feasibility, Costs and Benefits – Comprehensive Technical Report*. Victoria Transport Policy Institute (www.vtpi.org), 2001.
- ⁵⁰ Edlin, A. *Per-Mile Premiums for Auto Insurance*. Dept. of Economics, University of California at Berkeley (<http://emlab.berkeley.edu/users/edlin>), 1998.
- ⁵¹ London, *Congestion Charging: Update On Scheme Impacts And Operations*, Transport for London (www.tfl.gov.uk/tfl/downloads/pdf/congestion-charging/cc-12monthson.pdf), 2004.
- ⁵² RSPC (Royal Society of the Prevention of Accidents). Cited in “Fasten Your Safety Belts.” *The Economist*, 11 January 1997, p. 57.
- ⁵³ Project for Public Spaces, *The Role of Transit in Creating Livable Metropolitan Communities*, Transit Cooperative Research Program Report 22, National Academy Press (www.trb.org), 1997.
- ⁵⁴ Page, Y. “A Statistical Model to Compare Road Mortality in OECD Countries.” *Accident Analysis and Prevention*, Vol. 33 (www.elsevier.com/locate/aap), 2001, pp. 371-385.
- ⁵⁵ Todd Litman, *Active Transportation Policy Issues: Backgrounder*, Victoria Transport Policy Institute (www.vtpi.org), 2003.
- ⁵⁶ Todd Litman, *Quantifying the Benefits of Non-Motorized Transport for Achieving TDM Objectives*, Victoria Transport Policy Institute (www.vtpi.org), 2000.
- ⁵⁷ Andersen, Lars Bo, et al. “All-Cause Mortality Associated With Physical Activity During Leisure Time, Work, Sports and Cycling to Work.” *Archives of Internal Medicine* Vol. 160, No. 11 (<http://archinte.ama-assn.org/issues/v160n11/full/oi90593.html>). June 12, 2000, pp. 1621-1628.

- ⁵⁸ Pucher, J. and Dijkstra, L. "Making Walking and Cycling Safer: Lessons from Europe," *Transportation Quarterly*, Vol. 54, No. 3, Summer 2000; available at www.vtpi.org.
- ⁵⁹ Reid Ewing, et al., "Relationship Between Urban Sprawl and Physical Activity, Obesity, and Morbidity," *American Journal of Health Promotion*, Vol. 18, No. 1 (www.healthpromotionjournal.com), Sept/Oct. 2003, pp. 47-57, available at www.smartgrowth.umd.edu/pdf/JournalArticle.pdf.
- ⁶⁰ John Pucher and Lewis Dijkstra, "Promoting Safe Walking and Biking to Improve Public Health: Lessons From The Netherlands And Germany," *American Journal of Public Health*, Vol. 93, No. 9 (www.ajph.org), Sept. 2003, pp. 1509-1516.
- ⁶¹ Komanoff, C. and Roelofs, C. *The Environmental Benefits of Bicycling and Walking*. National Bicycling and Walking Study Case Study No. 15, USDOT, January 1993, FHWA-PD-93-015.
- ⁶² Mokhtarian, Patricia L. "A Synthetic Approach to Estimating the Impacts of Telecommuting on Travel." *Urban Studies* (www.engr.ucdavis.edu/~its/telecom), 2000.
- ⁶³ Shefer, D. and Rietvald, P. "Congestion and Safety on Highways: Towards an Analytical Model." *Urban Studies*, Vol. 34, No. 4, 1997, pp. 679-692.
- ⁶⁴ Stuster, J. and Coffman, Z. *Synthesis of Safety Research Related to Speed and Speed Limits*. FHWA-RD-98-154 Federal Highway Administration (www.tfhr.gov/safety/speed/speed.htm and www.tfhr.gov/safety/speed/speed.htm), 1998.
- ⁶⁵ Elvik, R. "Zero Killed in Traffic – from Vision to Implementation," *Nordic Road & Transport Research*, No. 1, 2001 (www.vti.se/nordic/1-01mapp/toi1.htm), 2001.
- ⁶⁶ Ewing R, Pendall R, and Chen D. *Measuring Sprawl and Its Impacts*. Smart Growth America (www.smartgrowthamerica.org), 2002.
- ⁶⁷ Friedman B, Gordon S, and Peers, J. "Effect of Neotraditional Neighborhood Design on Travel Characteristics," *Transportation Research Record 1466*, 1995, pp. 63-70.
- ⁶⁸ Frank, L. and Engelke, P. *How Land Use and Transportation Systems Impact Public Health*. Active Community Environments, Georgia Institute of Technology and Center for Disease Control (Atlanta; www.cdc.gov/nccdphp/dnpa/aces.htm), 2000.