Transportation and Public Health

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Abstract

This article investigates various ways that transportation policy and planning decisions affect public health and better ways to incorporate public health objectives into transport planning. Conventional planning tends to consider some public health impacts, such as crash risk and pollution emissions measured per vehicle-kilometer, but generally ignores health problems resulting from less active transport (reduced walking and cycling activity) and the additional crashes and pollution caused by increased vehicle mileage. As a result, transport agencies tend to undervalue strategies that increase transport system diversity and reduce vehicle travel. This article identifies various win-win strategies that can help improve public health and other planning objectives.

INTRODUCTION

Accessibility: people's overall ability to reach desired goods, services, and activities

Transportation policy and planning decisions can affect health in various ways. How people travel affects physical and mental health, including cancer, cardiovascular disease, vehicle crashes, and diabetes, four major causes of death (**Figure 1**).

New research is improving our understanding of these impacts (3, 13). Some of these relationships are indirect and complex: There are often several steps between a policy or planning decision, its land use, and travel behavior changes and its ultimate economic, social, and environmental impacts (**Figure 2**). Indirect impacts are frequently overlooked or undervalued in conventional planning. More comprehensive analysis is needed to better incorporate public health impacts into the planning process.

This complex process is a timely issue. Transportation planning is experiencing a paradigm shift: a change in the way problems are defined and solutions evaluated (4, 42) (**Table 1**). The old paradigm evaluated transport system performance primarily on the basis of automobile travel convenience, speed, and affordability and so tended to favor roadway expansion. It overlooked the tendency of some planning decisions, such as roadway expansions and generous parking requirements, to induce additional vehicle travel and reduce transport options, and the resulting costs (26, 60). The new paradigm considers a wider range of impacts and options. It evaluates transport system performance on the basis of accessibility rather than mobility and tends to support more integrated and multimodal planning. The new paradigm both supports and is supported by more comprehensive health impact analysis (43).

This article investigates these issues. It describes various ways that transport planning decisions affect public health, discusses methods for evaluating these impacts, identifies transport policies that tend to support health objectives, and describes various win-win solutions that support public health and other planning objectives. The analysis relies largely on North American data, but most of its conclusions are applicable in various ways to other regions,

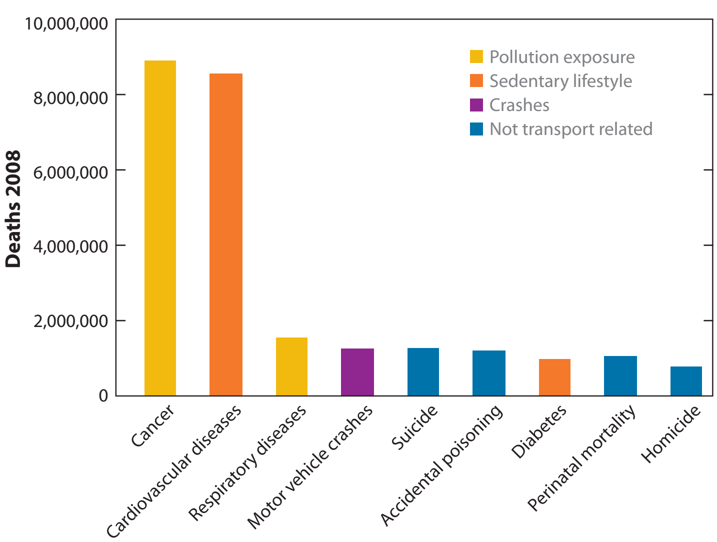

Figure 1

Leading causes of death in the United States (77). Transport planning decisions affect major health risks, including cancer, cardiovascular disease, traffic crashes, and diabetes, by influencing physical activity, pollution exposure, and crash risks.

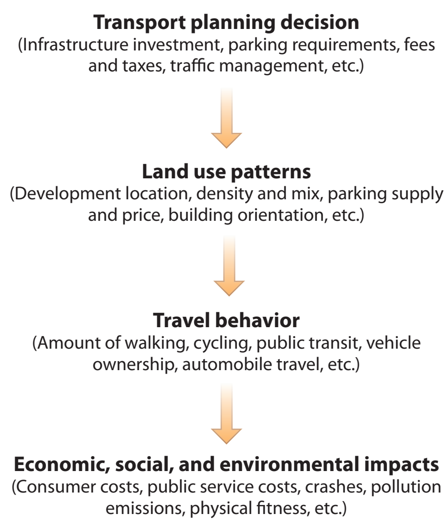

Figure 2

Steps between planning decisions and ultimate impacts. There may be several steps between a planning decision, its land use, and travel behavior impacts and its ultimate economic, social, and environmental impacts.

Table 1 Transportation planning paradigm shift. This table compares the old and new transport planning paradigms

	Old paradigm	New paradigm
Definition of transportation	Mobility (physical travel)	Accessibility (people's overall ability to reach services and activities)
Transport planning goals	Maximize travel speeds and minimize user costs	Optimize transport system efficiency and equity
Modes considered	Mainly automobile	Multimodal: walking, cycling, public transport, and automobile
Performance indicators	Vehicle traffic speeds, roadway level-of-service (LOS), distance-based crash and emission rates	Quality of transport options, multimodal LOS. Land use accessibility
Consideration of transportation demand management (TDM)	Generally considers vehicle travel reductions undesirable. Considers TDM a solution of last resort	Supports TDM whenever cost-effective
Favored transport improvement strategies	Road and parking facility expansion	Improve transport options, TDM, more accessible land development
Health impacts considered	Per-kilometer traffic crash and pollution emission rates	Per capita crash and emission rates, physical activity, and basic access

including developing countries where current planning decisions will affect future health conditions.

TRANSPORTATION HEALTH IMPACTS

This section discusses major categories of public health impacts that tend to be significantly affected by transport policies and planning decisions.

Traffic Crashes

Traffic crashes are a major cause of injuries and deaths (together called casualties), particularly for people aged 4–44 years (77). This risk can be viewed in different ways, which lead to different conclusions about this danger and the effectiveness of traffic safety strategies. The conventional paradigm assumes that motor vehicle travel is overall safe and that most crashes result from specific high-risk groups and behaviors, such as inexperienced and impaired driving, so safety programs should target these drivers and activities (81). From this perspective, it is inefficient and unfair to increase safety by reducing overall vehicle travel because this punishes all motorists for problems caused by an irresponsible minority.

Conventional traffic safety analysis tends to measure crash rates per unit of travel (i.e., injuries and fatalities per million vehicle-miles or billion passenger-kilometers). Evaluated this way, US crash rates declined nearly 80% between 1965 and 2010, indicating that conventional safety programs were successful. But per capita vehicle travel more than doubled during this period, which largely offset declining per-kilometer crash rates (**Figure 3**). If measured per capita (e.g., per 10,000 population), as with other health risks, there was little improvement despite large investments in safer roads, improved vehicle occupant crash protection, reductions in drunk driving, and improved emergency response and trauma care during this period.

Taking these factors into account, much greater casualty reductions should have been achieved. For example, the increase in seat belt use from nearly 0% in 1960 up to ∼75% in 2002 by itself should have reduced fatalities by ∼33% because wearing a seat belt reduces crash fatality rates by ∼45% (14); yet, per capita traffic deaths declined only ∼25% during this period. Some research indicates that safety strategies that make motorists feel safer, such as seat belts

Traffic crashes (also called accidents and collisions): unexpected collisions between vehicles and other objects

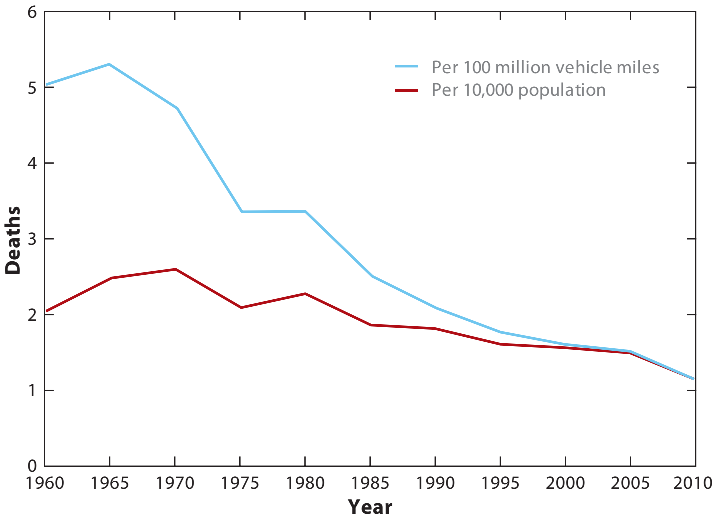

Figure 3

US traffic fatalities (61). This figure illustrates traffic fatality trends over five decades. Per-mile crash rates declined substantially, but per capita crash rates declined little despite significant traffic safety efforts.

and airbags, encourage more intensive (less cautious) driving, which reduces net safety gains (16).

The conventional safety paradigm assumes that because most crashes result from special risk factors, such as inexperienced or impaired drivers, general increases in vehicle travel need not increase crashes, and general (not targeted at high-risk driving) vehicle travel reductions do little to increase safety. However, research based on various analysis methods and data sets indicates that broad increases in motor vehicle travel do increase per capita crash casualty rates, and vehicle travel reductions do significantly reduce crashes (1, 22, 33, 44). This occurs because broad changes in mileage tend to include a mix of higher- and lower-risk vehicle travel, and because most injury crashes involve multiple vehicles, large vehicle travel reductions provide additional crash reductions by reducing traffic density and therefore the frequency of vehicle interactions (53).

The relationship between mileage and traffic fatalities varies across regions. Less developed countries tend to have high traffic casualty rates, which decline with increased motorization owing to improved vehicles, law enforcement, crash protection, emergency response, and medical treatment (67). However, among peer countries (countries at similar levels of development), per capita crash rates tend to increase with per capita vehicle travel (**Figure 4**). Thus the United States has the highest per capita crash rates among its peers despite aggressive traffic safety policies and programs. Conventional planning tends to focus on certain safety strategies, but overlooks or undervalues others. More comprehensive planning expands traffic safety evaluation to consider additional safety strategies and impacts (**Table 2**).

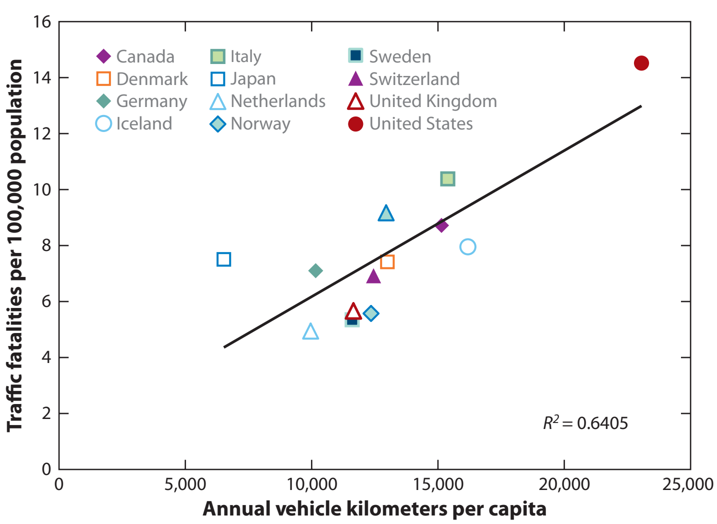

Figure 4

Vehicle travel and traffic fatality rates in OECD countries (64). Among developed countries, per capita traffic fatalities increase with per capita vehicle travel.

Vehicle Pollution Exposure

A second category of transport-related health impacts involves transportation pollution emissions. Motor vehicles produce various pollutants, which can cause health problems and ecological damage such as climate change (50). Although control technologies have reduced emissions per vehicle-kilometer, motor vehicle pollution remains a major health risk in part because reduced emission rates are

Table 2 Traffic safety strategies and impacts summary. Conventional planning tends to overlook some traffic-safety strategies and impacts

Conventional strategies	Targeted programs to reduce impaired driving. Restrictions on driving by higher-risk groups, such as youths and seniors (e.g., graduated licenses and cognitive drivers' tests). Crash protection (seat belts, air bags, energy-absorbing roadway barriers, etc.).
Additional strategies	Improving alternative modes (walking, cycling, and public transit). Pricing reforms (more efficient road and parking pricing, fuel price increases, distance-based insurance and registration fees). Mobility management marketing, which encourages shifts from automobile to alternative modes. Smart growth land use policies.
Often-overlooked impacts	Policies that make driving more convenient and affordable tend to increase per capita crash rates. Reducing congestion and increasing traffic speeds tend to increase crash severity. Automobile-dependent, sprawled land use development tends to increase per capita traffic casualty rates. Increasing the perception of vehicle and road safety encourages more intensive driving, which partly offsets crash-reduction benefits.

partly offset by increased vehicle travel (31). Motor vehicle air pollution probably causes a similar number of premature deaths as do traffic crashes (38). Conventional planning tends to focus on certain emission-reduction strategies and impacts but overlooks others (**Table 3**).

Physical Activity and Fitness

A third major category of health impacts concerns the effects that transport planning decisions have on physical activity and fitness (70). Public health officials are increasingly concerned about declining physical fitness, excessive body weight, and resulting increases in diseases such as diabetes (80). They recommend that adults average at least 150 weekly minutes (about 22 daily minutes) of moderate-intensity physical activity, and children average about three times that amount (79). A meta-analysis of 22 cohort studies concluded that, compared with no reported physical activity, 2.5 weekly hours of moderate activity is associated with a 19% reduction in mortality and 7 weekly hours is associated with a 24% reduction (84).

There are many ways to be physically active, but most, such as gym exercise and organized

Table 3 Vehicle pollution exposure reduction strategies and impacts summary. Conventional planning overlooks some emission-reduction strategies and impacts

Conventional strategies	Vehicle emission control technologies. Cleaner and alternative fuels. Reduced traffic congestion.
Additional strategies	Transportation demand management strategies that reduce total vehicle travel. Pricing reforms, particularly increased fuel taxes and emission fees. Restrict development of housing, schools, hospitals, and parks near major roads. Locate walking and cycling facilities away from busy roads.
Often-overlooked impacts	Policies that make driving more convenient and affordable tend to increase per capita emission rates. More sprawled development may increase distances between emission sources and lungs but increase total vehicle travel and per capita emissions.

Table 4 Physical activity strategies and impacts summary. Conventional planning tends to overlook some physical activity strategies and impacts

Conventional strategies	Exercise at a gym. Subsidize gym memberships. Participate in sports. Sponsor community sports programs. Promote recreational walking and cycling. Build recreational trails.
Additional strategies	Improve walking and cycling conditions. Encourage walking, cycling, and public transit travel. Create more compact, mixed, walkable, and bikeable communities.
Often-overlooked impacts	Wider roads and increased traffic speeds tend to discourage active transport. Sprawled development tends to reduce active transport.

sports, require special time, skill, and expense, which discourages consistent, lifetime participation, particularly by vulnerable populations such as people with low incomes or who are currently sedentary and overweight. Research indicates that automobile travel is positively associated with sedentary living and increased body weight (23), whereas increased walking and cycling are associated with reduced obesity and related illnesses such as high blood pressure and diabetes (1, 32). Because most public transit trips include walking links, physical activity tends to increase with public transit travel (39, 51). Many experts conclude that one of the most practical way to increase public fitness and health is to encourage walking and bicycling for both transportation (i.e., utilitarian) and recreational activities (85). Conventional planning often overlooks ways that transport policy and planning decisions affect public fitness and health. More comprehensive planning can help identify additional ways to support public fitness and health (**Table 4**).

Access to Health-Related Goods and Services

Transport planning decisions also affect basic access, which includes access to health-related goods and services such as health care, healthy food, and recreation. Conventional planning tends to focus on certain accessibility-improvement strategies, such as affordable automobile travel and public transit services, but overlook others, such as improving nonmotorized travel, more accessible land use development, and more affordable housing in accessible locations, and tends to give little consideration to the reduction in accessibility that can result from automobile dependency (**Table 5**). Automobile-dependent transport systems tend to limit access for physically, economically, and socially disadvantaged people (e.g., people who cannot drive because of a physical disability or who cannot afford a motor vehicle), which can contribute to health problems and increase health care costs (2). One survey found that 4% of US children (3.2 million) either missed a scheduled health care visit or did not schedule a visit during the preceding year because of transportation restrictions (71).

Mental Health Impacts

Transport planning decisions can also affect xmental health in various ways. Improving walking and cycling conditions and public transit tends to improve mental health by increasing physical activity and supporting community cohesion, that is, positive interactions among neighbors (49, 65). Increased neighborhood walkability is associated with reduced symptoms of depression in older men (8), and reduced frequency of dementia in women and men (40). In a study of 299 US older adults (mean age 78 years) Erickson et al. (18) found significantly higher rates of gray matter volume and cognitive ability in those who previously walked more than 72 blocks a week. High-quality public transit service can reduce commute stress compared with driving (83).

Table 5 Basic access strategies and impacts summary. Conventional planning often overlooks some strategies and impacts that affect basic access

Conventional strategies	Make automobile travel available and affordable. Provide public transit and special mobility services for people with disabilities. Apply universal design (transport facilities and services that accommodate all potential users, including people with disabilities and other impairments).
Additional strategies	Improve walking and cycling conditions. Support car sharing and taxi services. Apply smart growth policies to create more accessible, multimodal communities. Develop affordable housing in accessible locations.
Often-overlooked impacts	Policies that favor automobile travel and sprawl tend to reduce accessibility and increase transportation costs for nondrivers.

HEALTH IMPROVEMENT STRATEGIES

This section evaluates various transport strategies for improving public health (13, 82).

Traffic Calming and Speed Control

Traffic-calming and speed-reduction strategies (such as lower speed limits and improved speed enforcement) tend to improve safety by reducing crash frequency and severity and, in some circumstances, help total vehicle travel (7). Their impacts on pollution emissions vary depending on conditions (72); per-kilometer emission rates tend to decline with reductions from high to moderate traffic speeds, but rates increase at very low speeds (under 20 km per hour) and with more stop-and-go driving (for example, due to speed bumps). Speed reductions tend to improve walking and cycling conditions, which can reduce per-capita emissions, increase physical activity, and improve basic access (55).

Active Transport (Walking and Cycling) Improvements

Walking and cycling infrastructure improvements, such as better sidewalks, crosswalks, and paths, can reduce these modes' crash risk, and as previously described, by increasing active transport, they tend to reduce total crash rates owing to the "safety in numbers" effect (24). In a typical situation, doubling the distances walked and cycled in an area increases pedestrian and cycling injuries by 32% but reduces risk to other road users, resulting in a net reduction in traffic casualties (35). Shifts from driving to active modes can provide proportionately large air pollution emission reductions because these modes tend to substitute for shorter urban vehicle trips that have high per-kilometer emission rates due to cold starts and congestion; therefore, a 1% shift from motorized to nonmotorized modes typically reduces emissions by 2–4% (27). Such improvements also tend to increase physical activity and basic access (73).

Public Transit Service Improvements

Public transit service improvements, such as more routes, longer operating hours, and more frequent service, nicer vehicles and stations, grade separation, and improved user information, which attract discretionary users (people who would otherwise drive), tend to reduce total crash rates and pollution emissions (51). Public transit travel has an order of magnitude lower traffic fatality rate as does automobile travel, and high-quality public transit tends to leverage additional vehicle travel reductions by providing a catalyst for transit-oriented development, which creates neighborhoods where residents own fewer cars, drive less, and rely more on walking, cycling, and public transit, providing additional health and safety benefits (5, 45). These data help explain why per capita traffic deaths tend to decline significantly as per capita transit ridership increases in a community (see **Figures 5** and **6**).

Active transport: nonmotorized transport modes including walking, cycling, and variations such as wheelchair use

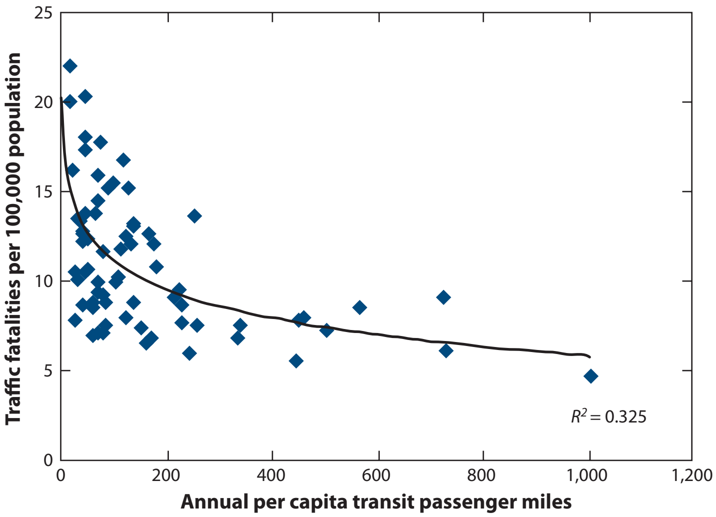

Figure 5

Traffic deaths (45). Per capita traffic fatalities tend to decline with increased transit ridership. These values include deaths to transit passengers, automobile passengers, and pedestrians.

Public transit can have other health impacts. By reducing congestion delays, bus priority lanes and signal controls can reduce bus emission rates. Transit improvements integrated with supportive land use policies can create transit-oriented development, which leverages additional vehicle travel reductions, providing additional benefits (76). Because most transit trips include walking and cycling links, transit improvements tend to increase physical fitness (39). Transit improvements also tend to improve basic access, and high-quality public transit can reduce commuter stress (83).

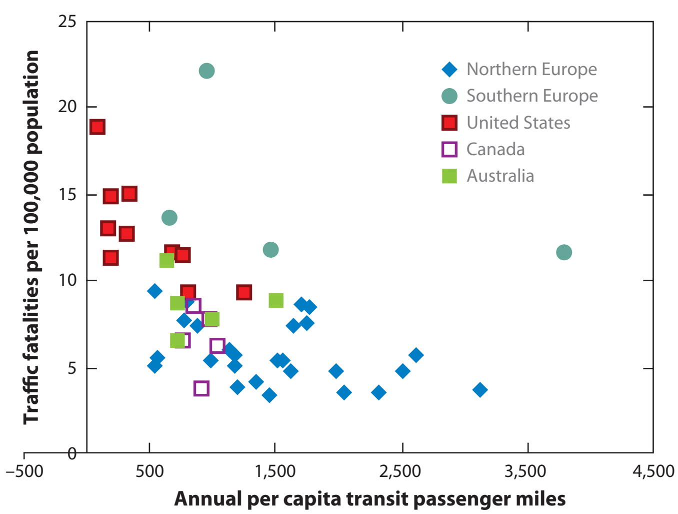

Figure 6

International traffic deaths (37). International data indicate that crash rates decline with increased transit ridership.

Transport Pricing Reforms

Transport pricing reforms include efficient road and parking pricing (motorists pay directly for using roads and parking facilities, with higher prices under congested conditions), parking unbundling (parking is rented separately from building space, so occupants pay only for parking spaces they want) and cash out (travelers who are offered a subsidized parking space can instead choose its cash value if they use alternative modes), higher fuel prices, and distance-based vehicle insurance and registration fees (motorists pay in proportion to their annual vehicle travel). These pricing reforms can provide significant health benefits (52). Grabowski & Morrisey (28) estimate that a one-cent state gasoline tax increase reduces per capita traffic fatalities 0.25% and traffic fatalities per vehicle-mile by 0.26%. Leigh & Geraghty (41) estimate that a sustained 20% gasoline price increase would prevent ∼2,000 traffic crash deaths (∼5% of the total), plus ∼600 air pollution deaths. Studies by Chi et al. (15) show that fuel price increases reduce per-mile crash rates, so a 1% vehicle travel reduction reduces crashes more than 1%. Pricing reforms tend to increase use of active modes and therefore physical fitness.

Mobility Management Marketing

Mobility management marketing refers to various programs and information resources that encourage people to shift travel from automobiles to alternative modes. Methods includes commute trip reduction programs through which employers encourage their employees to use alternative modes, transportation management associations through which businesses support alternative modes, ride matching and vanpool support programs, and direct marketing programs that encourage travelers to try alternative modes.

Complete Streets

Complete Streets is a set of policies and planning practices intended to ensure that roadways accommodate diverse users and uses including walking, cycling, public transport, and automobile travel, plus recreational, residential, and commercial activities that may occur nearby (74). These policies and planning practices help communities implement more integrated and multimodal transport planning. They represent a change from past planning and design practices, which focused primarily on maximizing vehicle traffic and treated nonmotorized and public transit as nonessential modes that could be ignored if resources (road space and money) are constrained.

Smart Growth Land Use Development Policies

Smart growth policies encourage more compact and mixed development, more connected path and road networks, better integration between transport and land use planning, improved walkability, more efficient parking management, and other features that improve accessibility and transport diversity (75). People who live and work in such communities tend to own fewer motor vehicles, drive less, and rely more on walking, cycling, and public transport (12). Smart growth residents typically drive 20–40% less than they would if located in automobile-dependent sprawl (20). Smart growth residents tend to have substantially lower per capita traffic casualty rates than do residents of automobile-dependent sprawl (21).

These vehicle travel reductions tend to reduce pollution emissions, although more compact development may increase some pollution exposure, for example, if more people walk, bike, live, and work close to busy roadways or if tall buildings create a canyon effect on urban roads. These risks can be mitigated through targeted strategies such as using cleaner transit vehicles on major urban roads and locating sidewalks and paths away from traffic (10). Smart growth tends to increase active transport significantly because more destinations are within walking and cycling distances, and it includes improvements to walking, cycling, and public transport such as better sidewalks and crosswalks, traffic calming, bike and bus lanes, and bike racks.

Smart growth: land use development policies that help create more compact, accessible, multimodal communities

Transportation demand management (TDM, also called mobility management): various policies and programs intended to increase transport system efficiency by changing travel activity

Public Health Impacts Summary

Table 6 compares the impacts of various transport safety and health strategies. Most conventional strategies, such as targeted safety programs (e.g., graduated licenses and anti-drunk-driving campaigns), crash protection (e.g., seat belt, helmet, and airbag regulations and encouragement), more efficient and alternative fuel (e.g., hybrid and electric) vehicles, and exercise programs, provide limited benefits. Transportation demand management (TDM) strategies, which improve travel options and encourage travelers to choose the most efficient option for each trip, tend to provide multiple public health benefits and support other planning objectives.

More comprehensive planning can provide additional support for these innovative TDM strategies. **Table 7** compares how various types of transport improvement strategies affect ten major planning objectives. Conventional strategies, such as roadway expansion and incentives to choose more fuel-efficient vehicles (such as fuel efficiency standards and rebates), generally achieve only one or two planning objectives and, to the degree that they induce additional vehicle travel, tend to contradict others (46). TDM and smart growth strategies, which improve overall accessibility and reduce total vehicle travel, tend to achieve multiple planning objectives and so are considered win-win strategies.

This is not to suggest that roadway-expansion and fuel-efficiency incentives are necessarily inefficient and harmful; however, it does illustrate how some transport policy and planning decisions can have undesirable

Table 6 Public health impact summary. This table summarizes safety, emission reductions, fitness, and basic access impacts of various strategies. Actual impacts can vary significantly depending on specific conditions

Strategies	Safety	Pollution reduction	Fitness	Basic access	Other impacts
Conventional safety and health strategies					
Targeted safety programs	Large benefits	No benefit	No benefit	No benefit	
Crash protection	Large benefits	No benefit	No benefit	No benefit	
Efficient and alternative fuel vehicles	Smaller vehicles can increase crash risk	Large benefits	No benefit	No benefit	Energy conservation
Exercise and sport promotion	No benefit	No benefit	Large benefits	No benefit	User enjoyment
Innovative transportation demand management strategies					
Traffic calming and speed control	Large benefits	Mixed impacts	Medium to large benefit	Medium to large benefit	
Active transport improvements	Medium to large benefits	Medium to large benefits	Large benefits	Large benefits	Reduced traffic and parking congestion
Public transit improvements	Large benefits	Large benefits	Large benefits	Large benefits	Reduced congestion
Transport pricing reforms	Large benefits	Large benefits	Large benefits	Mixed impacts	Reduced congestion
Mobility management marketing	Small to medium benefits	Small to medium benefits	Medium benefits	Small benefits	Reduced congestion
Complete streets	Large benefits	Medium to large benefits	Large benefits	Large benefits	Mixed
Smart growth development policies	Large benefits	Mixed. Reduces emissions but may increase proximity	Large benefits	Large benefits	Open space preservation, more efficient public services

indirect impacts, whereas others may provide significant additional cobenefits, which are often overlooked or undervalued in conventional planning. More comprehensive evaluation helps identify truly optimal solutions, considering all benefits and costs, including public health impacts.

TRANSPORT PLANNING REFORMS FOR HEALTHIER COMMUNITIES

This section discusses transport planning reforms to support public health.

Planning Biases

Conventional planning tends to be biased in various ways that encourage automobile travel and sprawl (6, 11, 25, 30):

- Transport system performance is evaluated primarily on the basis of automobile traffic speed; other modes of travel and other planning objectives often receive less consideration.
- A major portion of transport funding is dedicated to roadways and cannot be used for alternative modes or TDM strategies,

Table 7 Comparing strategies (48). Most conventional transport improvement strategies help achieve only one or two objectives (✓), but by inducing additional vehicle travel, they often contradict others (×). Transportation demand management (TDM) and smart growth strategies help achieve multiple planning objectives and so are considered win-win strategies

Planning objective	Roadway expansion	Fuel-efficient vehicles	TDM and smart growth
User convenience and comfort	✓	×	✓
Congestion reduction	✓	×	✓
Parking cost savings	×	×	✓
Roadway facility cost savings	×	×	✓
Consumer cost savings	×		✓
Reduced traffic crashes	×	×	✓
Improved mobility options	×		✓
Energy conservation	×	✓	✓
Pollution reduction	×	✓	✓
Physical fitness and health	×		✓
Land use objectives	×	×	✓

even if they are more cost-effective and beneficial overall.

- Most jurisdictions require developers to provide generous parking supply, which stimulates sprawl and subsidizes automobile travel.
- Restrictions are placed on development density and mix, and fees and taxes fail to reflect the higher costs of providing public services to more dispersed locations.

Although these policies may individually seem justified, their impacts are cumulative and synergistic, creating a self-reinforcing cycling of automobile dependency and sprawl (**Figure 7**). They create automobile-dependent communities in which most trips are made by automobile, active transport is difficult and uncommon, households spent a relatively large portion of their time and financial budgets on driving, nondrivers are significantly disadvantaged, and high-risk motorists continue to drive because of inadequate alternatives (55). This cycle exacerbates health problems, including crash risk, pollution, sedentary living, and inaccessibility (56). Correcting these distortions is important, even essential, for achieving public health objectives and can help achieve other planning objectives such as congestion reduction, housing affordability, and habitat preservation.

Impacts of Reforms

How much would travel activity change if planning were less biased and pricing more efficient? Probably a great deal. Current planning significantly underinvests in nonmotorized

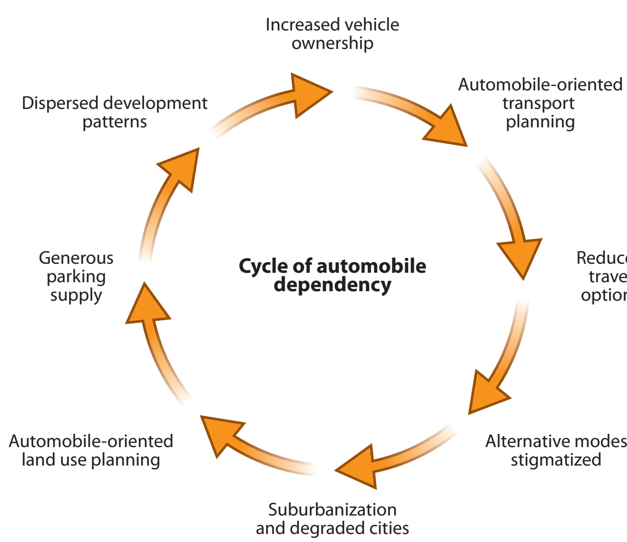

Figure 7

Cycle of automobile dependency and sprawl. This figure illustrates the self-reinforcing cycle of increased automobile dependency and sprawl.

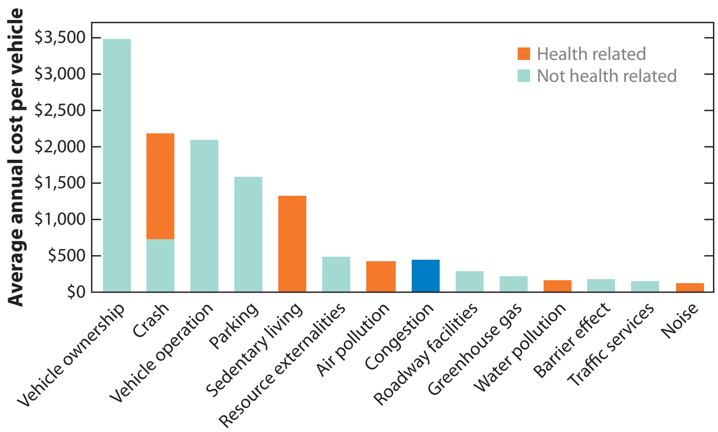

Figure 8

Estimated US automobile costs, 2011 (50). Illustrates the estimated magnitude of various transportation costs. Health-related impacts are significant but seldom fully recognized in transport project economic evaluation.

travel and fails to give public transit roadways priority when justified for efficiency (47, 66). Nationwide, ∼12% of total trips are made by nonmotorized modes, and more trips are made in cities, yet in most jurisdictions only 1–3% of total transport funding is devoted to nonmotorized facilities (1). Likewise, only a tiny portion of urban arterials have high-occupancy vehicle or bus lanes, even though high-occupancy vehicles can carry far more peak-period travelers than can a general purpose lane, and they support other planning objectives such as basic access for nondrivers. More multimodal planning can significantly increase walking, cycling, and public transit travel and reduce automobile travel (29). For example, walking and cycling more than doubled in nine US cities that invested in active transport programs (69), and urban regions with high-quality public transit systems tend to have 10–30% less per capita driving, and comparable reductions are observed in per capita traffic deaths and pollution emissions (45, 54). International comparisons show even greater effects: Wealthy countries with multimodal planning and high fuel prices have much more walking, cycling, and public transport travel, and less than half the per capita automobile travel, as does the United States (59, 68).

Incorporating Health Impacts into Economic Evaluation

One important policy reform is to apply more comprehensive analysis of health impacts when evaluating transport policies and projects. Transport projects are often evaluated primarily on the basis of monetized (measured in monetary units) estimates of travel time and vehicle operating cost savings, which tend to favor automobile-oriented improvements such as urban highway expansion (58, 78). Estimates of other transport costs are available (50, 57), including crash damages (9), energy production externalities (19), pollution emission damage (17), and physical activity (27, 36). The *Active Transport Quantification Tool* (34) describes how to value the vehicle cost savings, reductions in heart disease, diabetes risk, congestion, pollution and crash risk, and increased happiness from more active transport (walking and cycling). On the basis of detailed analysis of the net health benefits of increased physical activity, in addition to reduced congestion and air pollution, the New Zealand Transport Agency's *Economic Evaluation Manual* estimates social benefits to total NZ$2.70 per additional kilometer (US$3.70 per additional mile) walked and NZ$1.40 per additional kilometer (US$1.92 per additional mile) cycled (62, 63).

Figure 8 compares the estimated magnitude of various transport costs, assuming that automobile dependency contributes to the health costs of sedentary living, by reducing walking by one mile per day ($3.70 × 365 days per year). As previously mentioned, air pollution damages probably cause about the same number of deaths as do traffic crashes but cause smaller reductions in longevity because crash victims are younger, on average, than people who die from air pollution and cause little property damage. These data have important implications for healthy community planning. Health-related costs, including most crash costs (excluding property damages), sedentary living costs, local air pollution, water pollution, and noise, are large but often overlooked in transport economic evaluation.

Conventional planning tends to focus on congestion costs (the additional travel time and vehicle operating expenses associated with traffic congestion), although it is actually modest compared with other automobile costs. Thus a congestion-reduction strategy that causes even small increases in crashes, sedentary living, or pollution exposure is probably not cost-effective, but a congestion-reduction strategy becomes more cost-effective if it provides even small reductions in crashes, pollution, or sedentary living costs. For example, if a roadway-expansion project reduces congestion 10% but increases crash costs 2% by increasing traffic volumes and speeds, its incremental costs equal its incremental benefits; however, a congestion-reduction strategy is worth twice as much if it also reduces traffic crashes just 2%.

CONCLUSIONS

Transportation planning decisions can have significant health impacts by influencing traffic crash and pollution emission rates, physical activity, basic access, and mental health. Conventional planning tends to consider some of these impacts, per-kilometer crash and pollution emission rates in particular, but generally ignores the health problems caused by degraded walking and cycling conditions and the additional crashes and pollution emissions caused by increased vehicle mileage.

Health impacts tend to be relatively large compared with other impacts that tend to receive greater consideration in the planning process, such as traffic speeds, congestion delays, and vehicle operating costs. As a result, a policy or project that helps reduce congestion delay or vehicle operating costs provides far smaller net benefits if it also increases crash, pollution, or sedentary living costs; however, it provides far greater benefits if it also helps achieve health objectives. More comprehensive analysis of health impacts can significantly change planning decisions.

The new transport planning paradigm applies more comprehensive analysis of impacts and options. It evaluates transport system performance on the basis of accessibility rather than mobility and so recognizes the important role that nonmotorized and public transport modes play in an efficient and equitable transport system. It supports more integrated, multimodal planning, including improvements to alternative modes, more TMD, and smart growth development policies. The new paradigm both supports and is supported by more comprehensive analysis of health impacts.

This article identifies various win-win strategies that provide public health benefits and help achieve other planning objectives. This analysis indicates that 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 a more efficient and diverse transport system.

FUTURE ISSUES

The following areas need to be addressed:

- Develop better transport models for predicting how various policy and planning reforms affect travel activity, including the amount that people walk, bike, drive, and use public transit.
- Investigate how various changes in travel activity affect public health, including crash risk, pollution exposure, physical activity, and basic access.
- Identify policy and planning reforms that support public health objectives.
- Investigate how to build political and popular support for policy and planning reforms, including demand management strategies such as pricing reforms and smart growth land use policies.

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LITERATURE CITED

1. Alliance for Biking and Walking. 2010. *Bicycling and Walking in the U.S.: 2010 Benchmarking Report*. Washington, DC: Alliance for Biking and Walking. **http://www.peoplepoweredmovement.org/site/index.php/site/memberservices/C529**
2. Am. Public Transp. Assoc. (APTA). 2003. *The Benefits of Public Transportation: The Route to Better Personal Health*. Washington, DC: APTA. **http://www.apta.com/resources/reportsandpublications/Documents/better_health.pdf**
3. Am. Public Health Assoc. (APHA). 2010. *The Hidden Health Costs of Transportation: Backgrounder*. Washington, DC: APHA. **http://www.apha.org/NR/rdonlyres/E71B4070-9B9D-4EE1-8F43-349D21414962/0/FINALHiddenHealthCostsShortNewBackCover.pdf**
4. Asian Dev. Bank. 2009. *Changing Course: A New Paradigm for Sustainable Urban Transport.* Manila: ADB. **http://www.adb.org/sites/default/files/pub/2009/new-paradigm-transport.pdf**
5. Bailey L, Mokhtarian PL, Little A. 2008. *The Broader Connection Between Public Transportation, Energy Conservation and Greenhouse Gas Reduction*. Fairfax, VA: ICF Int. **http://www.apta.com/gap/policyresearch/Documents/land_use.pdf**
6. Bartholomew K. 2007. The machine, the garden, and the city: toward an access-efficient transportation planning system. *Environ. Law Rep. News Anal.* 37(8):10593–614
7. Bellefleur O, Gagnon F. 2012. *Urban Traffic Calming and Health: A Literature Review*. Montreal: Natl. Collab. Cent. Healthy Public Policy (NCCHPP). **http://www.ncchpp.ca/docs/ReviewLiteratureTrafficCalming_En.pdf**
8. Berke EM, Gottlieb LM, Moudon AV, Larson EB. 2007. Protective association between neighborhood walkability and depression in older men. *J. Am. Geriatr. Soc.* 55(4):526–33
9. Blincoe L, Seay E, Zaloshnja T, Miller T, Romano E, et al. 2002. *The Economic Impact of Motor Vehicle Crashes 2000. Rep. DOT HS 809 446*. Washington, DC: US Dep. Transp., NHTSA. **http://www.cita-vehicleinspection.org/Portals/cita/autofore_study/LinkedDocuments/literature/NHTSA%20the%20economic%20impact%20of%20motor%20vehicle%20crashes%202000%20USA%202002.pdf**
10. Brauer M, Reynolds C, Hystad P. 2012. *Traffic-Related Air Pollution and Health: A Canadian Perspective on Scientific Evidence and Potential Exposure-Mitigation Strategies*. Ottawa: Health Canada. **https://circle.ubc.ca/bitstream/handle/2429/41542/2012-03-01%20Traffic%20and%20Health%20FINAL.pdf?sequence=1**
11. Brown JR, Morris EA, Taylor BD. 2009. Paved with good intentions: fiscal politics, freeways, and the 20th century American city. In *Access 35*, 35:30–37. Berkeley: Univ. Calif. Transp. Cent. **http://www.uctc.net/access/35/access35.shtml**
12. Calif. Environ. Prot. Agency, Air Resour. Board. 2011. *Research on Impacts of Transportation and Land Use-Related Policies*. Sacramento: Calif. Air Resour. Board. **http://arb.ca.gov/cc/sb375/policies/policies.htm**
13. Cent. Dis. Control Prev. (CDC). 2010. *CDC Transportation Recommendations*. Atlanta: CDC. **http://www.cdc.gov/transportation/default.htm**
14. Cent. Dis. Control Prev. (CDC). 2011. *Policy Impacts: Seat Belts*. Atlanta: CDC, Natl. Cent. Inj. Prev. Control. **http://www.cdc.gov/MotorVehicleSafety/pdf/PolicyImpact-SeatBelts.pdf**
15. Chi G, Cosby AG, Quddus MA, Gilbert PA, Levinson D. 2010. Gasoline prices and traffic safety in Mississippi. *J. Saf. Res.* 41(6):493–500
16. Chirinko R, Harper E. 1993. Buckle-up or slow-down? New estimates of offsetting behavior and their implications for automobile safety regulation. *J. Policy Anal. Manag.* 12(2):270–96
17. Econ. Dev. Res. Group. 2007. *Monetary Valuation per Dollar of Investment in Different Performance Measures*. NCHRP 8-36-61. Washington, DC: Natl. Coop. Highw. Res. Progr. **http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-36(61)_FR.pdf**

18. Erickson KI, Raji CA, Lopez OL, Becker JT, Rosano C, et al. 2010. Physical activity predicts gray matter volume in late adulthood: the Cardiovascular Health Study. *Neurology* 75:1415–22
19. Eur. Comm. 2005. *ExternE: Externalities of Energy. Methodology 2005 Update*, ed. P Bickel, R Freidrich. Luxemburg: Eur. Comm. **http://maxima.ier.uni-stuttgart.de/brussels/methup05.pdf**
20. Ewing R, Cervero R. 2010. Travel and the built environment: a meta-analysis. *J. Am. Plann. Assoc.* 76(3):265–94
21. Ewing R, Schieber RA, Zegeer CV. 2003. Urban sprawl as a risk factor in motor vehicle occupant and pedestrian fatalities. *Am. J. Public Health* 93(9):1541–45
22. Ferreira J, Minikel E. 2010. *Pay-As-You-Drive Auto Insurance in Massachusetts: A Risk Assessment and Report on Consumer, Industry and Environmental Benefits*. Cambridge, MA: Dep. Urban Stud. Plan., Mass. Inst. Technol. **http://www.clf.org/wp-content/uploads/2010/12/CLF-PAYD-Study_November-2010.pdf**
23. Frank L, Andresen MA, Schmid TL. 2004. Obesity relationships with community design, physical activity and time spent in cars. *Am. J. Prev. Med.* 27(2):87–97
24. Frank L, Devlin A, Johnstone S, van Loon J. 2010. *Neighbourhood Design, Travel, and Health in Metro Vancouver: Using a Walkability Index*. Vancouver: Act. Transp. Collab., Univ. B. C. **http://health-design.spph.ubc.ca/files/2011/06/WalkReport_ExecSum_Oct2010_HighRes.pdf**
25. Goodwin P. 2004. *Valuing the Small: Counting the Benefits*. London: Cent. Transport Stud., Univ. Coll. London. **http://discovery.ucl.ac.uk/1263/1/2004_27.pdf**
26. Gorham R. 2009. *Demystifying Induced Travel Demand*. Sustain. Transp. Tech. Doc. 1. Eschborn, Ger.: Dtsch. Gessellschaft Tech. Zusammenarbeit. **http://www.calicomovamos.org.co/calicomovamos/files/Escuchando%20Expertos/TD-Induced-Demand.pdf**
27. Grabow ML, Spak SN, Holloway T, Stone B, Mednick A, Patz JA. 2012. Air quality and exercise-related health benefits from reduced car travel in the midwestern United States. *Environ. Health Perspect.* 120(1):68–76
28. Grabowski DC, Morrisey MA. 2006. Do higher gasoline taxes save lives? *Econ. Lett.* 90:51–55
29. Guo JY, Gandavarapu S. 2010. An economic evaluation of health-promotive built environment changes. *Prev. Med.* 50(Suppl. 1):S44–49
30. Hallenbeck ME, Carlson D, Ganey K, Vernez Moudon A, de Montigny L, Steiner R, Wash. State Transp. Res. Cent. (TRAC-UW). 2006. *Options for Making Concurrency More Multimodal*. Seattle: TRAC-UW, Univ. Wash. **http://depts.washington.edu/trac/bulkdisk/pdf/ConcurrencyOptions.pdf**
31. Health Effects Inst. (HEI). 2010. *Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects*. HEI Spec. Rep. 17. Boston: HEI. **http://pubs.healtheffects.org/getfile.php?u=553**
32. Hoehner CM, Barlow CE, Allen P, Schootman M. 2012. Commuting distance, cardiorespiratory fitness, and metabolic risk. *Am. J. Prev. Med.* 42(6):571–78
33. Ilyushchenko S. 2008. Fatal US car collisions, 2005–2007. *Blogroll: The Days Are Numbered* (blog), Nov. 22, **http://www.thedaysarenumbered.com/2008/11/fatal-us-car-collisions-2005-2007.html**
34. Int. Counc. Local Environ. Initiat. (ICLEI). 2007. *Active Transportation Quantification Tool*. Melbourne, Aust.: Cities for Clim. Prot., ICLEI. **http://www.iclei.org/index.php?id=8394**
35. Jacobsen PL. 2003. Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Inj. Prev.* 9:205–9
36. Kahlmeier S, Racioppi F, Cavill N, Rutter H, Oja P. 2010. "Health in all policies" in practice: guidance and tools to quantifying the health effects of cycling and walking. *J. Phys. Act. Health* 7(Suppl. 1):S120–25
37. Kenworthy J, Laube F, Inst. Sustain. Technol. Policy (ISTP). 2000. *Millennium Cities Database For Sustainable Transport*. Brussels: Int. Union Public Transp. (UITP)
38. Krzyzanowski M, Kuna-Dibbert B, Schneider J, eds. 2005. *Health Effects Of Transport-Related Air Pollution*. Copenhagen: World Health Organ. (WHO) Reg. Off. Eur. **http://www.euro.who.int/__data/assets/pdf_file/0006/74715/E86650.pdf**
39. Lachapelle U, Saelens BE, Sallis JF, Conway TL. 2011. Commuting by public transit and physical activity: where you live, where you work, and how you get there. *J. Phys. Act. Health* 8(Suppl. 1):S72–82
40. Larson EB, Wang L, Bowen JD, McCormick WC, Teri L, et al. 2006. Exercise is associated with reduced risk for incident dementia among persons 65 years of age and older. *Ann. Intern. Med.* 144(2):73–81

41. Leigh JP, Geraghty EM. 2008. High gasoline prices and mortality from motor vehicle crashes and air pollution. *J. Occup. Environ. Med.* 50(3):249–54
42. Litman T. 1999. Reinventing transportation: exploring the paradigm shift needed to reconcile sustainability and transportation objectives. *Transp. Res. Rec. 1670*, pp. 8–12, Transp. Res. Board, Washington, DC. **http://www.vtpi.org/reinvent.pdf**
43. Litman T. 2003. Integrating public health objectives in transportation decision-making. *Am. J. Health Promot.* 18(1):103–8
44. Litman T. 2004. Impacts of rail transit on the performance of a transportation system. *Transp. Res. Record 1930*, pp. 23–29, Transp. Res. Board, Washington, DC. **http://trb.metapress.com/content/y1j5v644r6jlw845/**
45. Litman T. 2012. *Rail Transit in America: A Comprehensive Evaluation of Benefits*. Victoria, BC: Victoria Transp. Policy Inst. (VTPI). **http://www.vtpi.org/railben.pdf**
46. Litman T. 2005. Efficient vehicles versus efficient transportation: comparing transportation energy conservation strategies. *Transp. Policy* 12(2):121–29
47. Litman T. 2006. Transportation market distortions. *Berkeley Plann. J.* 19:19–36
48. Litman T. 2006. *Win-Win Transportation Solutions: Cooperation for Economic, Social and Environmental Benefits*. Victoria, BC: Victoria Transp. Policy Inst.
49. Litman T. 2007. *Community cohesion as a transport planning objective*. Pap. 07–0550. Presented at Annu. Meet. Transp. Res. Board, Washington, DC
50. Litman T. 2009. *Transportation Cost and Benefit Analysis: Techniques, Estimates and Implications*. Victoria, BC: Victoria Transp. Policy Inst. 2nd ed. **http://www.vtpi.org/tca/tca01.pdf**
51. Litman T. 2011. *Evaluating Public Transportation Health Benefits*. Victoria, BC: Victoria Transp. Policy Inst. and Washington, DC: Am. Public Transp. Assoc. **http://www.vtpi.org/tran_health.pdf**
52. Litman T. 2012. *Pricing For Traffic Safety: How Efficient Transport Pricing Can Reduce Roadway Crash Risk*. Transp. Res. Board Annu. Meet. Pap. 12–5310. Victoria, BC: Victoria Transp. Policy Inst. **http://www.vtpi.org/price_safe.pdf**
53. Litman T, Fitzroy S. 2012. *Safe Travels: Evaluating Mobility Management Traffic Safety Benefits*. Victoria, BC: Victoria Transp. Policy Inst. **http://www.vtpi.org/safetrav.pdf**
54. Liu HF. 2007. *Vehicle CO2 Emissions and the Compactness of Residential Development*. Spec. Stud., Dec. 12th. Washington, DC: Natl. Assoc. Home Build. http://**www.nahb.org/fileUpload_details.aspx?contentTypeID=3&contentID=86266&subContentID=125229**
55. Mackett RL, Brown B. 2011. *Transport, Physical Activity and Health: Present Knowledge and the Way Ahead*. London: Cent. Transp. Stud., Univ. Coll. London. **http://www.ucl.ac.uk/news/pdf/transportactivityhealth.pdf**
56. MacMillen J, Givoni M, Banister D. 2010. Evaluating active travel: decision-making for the sustainable city. *Built Environ.* 36(4):519–36
57. Maibach M, Schreyer C, Sutter D, van Essen HP, Boon BH, et al. 2008. *Handbook on Estimation of External Cost in the Transport Sector: Produced within the study Internalisation Measures and Policies for All external Cost of Transport (IMPACT)*. CE Delft: Eur. Comm. DG TREN. **http://ec.europa.eu/transport/themes/sustainable/doc/2008_costs_handbook.pdf**
58. McFarland WF, Memmott J, Chui M, Richter M, Castano-Pardo A. 1993. *MicroBENCOST User's Manual*. NCHRP Proj. 7–12. College Station: Tex. Transp. Inst., Tex. A&M Univ.
59. Millard-Ball A, Schipper L. 2010. Are we reaching peak travel? Trends in passenger transport in eight industrialized countries. *Transp. Rev.* 31(3):357–78
60. Næss P, Nicolaisen MS, Strand A. 2012. Traffic forecasts ignoring induced demand: a shaky fundament for cost-benefit analyses. *Eur. J. Transp. Infrastruct. Res.* 12(3):291–309
61. Natl. Highw. Traffic Saf. Adm. (NHTSA). 2011. *National Statistics*. Washington, DC: NHTSA. **http://www-fars.nhtsa.dot.gov**
62. N. Z. Transp. Agency (NZTA). 2010. *Economic Evaluation Manual*, Vol. 1. Wellington: NZTA. **http://www.nzta.govt.nz/resources/economic-evaluation-manual/volume-1/index.html**
63. N. Z. Transp. Agency (NZTA). 2010. *Economic Evaluation Manual*, Vol. 2. Wellington: NZTA. **http://www.nzta.govt.nz/resources/economic-evaluation-manual/volume-2/docs/eem2-july-2010.pdf**

64. OECD. 2006. *OECD Factbook 2006*. Paris: OECD. **http://www.oecd.org/finance/oecdfactbook2006includesbroaderrangeofstatisticscountries.htm**
65. Ont. Coll. Family Phys. 2005. *The Health Impacts Of Urban Sprawl. Volume Four: Social and Mental Health. An Information Series*. Toronto: Ont. Coll. Family Phys. **http://www.ocfp.on.ca/docs/committee-documents/urban-sprawl—volume-4—social-and-mental-health.pdf?sfvrsn=5**
66. Pantell S. 2009. *Tipping the Playing Field: How America's Federal Funding Policy Heavily Favors Roads Over Transit*. Austin, TX: Light Rail Now. **http://www.lightrailnow.org/features/f_lrt_2009-05a.htm**
67. Peden M, Scurfield R, Sleet D, Mohan D, Hyder A, et al., eds. 2004. *World Report on Road Traffic Injury Prevention*. Geneva: World Health Organ. (WHO). **http://www.who.int/entity/world-health-day/2004/infomaterials/world_report**
68. Pucher J, Buehler R. 2009. Sustainable transport that works: lessons from Germany. *World Transp. Policy Pract.* 15(1):13–46
69. Pucher J, Buehler R, Seinen M. 2011. Bicycling renaissance in North America? An update and re-assessment of cycling trends and policies. *Transp. Res. A* 45(8):451–75
70. Racioppi F, Dora C, Krech R, von Ehrenstein O. 2002. *A Physically Active Life Through Everyday Transport: With a Special Focus on Children and Older People and Examples and Approaches from Europe*, ed. A Davis. Rome: WHO, Eur. Reg. Off. **http://www.euro.who.int/document/e75662.pdf**
71. Redlener I, Brito A, Johnson D, Grant R. 2006. *The Growing Health Care Access Crisis for American Children: One in Four at Risk*. New York: Children's Health Fund. **http://www.childrenshealthfund.org/sites/default/files/WhitePaper-May2007-FINAL.pdf**
72. Rosqvist LS. 2007. *Vehicular emissions and fuel consumption for street characteristics in residential areas*. Traffic Plan., Dep. Technol. Soc., Lund Univ., Lund, Swed. **http://www.lth.se/fileadmin/tft/dok/KFBkonf/1R_Smidfelt.PDF**
73. Sciara G-C, Handy S, Boarnet M. 2011. *Draft: Policy brief on the impacts of pedestrian strategies based on a review of the empirical literature*. Calif. Air Resour. Board, Sacramento. **http://www.arb.ca.gov/cc/sb375/policies/ped/ped_brief.pdf**
74. Smart Growth Am. 2011. *Complete Streets Local Policy Workbook*. Washington, DC: Smart Growth Am. **http://www.smartgrowthamerica.org/complete-streets**
75. Smart Growth Netw. 2011. *This Is Smart Growth*. Washington, DC: Smart Growth Netw., US Environ. Prot. Agency. **http://www.epa.gov/smartgrowth/tisg.htm**
76. Steuteville R. 2009. New urban community promotes social networks and walking. *New Urban News*: **http://www.newurbannews.com/14.6/sep09newurban.html**
77. Subramanian R. 2012. *Motor Vehicle Traffic Crashes as a Leading Cause of Death in the United States, 2008 and 2009*. DOT HS 811 620. Washington, DC: Natl. Highw. Traffic Saf. Inst. (NHTSA). **http://www-nrd.nhtsa.dot.gov/Pubs/811620.pdf**
78. Tex. A&M Transp. Inst. 2010. *Urban Mobility Study*. College Station: Tex. Transp. Inst. **http://mobility.tamu.edu/ums/**
79. US Dep. Health Hum. Serv. 2008. *2008 Physical Activity Guidelines for Americans.* Washington, DC: USDHHS. **http://health.gov/paguidelines/pdf/paguide.pdf**
80. US Dep. Health Hum. Serv., Phys. Act. Guidel. Advis. Comm. 2008. *Physical Activity Guidelines Advisory Committee Report, 2008*. Atlanta: USDHHS. **http://www.health.gov/paguidelines/report/pdf/CommitteeReport.pdf**
81. US Dep. Transp. Fed. Highw. Adm. (FHA). 2010. *Transportation Planner's Safety Desk Reference*. FHWA-HEP-10-001. Washington, DC: USDOT, FHWA. **http://tsp.trb.org/assets/FR1_SafetyDeskReference_FINAL.pdf**
82. Victoria Transp. Policy Inst. (VTPI). 2011. *Online TDM Encyclopedia*. Victoria, BC: VTPI. **http://www.vtpi.org/tdm**
83. Wener RE, Evans GW. 2007. A morning stroll: levels of physical activity in car and mass transit commuting. *Environ. Behav.* 39(1):62–74
84. Woodcock J, Franco OH, Orsini N, Roberts I. 2010. Non-vigorous physical activity and all-cause mortality: systematic review and meta-analysis of cohort studies. *Int. J. Epidemiol.* 40:121–38
85. World Health Organ. (WHO). 1999. *Charter on Transport, Environment and Health*. Geneva: WHO. **http://www.euro.who.int/__data/assets/pdf_file/0006/88575/E69044.pdf**