www.vtpi.org

Info@vtpi.org

250-508-5150

If Health Matters

Integrating Public Health Objectives in Transportation Planning

11 March 2025

Todd Litman
Victoria Transport Policy Institute

Abstract

This report investigates various ways that transportation planning decisions affect public health, and how planning practices can better incorporate public health objectives. Conventional planning tends to consider some public health impacts, particularly traffic accident risks and pollution emissions measured per vehicle-kilometer, but generally ignores the additional accidents and pollution emissions caused by increased vehicle mileage, and health problems resulting from less active transport (reduced walking and cycling activity). Traditional planning methods tend to undervalue the health benefits of strategies that increase transport system diversity and reduce vehicle travel. This study identifies various "win-win" strategies that help improve public health and achieve other planning objectives.

Summaries of this report were published in:

"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.

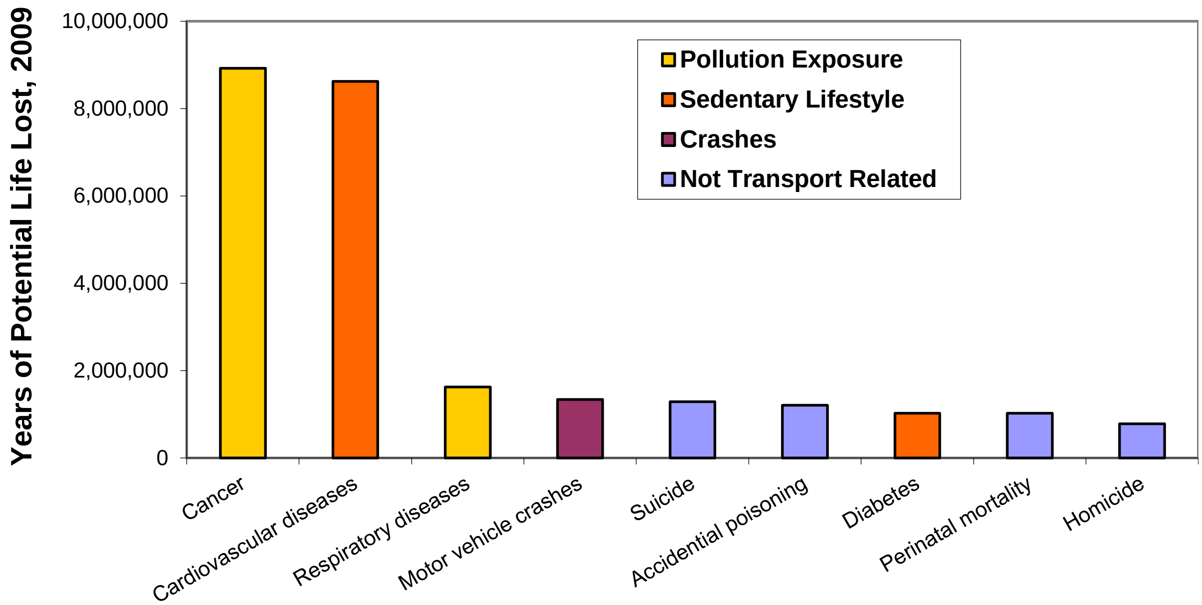
"Creating Safe and Healthy Communities," *Environments: A Journal of Interdisciplinary Studies; Special Issue: Planning for Health Through the Built Environment*, (www.fes.uwaterloo.ca/research/environments/index.html), Vol. 35, No. 3, 2008, pp. 21-43.

Contents

Introduction
Most people want healthy lifestyles. There is much that people can do individually to protect their health including exercising regularly, eating healthy food, avoiding tobacco and air pollution, driving safely and wearing seatbelts. However, many health risks are also influenced by community factors, including transportation and land use planning decisions. This report examines how transport policies and planning practices can help create healthier communities.

Transport affects health in various ways. Transport policies and planning decisions affect rates of cancer, cardiovascular disease and traffic crashes, (three of the leading causes of reduced longevity, as illustrated in Figure 1) and can also affect people's ability to access health-related goods and services such as food and healthcare.

Figure 1 **Leading Causes of Reduced Longevity, U.S.** (Subramanian 2012)



Transport planning decisions affect major health risks including cancer, cardiovascular disease, traffic accidents and diabetes by influencing pollution exposure, physical activity and crashes. Of course, other factors also affect these risks including other pollution sources and individual behaviors.

New research is revealing how specific policy and planning decisions affect health outcomes (APHA 2010; TRB 2019). Some of these relationships are indirect and complex, and so may be overlooked or undervalued in conventional planning. More comprehensive analysis can better incorporate public health objectives into transport planning (Ederer, et al. 2023).

This report investigates these issues. It describes how transport planning decisions affect public health, discusses new perspectives and strategies for evaluating public health impacts, and identifies "win-win" solutions that can help improve public health in addition to other planning objectives such as traffic and parking congestion reduction.

Transportation Health Impacts

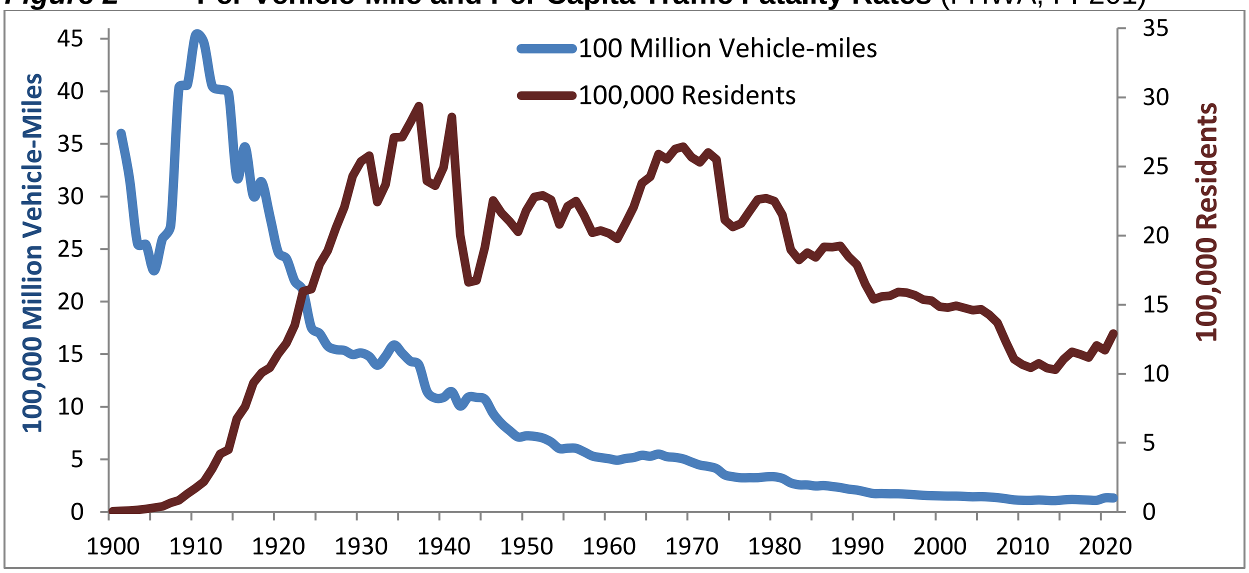
Major categories of transport-related public health impacts are discussed below.

Traffic Crashes

Traffic accidents are a major cause of injuries and deaths (together called *casualties*). 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 most crashes result from specific high-risk groups and behaviors such as inexperienced and impaired drivers, so safety programs should target these risks (FHWA 2010). Drivers tend to take pride in their skill and responsibility, and most consider themselves "safer than average," called *superiority bias* (McCormick, Walkey and Green 1986). From this perspective it would be inefficient and unfair to increase safety by reducing overall vehicle travel since this "punishes" all motorists for problems caused by an irresponsible minority. An alternative paradigm recognizes that all vehicle travel imposes risk; even drivers who observe all traffic laws contribute to accidents outside their control, such as a vehicle or roadway failure, and by being a potential target of another driver's errors.

Conventional traffic safety analysis often measures crash rates per unit of travel (i.e., injuries or fatalities per million vehicle-miles or billion passenger-kilometers). Evaluated this way, U.S. crash rates declined more than two thirds between 1960 and 2000, indicating that traffic safety programs are successful. However, per capita vehicle travel more than doubled during this period which largely offset declining per-kilometer crash rates. If measured per capita (e.g., per 100,000 population), as with other health risks, there was relatively little improvement despite large investments in safer roads, improved vehicle occupant crash protection, reductions in drunk driving, as well as improved emergency response and trauma care during this period, and death rates increased after 2012, as illustrated in Figure 2.

Figure 2 **Per Vehicle-Mile and Per Capita Traffic Fatality Rates** (FHWA, FI-201)



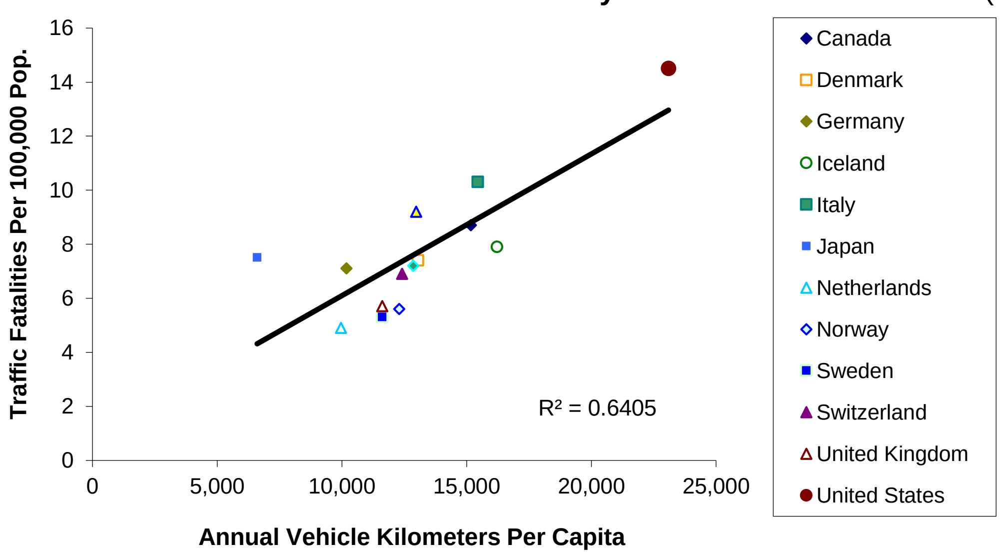
Traffic fatality rated declined during most of the Twentieth Century, but increased after 2012.

Taking these factors into account, much greater casualty reductions should have been achieved. For example, the increase in seat belt use, from about 0% in 1960 up to 75% in 2002, by itself should reduce fatalities by about 33% (wearing a seatbelt reduces crash fatality rates about 45%), yet, per capita traffic deaths only declined about 25% during that period. Some research indicates that if motorists feel safer, for example because their vehicles have airbags, they tend to drive more *intensively* (take more risks, such as driving faster) which reduces net safety gains (Chirinko and Harper 1993).

The conventional safety paradigm emphasizes that most crashes are associated with special risk factors, so general increases in vehicle travel need not increase crashes, and general (not targeted at high-risk driving) vehicle travel reduction strategies (called *mobility management* or *transportation demand management*) do little to increase safety. However, extensive research based on various analysis methods and data sets indicates that per capita traffic casualties do increase with per capita vehicle travel and general vehicle travel reductions do significantly reduce crashes (Duduta, Adriazola-Steil and Hidalgo 2013; Litman 2022; Sivak and Schoettle 2010). Although crash rates vary depending on driver, vehicle and conditions, broad changes in mileage tend to include a mix of higher- and lower-risk vehicle kilometers, and since most injury crashes involve multiple vehicles, broad vehicle travel reductions tend to provide additional safety by reducing traffic density and therefore the frequency of interactions among vehicles (Litman and Fitzroy 2011; Vickrey 1968).

The relationship between mileage and traffic fatalities varies between regions. Less developed countries tend to have high per-mile crash casualty rates, which decline with increased motorization due to improved roads and vehicles, better driver training and traffic law enforcement, plus improved emergency response and medical treatment (WHO 2004). However, among peer countries, per capita crash rates tend to increase with per capita vehicle travel, as illustrated below.

Figure 3 **Vehicle Travel and Traffic Fatality Rates in OECD Countries** (OECD 2006)



Among developed countries, per capita traffic fatalities increase with per capita vehicle travel.

Table 1 **Fatalities per Billion Miles Traveled, 2016** (BTS 2016; IIHS 2016; Litman 2019)

	User	Others	Totals
Passenger Vehicle	3,045	23,957	7.9
Large truck	113	662	5.9
Motorcyclist	22	5,337	243
Transit (All modes)	57	49	0.86
Rail	18	7	0.39
Bicyclist	8.9	835	93.8
Pedestrian	24.7	5,987	242

This table compares various travel mode's traffic fatality rates. Crash rates are lowest for public transit and rail, higher for automobile travel, and highest for walking, cycling and motorcycles.

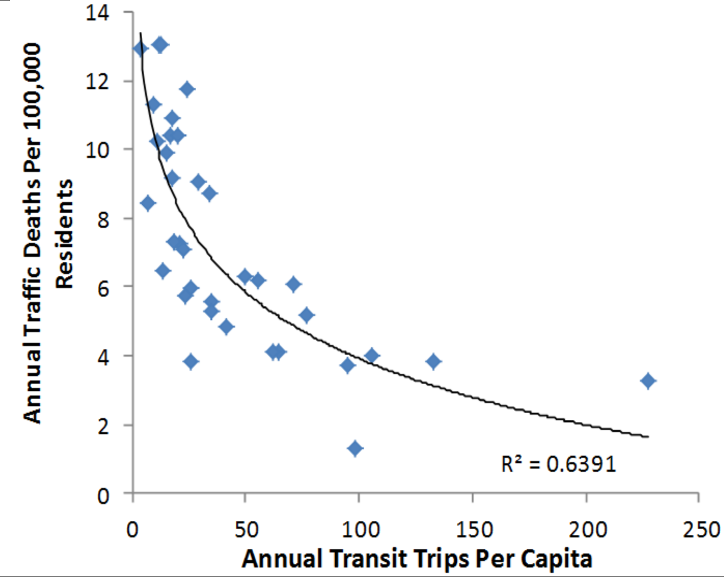
Traffic risk also varies by mode, as indicated in Table 1. Traffic casualty rates per passenger-mile or -kilometer tend to be lowest for public transit and rail travel, higher for automobile travel, and higher still for bicycling, walking and motorcycle travel. This implies that shifts from motorized to *active modes* (walking and cycling, also called *non-motorized transport*) increases crash risk. However, the actual incremental risk is smaller than these statistics suggest for the following reasons:

1. Active travel imposes minimal risk to other road users, reducing total crash risk.
2. Drivers tend to be more cautious and communities tend to invest in active transport improvements as walking and cycling increases in an area.
3. Walking and bicycling trips tend to be shorter than motorized trips and a local walking trip often substitutes for a longer automobile trip, so total per capita mileage declines. As active travel mode share increases in a community, total per capita vehicle travel, and therefore total crash risk exposure, tend to decline.
4. Some walking and cycling promotion programs include education and facility improvements that reduce per-kilometer bicycle crash rates.
5. High active mode crash and casualty rates 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 active travel is likely to experience less additional risk than average values suggest.
6. Walking and cycling provide health benefits, including pollution emission reductions and improved public fitness that may offset increased accident risks.

As active travel (walking and bicycling) increases in an area, both per capita and distance-based traffic casualty rates tend to decline (ABW 2010; Marshall and Garrick 2011), an effect called *safety in numbers* (Jacobsen 2003). Economically developed countries with high rates of active travel, such as Germany and the Netherlands, have pedestrian fatality rates per billion kilometers walked a tenth as high, and bicyclist fatality rates only a quarter as high, as in the United States (Fietsberaad 2008).

Traffic fatality rates also decline with increased transit travel, as illustrated below.

Figure 4 **U.S. Traffic Fatalities Versus Transit Trips** (FTA 2012; NHTSA 2012)

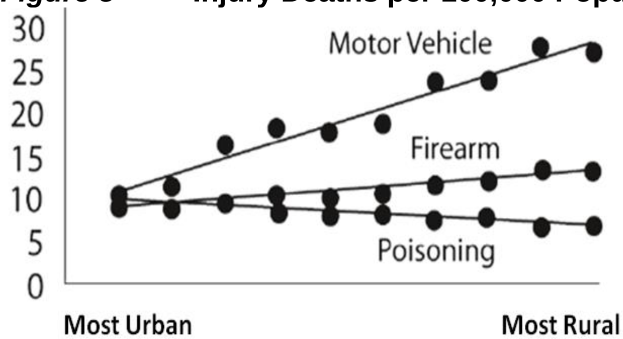


This graph illustrates the relationship between per capita transit ridership and total (including pedestrian, cyclist, automobile occupant and transit passenger) traffic fatalities for 35 large North American cities.

As transit travel increases, traffic fatalities tend to decline significantly. Cities with more than 50 annual transit trips per capita have about half the average traffic fatality rate as regions with less than 20 annual trips per capita, indicating that relatively modest increases in transit travel are associated with large traffic safety gains.

Overall, urban residents tend to be safer than suburban or rural residents taking into account both traffic fatality and homicide risks (Lucy 2002). Myers, et al. (2013) compared injury death rates for all U.S. counties rated on a ten-point urban-rural scale between 1999 and 2006. A total of 1,295,919 injury deaths in 3,141 counties were analyzed. The overall injury death rate was 56.2 per 100,000 residents, of which 27% were motor vehicle accidents, the largest risk category. Urban counties had the lowest death rates; after normalizing for factors such as income, education, race and region of the country injury death risk was 1.22 times higher in the most rural counties compared with the most urban, primarily due approximately three times higher traffic accident fatality rates, as illustrated in Figure 19.

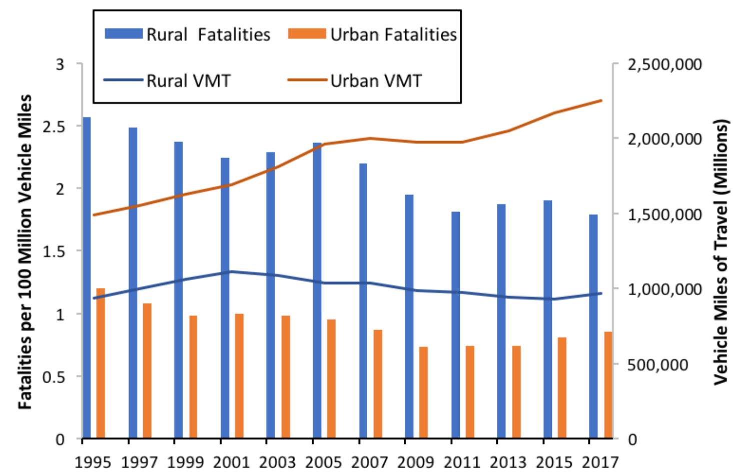
Figure 5 **Injury Deaths per 100,000 Population** (Myers, et al. 2013)



Total injury deaths increase as counties become more rural, primarily due to the much higher traffic fatality rates, the largest cause of injury deaths. The most rural counties have approximately three times the traffic crash death rate as the most urban counties.

Rural fatalities per vehicle miles travelled consistently outnumbered those of Urban fatalities over a 22 year period in the US as indicated in Figure 6. More compact and urban environments achieve an increase in traffic safety in terms of the number of deaths per unit distance travelled.

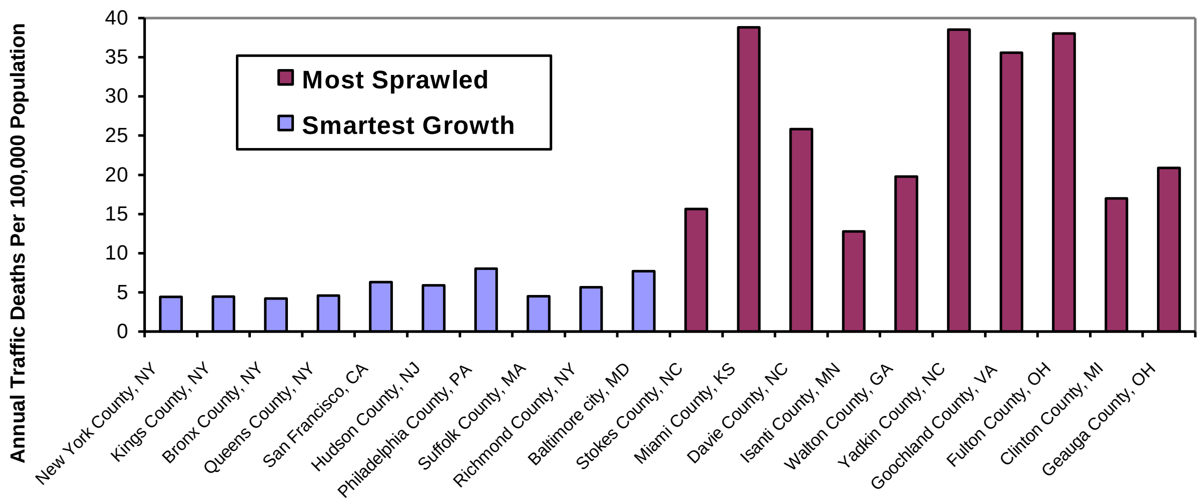
Figure 6 **Fatalities and VMT by Land Use Type (BTS 2017)**



Rural fatalities per vehicle miles travelled consistently outnumbered those of Urban fatalities over a 22 year period in the US as indicated in Figure 6. More compact and urban environments achieve an increase in traffic safety in terms of the number of deaths per unit distance travelled.

Compact, *smart growth* development tends to increase traffic density which increases crashes per vehicle-kilometer, but these are mostly minor collisions. Lower density, sprawled development tends to increase per capita vehicle travel and traffic speeds which increase traffic casualty rates. Smart growth communities have about a fifth the traffic fatality rate as sprawled, automobile dependent communities as illustrated in Figure 7.

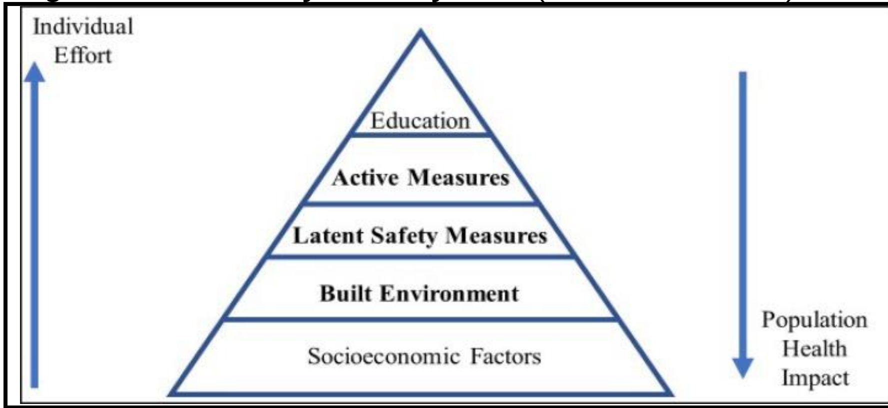
Figure 7 **Annual Traffic Death Rate** (Ewing, Schieber and Zegeer 2003)



Traffic fatality rates tend to increase with land use sprawl.

The article, "The Safe Systems Pyramid: A New Framework for Traffic Safety," (Ederer, et al. 2023), argues that conventional traffic safety programs use a narrow scope of analysis which ignores exposure (per capita vehicle travel) as a risk factor and vehicle travel reductions as a safety strategy. They recommend, for example, that a Safe Systems approach requires transportation agencies to in joint efforts with development and transit agencies to implement policies and projects that reduce the travel, such as more transit-oriented-developments.

Figure 8 **Safe Systems Pyramid** (Ederer, et al. 2023)



"The Safe Systems Pyramid," recognizes that socioeconomic and built environmental factors, and new "latent safety measures," tend to provide more traffic safety and population health benefits than conventional traffic safety and traveller education programs.

Conventional planning tends to focus on certain traffic safety impacts and strategies, but overlooks others, as summarized in Table 2. It favors targeted safety programs and improved crash protection but tends to ignore the additional crashes that can result from policies which stimulate more or faster vehicle travel and the safety benefits of mobility management strategies that reduce overall vehicle travel (Litman 2016).

Table 2 **Traffic Safety Strategies and Impacts Summary**

Conventional strategies	Restrictions or additional requirements for higher-risk drivers, such as youths and seniors (e.g. graduated licenses and cognitive drivers' tests). Targeted programs to reduce high-risk travel, such as impaired driving. Crash protection (seat-belts, air bags, energy-absorbing roadway barriers).
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. 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 tends to increase crash severity. Automobile-dependent, sprawled land use development tends to increase per capita traffic casualty rates. Increasing perceived vehicle and road safety encourages more intensive driving which partly offsets crash-reduction benefits.

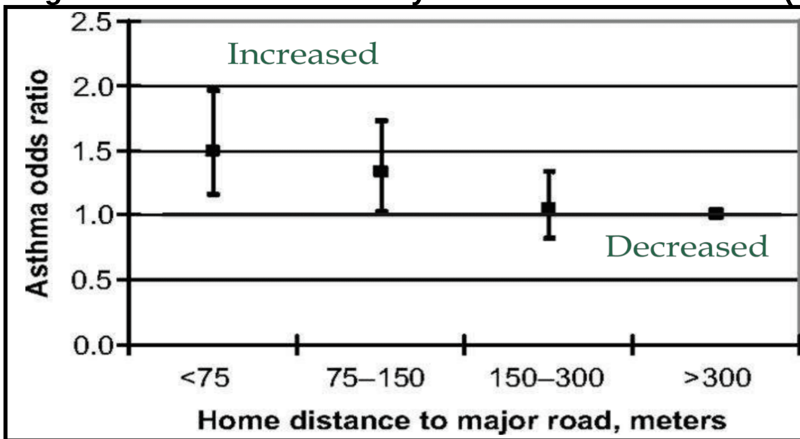
This table indicates conventional and additional traffic safety strategies and impacts that are often overlooked in conventional planning.

Vehicle Pollution Exposure

The second category of transport-related health impacts involve vehicle pollution emissions (called *mobile sources*). Motor vehicles produce various pollutants which can cause various health problems, plus ecological damages such as climate change (HEI 2010; Litman 2010; Gwilliam and Kojima 2004). Although control technologies have reduced emissions per vehicle-kilometer, mobile source pollution remains a major health risk, in part because reduced emission rates are partly offset by increased vehicle travel. Some pollutants, such as carbon monoxide and particulates, have localized impacts so their health risks are affected by the proximity of emissions and human lungs.

Proximity to major roadways tends to increase the incidence and severity of pollutant-related health problems, including lung and cardiovascular diseases (EPA 2014), two of the leading causes of reduced longevity in the US. Figure 8 shows the relationship between road proximity and asthma incidence in children. In North American cities, 30-45% of residents live within the 500-meter zone of greatest exposure to roadway traffic pollutants (HEI 2010).

Figure 9 **Road Proximity and Asthma Occurrence (Gilliland 2009)**



Asthma rates tend to increase residents proximity to major roads.

Potential transport emission exposure reduction strategies are summarized below.

Table 3 **Potential Vehicle Emission Exposure Reduction Strategies**

Reduce Emission Rates	Reduce Vehicle Travel	Reduce Proximity
New vehicles emission controls Improve emission violation identification and enforcement Smooth traffic flow (congestion reduction, replace stop signs with traffic circles) Encourage use of less polluting fuels (electric or natural gas)	Improve lower-polluting modes (walking, cycling and public transit). Encourage use of less-pollution vehicles through pricing reforms and incentives. Smart growth land use policies (more compact, mixed development).	Create walkways and bike lanes away from busy roadways. Discourage location of homes, schools and hospitals downwind of busy roadways. Setback buildings away from roadways. Locate building HVAC air intakes away from roadways.

There are many possible ways to reduce pollution exposure.

Some planning decisions can have mixed emission exposure impacts. For example, more compact land use development tends to reduce per capita vehicle travel and emissions but increases proximity between vehicles and human lungs. Similarly, shifts from motorized to non-motorized modes reduce emissions, but because pedestrians and cyclists inhale deeply they may have additional health risks when traveling along busy roadways.

Motor vehicle air pollution probably causes a similar number of premature deaths as traffic crashes. For example, a World Health Organization study concluded that "Initial estimates show that tens of thousands of deaths per year are attributable to transport-related air pollution in the Region, similar to the death toll from traffic accidents" (WHO 2005). Leigh and Geraghty (2008) estimate that sustained 20% increases in U.S. gasoline prices would reduce 1,994 traffic accident deaths and 600 air pollution deaths. Pollution-related deaths tend to involve older people and so are likely to cause smaller reductions in potential years of life lost ("Health and Safety," Litman 2010). Some studies indicate much larger total air pollution deaths (Pope, et al. 2009), but these generally include emissions from all sources; motor vehicles are estimated to contribute 5-55% of urban air pollution (HEI 2009).

Conventional planning tends to focus on certain emission reduction strategies and impacts, but overlooks others, as summarized in Table 4.

Table 4 **Vehicle Pollution Exposure Reduction Strategies and Impacts Summary**

Conventional strategies	Vehicle emission control technologies. Cleaner and alternative fuels. Reduce traffic congestion.
Additional strategies	Mobility management strategies that reduce total vehicle travel. Restrict development of housing, schools, hospitals and parks near major roads. Locate walking and cycling facilities away from busy roads. Design buildings with HVAC intakes away from busy roads.
Often-overlooked impacts	Policies that make driving more convenient and affordable stimulate sprawled development patterns that 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 emission rates.

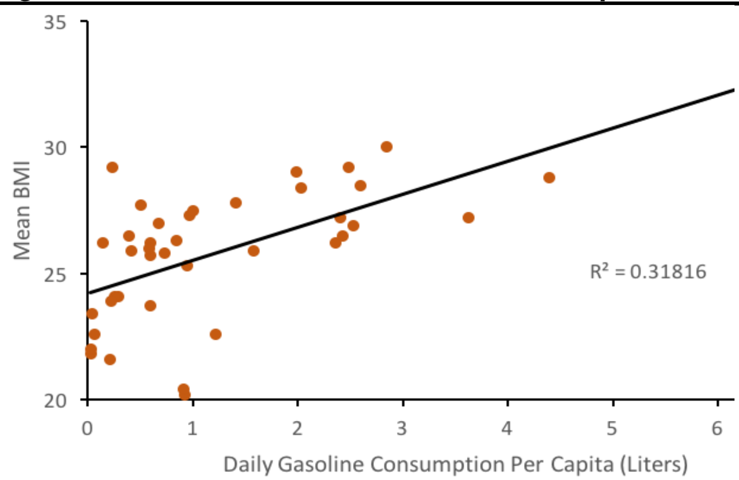
This table indicates conventional and additional emission reduction strategies and impacts that are often overlooked in conventional planning.

Physical Activity and Fitness

The third category of health impacts concerns the effects that transport planning decisions have on physical activity and fitness. Public health officials are increasingly concerned about declining physical fitness, excessive body weight and resulting health problems (Giles-Corti, et al. 2022; WHO 2024). They recommend that adults average at least 150 weekly minutes of moderate-intensity physical activity, and children average about three times that amount (CDC 2018). Increased automobile travel is associated with obesity and related health problems (Roberts 2011). To increase fitness and health a community can (CPSTF 2017):

- Improve walking and cycling conditions
- Improve public transit services
- Develop more connected roadway networks
- Develop more compact and mixed development
- Improve access to parks and recreational facilities
- Provide programs that promote active transport

Figure 10 **BMI versus Gasoline Consumption, 2016** (WHO 2016; GPP 2016)



This graph of 40 countries shows a positive relationship between vehicle fuel consumption and body mass index (BMI).

The *Aerobics Center Longitudinal Study*, which periodically evaluates 80,000 adults' health, concluded that sedentary living contributes to about 16% of all deaths, more than smoking, high cholesterol, hypertension and diabetes (Blair 2009). This suggests that a physically active (walks 30+ daily minutes), obese smoker is likely to live longer than a sedentary, thin non-smoker. 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 (Woodcock, et al. 2010).

There are many ways to be physically active, but most, such as gym exercise and organized sports, require special time, skill and expense, which discourages consistent lifetime participation. Many experts believe that high levels of automobile transport contribute to sedentary living. Creating more walkable and bikeable communities is one of the most practical and effective ways to increase public fitness and health. A study of 4,297 adults in Texan metropolitan areas which controlled for various demographic and health factors found that commute distance was negatively associated with physical activity and cardio-respiratory fitness, and positively associated with BMI, waist circumference, systolic and diastolic blood pressure, and continuous metabolic score (Hoehner, et al. 2012).

It's Better To Be Chubby And Fit Than Skinny And Stagnant
Jill Barker, *Vancouver Sun*, 27 December 2010 (https://bit.ly/30VACzx)

The struggle to lose weight is a see-saw between success and failure. The constant yo-yoing of weight loss and gain is not only frustrating, it makes you question whether all that hard work is worth it. Before you pack up your workout gear for good, however, rest assured that exercise is worth the time and effort - even if those extra pounds stubbornly refuse to disappear.

Exercise has a lot more to offer than just a means to lose weight. Its most important role is the impact it has on health – especially among those who carry extra pounds. Most people already know that exercise improves cardiovascular health and reduces the risks of some forms of cancer. What's less well known is that exercise also reduces the health risks associated with carrying extra weight. Studies suggest that chubby exercisers are healthier than skinny couch potatoes.

The first to speculate that it's possible to be fit and fat was Steven Blair, who in 1999 reported on a study of 22,000 men who were tested using treadmills and body-composition assessments. During the eight years of follow-up the results were surprising. Lean men who scored poorly on the treadmill test were twice as likely to have died compared with overweight but fit men. Similar results were found among women. Moderately fit women of all weights had a 48% lower risk of dying prematurely from all causes when compared with unfit women -- even the skinny ones. Blair concluded that it's possible to be fit and fat.

This is not to ignore the risks of excess body weight. High blood pressure, heart disease, diabetes, gallbladder disease, osteoarthritis, sleep apnea, and certain cancers are all more prevalent in the overweight population. But for those who struggle to reach their goal weight, it's worth noting that exercise can ameliorate many risks associated with obesity. Bones get stronger, blood pressure goes down, and psychological well-being improves. 150 weekly minutes of exercise isn't going to result in substantial weight loss. It will, however, result in substantial health benefits.

Increased walking and bicycling can provide significant health benefits, including reduced obesity and related illnesses such as high blood pressure and diabetes (ABW 2010; Cavill, et al. 2008). A major study of 429,334 UK residents found that, accounting for other demographic factors, incremental increases in neighborhood walkability are associated with significantly reduced blood pressure and hypertension risk, indicating large public health benefits (Sarkar, Webster and Gallacher 2018). Controlling for other factors Frank, et al. (2006) found that a 5% increase in a walkability index is associated with a 32% increase in active transport, a 0.23 point reduction in body mass index, a 6.5% VMT reduction, and reduced per capita air emissions. Chan, et al. (2025), found that higher *perceived* rather than objectively measured walkability is associated with reduced cardiovascular disease. Meta-analysis by de Hartog, et al. (2010) indicates that people who shift from car to bicycling live longer overall, indicating that health benefits offset any increase in traffic accident risk. Using data for 11,041 high-school students in 154 U.S. communities, Slater, et al. (2013) found that the odds of students being overweight or obese decreased with increased walkability index scores. There appears to be significant latent demand for active transport; many people want to walk or bicycle more than they do and will use these modes more if conditions are improved (ABW 2010; Litman 2008).

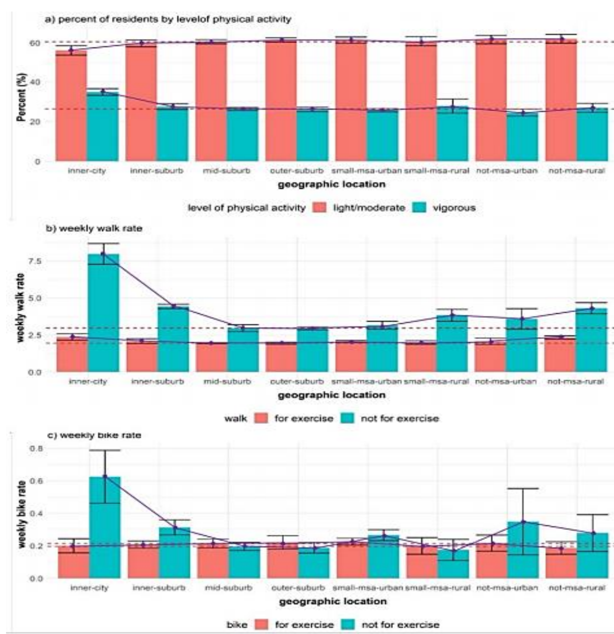
Most public transit trips include walking links, so physical activity tends to increase with transit travel (Besser and Dannenberg 2005; Litman 2011). Lachapelle (2010) found that transit users more frequently walk to destinations near the home and workplaces independent of neighborhood walkability, car availability, and enjoyment of moderate physical activity. Lachapelle, et al. (2011) found that transit commuters average 5 to 10 more minutes of moderate-intensity physical activity, and walked more to services and destinations than nonusers. Similarly, Melbourne, Australia residents who use public transit average 41 daily minutes of walking or cycling for transport, five times more than the 8 minutes averaged by residents who travel only by automobile (BusVic 2010).

Land use patterns also affect physical and mental health by affecting how people travel, including the amount that people walk and bicycle, and are therefore physically active, and total vehicle travel and therefore crash risk, pollution emissions and costs burdens. One study found that, accounting for demographic factors such as age, race/ethnicity, education and income, the frequency of self-reported chronic medical conditions such as asthma, diabetes, hypertension and cancer increased with sprawl (Creatore, et al. 2016). Shifting from very sprawled regions such as San Bernardino, California to less sprawled regions such as Boston, Massachusetts reduces approximately 200 chronic medical conditions per 1,000 residents, a 16% reduction. This effect appears to be particularly strong for older and lower-income people. In a study of in 14 cities, Sallis, et al. (2016) found that controlling for other demographic factors, net residential density, intersection density, public transport density and number of parks were significantly, positively related to physical activity. Residents of the most activity-friendly areas spend 68 to 89 more weekly minutes than the least activity-friendly areas, which represents about of the 150 minutes per week health targets. These statistics indicate that transportation and land use planning decisions significantly affect public fitness and health.

Using U.S. national travel survey data and accounting for demographic factors, Dong (2020) found higher rates of utilitarian walking and bicycling in central neighborhoods and suburbs, and in rural areas, than in outer suburbs. Inner-city residents walk and bicycle about three times more, and rural residents about 50% more, than in outer suburbs.

Conventional planning tends to consider physical fitness a special activity that requires special time and equipment, such as exercising at a gym or participating in organized sports. More comprehensive analysis recognizes that for many people the most practical way to increase physical activity is to walk and bicycle for recreation and transport, which requires supportive planning practices.

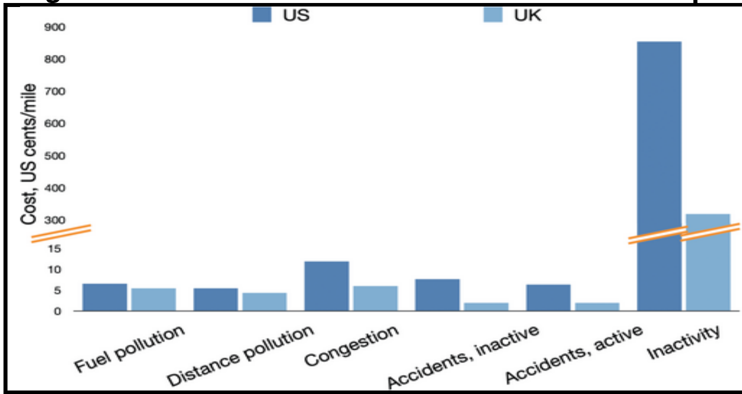
Figure 11 **Active Transport Rates by Geographic Location** (Dong 2020)



Utilitarian walking and bicycling are higher in central neighborhoods and rural areas than in outer suburbs, reducing the portion of residents

London School of Economics researchers estimate that physical inactivity is one of the largest costs of automobile travel, and public fitness and health is the largest benefit of improving and increasing active travel, as illustrated below.

Figure 12 **Social Costs of Car Travel in 2022 prices** (van den Bijgaart, et al. 2023)



The health costs of physical inactivity are by far the largest social costs from car use, and the health benefits of physical exercise tend to be the largest benefit of improving and increasing active travel.

The study, "Where Matters Health & Economic Impacts of Where We Live," found health benefits from improving local walkability and park access as, summarized below.

Table 5 **Health Impacts of Walkability and Park Access** (Frank, et al. 2019)

	Walkable Compared with Auto-Dependent	Many Parks Compared with No Parks
Physical Activity	45% more likely to walk for transportation and 17% more likely to meet physical activity targets.	20% more likely to walk for leisure or recreation and 33% more likely to meet the physical activity targets.
Obesity	42% less likely to be obese.	43% less likely to be obese.
Diabetes	39% less likely to have diabetes.	37% less likely to have diabetes.
Heart Disease	14% less likely to have heart disease.	39% less likely to have heart disease.
Stress	23% less likely, to have stressful days.	19% less likely to have stressful days.
Sense of Community	47% more likely to have a strong sense of community and belonging.	23% more likely to have a strong sense of community and belonging.

This study found significant positive relationships between walkability, park accessibility and health.

Table 6 **Physical Activity Strategies and Impacts Summary**

Conventional strategies	Gym exercise. 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, and public transit service. 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.

Conventional planning tends to overlook physical activity strategies and impacts.

Heat Stress

Global warming and urbanization are increasing the number of people living in communities that experience extreme heat (UCCRN 2018). Heat stress is particularly severe in cities due to the *heat island effect*, which increases ambient temperatures 1-7°F due to more dark surfaces (pavement and roofing), reduced greenspace (such as tree cover), and heat-generating activities (fuel and electricity consumption).

These conditions make outdoor physical activity, including walking and bicycling, and public transit access, uncomfortable, unattractive and unhealthy (Gössling, et al. 2023; WHO 2018). Since most public transit trips include walking links, this discourages public transit travel. This reduces physical activity and causes travellers to drive for trips that could be made by non-auto modes, increasing traffic risks and greenhouse gas emissions.

There are many ways to reduce urban heat exposure including designing buildings for natural and mechanical cooling, providing shade, and increasing greenspace and tree cover (Ladd and Meerow 2022). Pedestrians can be protected with *shadeways* (sidewalks and paths with at least 80% shade coverage during peak sun periods) and *pedways* (enclosed climate-controlled walkways). The *Cool Walkshed Index* (CWI) summarized below, can be used to evaluate hot-weather pedestrian accessibility for a building or neighborhood, identify where shadeways and pedways are justified, and set targets for improvements.

Cool Walkshed Index (CWI) Ratings (Litman 2023)

A: Connected to a continuous, enclosed, climate controlled pedway that provides access to commonly-used services (shops, restaurants, social and cultural activities), and high quality public transit stations.

B: Located within 1,000 feet (300 meters) of a pedway entrance where ambient temperatures frequently exceed 100° Fahrenheit (38°Celsius); and within 300 feet (100 meters) of a pedway entrance where temperatures frequently exceed 110° Fahrenheit (43° Celsius).

C: Connected to a continuous shadeway (walkway with at least 80% shade coverage during mid-day) that provides access to commonly-used services and high quality public transit, with shaded transit waiting areas.

D: Connected to a continuous but unshaded walkway that provides access to commonly-used services and high quality public transit.

E: Connected to an incomplete walkway that provides inadequate access to local services and public transit.

F: Has major barriers to walking to local services and public transit.

The Cool Walkshed Index (CWI) indicates the quality of walkability that serves a destination or area, taking into account thermal comfort. These values may be adjusted to reflect specific conditions and needs.

Shadeways and pedways must be properly designed and managed. They should reflect universal design principles to accommodate all types of users including people with disabilities, families with children, travellers with hand carts and wheeled luggage. They should have sufficient capacity to avoid crowding, and be well maintained for comfort, safety, security, and attractiveness.

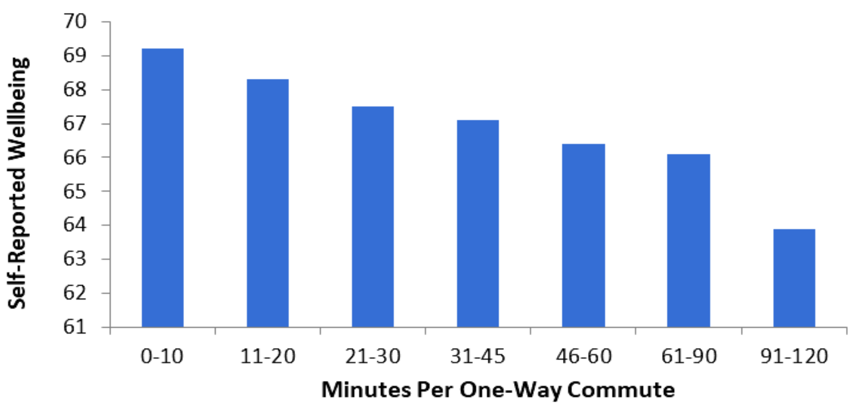
Mental Health and Wellbeing

Transportation planning also affects mental health and well-being by affecting travel activity and local environmental conditions (Crabtree 2010; Palencia et al. 2018). More compact, multimodal community design tends to increase physical activity and *community cohesion* (the quantity of interactions among neighbors, Litman 2025), reduce air and noise pollution, and increase affordability, which tend to reduce stress, depression and anxiety (Tremblay et al. 2010). Increased neighborhood walkability is associated with reduced depression (Berke, et al. 2007), and frequency of dementia (Larson, et al. 2006). Erickson, et al. (2010) found significantly higher rates of grey matter volume and cognitive ability in those who previously walked more than 72 blocks a week. Poor quality public transit is uncomfortable and stressful, while transit service improvements can reduce stress compared with driving (Wener and Evans 2007). An Australian study found that greener, more walkable neighborhoods had 1.6 times higher odds of reporting better mental health (Sugiyama, et al. 2008).

Gallup Healthways Index data indicates that, controlling for age, education, and income levels, more compact, multi-modal cities have higher rates of exercise and significantly lower levels of depression than more sprawled and automobile-dependent cities (Gallup 2016; Litman 2019). It also found that self-reported well-being declines with commute duration, as illustrated in Figure 10. Comparing the longest commute time of 91 – 120 minutes to the shortest commute time of 0-10 minutes resulted in the following differences (Gallup 2016):

- 12% increase of individuals who experienced worried the previous day.
- 8% decrease of individuals who experienced enjoyment in the previous day.
- 10% decrease in individuals who felt well rested the previous day.

Figure 13 **Wellbeing versus Commute Duration** (Crabtree 2010; Litman 2017)



People with shorter commutes tend to report higher well-being rating. This suggests that more compact development can increase happiness.

This suggests that the following transportation planning practices should be recognized as ways to improve mental health and wellbeing:

- Improving walking, bicycling and public transit service quality.
- Create neighborhoods where residents can interact in positive ways.
- Develop compact, multimodal communities with more affordable transport options and shorter and more comfortable commute options.

Affordability

Poor health is associated with poverty (Khullar and Chokshi 2018). Low incomes often impose emotional stress and prevent families from purchasing essential goods and service including healthy food, shelter, healthcare and medicines. Reducing the costs of these goods is equivalent to an increase in income, reflecting the principle that "a penny saved is a penny earned."

Affordability refers to people's ability to purchase essential goods and services, and therefore the prices of these goods relative to incomes (CNT 2018; Litman 2015). Since housing and transportation are most households' two largest expenditure categories, reducing these costs leaves households with more money to spend on other goods. When households cannot afford food, healthcare or medicines, the root problem is often excessive housing and transport costs. These costs often impose emotional stress. Vehicle failures, crashes or traffic law violations can impose large, unexpected costs that lead to a financial or legal crisis. Improving affordable housing and transport options can increase both physical and mental health.

Affordability is often defined as households spending no more than 30% of their budget on housing, but since households often make trade-offs between housing and transportation costs, many experts now recommend defining it as households spending no more than 45% of their budget on housing and transport combined, which recognizes that a cheap house is not truly affordable if located in an isolated area with high transport costs, and household can rationally spend more than 30% of their budget for housing in an accessible location where transportation costs can be minimized (CNT 2018). Unaffordability (households spending more than considered affordable on housing and transport) tends to increase with automobile dependency and sprawl, because they increase the need to drive and reduce affordable alternatives (ULI 2009).

Planning decisions often affect affordability. For example, many zoning codes discourage development of lower-cost housing options, such as townhouses, apartments and secondary suites, and impose excessive parking requirements and fees that drive up housing costs in multimodal neighborhoods. Similarly, since automobiles are costly to own and operate, automobile-dependent transportation planning and sprawled development patterns reduce transport affordability. Allowing more affordable housing in walkable urban neighborhoods tends to significantly increase affordability and improve residents' health (TPH 2013).

Table 7 **Affordability Strategies and Impacts Summary**

Conventional strategies	Minimize vehicle fuel prices, registration and parking fees. Subsidize public transit.
Additional strategies	Pedestrian and cycling improvements. Distance-based vehicle insurance premiums, registration fees and taxes. Smart growth policies to create more accessible, multi-modal communities. Affordable housing in accessible locations.
Often-overlooked impacts	Automobile-oriented transportation planning and sprawled development patterns significantly increase transport costs.

This table indicates conventional and additional physical activity strategies and impacts that are often overlooked in conventional planning.

Access to Health-Related Goods and Services

Transport planning decisions can affect disadvantaged people's ability to access health-related goods and services, such as healthcare, healthy food and recreation. *Basic mobility* and *basic access* are general terms for people's ability to reach essential goods and services.

Inadequate or expensive transportation can result in patients missing appointments, which can exacerbate medical problems and wastes medical resources, or forces patients or medical services providers to pay for more costly transport services, such as taxis (APTA 2003). Approximately 10% of U.S. women have difficulty travelling to healthcare services, and those women are 78% more likely to delay necessary medical care (PYMNTS 2024). About a quarter of missed medical appointments are caused by transportation problems (Silver, Blustein, and Weitzman 2012). Car owners were able to make 82% of booked appointments, compared with just 58% who lacked a car (Yang et al. 2006). One survey found that 4% of 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 (Redlener, et al. 2006). Similarly, inadequate travel options can prevent some households from accessing healthy food, exercise and sports activities, or other services and activities that contribute to health. Ray (2020) recommends a *Health in All Policies* framework to identify diverse public policies and programs, such as targeted transportation planning, and coordination between government agencies to improve access to healthcare and other health-related goods and services.

More compact, multi-modal planning can help increase health by improving economic mobility: the chance that a child born in a lower-income household becomes more economically successful as an adult (Bouchard 2015). Ewing, et al. (2016) found that doubling their compact community index increases the probability that a child born to a family in the bottom income quintile will reach the top quintile by age 30 by about 41%.

Conventional planning tends to support basic mobility by minimizing automobile costs, subsidizing public transit services, and applying universal design standards that accommodate people with disabilities. More comprehensive analysis also recognizes the role that active transport plays in providing basic access, the impacts of land use patterns on overall accessibility, and the tendency of automobile-oriented planning and sprawl to reduce accessibility for non-drivers and increase total transportation costs.

Table 8 **Basic Access Strategies and Impacts Summary**

Conventional strategies	Keep automobile travel available and affordable. Provide general public transit and special mobility services. Universal design (transport facilities and services that accommodate all potential users, including people with disabilities and other impairments).
Additional strategies	Pedestrian and cycling improvements. Carshare and taxi service improvements. Smart growth policies to create more accessible, multi-modal communities.
Often-overlooked impacts	Policies that favor automobile travel and sprawl tend to reduce accessibility for non-drivers and increase total transportation costs.

This table indicates conventional and additional physical activity strategies and impacts that are often overlooked in conventional planning.

Cumulative Effects

Several studies have examined how various transportation and land use policies affect overall health outcomes. International comparisons indicate that, despite high per capita healthcare expenditures, the United States has higher mortality rates and lower longevity than peer countries, with particularly high death rates from cardiovascular diseases and accidents (Sawyer and McDermott 2019; Woolhandler, et al. 2021). A major study by Weiss, et al. (2023) found diabetes rates declined with increased walking and public transportation usage and reduced air pollution. Although many factors may contribute to these outcomes, they probably reflect, in part, the high rates of automobile travel and low rates of active transport in the U.S.

A major study by the University of Utah's *Metropolitan Research Center* developed a sprawl index that considers four factors: *density* (people and jobs per square mile), *mix* (mix of homes, jobs and services), *centricity* (the strength of activity centers and downtowns) and *roadway connectivity* (the density of connections in the roadway network); a higher rating indicates more compact, *Smart Growth* development (Ewing and Hamidi 2014). The analysis indicates that:

- Smart Growth reduces the amount of time that residents spend driving and increases walking. For every 10% increase in index score, drive time declines 0.5% and walk mode share increases by 3.9%.
- Smart Growth community residents tend to live longer. For every doubling in an index score, life expectancy increases about 4%. For the average American with a life expectancy of 78 years, this translates into a three-year difference in life expectancy between people in a less compact versus a more compact county. This probably reflects significantly lower rates of traffic fatalities, obesity, high blood pressure and diabetes in Smart Growth communities, which are somewhat offset by slightly higher air pollution exposure and murder risk.
- Counties with less sprawl have more but less severe vehicle crashes. For every 10% increase in an index score, fatal crashes decrease by almost 15%. People in smarter growth communities also have significantly lower blood pressure and rates of diabetes.

Frederick, Riggs and Gilderbloom (2017), analyzed the relationships between commute mode diversity (CMD, the portion of commuters who do not drive an automobile, which ranges from 11% to 36%) as an indicator of a multimodal community, and twelve indicators of measure public health and quality of life outcomes for various mid-size U.S. cities and counties. The results indicate that, after adjusting for various demographic factors, there is a strong statistical relationship between more modal diversity and positive public health outcomes
These positive health outcomes include:

- Healthier behaviors reported in the Gallup/Healthway's Well-Being Index.
- More leisure quality reported by Sperling's Cities Ranked and Rated.
- More access to exercise reported by the Environmental Systems Research Institute.
- Less sedentary living and obesity reported in the Center for Disease Control's Diabetes Interactive Atlas.
- Lower *Years of Potential Life Lost* (an indicator of longevity and overall health).
- Higher birth weights (an indicator of infant health) reported by the National Center for Health Statistics.

These relationships are stronger than many other sociological, geographical, and economic indicators including density, latitude, race, education and income, suggesting that living in a more multimodal community provides significant health benefits. These findings underscore the positive impact of sustainable transportation policies on community health and open up a new direction for public health research and the built environment.

This research indicates that automobile-oriented planning and sprawled development patterns cause greater health risks, and more multimodal planning and Smart Growth development policies provide greater health benefits than are generally recognized, due in part to the following factors.

Induced Vehicle Travel

Induced travel refers to the additional vehicle travel that occurs when a roadway improvement increases traffic speeds or reduces vehicle operating costs. Conventional planning tends to overlook or underestimate the additional vehicle travel that results from urban roadway expansions, which exaggerates roadway expansion benefits and undervalues more multimodal planning.

Leverage Effects

Walking, bicycling and public transit improvements often leverage additional vehicle travel reductions, so an additional mile travelled by these modes reduces 3 to 12 motor vehicle miles (Litman 2010b). For example, Guo and Gandavarapu (2010) found that sidewalk improvements in a typical town reduces 12 motor vehicle miles for each additional mile of walking and bicycling. Similarly, each passenger-mile travelled by high quality public transit typically reduces 3-6 automobile miles of travel (ICF 2010). These result from the following factors:

- *Vehicle Ownership*. Motor vehicles are costly to own but relatively cheap to use, so once a household purchases an automobile they tend to use it, including discretionary travel that could easily be avoided. Households tend to own one vehicle per driver if located in an automobile-dependent community which results in more driving. Households own fewer vehicles in a multi-modal community and so drive significantly less.
- *Land Use Patterns*. Walking, bicycling and public transit improvements support more compact and mixed development by reducing the amount of land required for roads and parking facilities and encouraging local trips.
- *Social Norms.* In automobile-dependent communities, use of alternative modes tends to be stigmatized. Improving alternative modes can help make their use more socially acceptable.

Not every project has all these effects, and a portion of these impacts may reflect self-selection, that is, the types of people who choose to live in particular areas. However, under the right conditions, walking, cycling and public transit improvements implemented with supportive policies can cause large reductions in per capita automobile travel, including leverage effects. Conventional planning generally ignores these indirect impacts and so underestimates the full impacts and benefits of walking, bicycling and public transit improvements. Considering these indirect impacts can increase estimated benefits by an order of magnitude.

Health Improvement Strategies

This section evaluates various transport strategies for improving public health. For more information see APHA (2011), CDC (2010), Ederer, et al. (2023); and Shah and Wong (2020).

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 sometimes by reducing total vehicle travel (NCCHPP 2012). A study of British Columbia highway crashes found that each 10% increase in speed limits resulting in a 43% increase in insurance claims and a 118% increase in traffic fatalities in affected areas (Brubacher, et al. 2018).

Air emission impacts vary depending on traffic control type and conditions. Reductions from high to moderate speeds tend to reduce per-kilometer vehicle emission rates, but very low speeds or more stop-and-go driving tends to increase emission rates. Speed humps tend to increase local emissions while replacing traffic signals with traffic circles tends to reduce local emissions. Speed reductions tend to improve walking and cycling conditions which can reduce per-capita emissions, increase physical activity, and improve basic access.

Active Transport (Walking and Cycling) Improvements

Many walking and bicycling facility improvements (such as better sidewalks, crosswalks and paths), reduce these modes' crash risk, and as previously described, by increasing active transport they tend to reduce total crash rates due to the *safety in numbers* effect (Chriqui, Thrun and Sanghera 2018; Fitch-Polse and Agarwal 2025). In a typical situation, doubling active travel increases pedestrian and cycling injuries by 32%, while injuries to other road users decline, reducing total traffic casualties (Jacobsen 2003). Shifts from driving to active modes can provide proportionately large air pollution emission reductions since these modes tend to reduce shorter urban vehicle trips that have high per-kilometer emission rates due to cold starts and congestion, so each 1% shift tends to reduce emissions by 2-4%. Integrated walking and cycling improvement programs can leverage additional vehicle travel reductions, providing additional benefits. Such improvements tend to increase physical activity and basic access.

Public Transit Service Improvements

Public transit service improvements, such as more service, nicer vehicles and stations, grade separation, and improved user information, which attract discretionary users tend to reduce total crash rates and pollution emissions, and improve basic access (Heaps, Abramsohn and Skillen 2022; Jiao and Bischak 2018). Bus priority lanes and signal controls can reduce bus emission rates. Increased use of older diesel buses may increase local pollution. Transit improvements integrated with supportive land use policies can create transit-oriented development which leverages additional vehicle travel reductions, providing additional benefits. Since most transit trips include walking and cycling links, and transit-oriented development improves active transport conditions, transit improvements tend to increase physical fitness. Transit improvements also tend to improve basic access.

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 only pay for parking spaces they want) and *cash out* (travelers can choose cash instead of parking subsidies offered motorists).
- Reduced fuel subsidies and increased fuel taxes.
- Distance-based vehicle insurance and registration fees (motorists pay in proportion to their annual vehicle travel).

These can significantly reduce vehicle travel. For example, charging motorists directly for parking typically reduces affected vehicle trips by 20%, and distance-based insurance and registration fees can reduce affected vehicle travel by 10-12%.

Pricing reforms can provide significant health benefits (Hosford, et al 2021; Litman 2012). Grabowski and Morrisey (2006) 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 and Geraghty (2008) estimate that a sustained 20% gasoline price increase would reduce approximately 2,000 traffic crash deaths (about 5% of the total), plus about 600 air pollution deaths. Studies by Chi, et al. (2010a and 2010b) show that fuel price increases reduce per-mile crash rate, so a 1% vehicle travel reduction reduces crashes more than 1%. For example, in the state of Mississippi, controlling for other risk factors, they find that each 1% inflation-adjusted gasoline price increase reduces total (all types of drivers) crashes per million vehicle-miles 0.25% in the short-run and 0.47% in the medium-run (one to five years) (Chi, et al. 2010a). Efficient road and parking pricing should have similar impacts, and distance-based insurance can provide even larger crash reductions since higher-risk motorists pay more per vehicle-kilometer and so have the greatest incentive to reduce their mileage and crash risk (Ferreira and Minike 2010; Litman 2012).

Pricing reforms encourage use of active modes and therefore physical fitness, and reduce pollution emissions. Higher road, parking and fuel prices may reduce basic access for lower-income motorists, but if they contribute to alternative mode improvements (for example, if congestion pricing reduces bus delays, or fuel tax revenues are used to finance public transit improvements) they may increase basic access, particularly for non-drivers.

Mobility Management Marketing

Mobility management marketing includes various programs, incentives and information that encourage people to change their travel behavior. This includes commute trip reduction programs, through which employers encourage their employees to use alternative modes, transportation management associations through which businesses support and encourage use of alternative modes, ridematching and vanpool support programs, and direct marketing programs which encourage travelers to try alternative modes. Such programs tend to support transport options such as flextime, telework and delivery services, and implement strategies such as parking cash out and vanpool organizing. Voluntary programs typically reduce participant's vehicle travel 5% to 8%. Much larger reductions are possible with programs that include financial incentives, such as parking cash out (Spears, Boarnet and Handy 2011). Such programs probably provide similar reductions in traffic accidents and pollution emissions, and increased physical activity, although impacts may vary depending on circumstances and the degree they are integrated with other mobility management strategies such as improvements to alternative modes and transport pricing reforms.

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, particular for physically, economically and socially disadvantaged people. 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. Smart growth residents typically drive 20-40% less than they would if located in automobile-dependent sprawl (Ewing and Cervero 2012; Giles-Corti, et al. 2013; Litman 2008).

Ewing, et al. (2014) found that Smart Growth is associated with reduced obesity and associated health problems, and Ewing and Hamidi (2014) found that it increases longevity; doubling their Sprawl Index increased life expectancy approximately 4%, which translates into an average three-year difference in life expectancy between people in less compact versus more compact counties. Hamidi, et al. (2018) used cross-sectional to evaluate the associations between sprawl and life expectancy for U.S. metropolitan areas. Controlling for demographic factors this study found significantly higher live expectancy in compact than in sprawling counties. Compactness affects mortality both directly, and indirectly. Sprawling areas tend to have more driving per capita and higher traffic speeds which increase crash risk, slower emergency response, and less access to health care and healthy foods. Compactness affects mortality indirectly through by reducing physical activity which is a contributor to many chronic diseases. These findings support further research and practice aimed at identifying and implementing changes to urban planning designed to support health and healthy behaviors.

Creatore, et al. (2016) also found that Smart Growth community residents tend to live longer: for every doubling in a smart growth index score, life expectancy increases about 4%. For the average American this translates into a three-year difference in life expectancy between Smart Growth versus sprawl community residents. This probably reflects the combined effects of increased physical activity and significantly lower rates of traffic fatalities, obesity, high blood pressure and diabetes, although these may be offset by slightly higher air pollution exposure. The *Bicycling and Walking in the U.S.: 2014 Benchmarking Report* found a strong (R2=0.43) positive relationship between active transport (walking and cycling) commute mode share and the portion of the population that achieves national physical fitness targets of 150 weekly minutes of moderate physical activity (ABW 2014). It also found strong negative relationships between active transportation commute mode share and rates of traffic accidents, obesity, high blood pressure and diabetes.

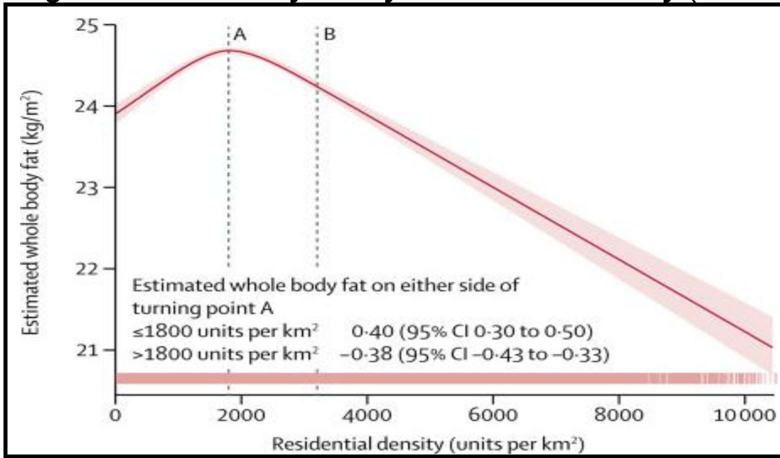
A detailed review of neighborhood attributes affecting cardiovascular disease (CVD) found that walkability, residential density, safety from traffic, recreation facilities, street connectivity, fast food restaurants and grocery stores affect physical activity, blood pressure, body mass index and diabetes which indirectly affect CVD, and high density traffic, road proximity and fast food restaurants were directly associated with CVDs outcomes (Malambo, et al. 2016).

Smart Growth tends to significantly increase active transport, because it includes walking and bicycling improvements, and because more destinations are within walking and cycling distances. This tends to improve public fitness and health. In a study that examined how land use factors affect travel activity in Vancouver, BC, Frank, et al. (2010 and 2022) found that:

- Increased neighborhood walkability and park supply reduces diabetes.
- Adults living in the top 25% most walkable neighborhoods walk, bike and take transit 2-3 times more, and drive approximately 58% less than those in more auto-oriented (less walkable) areas.
- Residents living in the most walkable areas, with good street connectivity and land use mix, were half as likely to be overweight than those in the least walkable neighborhoods.
- Living in a neighbourhood with at least one grocery store was associated with a nearly 1.5 times likelihood of getting sufficient physical activity, as compared to living in an area with no grocery store, and each additional grocery store within a 1-kilometer distance from an individual's residence was associated with an 11% reduction in the likelihood of being overweight.
- The most walkable neighborhoods have the least ozone but the most from nitric oxide pollution. Neighborhoods with relatively high walkability and low pollution levels exist across the region.

A major British study found the lowest obesity rates in the densest urban areas followed by rural areas, and the highest rates in suburban areas (Sarkar, Webster and Gallacher 2017). Increased densities provided particularly large benefits for younger, female, employed and physically active individuals. They conclude that public policies that discourage suburban densification, for example, by prohibiting the subdivision of single lot housing, may prevent suburbs from becoming healthier places to live.

Figure 14 **Body Fat by Residential Density** (Sarkar, Webster and Gallacher 2017)



Residents of denser urban areas have the lowest average body fat rates, with somewhat lower rates in rural areas. The highest rates are in suburbs with 2,000 residential units per square kilometer.

Lens (2021) argues that increasing allowable densities in walkable urban neighborhoods helps achieve health and equity goals by allowing more moderate-income households to live in safer and healthier communities.

Public Health Impacts Summary

Table 8 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., seatbelt, helmet, and airbag regulations and encouragement), more efficient and alternative fuel (e.g., hybrid and electric) vehicles, and exercise and sport fitness programs, provide limited benefits. Multimodal planning strategies, which improve travel options and encourage vehicle travel reductions, tend to provide multiple public health benefits and support other planning objectives, and so are considered win-win solutions. More comprehensive planning is needed for win-win solutions to be implemented as much as justified, as discussed in the next chapter.

Table 9 Public Health Impact Summary

Strategies	Safety	Pollution	Fitness	Affordability	Basic Access	Other
	Conventional Safety and Health Strategies					
Targeted safety programs	Large benefits	No impact	No impact	No impact	No impact	
Crash protection	Large benefits	No impact	No impact	Increases costs	No impact	
Efficient and alt. fuel vehicles	No benefit	Large benefits	No impact	No or negative impact	No impact	Energy conservation
Exercise and sport promotion	No benefit	No impact	Large benefits	Small benefit	No impact	User enjoyment
	Multimodal Planning Strategies					
Traffic calming and speed control	Large benefits	Mixed. May increase local emissions.	Large benefit	Small benefit	Large benefit	
Active transport improvements	Large benefits	Large benefits	Large benefits	Large benefit	Large benefits	Reduced traffic problems
Cool walkability planning	Moderate benefits	Large benefits	Large benefits	Large benefit	Large benefits	Reduced traffic problems
Public transit improvements	Large benefits	Large benefits	Large benefits	Large benefit	Large benefits	Reduced traffic problems
Transport pricing reforms	Large benefits	Large benefits	Large benefits	Mixed. Depends on use of revenues	Mixed. Can improve travel options.	Reduced traffic problems
Mobility management marketing	Moderate benefits	Moderate benefits	Moderate benefits	Small benefit	Small benefits	Reduced traffic problems
Smart growth development policies	Large benefits	Reduces emissions but can increase proximity	Large benefits	Large benefit	Large benefits	Open space preservation, more efficient public services

This table summarizes how various policy and planning practices affect various health objectives.

Transport Planning Reforms for Healthier Communities

This section discusses transport planning reforms to support public health.

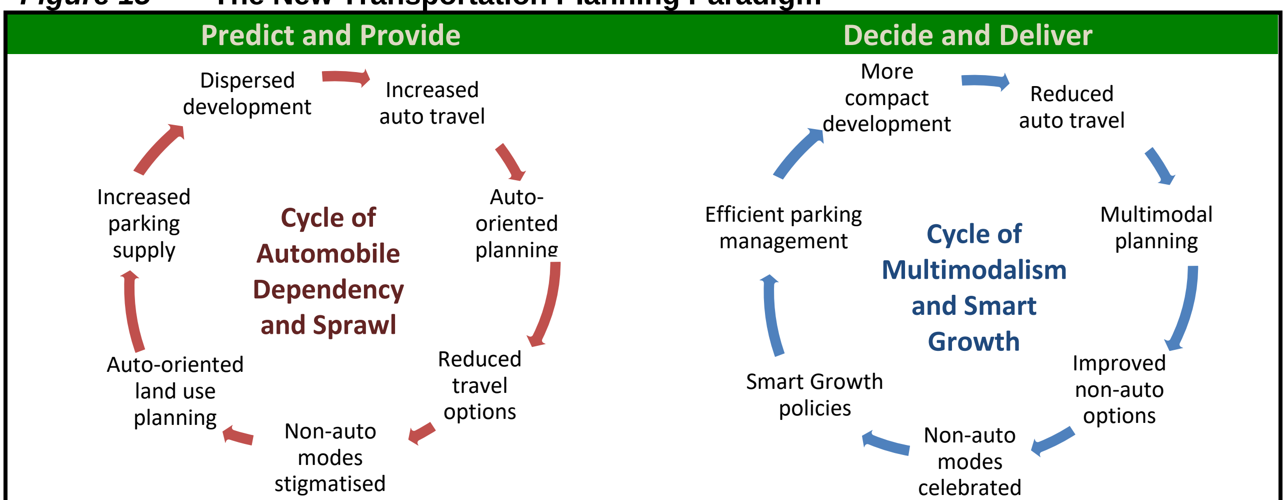
Planning Biases

Conventional planning tends to be biased in various ways that encourage automobile travel and sprawl (Blais 2010; Brown, Morris and Taylor 2009; Litman 2021):

- Transport system performance is evaluated based primarily on 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 mobility management strategies, 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 on development density and mix, and fees and taxes that fail to reflect the higher costs of providing public services to more dispersed locations.

These practices reflect “predict and provide” planning, in which roads and parking facilities were expanded in anticipation of future demands, as illustrated below. This created a self-reinforcing cycle of automobile dependency and sprawl, resulting in communities where most trips (often over 90%) are made by automobile, active travel is difficult and uncommon, non-drivers are significantly disadvantaged, and transportation is expensive. This exacerbates health problems including crash risk, pollution, sedentary living, inaccessibility and unaffordability (MacMillen, Givoni and Banister 2010; Tranter 2010). “Decide and deliver” planning can create more multimodal communities which are safer, healthier, and more resource-efficient.

Figure 15 **The New Transportation Planning Paradigm**



“Predict and provide” transportation planning expanded roads and parking facilities in anticipation of future demands, creating a self-reinforcing cycle of automobile dependency and sprawl. “Decide and deliver” planning sets multimodal travel targets and implements policies to achieve them.

Shift from Mobility- to Accessibility-Based Planning
A shift is occurring from *mobility*- to *accessibility-based* planning that has important implications for creating more efficient, equitable and healthier communities.

Mobility refers to physical travel. Mobility-based planning assumes that society's goal is to maximize the distances people can travel within their time and financial budget. It assumes that faster travel is better than slower travel, and so favors automobile travel over walking, cycling and public transit. It assumes that "transportation problem" refers to motorists' delays and costs, and "transportation improvement" refers to polices that increase vehicle travel speeds or reduces costs. These assumptions are incorporated in conventional planning which evaluates transport system performance based primarily on roadway *level-of-service* (LOS), an indicator of vehicle traffic speeds and delay, and in transport finance practices which dedicate a major portion of transport funding to roads and parking facilities.

But mobility is not generally an end in itself. The ultimate goal of most travel activity (except the small portion of travel that has no destination) is *accessibility* (or access), which refers to people's ability to reach desired goods, services and activities (together called *opportunities*). For example, the ultimate goal of commuting is to access employment and education activities, the ultimate goal of driving to a store is to access shopping opportunities, and the ultimate goal of a holiday trip is to access recreation activities.

Mobility is an important factor in overall accessibility – in general, the faster and cheaper people can travel – but other factors are also important, including roadway connectivity, land use patterns, modal options, and mobility substitutes such as telecommunications and delivery services that reduce vehicle trips. For example, increasing roadway connectivity and land use mix can reduce the distances people must travel to access services and activities, and improving walking, cycling, public transit service, telecommunications and delivery services can improve non-automobile accessibility.

Transport planning decisions often involve trade-offs between different types of accessibility. Expanding roadways to accommodate more and faster vehicle travel, and increasing parking requirements to increase driving convenience, often reduces pedestrian access, and since most transit trips involve walking links they also reduce transit access. Land use decisions that favors automobile access, such as locating services at major highway intersections, tends to reduce access by other modes. Money spent on roads and parking facilities is unavailable for other modes. Road space devoted to on-street parking is unavailable for sidewalks, bike and bus lanes.

Accessibility-based planning expands the scope of solutions that can be applied to transport problems. For example, with conventional, mobility-based planning, virtually the only solution to traffic or parking congestion is to expand facilities to accommodate more vehicle travel. Accessibility-based planning allows consideration of other solutions, including improvements to alternative modes, improved roadway connectivity, pricing reforms, and smart growth development policies, all of which can improve accessibility without increasing mobility.

Accessibility-based planning supports healthy community transport. It recognizes the value of slower alternative modes, such as walking, cycling and public transit; the value of mobility management strategies that discourage economically excessive motor vehicle travel; and the value of creating more accessible and multi-modal communities where residents drive less and rely more on alternative modes. Shifting from mobility- to accessibility-based planning is therefore an important contribution toward improving public health.

Impacts of Reforms

How much would travel activity change with more multimodal planning? Probably a lot. Current planning significantly under-invests in non-motorized travel, and fails to give public transit roadway priority when justified for efficiency. Nationwide, about 12% of total trips are made by non-motorized modes, and more in cities, yet in most jurisdictions only 1-3% of total transport funding is devoted to non-motorized facilities (ABW 2010). Only a tiny portion of urban arterials have HOV or bus lanes although they can carry far more peak-period travelers than a general-purpose lane and they support other planning objectives such as basic mobility for non-drivers.

More multi-modal planning can significantly increase walking, cycling and public transit travel, and reductions in automobile travel (Gotschi 2011; Guo and Gandavarapu 2010). For example, walking and cycling more than doubled in nine U.S. cities that invested in active transport programs (Pucher, Buehler and Seinen 2011), and urban regions with high-quality public transit systems tend to have 10-30% less per capita driving, with comparable reductions in per capita traffic deaths and pollution emissions (Liu 2007). International comparisons show even greater effects: wealthy countries with multi-modal planning have much more walking, cycling and public transport travel than in the U.S. (Pucher and Buehler 2009).

Economic theory can also help identify optimal transport patterns. A basic economic principle is that efficiency is maximized if *prices* (what consumers pay for a good) reflect the marginal cost of producing that good, including indirect and external costs. Efficient transport therefore requires that motorists pay directly for using roads and parking facilities, for congestion and accident risk imposed on others, plus any economic or environmental impacts associated with vehicle fuel production. Currently, less than half of U.S. roadway costs and a tiny portion of non-residential parking costs are borne by user fees, and congestion, accident risk and fuel costs are under-priced (Litman 2010; Parry and Small 2004). Efficient pricing would significantly increase road, parking and fuel costs, and vehicle insurance and registration fees would be distance-based; the additional costs would be offset by reductions in building rents and general taxes. Although it is difficult to predict exactly how much such reforms would reduce vehicle travel and associated public health risks, reductions are likely to be large (Litman 2005).

Conventional transport planning evaluation tends to overlook many of these impacts. Cities such as Davis, California and Eugene, Oregon invested in cycling facilities because local officials intuitively recognized that improving cycling conditions and encouraging cycling activity can provide significant community benefits. Similarly, public transit projects and smart growth development policies are often implemented despite, rather than supported by, conventional transport economic evaluation because most benefits they provide, including reduced accidents and pollution emissions, and improved physical fitness and mobility for non-drivers, are overlooked and undervalued in conventional transport planning. These planning biases and market distortions reduce public health.

Incorporating Health Impacts into Economic Evaluation

More comprehensive health impact analysis can help guide transportation planning. *Monetized* (measured in monetary units) estimates of health impacts can be incorporated into transportation project economic evaluation (Grabow, et al. 2011; Gotschi 2011; Fishman, et al, 2011; Wanjau, et al. 2022). For example, the *Active Transport Quantification Tool* (ICLEI 2007) describes how to value the cost savings, heart health, diabetes risk, congestion, pollution, crash risk, and happiness provided by active transport. The New Zealand Transport Agency's *Economic Evaluation Manual* provides the following values for active transport benefits:

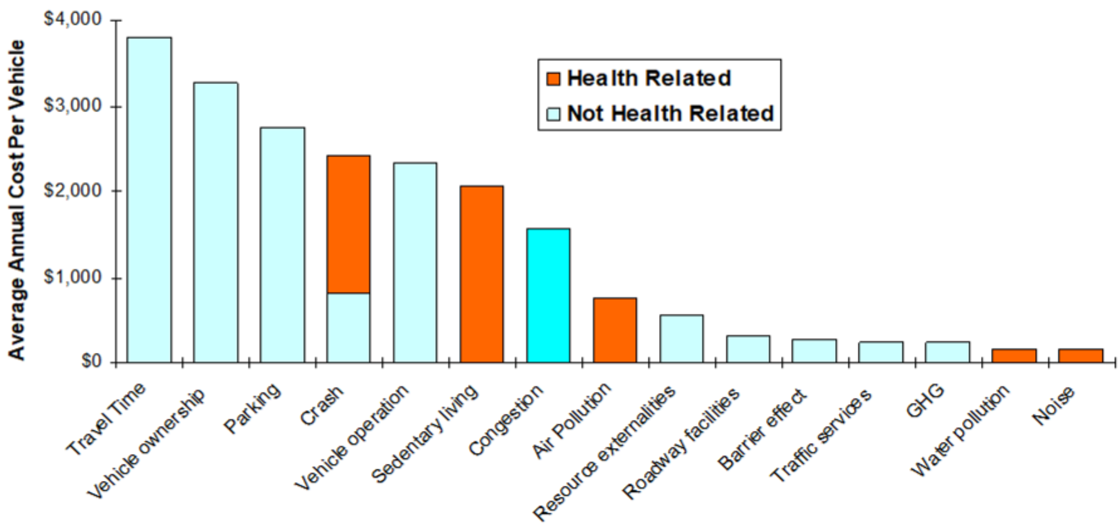
Table 10 **Active Transportation Health Benefits** (NZTA 2010, Vol. 2, p. 8-11)

	2008 $ NZ/km	2008 USD/mile
Cycling	$1.40	$1.60
Walking	$2.70	$3.00

This table indicates New Zealand's estimated value of increased walking and cycling.

Figure 13 compares the estimated magnitude of various transport costs, assuming that automobile-oriented transport planning reduces walking and cycling by one mile per day. As previously mentioned, air pollution damage probably causes a similar number of deaths as traffic accidents but causes smaller reductions in longevity and little property damage.

Figure 16 **Costs of Motor Vehicle Use in the U.S.** (Litman 2010)



This figure illustrates the estimated magnitude of various transportation costs. Health-related impacts are significant but seldom fully recognized in transport project economic evaluation.

This has 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. This indicates, for example, that a congestion reduction strategy that causes even small increases in crashes, sedentary living or pollution exposure is probably not cost effective. However, a congestion reduction strategy becomes much more cost effective if it provides even small reductions in crash or pollution costs, or small increases in physical activity.

Best Planning Practices

Below are healthy community planning practices (Horrox, et al. 2021; PfP 2011; Tam 2017).

Comprehensive Evaluation

Transport policy and planning analysis should consider all significant planning objectives and impacts, including indirect impacts. It should include health impact analysis, which considers how planning decisions affect crash risks, pollution exposure, physical activity and basic access (Ball, et al. 2009). Table 9 lists impacts that should be considered.

Table 11 **Comprehensive Planning Evaluation**

Indirect Travel	Economic	Social	Environmental
• Induced travel • Leverage effects of walking, cycling and public transit improvements • Land use accessibility	• Congestion • Road and parking facility costs • Vehicle costs • Fuel externalities • Accident costs • Hydrologic impacts	• Basic mobility for non-drivers • Transport and housing affordability • Public fitness and health	• Air pollution • Noise • Water pollution • Openspace and habitat • Heat island effects

Comprehensive transport project evaluation should consider all these impacts.

Multi-modal Planning

Transport planning should apply comprehensive multi-modal planning, which recognizes the diverse benefits provided by different travel modes, including safety and health benefits. Multi-modal planning tends to increase investments in walking, bicycling and public transit.

Mobility Management

Mobility management should be implemented whenever cost effective compared with roads and parking facility expansions. Money currently devoted only to roads and parking should be available to alternative modes and demand management programs. As much as possible, motorists should pay directly for road and parking facility costs, and any fuel production costs. This should include the following pricing reforms: efficient parking pricing or cash out, increased fuel prices to recover roadway costs, and distance-based insurance and registration fees.

Smart Growth Development Policies

Land use development policies should encourage the following:

- More compact and mixed development.
- More connected roadways.
- Better transport and land use coordination. For example, create communities where most students can walk and bicycle to school, and most jobs can be accessed without a car.
- Reduced development and utility fees for more accessible locations that have lower costs for providing public services
- Reduced and more flexible parking requirements
- Improved public realm.

Consumer Education

It is important to educate planning practitioners, real estate professionals and consumers regarding how to design and select healthier communities. The *Healthy Location Checklist* identifies features to consider.

Table 12 **Healthy Community Checklist**

Healthy Community Features	
Sidewalks and crosswalks on most streets	
Sidewalks accommodate wheelchairs and other mobility aids	
Moderate to low traffic speeds on local streets	
Streets are safe for cycling	
Well-connected paths and roadways provide multiple routes to destinations	
Most commonly-used services (shops, healthcare, parks) within convenient walking distance (less than a half-mile of homes), with good sidewalks and crosswalks	
Public parks are available nearby	
Streets have trees and other public greenspace	
High quality public transit (at least half-hour frequency) available within convenient walking distance	
Region has high quality public transit and high transit mode share	
Parking is efficiently priced and managed, so residents only pay for parking spaces they want	
Relatively high (at least 20%) non-automobile mode share	
Good air quality	

This checklist identifies specific features that indicate a healthy community

Tools for Transportation Health Impact Analysis

The following tools can help evaluate health impact for transportation and land use planning.

America's Health Rankings (www.americashealthrankings.org) provides state by state data on national indicators of health, environmental and socioeconomic characteristics aimed at establishing national health benchmarks and state rankings.

Building Healthy Places Toolkit (http://uli.org/wp-content/uploads/ULI-Documents/Building-Healthy-Places-Toolkit.pdf) by the Urban Development Institute, identifies opportunities to enhance health through changes in approaches to buildings and projects. It outlines 21 "Gold Star" recommendations for promoting health at the building or project scale. These are organized according to three categories: physical activity, healthy food and drinking water, and healthy environment and social well-being. A list of practical implementation strategies and best practices, grouped according to their available evidence base, supports each recommendation.

Built Environment and Public Health Clearinghouse (www.planning.org/nationalcenters/health/bephc)**.** This is a resource for training and analyzing the intersection of health and place, developed by APA, APHA, Georgia Tech, and the National Network of Public Health Institutes.

California Health Assessment Models (http://urbandesign4health.com/projects/california-statewide-public-health-assessment-model) is a comprehensive activity-based public health model that uses detailed data on land use, demographic, transportation, physical activity and health conditions to evaluate how transportation and land use factors affect health outcomes.

EPA Smart Locations Database (www.epa.gov/smartgrowth/smartlocationdatabase.htm). The SLDB is a nationwide geographic data resource for measuring location efficiency. It summarizes characteristics such as housing density, diversity of land use, neighborhood design, destination accessibility, transit service, employment, demographics plus accessibility indicators.

Healthy Community Design Checklist Toolkit (www.cdc.gov/healthyplaces/toolkit). This Toolkit can help public health and planning professionals consider health in community planning.

Health Economic Assessment Tool (HEAT) for Cycling and Walking (https://bit.ly/1q5KzlZ) calculates the economic value of the health benefits from increased walking and bicycling.

Health Transportation Shortage Index (http://docplayer.net/2072716-The-health-transportation-shortage-index.html) helps identify areas and communities where transportation shortages create barriers to health care access. The HTSI uses a scoring protocol to identify the most important factors associated with transportation barriers to child health care access.

Integrating Health and Transportation in Canada (www.tac-atc.ca/en/publications/ptm-ihtc-e). This guide describes various ways that transportation affects public health and provides recommendations for incorporating health goals into transport policy and planning decisions.

Integrated Transport and Health Impact Modeling Tool (www.cedar.iph.cam.ac.uk/research/modelling/ithim) assesses transport health impacts through changes in physical activity, road traffic injury risk, and urban air pollution.

Metrics for Planning Healthy Communities (https://bit.ly/2tSaCXh) by Ricklin and Shah (2017) provides guidance on ways that developers, property owners and managers, designers, and others involved in real estate planning can help create communities and that enhance health.

National Public Health Assessment Model (http://urbandesign4health.com/projects/hia-plug-in-scenario-planning) is empowers communities to evaluate relative health impacts of contrasting land use and transportation scenarios. It leverages nationally available built environment data from the EPA Smart Location Database and the Robert Wood Johnson Foundation National Environment Database. It can empower communities to choose investments that have the greatest potential to improve public health and quality of life, reduce health care costs, and address environmental justice related disparities.

National Environmental Database (http://urbandesign4health.com/projects/ned) establishes a nationally consistent, standardized, and centrally located set of individual and composite metrics that characterize the built, natural and social environment. It contains over 200 variables which have been demonstrated to best predict health outcomes. It provides planners, public health officials, and researchers with a single source of high quality, high resolution, environmental variables with uniform, nationwide coverage. It is updated periodically to include a broad set of environmental variables known to predict health outcomes and is designed to help researchers and practitioners assess how neighborhood context affects public health.

PAPREN (*Physical Activity Policy Research and Evaluation Network*, www.papren.org) supports collaborative research and evaluation to identify and implement local, state and national level policy approaches that influence opportunities for physical activity.

Sleep, Leisure, Occupation, Transportation, and Home-based activities (SLOTH) model (www.ncbi.nlm.nih.gov/pubmed/15450624). This model provides guidance regarding interventions that increase physical activity in various domains.

Street Smart (www.thinkstreetsmart.org) clearinghouse provides comprehensive information for integrating climate change, public health, and equity concerns into transportation planning.

Transportation and Health Toolkit (www.apha.org/advocacy/priorities/issues/transportation/Toolkit.htm). Provides information on links between health, equity, and transportation, and ways consider them in policy decisions.

Healthy Mobility Options Tool (https://skylab.cdph.ca.gov/HealthyMobilityOptionTool-ITHIM) The Healthy Mobility Options Tool is a new health impact analysis model that quantifies how potential transportation policy and system changes ("scenarios") affect physical activity, crash casualty risk and air pollution emissions. It calculates changes in deaths, years of life shortening and disability, and costs from changes in air pollution, physical activity, and traffic injuries associated with changes in active transportation (i.e., walking and cycling). It recognizes the "safety in numbers effect," which gives extra weight to policies that increase active travel mode share in a community. It also recommends policies that can help achieve health objectives.

Transportation Health Tool (www.transportation.gov/transportation-health-tool). This online tool developed by the USDOT and USEPA allows users to understand how specific communities or states compare in terms of key transportation and health indicators. For each indicator, the THT results show the raw value as well as a score from 0 to 100 that indicates what percentile the state, metropolitan area, or urbanized area is in. When viewing results, click on the name of each indicator for more information on what the indicator measures and data sources. It also provides information on strategies for addressing health problems.

Indicators:

- Alcohol-Impaired Fatalities (state and metro area level)
- Commute Mode Shares (state and metro area level)
- Complete Streets Policies (state and metro area level)
- Housing and Transportation Affordability (metro area level only
- Land Use Mix (metro area level only)
- Person Miles Traveled by Mode (state level only)
- Physical Activity from Transportation (state level only)
- Proximity to Major Roadways (state and metro area level)
- Public Transportation Trips per Capita (state and urbanized area level)
- Road Traffic Fatalities by Mode (state and metro area level)
- Road Traffic Fatalities Exposure Rate (state and metro area level)
- Seat Belt Use (state level only)
- Use of Federal Funds for Bicycle and Pedestrian Efforts (state level only)
- Vehicle Miles Traveled (VMT) per Capita (state and urbanized area level)

Walk Score (www.walkscore.com). This tool assigns a numerical walkability score to any address in the United States, Canada, and Australia. It also serves up data on travel time, food deserts, apartments, and neighborhoods.

Urban Design, Transport, and Health (www.thelancet.com/series/urban-design-2022)
The Lancet Global Health journal published the following series of articles that explore how to evaluate and guide local planning decisions to create healthy and sustainable cities:

- Creating healthy and sustainable cities: what gets measured, gets done.
- Urban design is key to healthy environments for all.
- Measuring what matters: supporting cities in tackling climate and health challenges.
- The future is urban: integrated planning policies can enable healthy and sustainable cities.
- City planning policies to support health and sustainability: an international comparison of policy indicators for 25 cities.
- Determining thresholds for spatial urban design and transport features that support walking to create healthy and sustainable cities: findings from the IPEN Adult study.
- Using open data and open-source software to develop spatial indicators of urban design and transport features for achieving healthy and sustainable cities.
- What next? Expanding our view of city planning and global health, and implementing and monitoring evidence-informed policy.

The table below summarizes urban design and transport health Indicators from this research.

Table 13 **Urban Design and Transport Health Indicators** (Giles-Corti, et al. 2022)

Policy Indicators	
Integrated transport and urban planning	National and state transport and urban planning legislation requires integrated transport and urban planning actions to create healthy and sustainable cities and regular review of progress.
Air pollution	National and state air pollution legislation seeks to protect and improve air quality.
Destination accessibility	National and state transport and urban planning legislation requires coordinated planning of transport, employment, land use, and infrastructure that ensures access by public transport.
Employment distribution	Urban planning and design codes require a balanced ratio of jobs to housing (e.g., from 1:0·8 to 1:1·2)
Demand management	Urban planning, building codes, and local government policies limit car parking and price parking appropriately for context
Design	Urban design codes create pedestrian-friendly and cycling-friendly neighbourhoods, requiring highly connected street networks, pedestrian and cycling infrastructure, and public open space; lot layouts maximize natural surveillance
Density	Urban design codes require minimum and maximum context-specific housing densities, including higher-density development around activity centres and transport hubs
Distance to public transport	Urban design codes require frequent service public transport to be within 400–800 m of residential walkable catchments
Diversity	Urban design codes require a diverse mix of housing types and local destinations needed for daily living
Desirability	Urban design codes incorporate crime prevention through urban design principles, manage traffic exposure, and establish urban greening provisions
Government transport investment	
Transport infrastructure investment by mode	Percentage of total government transport expenditure in a given financial year spent on pedestrian infrastructure, cycling infrastructure, public transport, and road infrastructure
Urban Design and Transport Features	
Public transport access	Percentage of population living within 400–800 m of high-frequency public transport
Employment	Percentage of population with employment within 30 min of their home by walking, cycling, or public transport
Distribution of employment	Urban planning and design codes require a balanced ratio of jobs to housing (e.g., from 1:0·8 to 1:1·2)
Transport infrastructure	Ratio of roads (km) to footpaths (km) and designated cycle lanes (km)
Design	Street connectivity (e.g., ≥0·6 within 0·8–1·2 km) of destinations.
Density	Dwellings per area within 1·2 km of activity centres and public transport hubs.
Distance to transit	Percentage of population living within 400 m of a bus stop and 800 m of a rail stop
Destinations	Percentage of (urban) land area allocated to destinations required for daily living. percentage of population living within 500 m of a fresh food market, a convenience store, and public transport
Open or green space	Percentage of (urban) land area allocated to open or green space. Percentage of population living within 500 m of a public open space.
Walkability	Combined population density, street intersection density, and daily living destinations in local neighbourhood.
Transport Outcomes	
Trip mode share	Proportion of total and commuting trips by walking, cycling, public transport, and private vehicle.

This table summarizes urban planning health indicators.

Conclusions

Transport policy and planning decisions can affect public health in various ways, including traffic crash risks, physical activity, pollution exposure, affordability, mobility for non-drivers, mental health, and access to healthcare services, as summarized in the table below. These impacts are large, and in many situations, growing (Gössling, Nicolosi and Litman 2021). New research can help identify policies and planning strategies that support public health objectives, as summarized below.

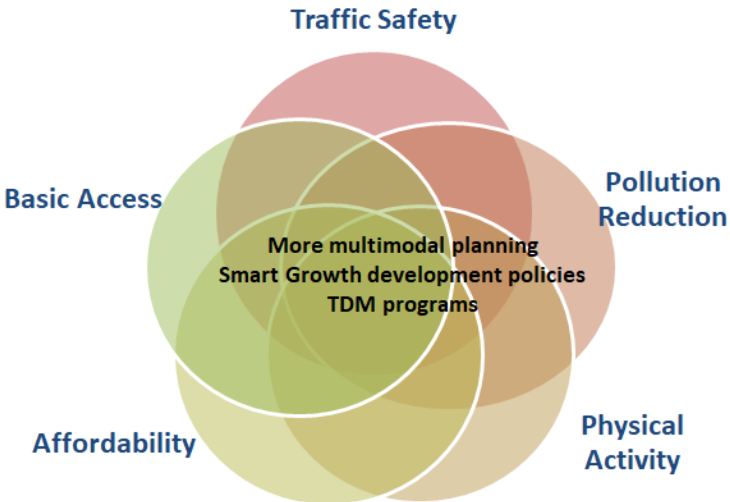
Table 14 **Transportation Health Impacts**

	Description	Transport Impacts	Transport Policies for Health
Crash Risks	Risk of traffic accidents, particularly for vulnerable modes (walking, bicycling and motorcycles).	Increased vehicle travel and higher traffic speeds tend to increase per capita crash risks.	Targeted traffic safety programs and vehicle travel reduction strategies.
Physical Activity	People's physical activity (target is at least 22 daily minutes of moderate activity).	Active transport (walking and bicycling) is one of the most practical ways to exercise.	Improve and encouraging walking, bicycling and public transit. Smart Growth development policies.
Heat Stress	Excessive heat that limits active travel.	Reduces active travel and increases driving.	Develop cool walkability networks.
Noise Exposure	Amount of noise people are exposed to.	Motor vehicles are major sources of noise.	Traffic noise reduction policies. Building design and location.
Air Pollution	Amount of air pollution people are exposed to.	Motor vehicles are major sources of air pollutants.	Reduce vehicle emissions. Separate people from traffic.
Affordability	Portion of household budgets that must be spent on transport.	Motor vehicle travel is costly and often unaffordable to lower-income households.	Improve affordable modes and affordable housing in accessible locations.
Mental health	Mental stress and unhappiness caused by Insecurity, physical inactivity, social isolation and unaffordability.	Transportation can affect mental health in many ways.	Create safer, more walkable (for exercise and community cohesion), and more affordable communities.
Access to services and activities needed for health	Ability to access healthcare services.	Inadequate transport can be a barrier to healthy food and healthcare for physically and economically disadvantaged people.	Improve affordable travel options. Better housing options in walkable neighborhoods. Identify and address barriers to healthy food and healthcare.

Transportation policies and planning decisions affect public health in several ways.

These policies overlap in many ways. Research described in this report indicate that most of these health risks (accidents, pollution emissions, sedentary lifestyles, unaffordability, etc.) tend to increase, and average lifespans tend to decline, with per capita motor vehicle travel, and residents tend to be healthier in more multimodal, compact communities. As a result, multimodal planning, Smart Growth development policies, and Transportation Demand Management programs tend to achieve multiple health objectives.

Figure 17 **Overlapping Benefits**



By increasing active travel and reducing motor vehicle travel and their associated costs, multimodal planning, Smart Growth development policies, and Transportation Demand Management (TDM) programs help achieve multiple health goals.

Conventional planning tends to consider some of these health impacts, particularly traffic accidents and per-kilometer pollution emission rates, but often ignores the additional crashes and pollution emissions caused by increased vehicle mileage, and the health problems caused by degraded walking and bicycling conditions. This overlooks many health problems caused by planning practices that increase automobile dependency and sprawl, and undervalues improvements to vehicle travel reduction strategies.

These often-overlooked health impacts are often greater in magnitude than impacts that dominate the planning process, such as traffic and parking congestion. A congestion reduction strategy that causes even small increases in crashes, pollution or physical inactivity is probably not cost effective overall, but a congestion reduction strategy that supports safety, environmental and health objectives can provide far greater total benefits. More comprehensive health impact analysis could significantly change planning decisions to favor alternative modes, mobility management and smart growth policies.

Conventional planning is biased in various ways that stimulate automobile dependency and sprawl, creating communities where driving is convenient and cheap, and other forms of travel are inconvenient, uncomfortable and even dangerous to use. This exacerbates transport-related health risks including per capita traffic casualties, pollution emissions, sedentary living, and inadequate access to essential goods and services. There are many justifications for planning reforms that create more efficient and diverse transport systems, of which improving public health is among the largest.

This study identified numerous 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. Improved public health can be among the greatest benefits of a more efficient and diverse transport system.

Information Resources

Below are various information resources concerning transportation and health.

AARP and CNU (2021), *Enabling Better Places: A Handbook for Improved Neighborhoods*, American Association of Retired Persons (www.aarp.org); at https://tinyurl.com/22b45e9y.

ABW (various years), *Bicycling and Walking in the U.S.: Benchmarking Reports*, Alliance for Biking & Walking (www.peoplepoweredmovement.org); at https://bit.ly/3QMF4h7.

Kristin N. Agnello (2020), *Child in the City: Planning Communities for Children & Their Families*, Plassurban (www.plassurban.com); at https://bit.ly/3xoYhd8.

APHA (2010), *The Hidden Health Costs of Transportation: Backgrounder*, American Public Health Association (www.apha.org); at https://bit.ly/31U1D9X.

APHA (2011), *Transportation Issues from the Public Health Perspective: Website*, American Public Health Association (www.apha.org).

APTA (2003), *The Route to Better Personal Health*, American Public Transportation Association (www.apta.com); at http://spider.apta.com/lgwf/legtools/better_health.pdf.

J. Ball, et al. (2009), *Applying Health Impact Assessment to Land Transport Planning*, Report 375, New Zealand Transport Agency (www.landtransport.govt.nz); at https://bit.ly/2kBdbMo.

David Bassett, et al. (2011), "Active Transportation and Obesity in Europe, North America, and Australia," *ITE Journal*, Vol. 81/8, pp. 24-28; abstract at www.ite.org/itejournal/1108.asp.

Lilah M. Besser and Andrew L. Dannenberg (2005), "Walking to Public Transit: Steps to Help Meet Physical Activity Recommendations," *American Journal of Preventive Medicine*, Vo. 29, No. 4 (www.acpm.org); at www.cdc.gov/healthyplaces/articles/besser_dannenberg.pdf.

Ethan M. Berke, et al. (2007), "Protective Association Between Neighborhood Walkability and Depression in Older Men," *Journal of the American Geriatrics Society* (www.blackwell-synergy.com), Vol. 55, No. 4, pp. 526–533 (www.ncbi.nlm.nih.gov/pubmed/17397430).

Steven Blair (2009), "Physical Inactivity: The Biggest Public Health Problem of the 21st Century," *British Journal of Sports Medicine*, Vol. 43, pp. 1-2; at http://bjsm.bmj.com/content/43/1/1.full.

Pamela Blais (2010), *Perverse Cities: Hidden Subsidies, Wonky Policy, and Urban Sprawl*, UBC Press (http://perversecities.ca).

Mikayla Bouchard (2015), "Transportation Emerges as Crucial to Escaping Poverty," *New York Times*, at https://nyti.ms/2nyvbqe.

Jeffrey Brubacher, et al. (2018), "Road Safety Impact of Increased Rural Highway Speed Limits in British Columbia, Canada," *Sustainability*. vol. 10, no. 10; at https://bit.ly/2Nu7a2e.

Jeffrey R. Brown, Eric A. Morris and Brian D. Taylor (2009), "Paved with Good Intentions: Fiscal Politics, Freeways, and the 20th Century American City," *Access 35* (www.uctc.net), Fall, pp. 30-37; at www.uctc.net/access/35/access35.shtml.

BTS (annual), *Transportation Safety Data*, Bureau of Transportation Statistics (www.bts.gov).

Building Healthy Places Initiative (http://americas.uli.org/health) is an *Urban Development Institute* program to develop tools to create healthier communities.

Built Environment and Public Health Clearinghouse (www.bephc.gatech.edu) provides university and professional level training resources for designing healthier communities.

BusVic (2010), *Public Transport Use: A Ticket to Health*, Briefing Paper, Bus Association Victoria (www.busvic.asn.au); at https://bit.ly/3vFmElm.

Nick Cavill, et al. (2008), "Economic Analyses of Transport Infrastructure and Policies Including Health Effects Related to Cycling and Walking: A Systematic Review," *Transport Policy*, Vol. 15, No. 5, pp. 291–304.

CDC (2018), *Physical Activity Guidelines*, Center for Disease Control and Prevention (www.convergencepartnership.org); at www.cdc.gov/physical-activity-basics/guidelines.

CDC (2009), *Transportation and Health Toolkit*, Active Living Convergence Partnership, Center for Disease Control and Prevention (www.convergencepartnership.org/th101).

CDC (2010), *CDC Transportation Recommendations*, Center for Disease Control and Prevention (www.cdc.gov); at www.cdc.gov/transportation/recommendation.htm.

CDC Foundation (2020), *Public Health Action Guide*, CDC Foundation (www.cdcfoundation.org); at www.cdcfoundation.org/sites/default/files/files/HI5_TransportationGuide.pdf.

J.A. Chan, et al. (2025), "Association of Neighborhood Walkability and Food Environment with Incident Cardiovascular Disease, *Health & Place* (10.1016/j.healthplace.2025.103432)

G. Chi, et. al. (2010a), "Gasoline Prices and Traffic Safety in Mississippi," *Journal of Safety Research*, Vol. 41(6), pp. 493−500; at https://conservancy.umn.edu/handle/11299/180001.

G. Chi, et al. (2010b). "Gasoline Prices and Their Relationship to Drunk-Driving Crashes," *Accident Analysis and Prevention*, Vo. 43(1), pp. 194–203 (DOI: 10.1016/j.aap.2010.08.009); at https://bit.ly/2O4sacG.

Jamie F. Chriqui, Emily Thrun and Anmol Sanghera (2018), *Components of Local Land Development and Related Zoning Policies Associated with Increased Walking*, Institute for Health Research and Policy (go.uic.edu/zoningprimer); at https://bit.ly/3heEfyb.

Robert Chirinko and Edward Harper Jr. (1993) "Buckle Up or Slow Down? New Estimates of Offsetting Behavior and their Implications for Automobile Safety Regulation," *Journal of Policy Analysis and Management*, Vol. 12, No. 2, pp. 270-296.

CNT (2018), *Housing and Transportation Affordability Index*, Center for Neighborhood Technology (www.cnt.org); at https://htaindex.cnt.org.

CPSTF (2017), *Physical Activity: Built Environment Approaches Combining Transportation System Interventions with Land Use and Environmental Design*, Community Preventive Services Task Force (www.thecommunityguide.org); at https://bit.ly/3fa7Kei.

Steve Crabtree (2010), *Wellbeing Lower Among Workers with Long Commutes*, Gallup (www.gallup.com); at https://bit.ly/1oi5zpx.

Maria I. Creatore, et al. (2016), "Association of Neighborhood Walkability with Change in Overweight, Obesity, and Diabetes," *JAMA*, Vol. 315/20, p. 2211 (DOI:10.1001/jama.2016.5898); at www.sciencedaily.com/releases/2016/05/160524124052.htm.

Jeroen Johan de Hartog, et al. (2010), "Do the Health Benefits of Cycling Outweigh the Risks?" *Environmental Health Perspectives*, Vol. 118, pp. 1109-16 (doi:10.1289/ehp.0901747).

Nicolae Duduta, Claudia Adriazola-Steil and Dario Hidalgo (2013), *Saving Lives With Sustainable Transportation*, EMBARQ (www.embarq.org); at https://bit.ly/38Ww95P.

David J. Ederer, et al. (2023), "The Safe Systems Pyramid: A New Framework for Traffic Safety," *Transportation Research Interdisciplinary Perspectives* (doi.org/10.1016/j.trip.2023.100905).

EPA (2014), *Near Roadway Air Pollution and Health: Frequently Asked Questions*. United States Environmental Protection Agency (www.epa.gov); at https://bit.ly/2RoXckk.

K.I. Erickson, et al. (2010), "Physical Activity Predicts Gray Matter Volume in Late Adulthood," *Neurology* 75, pp. 1415–1422; at www.ncbi.nlm.nih.gov/pubmed/20944075.

Reid Ewing and Robert Cervero (2010), "Travel and the Built Environment: A Meta-Analysis," *Journal of the American Planning Association*, Vol. 76, No. 3, Summer, pp. 265-294; at http://pdfserve.informaworld.com/287357__922131982.pdf.

Reid Ewing, Richard A. Schieber and Charles V. Zegeer (2003), "Urban Sprawl as a Risk Factor in Motor Vehicle Occupant and Pedestrian Fatalities," *American Journal of Public Health* (www.ajph.org); at www.ncbi.nlm.nih.gov/pmc/articles/PMC1448007.

Reid Ewing, et al. (2014), "Relationship Between Urban Sprawl and Physical Activity, Obesity, and Morbidity – Update and Refinement," *Health & Place*, Vol. 26, pp. 118-126; at www.sciencedirect.com/science/article/pii/S135382921300172X.

Reid Ewing and Shima Hamidi (2014), *Measuring Urban Sprawl and Validating Sprawl Measures*, University of Utah (www.arch.utah.edu) for the National Cancer Institute (https://gis.cancer.gov); at https://gis.cancer.gov/tools/urban-sprawl/sprawl-report-short.pdf.

Reid Ewing, Shima Hamidi and James Grace (2016), "Urban Sprawl as a Risk Factor in Motor Vehicle Crashes," *Urban Studies*, Vol. 53/2, pp. 247-266 (https://doi.org/10.1177/0042098014562331); at https://bit.ly/2L9zGQT.

Reid Ewing, et al. (2016), "Does Urban Sprawl Hold Down Upward Mobility?," *Landscape and Urban Planning*, Vo. 148, pp. 80-88 (https://doi.org/10.1016/j.landurbplan.2015.11.012).

Joseph Ferreira Jr. and Eric Minike (2010), *A Risk Assessment of Pay-As-You-Drive Auto Insurance*, Department of Urban Studies and Planning, Massachusetts Institute of Technology (http://dusp.mit.edu); at https://bit.ly/3mH9eRR.

FHWA (2010), *Transportation Planner's Safety Desk Reference*, Federal Highway Administration; at http://tsp.trb.org/assets/FR1_SafetyDeskReference_FINAL.pdf.

FHWA (various years), *Highway Statistics*, Federal Highway Administration (www.fhwa.dot.gov); at www.fhwa.dot.gov/policyinformation/statistics/2015/fi200.cfm.

Fietsberaad (2008), *Cycling in the Netherlands*, Ministry of Transport, Public Works and Water Management, The Netherland.

FHWA (2010), *Transportation Planner's Safety Desk Reference*, Federal Highway Administration; at http://tsp.trb.org/assets/FR1_SafetyDeskReference_FINAL.pdf.

Elliot Fishman, et al. (2011), *Cost and Health Benefits of Active Transport in Queensland: Research and Review*, prepared by CATALYST for Health Promotion Queensland (www.education.qld.gov.au/health/research/index.html); summary at https://bit.ly/2rCgplW.

Dillon Fitch-Polse and Swati Agarwal (2025), "The Benefits of Active Transportation Interventions: A Review of the Evidence," *Journal of Transport and Land Use*, 18(1), 77–122. (https://doi.org/10.5198/jtlu.2025.2468).

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

Lawrence Frank, et al. (2010), *Neighbourhood Design, Travel, and Health in Metro Vancouver: Using a Walkability Index*, Active Transportation Collaboratory, UBC (www.act-trans.ubc.ca); at https://bit.ly/3g70Iub.

Lawrence Frank, et al. (2019), *Where Matters Health & Economic Impacts of Where We Live*, Metro Vancouver (https://metrovancouver.org); at http://tinyurl.com/5c4u59c6.

Lawrence D. Frank, et al. (2022), "Chronic Disease and Where You Live: Built and Natural Environment Relationships with Physical Activity, Obesity, and Diabetes," Environment international (DOI: 10.1016/j.envint.2021.106959).

Chad Frederick, Anna Hammersmith and John Hans Gilderbloom (2019), "Putting 'Place' in its Place: Comparing Place-based Factors in Interurban Analyses of Life Expectancy in the U.S.," *Social Science & Medicine*, Vo. 232, pp. 148-155 (doi.org/10.1016/j.socscimed.2019.04.047); at https://bit.ly/2REhmUG.

Chad Frederick, William Riggs and John Hans Gilderbloom (2017), "Commute Mode Diversity and Public Health: A Multivariate Analysis of 148 US Cities," *International Journal of Sustainable Transportation* (http://dx.doi.org/10.1080/15568318.2017.1321705).

FTA (annual reports), *National Transit Database*, Federal Transit Administration (www.fta.dot.gov), at www.ntdprogram.gov/ntdprogram.

Gallup (2016), *Active Living Environment in U.S. Communities; State of American Well-being*, Gallup (www.gallup.com); at www.well-beingindex.com/2016-community-impact.

J. A. Genter, et al. (2008), *Valuing the Health Benefits of Active Transport Modes*, Research Report 359, NZ Transport Agency (www.nzta.govt.nz); at www.nzta.govt.nz/assets/resources/research/reports/359/docs/359.pdf.

Billie Giles-Corti, et al. (2013), "The Influence of Urban Design on Neighbourhood Walking Following Residential Relocation: Longitudinal Results from the RESIDE Study," *Journal of Social Science & Medicine*, Vol. 77, Pages 20–30 (http://dx.doi.org/10.1016/j.socscimed.2012.10.016); summary at www.sciencedaily.com/releases/2013/03/130307124427.htm.

Billie Giles-Corti, et al. (2016), "City Planning and Population Health: a Global Challenge," *The Lancet*, (ttp://dx.doi.org/10.1016/S0140-6736(16)30066-6); at https://bit.ly/3FZl4jM.

Billie Giles-Corti, et al. (2022), "Creating Healthy and Sustainable Cities: What Gets Measured, Gets Done, *The Lancet*, Vo. 10/6, pp. E782-E785 (https://doi.org/10.1016/S2214-109X(22)00070-5).

Gilliland (2009), *Outdoor Air Pollution, Genetic Susceptibility, and Asthma Management: Opportunities for Intervention to Reduce the Burden of Asthma*; at https://bit.ly/3qup5oO.

Thomas Gotschi (2011), "Costs and Benefits of Bicycling Investments in Portland, Oregon," *Journal of Physical Activity and Health*, Vol. 8, Supplement 1, pp. S49-S58; at https://bit.ly/3h4a098.

Stefan Gössling, Jessica Nicolosi and Todd Litman (2021), "The Health Cost of Transport in Cities," *Current Environmental Health Reports*, Vo. 8, pp. 196–201 (https://doi.org/10.1007/s40572-021-00308-6).

Stefan Gössling, et al. (2023), "Weather, Climate Change, and Transport: A Review," *Natural Hazards*, pp. 1-(DOI: 20. 10.1007/s11069-023-06054-2).

GPP (2016), *Gasoline Consumption per Capita around the World*, Global Petrol Prices (www.globalpetrolprices.com); at www.globalpetrolprices.com/articles/52.

Maggie L. Grabow, et al. (2011), "Air Quality and Exercise-Related Health Benefits from Reduced Car Travel in the Midwestern United States," *Environmental Health Perspectives*, (www.ehponline.org); http://dx.doi.org/10.1289/ehp.1103440.

Jessica Y. Guo and Sasanka Gandavarapu (2010), "An Economic Evaluation of Health-Promotive Built Environment Changes," *Preventive Medicine*, Vol. 50, Supplement 1, January, pp. S44-S49; at www.activelivingresearch.org/resourcesearch/journalspecialissues.

Ken Gwilliam and Masami Kojima (2004), *Urban Air Pollution: Policy Framework for Mobile Sources*, Prepared for the Air Quality Thematic Group, World Bank (www.worldbank.org); at www.cleanairnet.org/cai/1403/articles-56396_entire_handbook.pdf.

Shima Hamidi, et al. (2018), "Associations between Urban Sprawl and Life Expectancy in the United States," *International Journal of Environmental Research and Public Health*, Vol. 15/5 (doi:10.3390/ijerph1505086); at https://bit.ly/2Ni4L5i.

Health Impact Assessment Website (www.ph.ucla.edu/hs/health-impact) provides information on ways to systematically evaluate and communicate potential health impacts in policy and planning analysis.

Health Economic Assessment Tool (HEAT) for cycling is a science-based computer model developed by the World Health Organization that calculates the human health benefits that result from increased cycling activity (http://euro.who.int/transport/policy/20081219_1).

Healthy Mobility Options Tool (https://skylab.cdph.ca.gov/HealthyMobilityOptionTool-ITHIM) quantifies how potential transportation policy and system changes affect physical activity, crash casualty risk and air pollution emissions.

Health System Tracker (www.healthsystemtracker.org) provides comprehensive information on morbidity and mortality, and public health spending, in the Unites States and peer countries.

Wendy Heaps, Erin Abramsohn and Elizabeth Skillen (2022), "Public Transportation in the US: A Driver of Health and Equity," *Health Affairs* (www.healthaffairs.org); at https://bit.ly/3EGtoVK.

HEI (2010), *Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects*, HEI Special Report 17, Health Effects Institute (www.healtheffects.org); at http://pubs.healtheffects.org/getfile.php?u=553.

Christine M. Hoehner, et al. (2012), "Commuting Distance, Cardiorespiratory Fitness, and Metabolic Risk," *American Journal of Preventive Medicine* (DOI: 10.1016/j.amepre.2012.02.020).

James Horrox, et al. (2021), *Transform Transportation Strategies for a Healthier Future*, Arizona PIRG (https://arizonapirgedfund.org) and Frontier Group; at https://bit.ly/3nzk10Z.

Kate Hosford, et al. (2021), "The Effects of Road Pricing on Transportation and Health Equity: A Scoping Review," *Transport Reviews* (DOI: 10.1080/01441647.2021.1898488).

ICF (2010), *Current Practices in Greenhouse Gas Emissions Savings from Transit*, TCRP 84, TRB (www.trb.org); at http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_syn_84.pdf.

ICLEI (2007), *Active Transportation Quantification Tool*, Cities for Climate Protection, International Council for Local Environmental Initiatives (http://att.ccp.iclei.org); at http://att.ccp.iclei.org/more/about.

IIHS (2016), *Fatality Rates; Pedestrians and Bicyclists*, Insurance Institute for Highways. https://m.iihs.org; at www.iihs.org/iihs/topics/t/pedestrians-and-bicyclists/fatalityfacts/bicycles

Peter L. Jacobsen (2003), "Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling," *Injury Prevention* (http://ip.bmjjournals.com), Vol. 9, pp. 205-209; at https://bit.ly/2TRkBur.

Jenfeng Jiao and Chris Bischak (2018), People are Stranded in 'Transit Deserts' in Dozens of US Cities," *The Conversation* (https://theconversation.com); at https://bit.ly/3gEoVES.

Dhruv Khullar and Dave A. Chokshi (2018), *Health, Income, & Poverty: Where We Are & What Could Help*, Health Affairs Health Policy Brief (10.1377/hpb20180817.901935)

Ugo Lachapelle (2010), *Public Transit Use as a Catalyst for an Active Lifestyle: Mechanisms, Predispositions and Hindrances*, PhD Dissertation, University of British Columbia (http://hdl.handle.net/2429/30239).

Ugo Lachapelle, et al. (2011), "Commuting by Public Transit and Physical Activity: Where You Live, Where You Work, and How You Get There," *Journal of Physical Activity and Health* (http://journals.humankinetics.com/jpah), Vol. 8, pp. S72-S82; at https://bit.ly/2fhEnYY.

Keith Ladd and Sara Meerow (2022), *Planning for Urban Heat Resilience*, PAS Report 600, American Planning Association (www.planning.org); at www.planning.org/publications/report/9245695.

Eric B. Larson, et al. (2006), "Exercise Is Associated with Reduced Risk for Incident Dementia among Persons 65 Years of Age and Older," *Annals of Internal Medicine*, 17 January 2006, Vol. 144, No. 2, pp. 73-81 (www.ncbi.nlm.nih.gov/pubmed/16418406).

J. Paul Leigh and Estella M. Geraghty (2008), "High Gasoline Prices and Mortality From Motor Vehicle Crashes and Air Pollution," *Journal of Occupational and Environmental Medicine*, Vol. 50, Is. 3, March, pp. 249-54; at www.ncbi.nlm.nih.gov/pubmed/18332774.

Michael Lens (2021), *Low-Density Zoning, Health, and Health Equity*, Health Affairs (www.healthaffairs.org); at www.healthaffairs.org/do/10.1377/hpb20210907.22134/full.

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

Todd Litman (2008), *Land Use Impacts on Transport: How Land Use Factors Affect Travel Behavior*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/landtravel.pdf.

Todd Litman (2009), "Transportation Policy and Injury Control," *Injury Prevention*, Vol. 15, Issue 6, (http://injuryprevention.bmj.com/content/15/6/362.full); at www.vtpi.org/tpic.pdf.

Todd Litman (2010), *Transportation Cost and Benefit Analysis Guidebook*, Victoria Transport Policy Institute (www.vtpi.org/tca).

Todd Litman (2010b), *Evaluating Public Transit Benefits and Costs*, VTPI (www.vtpi.org); at www.vtpi.org/tranben.pdf.

Todd Litman (2011), *Evaluating Public Transportation Health Benefits*, American Public Transportation Association (www.apta.com); at www.vtpi.org/tran_health.pdf.

Todd Litman (2011b), *Evaluating Non-Motorized Transportation Benefits and Costs*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/nmt-tdm.pdf.

Todd Litman (2012), *Pricing for Traffic Safety: How Efficient Transport Pricing Can Reduce Roadway Crash Risk*, Transportation Research Board Annual Meeting paper 12-5310, forthcoming *Transportation Research Record* (www.trb.org); at www.vtpi.org/price_safe.pdf.

Todd Litman (2013), *Safer Than You Think! Revising the Transit Safety Narrative*, Transportation Research Board Annual Meeting paper 13-4357; at www.vtpi.org/safer.pdf.

Todd Litman (2013), "Transportation and Public Health," *Annual Review of Public Health*, Vol. Vol. 34, pp. 217-233 (https://bit.ly/1GrU1Ye); draft at www.vtpi.org/ARPH_Litman_2012.pdf.

Todd Litman (2014), *Analysis of Public Policies That Unintentionally Encourage and Subsidize Urban Sprawl*, commissioned by LSE Cities (www.lsecities.net), for the Global Commission on the Economy and Climate (www.newclimateeconomy.net); at https://bit.ly/2QqPhzc.

Todd Litman (2015), *Transportation Affordability*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/affordability.pdf.

Todd Litman (2016), *The Hidden Traffic Safety Solution: Public Transportation*, American Public Transportation Association (www.apta.com); at https://bit.ly/2bYqQpr.

Todd Litman (2017), *Urban Sanity: Understanding Urban Mental Health Impacts and How to Create Saner, Happier Cities*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/urban-sanity.pdf.

Todd Litman (2021), *Fair Share Transportation Planning*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/fstp.pdf.

Todd Litman (2022), *A New Traffic Safety Paradigm*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/ntsp.pdf.

Todd Litman (2023), *Cool Walkability Planning*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/cwi.pdf.

Todd Litman (2024), *Completing Sidewalk Networks: Benefits and Costs*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/csn.pdf.

Todd Litman (2025), *Planning for Quality of Life: Considering Community Cohesion and Related Social Goals*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/cohesion.pdf.

Todd Litman and Steven Fitzroy (2011), *Safe Travels: Evaluating Mobility Management Traffic Safety Benefits,* Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/safetrav.pdf.

Helen Fei Liu (2007), *Vehicle CO2 Emissions and the Compactness of Residential Development*, HousingEconomics.com.

William Lucy (2002), *Danger in Exurbia: Outer Suburbs More Dangerous Than Cities,* University of Virginia (www.virginia.edu); summarized at https://at.virginia.edu/1IIpme2.

James MacMillen, Moshe Givoni and David Banister (2010), "Evaluating Active Travel: Decision-Making for the Sustainable City," *Built Environment*, Vol. 36, No. 4, Dec. pp. 519-536; summary at www.atypon-link.com/ALEX/doi/abs/10.2148/benv.36.4.519.

P. Malambo, et al. (2016), "Built Environment, Selected Risk Factors and Major Cardiovascular Disease Outcomes: A Systematic Review," *PLoS One*, Vo. 11/11 (doi:10.1371/journal.pone.0166846).

Theodore J. Mansfield and Jacqueline MacDonald Gibson (2015), "Health Impacts of Increased Physical Activity from Changes in Transportation Infrastructure," *BioMed Research International* (http://dx.doi.org/10.1155/2015/812325); at www.hindawi.com/journals/bmri/2015/812325.

Iain A. McCormick, Frank H. Walkey and Dianne E. Green (1986), "Comparative Perceptions Of Driver Ability— A Confirmation and Expansion," *Accident Analysis & Prevention*, Vol. 18, Is. 3, June, Pages 205-208, doi:10.1016/0001-4575(86)90004-7.

Wesley E. Marshall and Norman W. Garrick (2011), "Evidence on Why Bike-Friendly Cities Are Safer for All Road Users," *Environmental Practice*, Vol 13/1, March; at http://files.meetup.com/1468133/Evidence on Why Bike-Friendly.pdf.

Sage R. Myers, et al. (2013), "Safety in Numbers: Are Major Cities the Safest Places in the United States?" *Annals of Emergency Medicine*, American College of Emergency Physicians (http://dx.doi.org/10.1016/j.annemergmed.2013.05.030); at https://bit.ly/1B8Rlvz.

TRB (2019), *A Research Roadmap for Transportation and Public Health Management*, Transportation Research Board (www.trb.org); at https://doi.org/10.17226/25644.

NCCHPP (2012), *Urban Traffic Calming and Health: A Literature Review*, National Collaborating Centre for Healthy Public Policy (www.ncchpp.ca); at https://bit.ly/2XYp65y.

NHTSA (2016), *2015 Motor Vehicle Crash Data from FARS and GES*, National Highway Traffic Safety Administration (https://nhtsa.dot.gov); at https://crashstats.nhtsa.dot.gov/Api/Public/Publication/812384.

NZTA (2010), *Economic Evaluation Manual*, Volumes 1 and 2, New Zealand Transport Agency (www.nzta.govt.nz); at https://bit.ly/2KC3k17 and https://bit.ly/2P0wpEd.

OECD (2006), *OECD Factbook*, Organization for Economic Cooperation and Development (www.sourceoecd.org/factbook).

Avila Palencia (2018), "The Effects of Transport Mode Use on Self-Perceived Health, Mental Health, and Social Contact Measures: A Cross-Sectional and Longitudinal Study," *Environment International*, Vol. 120, pp. 199-206 (Doi: https://doi.org/10.1016/j.envint.2018.08.002).

PAPREN (*Physical Activity Policy Research and Evaluation Network*, www.papren.org) supports collaborative research and evaluation to identify and implement local, state and national level policy approaches that influence opportunities for physical activity.

Ian W. H. Parry and Kenneth A. Small (2004), *Does Britain or the United States Have the Right Gasoline Tax?*, Resources for the Future; Discussion Paper 02-12 (www.rff.org); at www.rff.org/Documents/RFF-DP-02-12.pdf.

PfP (2011), *Transportation and Health: Policy Interventions for Safer, Healthier People and Communities*, Partnership for Prevention, Booz Allen Hamilton, and the Centers for Disease Control and Prevention) (www.prevent.org); at www.trb.org/Main/Blurbs/165700.aspx.

PYMNTS (2024), *Women's Wellness Index Report*, PYMNTS Intelligence (www.pymnts.com); at https://tinyurl.com/ydcmp3rk.

C. Arden Pope III, Majid Ezzati and Douglas W. Dockery (2009), "Fine-Particulate Air Pollution and Life Expectancy in the United States," *New England Journal of Medicine*, Vol. 360, pp. 376-86; at www.northeastdiesel.org/pdf/Pope-PM-life-expectancy-NewEngJMed2009.pdf.

PPS (2016), *The Case for Healthy Places: Improving Health Outcomes Through Placemaking*, Project for Public Spaces (www.pps.org); at https://bit.ly/2gkYvxe.

John Pucher and Ralph Buehler (2009), "Sustainable Transport that Works: Lessons from Germany," *World Transport Policy and Practice*, Vol. 15, No. 1, May, pp. 13-46 (www.eco-logica.co.uk/pdf/wtpp15.1.pdf).

John Pucher, Ralph Buehler and Mark Seinen (2011), "Bicycling Renaissance in North America? An Update and Re-Assessment of Cycling Trends and Policies," *Transportation Research A*, Vol. 45, No. 8, pp. 451-475; at http://policy.rutgers.edu/faculty/pucher/TRA960_01April2011.pdf.

Renee Autumn Ray (2020), *Increasing Access to Essential Health Functions: The Role of Transportation in Improving America's Health*, Eno Center for Transportation (www.enotrans.org); at https://bit.ly/2Q3xuBw.

Irwin Redlener, Arturo Brito, Dennis Johnson and Roy Grant (2006), *The Growing Health Care Access Crisis for American Children: One in Four at Risk*, The Children's Health Fund (www.childrenshealthfund.org); at https://bit.ly/38XHWy9.

Ian Roberts (2012), *The Energy Glut: Transport and the Politics of Fatness and Thinness*, Transportation Research and Injury Prevention Programme (http://tripp.iitd.ernet.in); at http://tripp.iitd.ernet.in/4thlecture%20ian%20roberts.pdf.

James F. Sallis, et al. (2016), "Physical Activity in Relation to Urban Environments in 14 Cities Worldwide: A Cross-Sectional Study," *The Lancet*, Vol. 387, No. 10034, pp. 2207–2217; at https://bit.ly/1RSchnU.

Laura Sandt, et al. (2012), "Leveraging the Health Benefits of Active Transportation: Creating an Actionable Agenda for Transportation Professionals," *TR News* 280, May-June; at https://bit.ly/2TQ1fmD.

Chinmoy Sarkar, Chris Webster and John Gallacher (2017), "Association Between Adiposity Outcomes and Residential Density: A Full-Data, Cross-Sectional Analysis of 419,562 UK Biobank Adult Participants," *The Lancet Planetary Health*, Vol. 1/7, pp. e277-e288 (https://doi.org/10.1016/S2542-5196(17)30119-5) at https://bit.ly/2FpS0Ws.

Sagar Shah and Brittany Wong (2020), *Toolkit to Integrate Health and Equity Into Comprehensive Plans Using the Sustaining Places-Best Practices for Comprehensive Plans Framework*, American Planning Association (www.planning.org); at https://bit.ly/3tsI97e.

Diana Silver, Jan Blustein and Beth Weitzman (2012), "Transportation to Clinic: Findings from a Pilot Clinic-based Survey of Low-income Suburbanites," *Journal of Immigrant and Minority Health*, Vol.14, no.2, pp.350-355 (https://doi.org/10.1007/s10903-010-9410-0).

Michael Sivak and Brandon Schoettle (2010), *Toward Understanding the Recent Large Reductions in U.S. Road Fatalities*, University of Michigan Transportation Research Institute (www.umich.edu/~umtriswt); at https://bit.ly/2rRoBf3.

Sandy J. Slater, et al. (2013), "Walkable Communities and Adolescent Weight," *American Journal of Preventive Medicine*, Vol. 44, Is. 2, February, pp. 164-168; at https://bit.ly/2Q0i4Ni.

Bradley Sawyer and Daniel McDermott (2019), *How do Mortality Rates in the U.S. Compare to Other Countries?* Health System Tracker (www.healthsystemtracker.org); at https://bit.ly/2OJDrTB.

Steven Spears, Marlon G. Boarnet and Susan Handy (2011), *Policy Brief on the Impacts of Voluntary Travel Behavior Change Programs Based on a Review of the Empirical Literature*, California Air Resources Board (http://arb.ca.gov/cc/sb375/policies/policies.htm).

Street Smart (www.thinkstreetsmart.org) is a clearinghouse that provides comprehensive, evidence-based information for integrating climate change, public health, and equity concerns into transportation planning.

Rajesh Subramanian (2012), *Motor Vehicle Traffic Crashes as a Leading Cause of Death in the United States*, National Highway Traffic Safety Institute (www-nrd.nhtsa.dot.gov); at www-nrd.nhtsa.dot.gov/Pubs/811620.pdf.

T Sugiyama**,** et al. (2008), "Associations of Neighbourhood Greenness with Physical and Mental Health: Do Walking, Social Coherence and Local Social Interaction Explain the Relationships?" *Journal of Epidemiology and Community Health, V*ol.62/5; at https://jech.bmj.com/content/62/5/e9.

Sam Swartz (2012), *Steps to a Walkable Community: A Guide for Citizens, Planners, and Engineers*, America Walks (www.americawalks.org/walksteps).

TAC (2019), *Integrating Health and Transportation in Canada*, PTM-IHTC-E, Transportation Association of Canada (www.tac-atc.ca); at www.tac-atc.ca/en/publications/ptm-ihtc-e.

Theresa Tam (2017), D*esigning Healthy Living*, Public Health Agency of Canada (www.cip-icu.ca); at www.cip-icu.ca/Files/WTPD/2017-designing-healthy-living-eng.aspx.

TPH (2013), *Next Stop Health: Transit Access and Health Inequities in Toronto*, Toronto Public Health (www.toronto.ca/health); at https://bit.ly/32bCs1I.

Mark Tremblay, et al. (2010), "Physiological and Health Implications of a Sedentary Lifestyle," *Applied Physiology, Nutrition, and Metabolism*, vol. 35, No.6, pp. 725-740; at www.nrcresearchpress.com/doi/full/10.1139/H10-079#.XM5DUJNKg6V.

Paul Joseph Tranter (2010), "Speed Kills: The Complex Links Between Transport, Lack of Time and Urban Health," *Journal of Urban Health*, Vol. 87, No. 2 (doi:10.1007/s11524-009-9433-9); at www.springerlink.com/content/v5206257222v6h8v.

TRB (2018), *Arterial Roadways Research Needs and Concerns: Informing the Planning, Design, and Operation of Arterial Roadways Considering Public Health*, Transportation Research Board (www.trb.org); at http://onlinepubs.trb.org/onlinepubs/circulars/ec239.pdf.

UCCRN (2018), *The Future We Don't Want: How Climate Change Could Impact the World's Greatest Cities*, Urban Climate Change Research Network (https://uccrn.ei.columbia.edu); at https://bit.ly/3ovpXwR.

UDI (2018), *Healthy Housing for All: How Affordable Housing is Leading the Way*, Urban Development Institute (www.uli.org); at https://bit.ly/2W2FJLw.

Urban Design for Health (http://urbandesign4health.com) develops practical tools for incorporating health objectives into community planning, including the *National Environmental Database* which includes built, natural and social environmental health performance indicators.

Urban Design 4 Health and AECOM (2016), *Active Transportation Health and Economic Impact Study*, Southern California Association of Governments; at https://bit.ly/2FeHSi3.

Inge van den Bijgaart, et al. (2023), "Healthy Climate, Healthy Bodies: Optimal Fuel Taxation and Physical Activity," *Economica* (doi:10.1111/ecca.12497). Also see, *Economic Transport Policy Should Prioritise Physical Activity*, LSE Blogs (https://tinyurl.com/fxe6hdnd).

William Vickrey (1968), "Automobile Accidents, Tort Law, Externalities, and Insurance," *Law and Contemporary Problems*, Vo. 33, pp. 464-487; at www.vtpi.org/vic_acc.pdf.

VTPI (2011), *Online TDM Encyclopedia*, Victoria Transport Policy Institute (www.vtpi.org).

Mary Wanjau, et al. (2022), *Economic Active Transport Project to Deliver a Best Practice Method to Cost the Health Benefits of Active Transport in NSW*, New South Wales Health (https://www.health.nsw.gov.au); at https://bit.ly/47PGJZm.

Richard E. Wener and Gary W. Evans, (2007), "A Morning Stroll: Levels of Physical Activity in Car and Mass Transit Commuting," *Environment and Behavior*, Vol. 39, No. 1, 62-74 (http://eab.sagepub.com/cgi/content/abstract/39/1/62).

WHO (2004), *World Report on Road Traffic Injury Prevention*, World Health Organization and World Bank (www.who.int); at https://bit.ly/2Rjy2yC.

WHO (2005), *Health Effects of Transport-Related Air Pollution*, World Health Organization Regional Office for Europe (www.euro.who.int); at https://bit.ly/1MK9ppe.

WHO (2016), *Health Topics; Obesity*, World Health Organization (www.who.int); at www.who.int/topics/obesity/en.

WHO (2018), *Heat and Health*, World Health Organization (www.who.int); at https://bit.ly/3O72CLO.

WHO (2024), *Global Action Plan on Physical Activity 2018–2030: More Active People for a Healthier World*, World Health Organization (https://iris.who.int); at https://iris.who.int/bitstream/handle/10665/272722/9789241514187-eng.pdf.

Margaret C. Weiss, et al. (2023), "Transportation-related Environmental Mixtures and Diabetes Prevalence and Control in Urban/Metropolitan Counties in the United States," *Journal of the Endocrine Society*, Vo. 7, Is. 6, (https://doi.org/10.1210/jendso/bvad062).

James Woodcock, Oscar H Franco, Nicola Orsini and Ian Roberts (2010), "Non-Vigorous Physical Activity and All-Cause Mortality: Systematic Review and Meta-Analysis of Cohort Studies," *International Journal of Epidemiology*, (doi:10.1093/ije/dyq104); at https://bit.ly/2RoHyRm.

Steffie Woolhandler, et al. (2021), "Public Policy and Health in the Trump Era," *The Lancet* (DOI:https://doi.org/10.1016/S0140-6736(20)32545-9)

Serena Yang, et. al. (2006), "Transportation Barriers to Accessing Health Care for Urban Children," *Journal of Health Care for the Poor and Underserved*, Vol. 17, no. 4, pp. 928-943. (doi:10.1353/hpu.2006.0137).

www.vtpi.org/health.pdf