Public Health and Transportation Policy: Integrating the Consequences of Physical Inactivity Into the Transportation Policy Structure

by

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Introduction/Abstract

When governmental agencies decide to change, limit, or expand the transportation infrastructure, their decision affects more than the speed of car travel. Because transportation infrastructure affects how much physical activity people can pursue by either providing or limiting access to sidewalks, bikeways, and trails, transportation decisions affect public health.

In this paper, I examine the complex structure of transportation policy, decision-making, and funding. By analyzing the assumptions, biases, and historical path dependence that permeate the transportation decision process, I demonstrate the ways in which the transportation decision structure (including funding, models, and political will) continues to favor automobile travel over physically active travel and neglects consideration of health consequences.

I also discuss how the transportation policy structure is dispersed over Federal, state, and local jurisdictions, and how this diffuse structure can lead to disagreement over priorities. While one area of government might change its transportation policy, this does not necessarily affect the other areas of government, and thus, little overall change may occur.

Stakeholders in transportation have a long history of developing ideas to limit automobile usage, primarily to limit air pollution. I discuss these methods, as well as how the policy framework to limit air pollution provides one model for how societal consequences can be integrated into the transportation decision structure.

I argue that the ongoing increase in the prevalence of obesity represents one of the significant societal costs resulting from the limitation of physical
activity, and discuss the extent of that societal burden and evidence to support the linkage between transportation infrastructure and physical activity. I propose how transportation policy can and should be changed on multiple levels to reflect these societal costs, and to promote equal standing between physically active modes of transportation and sedentary modes of transportation.

THE LINK BETWEEN HEALTH AND URBAN FORM

The connection between urban design and health is not a novel concept. The disciplines of urban planning and public health both developed as a response to the struggle to prevent epidemics of infectious disease. In the late 19th century and early 20th century, recognition of a connection between urban design, a lack of sanitation, and the regular outbreaks of disease led to the adoption of zoning codes, development of sewer systems, and an ongoing urge to move people out of the city into ‘less crowded’ conditions.¹

With the professionalization of urban planning and public health in the early 20th century, a division occurred between the two initially conjoined disciplines. As scientific inquiry elucidated the origin of infectious disease, public health began to focus more upon methods to eradicate microbes rather than upon urban design. Urban planning matured into a discipline informed by the ideas of the ‘Sanitary Movement’ and profoundly influenced by the invention and rapid dissemination of the personal automobile.²

Transportation planning and policy developed as a response to the immense popularity of the automobile. Ideas of progress and efficiency were linked with the push to move ‘more cars, faster’. No single policy act typified this ideal more than the Interstate Highway and Defense Act of 1956. A 41,000-mile
mile highway system conceived by Eisenhower and Congress would be built to move cars and trucks across the country. Engineering standards were defined by the American Association of State Highway and Transportation Officials (AASHTO) to move cars safely at average speeds of 50 to 70 mph and meet predicted travel volumes for 1975. Half of the entire system was built in just nine years; between 1956 and 1991, 42,843 miles of interstate would be constructed, at a cost of $128 billion. By contrast, bicycle and pedestrian programs did not receive Federal DOT funding until 1991.

The rapid growth of the Interstate Highway System and concomitant automobile traffic became the first impetus to forge a new linkage between transportation planning and public health. Although numerous factors contributed to the rise of the environmental movement in the 1960s, the Interstate Highway System became symbolic of the environmental impact resulting from 'the machine in the garden.' One result of the environmental movement was the implementation of the National Environmental Policy Act of 1969 and the Clean Air Act of 1970. For the first time, a direct policy link would be developed between the increase in highway infrastructure and environmental as well as, indirectly, human health consequences.

Although no programs to increase physically-active transportation would be federally-funded until 1991, the justification for these programs would arise from the established policy linkage between air quality and transportation. Theory and programs designed to limit automobile usage, and thus indirectly increase physically-active transportation (called Transportation Control Measures), would also develop out of the need to control air pollution and its consequences.

Through the 1990s, a growing body of evidence began to support a link between urban form, physical activity and the rising population prevalence of
obesity. During the late 1990s, the CDC began to study “Active Community Environments” (which were defined as higher density, walkable environments). They compared these areas with lower density suburbs, typified by separation of land uses and little walking or biking infrastructure to assess whether different environments affected rates of chronic illness. In 2000, the CDC stated that living in these lower-density, suburban areas (so-called “urban sprawl”) could adversely affect public health.\(^8\)

That same year, the Institute of Medicine held a workshop entitled “Rebuilding the Unity Between Health and Environment” that brought together professionals from an array of disciplines to discuss the wide-ranging impact of urban sprawl on public health.\(^9\) The workshop outlined a research agenda, focused initially on the difficulty of walking and biking in the automobile-based urban form, with presentation of early data to demonstrate less walking, biking, and less overall physical activity in automobile-centric areas.\(^10\)

Since that time, more research has been undertaken to study the relationship between urban design elements (such as land usage and transportation infrastructure) and public health. Because of concern about the rising population prevalence of obesity over the past 40 years, most research has continued to focus upon relationships between urban design elements (also called ‘urban form’), physical activity, and measures of obesity. These studies remain predominantly cross-sectional, and most data has been collected from self-reported survey data.\(^11\)

Despite these limitations, researchers have generated multiple studies that substantiate a positive relationship between ‘urban sprawl’, reduced physical activity, and obesity. Multiple studies have documented a self-reported positive relationship between the presence of venues for walking, physical activity, and
health. In addition, several studies have used objectively measured data. For example, data from the BRFSS were used to show a positive correlation between car-based, sprawling environments, obesity, and hypertension in a 2003 study.\textsuperscript{12} Objectively measured neighborhood design has been shown to be significantly associated with objectively measured physical activity in neighborhood residents.\textsuperscript{13} A systematic review of the literature, published in 2004, noted that there were few longitudinal studies, and that results from these studies have been mixed.\textsuperscript{14} However, there is longitudinal data to suggest that people walk or bike more when they move to areas with active transportation infrastructure.\textsuperscript{15}

(Please see Appendix II, a summary table of urban form/physical activity research)

While the existing literature suggests a significant connection between urban form, physical activity, and obesity, there is, as yet, no data to 'prove' causation. Because urban form is defined by a complex mix of variables, motivation for physical activity is multi-dimensional, and the etiology of obesity is multi-factorial, well-controlled studies may remain elusive.

For several reasons, changes in transportation policy should not be delayed until researchers might deliver strong evidence for causation. The aforementioned difficulty in conducting well-controlled studies is one reason. A second reason is that the sort of infrastructure changes necessary to acquire before and after data from a large cohort cannot occur without changing transportation policy first. Third, correlational data should be sufficient to support policy change; our current transportation policy has never been 'proven' to cause an improvement in public health or even quality-of-life. Fourth, obesity does not stand alone as a reason to change transportation policy. Other public health
issues, such as illness from air pollution, as well as issues of equity and quality of life necessitate similar changes.

Although ideas to decrease automobile usage and increase physically active modes of transportation (Transportation Control Measures) have been in place since the Clear Air Act, decision-makers have chosen to avoid the difficult political task of increasing the cost of driving, relying on technologic measures to achieve air pollution goals. The societal costs of decreased physical activity, including the increasing prevalence of obesity have been rising for the past 40 years. These costs have given new relevance to physically active transportation and the need to fully integrate public health costs into transportation policy.

**PHYSICAL ACTIVITY**

Regular physical activity is an essential component of a healthy lifestyle. The current literature suggests that individuals should pursue 30 minutes of moderate to strenuous exertion, most if not all days of the week.\(^\text{16}\) Few Americans get the currently recommended amount of physical activity; 25% of adults and 27% of high-school students maintain a regular moderate exercise regimen\(^\text{17}\) and at least 25% of all Americans are completely sedentary.\(^\text{18}\)

Most health-focused exercise pursued by Americans is *recreational* rather than *utilitarian*. *Recreational exercise* is defined by physical activity as an end unto itself, i.e. a sporting activity or a gym workout. *Utilitarian exercise* consists of physical activity to accomplish another purpose or task, such as walking to work.\(^\text{19}\) As technology has replaced labor over the past century, increasingly sedentary lifestyles have come to predominate in American society.\(^\text{20}\) While this trend is pervasive, the automobile has had a singular effect in shifting patterns of
physical activity. The car obviated the 'need' for utilitarian transportation. This marginalized physical activity as recreation – an extra activity pursued for fun. At the same time, attempts to integrate the automobile into the urban environment caused a massive reshaping of the urban form, to the detriment of the infrastructure for physical activity.

**Strategies to Increase Physical Activity**

As few Americans perform the recommended amount of physical activity, there is great interest in how we, as a society, might increase the number of people who exercise. Some methods for increasing physical activity in the population are more effective than others. Medical providers, for instance, typically recommend physical activity to their patients. However, the United States Preventive Services Task Force (USPSTF) has found the evidence for counseling to encourage physical activity as a strategy for obesity prevention to be inconclusive.\(^{21}\)

Community strategies to promote physical activity have been more effective. The Guide to Community Preventive Services identifies several community interventions with strong evidence to support their implementation. These include community-wide promotion campaigns, individually adapted health behavior change, school-based physical education, and non-family social support. Strong evidence has also been found to support the creation or enhancement of access to places that support physical activity\(^{22}\) as well as for land use policies that support better connectivity and higher building density.\(^{23}\) The evidence therefore supports the consideration of land use policy and transportation policy as public health issues.
How Urban Form Can Discourage Physical Activity

A city is composed of ‘urban design elements’ that, collectively, may be referred to as ‘urban form.’ These elements include streets, sidewalks, benches, street trees, buildings, subways and much more. While all of these elements may affect the way that we interact with our environment, there are specific characteristics of the urban environment that can impede physically-active transportation.

Sidewalks

Sidewalks represent the primary transportation infrastructure for pedestrians. Sidewalks are frequently discontinuous or absent, particularly in suburban areas. Wide streets with resultant wide intersections are difficult to cross. A lack of buffer (such as parallel parking or street trees) between sidewalks and cars discourages sidewalk use through the perception of decreased safety.24

Bicycle Right-of-Way

A lack of bike lanes or sufficient shoulders forces bicyclists to compete with automobiles for space in the street right-of-way. Safety issues and antagonism from motorists may discourage bicycle use in such environments. Roads designed for higher vehicular speeds are likely to be unsafe for bicyclists, and they may be prohibited from using those transportation corridors.25

Density

Low-density land usage promotes car use rather than utilitarian physical activity due to the significant time necessary to traverse the distances between origin and destination.
Although it is frequently combined with other elements that discourage active access (such as no sidewalks) this is primarily an issue of scale. A developer may not think twice about locating a new store far away from the urban core because it is only "15 minutes away." However, that distance may be an hour or more for a bicyclist, or 3 hours for a walker.26

Public Transit

Public transportation represents a bridge between distant walkable destinations. Absent service or inadequate service discourages the use of public transportation in conjunction with physically active transit. Because public transit generally incurs more walking or biking between trip origin/destination and transit stops, it is considered more physically active than automobile use for the purpose of this paper.

Consequences of Limiting Physical Activity

Physical inactivity has a profound societal impact. Low levels of physical activity were estimated in 1996 to cause 255,000 excess deaths per year in the United States27, and direct medical costs attributable to a lack of physical activity were estimated to exceed $76 billion in 2000.28 The individual health benefits resulting from regular physical activity are numerous, including (but not limited to) reduced risk of premature death from cardiovascular disease, reduced risk of developing non-insulin dependent diabetes, reduced blood pressure, improved bone density, reduced feelings of depression and anxiety, and reductions in overweight and obesity.

Obesity (defined as a body mass index > 30) has garnered the most attention over the past 5 to 10 years, due to rising prevalence, and the implications for obesity-related disease. The prevalence of obesity rose from
15% in 1980 to 31% in 2002. Mortality attributable to obesity is estimated to be between 112,000 and 300,000 excess deaths per year, which, at the higher estimate, would be the second highest cause of preventable death, after smoking. Relative risks of death attributable to obesity range from 1.38 to 1.58.

The economic costs of obesity are substantial. Economic estimates from the 1998 Medical Expenditure Panel Survey (MEPS) and 1996/7 National Health Interview Surveys (NHIS) estimate 1998 fiscal year overweight/obesity-related medical expenditures at $51.5 billion and $78.5 billion respectively. (The large differential is primarily due to the inclusion of nursing home expenditures in NHIS.) Half of these costs were paid by either Medicaid or Medicare. More data, using the above sources in conjunction with the Behavioral Risk Factor Surveillance System (BRFSS) estimated total obesity-related medical expenses at $75 billion, with individual states ranging from $87 million (Wyoming) to $7.7 billion (California). Other social costs, such as decreased productivity, worker’s compensation injuries to medical personnel who attempt to transport obese patients, discrimination, infrastructure costs, and social isolation are more difficult to estimate.

Because it is difficult to estimate what portion of obesity is due to lower levels of physical activity versus other factors (such as inappropriate nutrition), deriving the exact proportion of disease that is attributable to specific changes in urban design may not be possible. Similarly, not all physical inactivity is due to poor urban design. Further research is needed to elucidate the strength of association and/or causation between urban design, physical activity, and disease.

However, the current structure of transportation policy and decision-making does not account for the consequences of limiting physical activity by
limiting the active transportation infrastructure at all. The structure of transportation policy continues to reflect the historical and ongoing preeminence of the automobile, and acknowledges societal costs only in a very limited framework. These concessions exist primarily in the realms of air pollution (the Clean Air Act) and Environmental Justice. The structure of Clean Air Act policy will be considered in more detail as it has been the primary impetus for limitation of automobiles and encouragement of physically-active transportation. Environmental Justice utilizes a model for assessment of community impact in transportation projects, which mirrors the structure for Health Impact Assessment (HIA).35

The current structure of transportation policy is a complex mix of funding programs, governmental hierarchy, and engineering/planning disciplines that leaves considerable gaps in the assessment of health consequences.

STRUCTURE OF TRANSPORTATION POLICY AND FUNDING

The structure of the transportation policy and implementation process is diffused across federal, state, regional and local government. In the broadest terms, funding is primarily Federal, decisions are primarily made at the state level, and most need is local. Some funding is targeted towards specific uses, and other funding can be used more flexibly. Whether funds have designated uses, and whether state or local governments control fund use significantly determines what type of projects are built.
Funding Structure

In general, transportation funding comes from the federal government, and implementation is the responsibility of the state government. Historically (particularly since the Interstate Highway and Defense Act), funding was targeted towards highway expansion, and decisions about project necessity were the purvey of state governments. Local governments historically have had little say in the transportation decision process, except by directly lobbying their state governments.36

The 1970 Clean Air Act set National Ambient Air Quality Standards (NAAQS) for specific air pollutants and required each state Department of Transportation to submit a State Implementation Plan (SIP). The SIP is a transportation plan that includes all of the transportation projects planned by the state; it also must outline how the state plans to meet air quality standards in the context of their planned projects. Ongoing, severe violation of air quality standards could result in the ultimate disincentive: withholding of Federal highway funds. After passage of the Clean Air Act, funding priorities for infrastructure seemed better designed to consider the consequences of increasing automobile transportation. However, the reality of implementation changed very little, at least until 1990.37

In the 30 years following the 1970 Clean Air Act, the policy structure changed further, with the creation of Metropolitan Planning Organizations (MPO) in 1974 and the passage of the 1990 Clean Air Act and the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA).
MPOs are regional, multi-stakeholder groups for metropolitan areas with populations that exceed 50,000. They formulate a transportation plan for their metropolitan area, which becomes the basis for the state transportation plan for that area. The power of the MPO in transportation decisions improved during the 1990s, with the passage of ISTEA and its follow-up, the Transportation Equity Act for the 21st century (TEA-21). However, in many areas, the MPO plan remains more of a “wish list” for the state Department of Transportation (DOT) to accept or reject. 

ISTEA, the Clean Air Act of 1990, and TEA-21 changed the structure of Federal transportation funding to shift priorities away from highway expansion. MPOs were given increased authority to approve projects and work more cooperatively with state DOTs in determining funding priorities. Three new programs were created that could provide funding for active transportation. One program, the Congestion Mitigation and Air Quality Improvement Program, or ‘CMAQ’, was targeted towards areas with higher air pollution. A new program was created to fund new public transportation systems, called ‘New Starts’. In addition, more of the general “Surface Transportation Funds” (STF) could be used for projects other than highway expansion. This was termed “flexible funding”. Ten percent of STF was to be used exclusively for Transportation Enhancement programs, which from among a list of 12 varied activities (including such diverse items as landscaping and preservation of historic transit buildings), could include bicycle/pedestrian programs.

TEA-21 remains the operative Federal transportation funding agreement, although there are Senate (TEA-LU) and House (SAFETEA) versions of a new funding package in process. The three new programs developed under TEA-21,
detailed below, remain the primary funding avenues for active transportation projects.

Congestion Mitigation and Air Quality Improvement Program (CMAQ)

The Congestion Mitigation and Air Quality Improvement Program (CMAQ) was first implemented in 1991 as part of the ISTEA transportation bill. The primary goal of CMAQ is to fund pollution-abating transportation projects in air quality non-attainment and maintenance areas, which includes physically active modes. CMAQ funds constitute only about 1 percent of federal transit funds, so large projects generally cannot be undertaken. However, CMAQ funds are quite flexible and may be used for a variety of active transportation measures, including Bike/Pedestrian programs and public transportation.\(^{41}\) CMAQ funds are provided to State DOTs, not directly to the area MPOs.\(^{42}\)

Surface Transportation Funds

Surface Transportation Fund flexibility that began with ISTEA was supposed to diversify transit options and allow more local decision-making. However, as with CMAQ, Surface Transportation funding goes to State DOTs, and thus how those funds are allocated to local areas remains primarily under the control of state Departments of Transportation. Some states do directly suballocate CMAQ and Surface Transportation Funds to the MPOs for local transportation decision-making, but most do not. States that maintain more control over surface transportation funds and CMAQ funds have not funded local/regional non-highway transportation projects as well as states that directly
allocate funds/decision-making to MPOs. As such, only 6% of flexible funding has been used for transit projects or bicycle/pedestrian projects. A majority of states continue to maintain direct or indirect control over MPO funds and local decision-making. As alternative transportation systems are primarily local/metropolitan structures, and often expensive, states are generally much less likely to fund mass transit or bike/pedestrian projects as opposed to 'state-level' projects.

New Starts

The primary direct federal funding for local transit projects comes through the Federal Transit Authority (FTA) “New Starts” program. Only the New Starts program provides all of its funding to MPOs, constituting 7% of federal transportation funding. The small amount of funding for this program, combined with intense competition for funds between dozens of metropolitan areas means that many projects will not be funded, despite local or MPO preference.

Transportation Planning: Decision Process

State DOTs and local MPOs are the primary agents in the decision to modify or expand transportation infrastructure. While funding constraints, as noted above, can dictate the type, scope, and mix of projects undertaken, the specific projects are generated by state and local authorities. Two central components of this process are Level of Service (LOS) indicators and Demand Models.

The fundamental tenet of transportation decision-making is that it attempts to be demand-responsive. Expansions of the road network, and the characteristics of that expansion are meant to reflect either 1) currently ‘unmet demand’, in the
form of congestion, or 2) anticipated demand based upon predicted changes in land use.\textsuperscript{47}

Levels of Service ascribe a grading system to roads based upon several road conditions, including both the state of the infrastructure (cracks in road) and performance (speed and flow of vehicles.) Roads with a low level of service ("F") might have poor physical condition combined with gridlock. Roads with low levels of service are targeted for expansion, based upon the idea that demand, in a gridlock situation, exceeds capacity.\textsuperscript{48}

Demand Models are used by transportation planners to anticipate demand based upon changing land use patterns. For example, if a large new housing development were to be built along a two-lane highway, transportation planners would use linear regression models to predict the amount of new trips that would generated, and what mode (car, bus, bike, walk) they would use. They then expand roadways to a capacity level commensurate with anticipated demand.\textsuperscript{49}

Transportation Control Measures

Although ISTEA and TEA-21 represented a sea change in the philosophy of Federal transportation funding, the funding allocated and actually ‘flexed’ to these programs remains small. The primary impetus for funding of active transportation remains “non-attainment” of air pollution goals in a specific metropolitan area.

Historically, part of the State Implementation Plan for areas that were in violation of the air quality standards was to include “Transportation Control Measures” (TCMs). Transportation Control Measures are a set of strategies to
reduce automobile use, and are often referred to in contemporary literature as "Transportation Demand Management." Transportation analyst Michael Meyer refers to these strategies as "carrots and sticks." While programs to improve the active transportation infrastructure could be considered 'incentives' for physical activity, Transportation Control Measures also include 'disincentives' to drive. Categories of TCM include: *Traffic Limitation*, which can range from traffic-calming measures to car-free zones, aims to impede automobile use, *User Fees*, which use market theory to pass on more of the cost of driving infrastructure and associated costs to drivers, and *Land Use/Transportation Linkages*, which seek to develop cities in such a way as to encourage non-automobile transit modes and reduce trip length.

By 1971 the EPA had outlined 10 sample TCMs, broadly including emission control measures, traffic control measures, bicycle/pedestrian programs, and mass transit measures. This was the first point at which the federal government attempted to shift people away from car trips towards other modes of transportation. However, the presence of emission controls allowed states a technological 'out' from the politically difficult challenge of limiting driving. Emission controls became the de facto standard, while other Transportation Control Measures were not as widely implemented. One reason is that many states felt that the alternative transit options were the most expensive option to meet the air quality goals. Federal Highway funds could not be diverted to pay for mass transit or bicycle/pedestrian strategies. Thus, while states with areas in violation of the air quality standards were required to place TCMs in their implementation plans, the chosen TCMs rarely involved changing travel behavior.
Each of these broad methods can be used alone, or, more typically, in concert with one or more other methods. For instance, a 'Transit-Oriented Development' would generally cluster dense residential and commercial development around a public transit station, networked with good bike and pedestrian accessibility, possibly with traffic-calming measures to make the streets more pedestrian friendly.

User Fees

Market based fees include a range of interventions, some of which have both conservative and liberal political support. Internalizing more the 'real' cost of driving and car use into what the consumer pays can level the market playing field between car use and physically active transit. User fees can act as both a disincentive to wasteful car use, as well as a source of infrastructure revenue.

Types of user fees can include road pricing, which includes standard toll lanes, as well as more sophisticated permutations such as High Occupancy Toll (HOT) lanes and congestion pricing which varies toll prices with traffic congestion. Distance pricing is a more controversial user fee, which uses a variety of mechanisms to charge user fees for greater distance driven. Permutations include pay as you drive insurance, and distance fees paid at gas pumps, inspection, or registration.

Marketing

Programs that seek to shift transportation behavior through marketing strategies have potential to reduce trips and increase modal shift. Two social
marketing programs, IndiMark, originating in Europe, and Travel Blending, originating in Australia, seek to link messages to promote reduction of car trips and choice of non-car modes of transportation to individual motivation. Through a combination of individually tailored education, motivation, and reinforcement, the individual benefits (such as time/money savings) of less car trips and more use of alternative transportation are emphasized.

These methods have, in specific areas of Europe and Australia, lowered the number of individual car trips, and shifted more people towards public and physically-active transportation.57

Land Use Modification

Land use and transportation linkages are policy modifications that seek to link transportation planning with land-use planning such that land use reflects the overall goal of trip shortening and/or reduction and encouragement of alternative mode use. In the context of new construction, this is most frequently referred to as Transit Oriented Development (TOD). TOD is, in a general sense, less about retrofitting the current built environment with functional transit than about creating a new urban environment consisting of land use and transit as a cohesive structure. As such, it uses a mixture of the above modalities. Lower-density urban form (such as in a typical suburb) are difficult to service with public transit. The larger distances between structures, and the typically poor bicycle or pedestrian connectivity may mean that fixed transit stations are “inaccessible” to almost everyone, and physically active transportation impractical. Thus car use is self-sustaining; transit is inaccessible, sidewalks are non-existent, bicycles are unsafe on high-speed roads, so people use their cars. More car-oriented
development is built, making destinations more inaccessible, so people use their cars more. If higher density, walkable areas are built around transit stations, the potential exists to make transit accessible for longer trips, and walking or bicycling feasible for shorter trips. In this way, planners and developers seek to emulate the late 19th century streetcar suburbs – dense, walkable areas clustered around stops on the rail line.\textsuperscript{58} This concept can create “town centers” around rail stops, if judicious planning is involved.\textsuperscript{59} This type of planning, based on “new urbanist” or “smart growth” principles, seeks to create mixes of commercial and residential uses.

Land-use and transportation linkages have been most successfully implemented in Portland, Oregon. The 1000 Friends of Oregon succeeded in implementing the LUTRAQ (Making the Land Use, Transportation, and Air Quality Connection) plan and defeating a proposed highway bypass. The policy changes have included land use strategies typified by TOD, as well as bolstering of alternative modes and parking fees. These policies also exist in concert with Portland’s urban growth boundary (UGB) which limits the outward spread of development from the urban center.\textsuperscript{60}

**Barriers to Implementation of Transportation Demand Management and Active Transportation**

While the design and policy tools to create an active transportation environment are no mystery, implementation of these tools remains suboptimal. While specific areas, such as Portland, have successfully implemented strategies to improve active transportation, most other areas have not. Multiple barriers continue to prevent the realization of a robust active transportation network.
Flaws in the Decision Process

As noted above, when a roadway receives a poor Level of Service grade, the traditional response of the state DOT is to expand the roadway. Theoretically, this would alleviate road congestion. However, there is serious concern, and supporting data, that road expansion does not satisfy demand, but rather induces demand. Thus, the more additional lanes that are added to a road network, the more vehicular trips will be made, until, presumably, gridlock resumes.

The Demand Models used to predict trip generation come from the Institute of Transportation Engineers (ITE). The quality of data used to generate the models varies widely, and the degree of variation explained by the models (R-squared) is often poor. Moreover, the data used to generate the models was typically gathered in suburban settings (such as housing developments and shopping malls) with large amounts of free parking, little or no bike/pedestrian infrastructure, and no public transit. These models are used to assess "mode choice" (which form of transportation individuals choose to utilize). Mode choice models strongly favor automobile usage, because the majority of individual trips are by car or truck. The question is whether this truly represents a choice; i.e. does the state of the transportation network allow people to make an effective choice between modes? If there are no sidewalks, bike lanes, or public transit, then choice does not truly exist. When these models are used to create new transportation networks, the networks they create will resemble those of the suburban data sources.

The cycle created by highway expansion -> induced demand -> suburban development -> predictive demand modeling -> highway expansion can function
as an ongoing engine for urban sprawl. When combined with funding priorities geared towards highway and road building rather than physically active transit, there is little impetus to create bicycle, pedestrian, or mass transit networks.

Engineering Conflicts

Transportation engineers use a set of standards to formulate the design of a highway. The most commonly used reference is the *Policy on Geometric Design for Highways and Streets*, published by AASHTO, and commonly referred to as the "Green Book". The Green Book, as previously noted, was adopted as a set of standards for the design and construction of the Interstate Highway System. Under 1991, any road built with Federal funds was required by the Federal government to be built according to Green Book standards.63

The Green Book is primarily focused on vehicular safety. What this means for road design is straighter, wider roads with few opportunities for collision. Roads are designed to have a significant margin for error. While in principle, this seems to be sensible, in practice the safety concern and performance concern is for the drivers, not the bicyclists or pedestrians who seek to share the right-of-way. Features that make pedestrians feel safer, such as trees or parked cars between the sidewalk and the street, are potential collision hazards for automobiles. Wide lane widths may not leave room for bike lanes, and bicycle and/or pedestrian infrastructure may be omitted to prevent cars from hitting them.64

While the Green Book is no longer required for Federally funded roads, in practice, transportation engineers continue to follow the guidelines. The primary reason is to avoid liability. Government agencies and individual engineers are
concerned that deviation from the standard might expose them to increased liability, should accidents occur along a 'non-standard' right-of-way. However, integrating bicycle/pedestrian infrastructure into the right-of-way often requires 'non-standard' design, and thus may face a more arduous approval process.65

Emission Models

When faced with how they will meet deteriorating air quality standards, most state DOTs have opted to use surface transportation funds to increase highway capacity rather than fund active transportation. Theoretically, this will increase vehicle operating speeds, which should produce less air pollution than stop/start traffic. Thus, when using predictive models for their State Implementation Plans, most air quality goals are “met” in the models by increasing highway capacity. This allows state DOTs to maintain an automobile-focused transportation infrastructure and avoid implementation of infrastructure and policy more conducive to active transportation.66

However, the modeling system (called “MOBILE”) makes a series of assumptions about other factors, such as land use, trip length distribution, and time of travel that assume no change in those factors for build vs. no-build arguments. By holding other factors constant, the DOT can show emissions reductions based upon more vehicles moving at ‘ideal’ speeds for lowest emissions.67 Thus, predictive models may show that active modes of transportation are not ‘necessary’ in order to achieve air pollution goals.

Fund Distribution

While urban areas are most likely to be concerned with infrastructure for active transportation, several factors put urban areas at a funding disadvantage.
The urban road infrastructure is generally owned by the urban government, whereas rural roadways tend to be owned by state government. Three million out of the 4 million miles of roads in the US are locally owned. State controlled funds thus tend to favor rural road building and maintenance. Cities tend to contribute more to transportation tax revenues than they get in return. For instance, Denver receives 69% of contributions to transportation revenue, Seattle raised 51% of Washington state's total revenue and received 39% of its transportation funding. Also, MPOs are, by federal law, comprised of a diverse group of stakeholders, including freight, public transit, Amtrak, port, and airport authorities. State planning processes are not subject to federal certification; although the state plan is reviewed by the federal government, failure to consider specific factors or groups is not subject to court review or penalty.

Community Impact Assessments

As an outgrowth of the assessment requirements delineated by the National Environmental Policy Act (NEPA) of 1969 and Title VI of the Civil Rights Act of 1964, governmental agencies (including transportation agencies) are required to perform impact assessments for government-funded projects. These assessments must include an accounting of the negative effects that may result from the implementation of said projects. Additional federal legislation has expanded the role of community impact assessment to include areas such as environmental justice. The most stringent requirements revolve around the formation of an Environmental Impact Statement (EIS) as defined under NEPA. An EIS is not only a matter of public record, but must be shared with all other governmental agencies that may have direct or indirect stewardship of the affected environment.
Community or environmental impact assessments do not account for the range or severity of health effects that can result from the limitation of physically-active transit. An assessment of disease attributable to policy change or project A full Health Impact Assessment (HIA) is recommended for transportation projects by the World Health Organization (WHO) for its "ability to influence policies, programmes and/or projects. This provides a foundation for improved health and well-being of people likely to be affected by such proposals."72

Cost-Benefit Analysis

Cost-Benefit Analysis (CBA) is an economic tool used by decision-making organizations to quantify the net economic effect of a project or intervention. Because governmental bodies place a strong emphasis on cost-benefit analysis in deciding whether a project should move forward, the analysis should include the full spectrum of societal costs.

However, the direct and indirect health costs of transportation decisions are not generally factored into the cost-benefit analysis (CBA) of transportation projects.73 One difficulty with doing so is that the portion of health costs attributable to a lack of active transportation infrastructure is not easily separated from total costs. More easily defined health risks, such as the costs of injury due to motor vehicle accidents, are generally included in the CBA. There is significant argument regarding the validity of CBA; depending on the previously established view of the critic, some detractors argue that CBA undervalues benefits, others argue that it overstates costs.74
Political Resistance

Attempts to implement Transportation Control Measures may incur significant resistance. State Departments of Transportation, property rights advocates, business advocates, road construction interests, automobile manufacturers and many others have a vested interest in the ongoing growth of the automobile/road-based infrastructure.

Even when Transportation Control Measures are included in state transportation plans, many states do not adequately implement them. In 2002, EarthJustice sued the San Francisco transportation authority for failure to take steps to boost ridership of public transportation in the Bay Area. The grounds were the failure to enforce “TCM2”, a set of transportation control measures adopted by CA in 1983.75

Public and corporate resistance to demand management strategies is often a significant barrier to implementation. The South Coast Air Quality Management District (SCAQMD) of southern California attempted to enact regulations that would require companies with 100 or more employees to increase the average vehicle ridership over a specified period, using any combination of strategies. When this proved to be of negligible effectiveness, SCAQMD instituted Rule 2202, which required employers to reduce incoming car trips to meet a site-specific air pollution target. Resistance from the corporate sector led to a series of enfeebling measures by the California State Legislature. The voluntary character of the new regulations resulted in minimal participation in the program by eligible companies.76
FUTURE POLICY DIRECTIONS

Despite resistance, progress has occurred since the enactment of ISTEA. Funding has shifted from highway building to maintenance (from $6 billion to $16 billion.) Money spent on transit has doubled, from $3 billion to $6 billion. Spending on bicycle/pedestrian programs has increased from $7 million to $222 million. New transit systems are being built or planned in multiple communities, even traditionally sprawl-based communities such as Dallas, Las Vegas, San Jose, and Charlotte. For the first time since World War II, growth in transit ridership has outpaced growth in driving for 5 straight years. However, the overall investment in active modes of transportation remains miniscule in comparison to that for cars or trucks. Policy modifications are necessary to adequately link the health consequences of physical inactivity with transportation decisions and funding.

The Need for Research

Robust data are needed to substantiate the strength of the link between urban form, physical activity, and the consequences of limiting active transportation. While research is ongoing, this remains a nascent field. Multiple research projects are underway to better define the parameters of urban form that most significantly affect human health. Although well-controlled studies will be difficult, evidence for causation is particularly essential.

In addition, research is needed to improve the data used in the transportation demand modeling structure. Both quantity and quality of data are lacking, and data tailored to more specific environments (such as new developments with traditional neighborhood design) are needed.
With this combination of improved data, the potential exists for more sophisticated models that combine spatial epidemiologic data for environmental disease with trip generation data, using interaction terms, to estimate trip generation at the 'socially optimal' level.

Transportation Process Reform

A multi-disciplinary perspective must extend to the tools used by transportation planners and engineers to develop new infrastructure. Broad policy changes will be ineffectual if the assumptions built into the transportation planning tools continue to devalue active transportation.

The Level of Service (LOS) assessment process is in need of reform. High road congestion levels should not necessarily imply a poor LOS grade. Considering what we know about induced demand\textsuperscript{76}, congestion may represent an equilibrium point in a supply/demand function. When this congestion is framed as a problem to be solved (by widening roads), the supply/demand function will shift to the new equilibrium point. Congestion represents a cost of driving; by continuing, as a society, to subsidize this cost, we create an incentive to drive more.

Level of Service also contains an assessment of road connectivity, condition, and safety. This is an appropriate assessment of infrastructure condition, and such measures should be assessed for the active transportation network as well. By not assessing the active transportation infrastructure, transportation officials can turn a blind eye to the network, and it becomes nobody's problem rather than everyone's.

Predictive models of transportation "trip generation" and "mode choice" are predicated on several assumptions: that people have a true choice, that car-
based suburban models are adequate data sources, and that even that individual ‘choice’ is the best basis for decisions about societal investment. By framing the models as ‘choice’, transportation decision-makers give the impression that the process is positive rather than normative, i.e. it reflects ‘reality’ rather than being prescriptive. However, when the chosen reality is biased towards a specific land-use and transportation mix, they are, in fact, normative. Models based upon individual choice should reflect decisions made in an environment with transportation equality.

Transportation planning and land use planning need better integration at every level of government. Bicycle/pedestrian networks will not function optimally without a concomitant reduction in urban sprawl. While a full discussion of policy to promote denser land use is beyond the scope of this paper, solutions generally fall into two broad categories: 1) strategies to develop the traditional urban frame (the “pre-car” city) and 2) strategies to build new development with greater density (new urbanism).

A sampling of strategies to promote redevelopment of the urban core would include: revision of federal mortgage insurance guidelines to favor (or at least not disfavor) infill development and small-scale mixed use projects. Historic preservation tax credits should be extended to include residential properties and should apply to any pre-1950s structure, not just those in historic districts. Legislation to make this change was last introduced in the 107th Congress (H.R.1172) and referred to the House Ways and Means Committee as its last action. Non-rural zoning should have property taxes increase with distance from the city center. The EPA Brownfields Initiative and funding from the Brownfields Revitalization Act (2002) help to spur redevelopment of urban industrial sites and should be extended.
A sampling of strategies to promote denser suburban development would include public-private partnerships to develop dense communities around planned mass transit stops (the aforementioned Transit Oriented Development). Urban growth boundaries have had some success in Portland, OR, by constraining available space for development. Local changes in outdated zoning regulations that prohibit mixed use development and codify the 'typical' subdivision are needed. Government needs to modify its own actions in promoting sprawl; legislation was introduced in the 107th Congress to have the Council for Environmental Quality study urban sprawl for inclusion under National Environmental Policy Act (whereby 'sprawl-inducing' actions would need to be considered in any new Federal project) (HR1739). Its last action was referral to the Committee on Energy and Air Quality in 2001.80

Federal Funding Linkages and Reform

Ongoing shifts in federal transportation funding to even the playing field between active and motorized transportation are necessary. Significant increases in funding for bicycle and pedestrian programs should be directly suballocated to Metropolitan Planning Organizations, where they are most needed. Recognition of an explicit link between transportation and health should be codified in federal policy, such as defined funding linkages between DOT funding, HHS funding, and HUD funding. Integrated programs can fund community redevelopment, bicycle/pedestrian infrastructure, and community health education and promotion as a model of multi-disciplinary partnership.

Federal agencies could also implement a conformity structure, modeled upon the Clean Air Act conformity structure, to assess other societal consequences of transportation decisions, such as obesity. Transportation
funding could then be tailored to favor active modes and institute Transportation Control Measures in areas with, for instance, a higher prevalence of obesity. Experience with the Clean Air Act would suggest that such a structure could only be implemented under unique circumstances, and that loopholes would be likely additions.

The structure of transportation funding will need to change to allow more funding control for local governance structures where local issues are concerned. A greater percentage of Surface Transportation Funds should be directly suballocated to the Metropolitan Planning Organizations for transit and bike/pedestrian funding. All CMAQ funding should be directly suballocated to MPOs in air pollution violation areas. This would allow these funds to be used for local Transportation Control Measures, where they are most needed.\(^{81}\) The stature of MPOs needs to be elevated in policy and decision making, particularly in areas that suffer the greatest burden of problems that could be exacerbated by not funding active transportation. These areas should be able to submit their transportation plans directly to the FHWA, so as to not have their transportation modification needs subsumed to the state.

Highway dedicated funding should focus away from highway expansion and provide funding primarily for safety and maintenance (a trend begun with ISTEA and TEA-21). Expansion funding should default to HOT or HOV lanes (including dedicated busways), which have politically conservative support. A multi-stakeholder review of modeling programs should be undertaken to determine their "realism level" in the face of outward expansion that meets and exceeds highway capacity.

The true costs of automobile transportation need to be internalized to automobile consumers. Increases in gasoline taxes to reflect the full costs of
energy use, infrastructure, pollution, inspection programs, enforcement, licensing, and safety, would put automobiles more on a par with alternative transportation.

Expansion of the Commuter Tax Fringe Benefit (which currently allows employers to offer untaxed benefits to their employees who carpool or vanpool) to include bicycle/pedestrian commuters should remain on the policy agenda. Legislation was introduced in the 107th Congress to extend this benefit to bicycle commuters (HR1265), but remained in committee. (Thomas.gov, 2005)

A more radical funding reform would be to tie federal health care funding to transportation and/or land use. As immense (and growing) federal money goes to fund not only Medicare and Medicaid, but also FEHBP, VA, active military, HRSA, and innumerable other programs, the federal government is a major stakeholder in the health effects of inactive transportation (as well as all land use decisions affecting human health). Areas that fail to develop a suitable action plan to increase the active transportation infrastructure would receive lower Medicare reimbursement or Medicaid funding. Although highly unlikely, linking reductions in health-care reimbursement to inadequate attention to environmental disease risk factors would be less capricious than the current policy of reductions based simply upon the expense of health care. If this were to include reversals of the massive traditional federal subsidy of tax exemptions for employers for payment of their employees private health insurance, as well as eventual, phased-in lowering of Medicare payments to providers practicing in areas that do not follow through on action plans, pressure on state and local agencies from constituents would be significant. Incentives (greater than typical payments) could be extended to areas that make significant progress in environmental improvement. While lowering payments to areas with potentially
greater health impacts may seem unethical, the federal government is such a major stakeholder in health effects that such measures are justifiable.

Health Impact Assessment

Policies supporting the inclusion of HIAs exist throughout individual European countries, in the European Union constitution, and in Australia and New Zealand. Multiple projects have utilized HIAs, and WHO has endorsed their effectiveness in these projects.\textsuperscript{82} The British Department for Transport (the equivalent of the U.S. DOT) endorses the use of HIA in project development, and acknowledges the role of transportation policy in the prevalence of CHD.\textsuperscript{83}

As of yet, HIAs are not a part of the formal policy structure in the United States. Although community or social impact assessments may include information about community health\textsuperscript{84}, there is no specific policy mandate to account for human health effects, as is required for the environment by NEPA. A model health impact assessment, along the lines of a NEPA-required environmental impact statement, is being developed by a coalition in Detroit, MI with reference to a proposed widening of the Ambassador Bridge.\textsuperscript{85} The San Francisco Department of Health has also begun developing Health Impact Assessments for local transportation projects.\textsuperscript{86}

Cost-Benefit Analysis Inclusive of Health Costs

Although it is likely impossible to establish an unbiased economic evaluation tool, evidence of an association between poor active transportation infrastructure and sedentary lifestyle should not be ignored in CBA. While quantifying these costs will remain a point of debate, poorly defined costs, such as environmental externalities and lives lost due to injury, are included in CBA.\textsuperscript{87}
If the ongoing accumulation of evidence continues to support a positive correlation and better evidence for causality emerges, a reasonable case exists to develop a framework for inclusion of sedentary lifestyle costs in CBA.

**Integrated Public Health and Urban Planning**

New linkages between the policy, community program planning, and research arms of public health and urban planning are necessary. Although still quite new, partnerships are more mature in the program planning and research arenas than they are in the formal policy structures of government. Local public health departments generally have a minor role in local public health decisions, centered on issues of sanitation. However, local health departments should embrace a formal role in the local transportation and land use decision process that reflects the potential health consequences of those decisions. Co-directed programs focused on cross-disciplinary public needs, such as a nutrition, exercise, and trail/sidewalk building program, have the potential to reduce communication barriers and provide a more efficient utilization of resources.

**Mobilization of Health Providers in Community Prevention**

Health providers are an essential part of the process to increase physical activity. However, several barriers must be surmounted to fully engage medical providers. First, providers struggle to deliver adequate preventive care services. Second, the traditional message of exercise is recreational, rather than utilitarian. Third, even providers who excel at delivering preventive services may not think of community prevention as part of their job; i.e. all prevention should be delivered in the context of an office visit. While community prevention is the traditional
purvey of public health departments, providers have actual contact with the patients, and can potentially provide a more accurate assessment of community need from the perspective of the community. The barriers between preventive services and reactive service as well as medical providers and public health officials reach far beyond issues of active transportation networks. However, recognition of longstanding cultural barriers is key to designing an effective program.

At a minimum, providers should recognize and discuss the benefits of utilitarian exercise and should question patients about the status of their surrounding environment. Do they have a place to walk? Are they afraid to exercise because of traffic, poor lighting, or bad sidewalk conditions? Such information is essential to adequate preventive counseling.

Conclusion

Transportation engineers and planners have argued that building automobile infrastructure to meet what they perceive as current and anticipated future demand is both the most relevant and the most necessary function of transportation planning. They have also argued that doing so does not promote increased use of automobiles. Their argument is that people want to drive, and the job of transportation planning is to meet that demand. Expanding the automobile transportation network theoretically improves transportation efficiency to help the economy grow.

It is true that public transit, even when available, is often underused. People who choose where to live based upon their ability to walk or bike to work are anecdotally uncommon, and trips made by automobile dwarf those by active
modes. In the most recent Bureau of Transportation Statistics National Household Travel Survey, 87% of daily trips were made by personal automobile, 8.6% by walking, 1.5% by transit. 94

What is unclear is whether this represents solely a choice to drive, or whether driving is really the only tenable option to reach a destination. If the alternative necessitates using a chronically underfunded, oft poorly connected infrastructure to travel between distant origins and destinations, then there is little choice involved.

Thus, do Americans have the choice to pursue active living in accordance with exercise recommendations? Or does inadequate infrastructure prevent them from doing so? What evidence exists suggests that it does. 95

By not accounting for the health consequences of transportation decisions that limit active transportation, policy-makers ignore the true societal costs of a automobile-dominant transportation infrastructure. Frequently, the federal government is paying twice: once for the transportation infrastructure, and again for Medicare/Medicaid costs to treat diseases exacerbated by environmentally.

To stem the rising prevalence of diseases related to a sedentary lifestyle, transportation policy, funding, and decision-making must change to reflect the consequences of a paradigm that effectively excludes active transportation. Transportation decisions do not affect cars in isolation. The decision to build a road rather than a sidewalk has broad societal effects, including an effect on the health of the population. Transportation decisions must include a multidisciplinary perspective, as well as explicit consideration of the wide-ranging benefits and consequences of specific actions for transportation infrastructure to truly be for the 'greater good' of society.
## Appendix I

Guide to Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>BRFSS</td>
<td>Behavioral Risk Factor Surveillance System</td>
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<td>CAA</td>
<td>Clean Air Act</td>
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<tr>
<td>CAAA</td>
<td>Clean Air Act Amendments</td>
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<td>CBA</td>
<td>Cost-Benefit Analysis</td>
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<td>CIA</td>
<td>Community Impact Assessment</td>
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<td>CDC</td>
<td>Centers for Disease Control</td>
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<td>CMAQ</td>
<td>Congestion Mitigation for Air Quality</td>
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<td>DOT</td>
<td>Department of Transportation</td>
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<td>EIS</td>
<td>Environmental Impact Statement</td>
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<td>EPA</td>
<td>Environmental Protection Agency</td>
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<td>FEHBP</td>
<td>Federal Employees Health Benefits Program</td>
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<td>FHWA</td>
<td>Federal Highway Administration</td>
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<td>FTA</td>
<td>Federal Transit Authority</td>
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<td>HIA</td>
<td>Health Impact Assessment</td>
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<td>HOT</td>
<td>High Occupancy Toll</td>
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<td>HOV</td>
<td>High Occupancy Vehicle</td>
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<td>ISTEA</td>
<td>Intermodal Surface Transportation Efficiency Act</td>
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<td>ITE</td>
<td>Institute of Transportation Engineers</td>
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<td>LOS</td>
<td>Level of Service</td>
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<td>MEPS</td>
<td>Medical Expenditure Panel Survey</td>
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<td>MPO</td>
<td>Metropolitan Planning Organization</td>
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<td>NEPA</td>
<td>National Environmental Policy Act</td>
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<td>NHANES</td>
<td>National Health and Nutrition Examination Survey</td>
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<tr>
<td>NHES</td>
<td>National Health Examination Survey</td>
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<td>NHIS</td>
<td>National Health Interview Survey</td>
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<td>SCAQMD</td>
<td>South Coast Air Quality Management District</td>
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<td>SIP</td>
<td>State Implementation Plan</td>
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<td>STF</td>
<td>Surface Transportation Funds</td>
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<tr>
<td>TCM</td>
<td>Transportation Control Measures</td>
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<td>TDM</td>
<td>Transportation Demand Management</td>
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<tr>
<td>TEA-21</td>
<td>Transportation Equity Act for the 21st Century</td>
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<tr>
<td>TIP</td>
<td>Transportation Improvement Plan</td>
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<td>TOD</td>
<td>Transit Oriented Development</td>
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<tr>
<td>USPSTF</td>
<td>United States Preventive Services Task Force</td>
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<tr>
<td>VHT</td>
<td>Vehicle Hours Traveled</td>
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<tr>
<td>VMT</td>
<td>Vehicle Miles Traveled</td>
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<td>WHO</td>
<td>World Health Organization</td>
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Appendix II: Evidence Tables

The following tables summarize the evidence linking urban form, physical activity, and health. Two articles included in the table are reviews of the previous literature. As these articles review the vast majority of the extant cross-sectional, survey-based studies, only some individual studies of this type are included individually in the table.

The articles were appraised on the basis of study design (cross-sectional, cohort), sample collection (size, randomization), presence of adequate comparison group, measurement of variables, intervention (if present) and adequacy of analysis. A general grade was then attached to each study, on a scale of Poor-Fair-Good-Very Good-Excellent. I consulted a study of evidence-grading, for general ideas, but this assessment is not meant to reflect their previously promulgated standard.96

Studies that were cross-sectional, non-random surveys with relatively small samples were considered to be poor evidence due to lack of external validity and confounding issues. The gold standard study design was considered to be large sample, cohort, objectively measured variables, intervention with adequate control group, long-duration, and robust analysis. As no studies to date reach all of these goals, the highest rating I gave to a study was “Good”.

These ratings are intended to assess the quality of evidence gleaned from each study, and are not intended to present a judgment of the study authors or their efforts.
<table>
<thead>
<tr>
<th>Citation</th>
<th>Population</th>
<th>Measure of Physical Activity</th>
<th>Measure of Health Variable</th>
<th>Measure of Environment</th>
<th>Study Design</th>
<th>Results</th>
<th>Quality of Evidence</th>
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<tr>
<td>Lopez, R. Urban Sprawl and risk for being overweight or obese. Am Jnl Pub Hlth. 2004 94(9): 1574-9</td>
<td>Adults, BRFSS</td>
<td>None</td>
<td>BMI</td>
<td>Sprawl Index</td>
<td>Cross-Sectional</td>
<td>Significant association s in regression model</td>
<td>Fair to Poor</td>
</tr>
<tr>
<td>Saelens et al. Neighborhood-based differences in physical activity: an environment-scale evaluation. AJPH. 2003 93(9): 1552-8</td>
<td>Adults, San Diego</td>
<td>Self-report and accelerometer data</td>
<td>Height, Weight (self-report)</td>
<td>Area specific land-use measures and transportatio n measures</td>
<td>Cohort</td>
<td>Signif. assoc b/t neighborhood chars., PA, and self-reported PA</td>
<td>Fair</td>
</tr>
<tr>
<td>Citation</td>
<td>Population</td>
<td>Measure of Physical Activity</td>
<td>Measure of Health Variable</td>
<td>Measure of Environment</td>
<td>Study Design</td>
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<td>Quality of Evidence</td>
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<td>Rohrer, et al.</td>
<td>Adults, Community Clinic Patients</td>
<td>None</td>
<td>Health (Likert)</td>
<td>Self Report</td>
<td>Cross-sectional</td>
<td>Associatioin between self-reported health and availability of walkable destinations</td>
<td>Poor</td>
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<tr>
<td>Powell, et al.</td>
<td>Adults, Georgia BRFSS</td>
<td>Survey</td>
<td>None</td>
<td>Survey - available places to walk</td>
<td>Cross-Sectional</td>
<td>Significant association between S-R places to walk and PA</td>
<td>Fair to Poor</td>
</tr>
<tr>
<td>Frank et al.</td>
<td>Adults, Atlanta</td>
<td>Survey, walking and time spent in car</td>
<td>Survey, BMI, Obesity</td>
<td>Area specific land use measures, transportatio measures</td>
<td>Cross-sectional</td>
<td>Significant relationship b/t time in car, activity, urban form and obesity</td>
<td>Fair</td>
</tr>
<tr>
<td>Cervera, et al.</td>
<td>Adults, San Francisco</td>
<td>Survey - Bay Area Travel Survey</td>
<td>None</td>
<td>Census data/Employment data to determine land use</td>
<td>Cross-Sectional</td>
<td>Land-Use Diversity significantly affects walking, LUD and infrastructure sig affect biking</td>
<td>Fair</td>
</tr>
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<td>Citation</td>
<td>Population</td>
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<td>Measurement of Health Variable</td>
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<td>Quality of Evidence</td>
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<tr>
<td>King, et al. Rel. between Convenience of Destinations and Walking Levels in Older Women. <em>Am J Hlth Prom.</em> 2003 18(1): 74-82</td>
<td>Adults -</td>
<td>Survey</td>
<td>None</td>
<td>Survey – available places to walk</td>
<td>Cross-Sectional</td>
<td>Significant association between S-R places to walk and PA</td>
<td>Fair to Poor</td>
</tr>
<tr>
<td>Frank et al. Linking Objectively Measured PA w/ Objectively Measured Urban Form: SMARTRAQ. <em>Am J Prev Med</em> 2005; 28(2) 117-125</td>
<td>Adults, Atlanta</td>
<td>Accelerometer worn by participants</td>
<td>None</td>
<td>Area specific land use measures, transportatio measures</td>
<td>Cross-sectional</td>
<td>Significant relationship b/t PA, and, urban form</td>
<td>Good</td>
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<tr>
<td>Handy, SL. Urban Form and Pedestrian Choices: Study of Austin Neighborhoods. <em>Trans Rsch Rec.</em> 1552: 135-144</td>
<td>Adults, Austin</td>
<td>Survey</td>
<td>Area-Specific urban form measures</td>
<td>Cross-sectional</td>
<td>Signif. assoc. between walkable neighborhoods and walking trips</td>
<td>Fair</td>
<td></td>
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<tr>
<td>Citation</td>
<td>Population</td>
<td>Measurement of Physical Activity</td>
<td>Measurement of Health Variable</td>
<td>Measurement of Environment</td>
<td>Study Design</td>
<td>Results</td>
<td>Quality of Evidence</td>
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<td>Patterson PK, Chapman NJ. Urban Form and Older Residents' service use, walking driving, QOL, neighborhood satisfaction. <em>Am J Hlth Prom.</em> 2004; 19(1): 45-52</td>
<td>Females, Age &gt; 70 yrs, 6 census tracts in Portland, OR</td>
<td>Survey</td>
<td>Survey</td>
<td>Objective Assessment of Census Tract characteristics</td>
<td>Cross-Sectional</td>
<td>Signif. assoc. b/t neighborhood design, access to services, physical activity</td>
<td>Fair</td>
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<td>Krizek, KJ. Pretest-Posttest strategy for researching neighborhood scale urban form and travel behavior <em>Trans Res Rec.</em>; 1722:48 - 56</td>
<td>Adults, Seattle</td>
<td>Survey</td>
<td>None</td>
<td>Assessment of urban form characteristics</td>
<td>Longitudinal Prospective Cohort x 11 yrs</td>
<td>As people move to more walkable neighborhoods, they shift some car trips to active trips</td>
<td>Good</td>
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<tr>
<td>Does the Built Environment Influence Physical Activity? Joint Report of the IOM and TRB (special report 282). Jan 2005</td>
<td>Varied</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Systematic Review</td>
<td>Evidence supports a link between the built environment and physical activity</td>
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</table>
2 Ibid, pp. 11-37


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