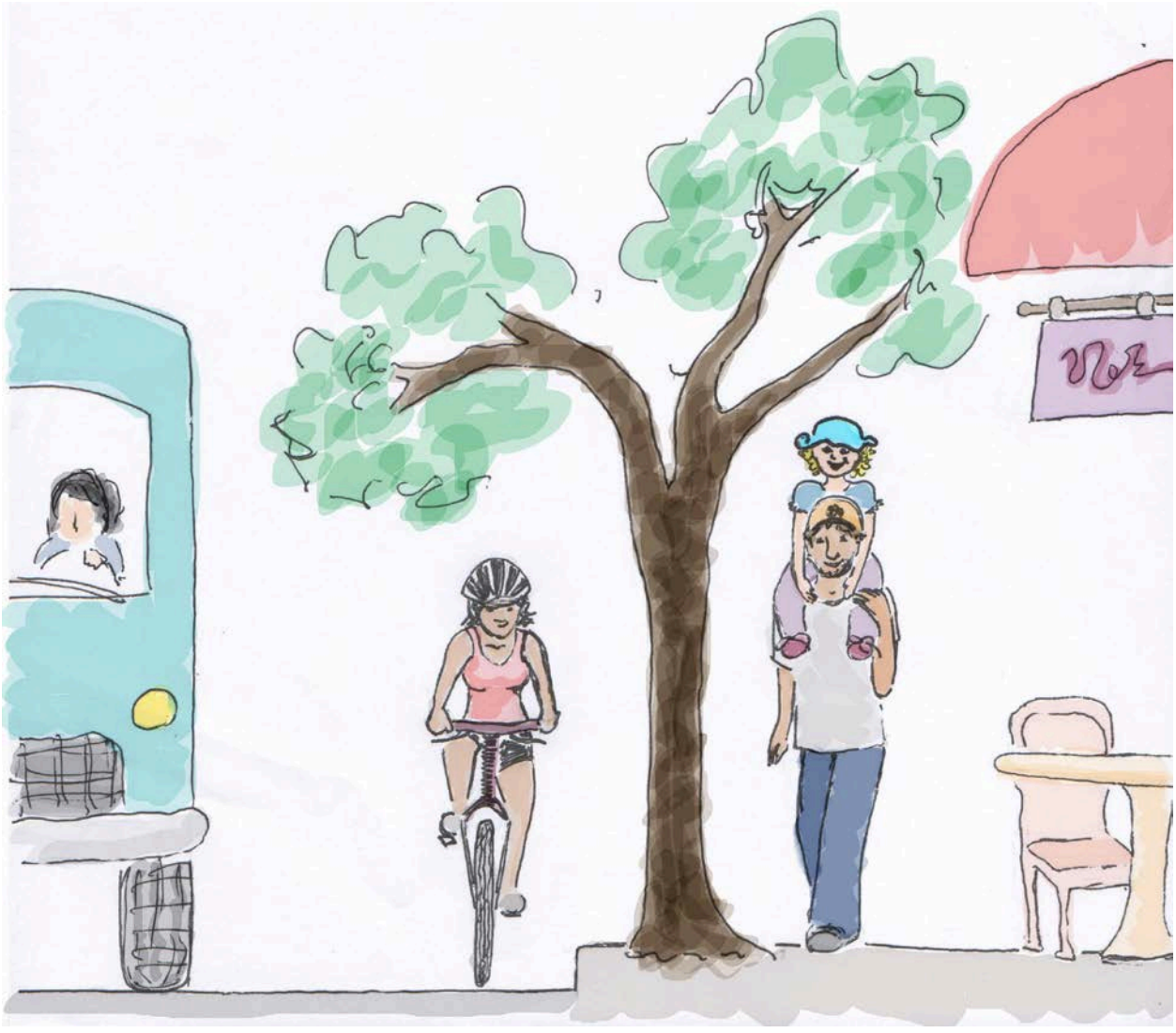
# Transportation & Health Literature Review

*Produced as part of the Bernalillo County Complete Streets Project by the Mid-Region Council of Governments*



# Transportation and Health Literature Review

## Summary

This literature review was produced as part of the *Bernalillo County Complete Streets Project*, a collaborative effort between Bernalillo County and the Mid-Region Council of Governments to provide resources to expand the knowledge base around Complete Streets principles, and emphasize the health and social benefits to communities of integrating a variety of transportation modes into street design plans, policies and programs.

In conventional planning, some public health impacts are considered, such as crash risk and the pollution from vehicle emissions, but many less easily quantifiable (yet highly impactful) factors are undervalued. These factors range from air pollution, water pollution and noise, to the negative health externalities that accompany sedentary lifestyles. While the effects from these factors are often difficult to measure, the evidence linking active transportation and health is overwhelming. Acknowledging this relationship and incorporating health data into transportation decisions will produce healthier, happier communities. **The purpose of this literature review is to provide quick access to some of the plentiful body of research evaluating the relationship between public health outcomes and active transportation.**

Accommodating active modes of transportation is a crucial element of creating healthier communities. A sedentary lifestyle has been consistently cited as a major contributing factor for obesity and related diseases such as heart disease and high blood pressure. It has been estimated that obesity and its related health problems rival tobacco in negative health impacts[1]. One study found that that "…each additional hour spent in a car per day was associated with a 6 percent increase in the likelihood of obesity," and that the inverse is true for public transit users due to the fact that transit users walk to and from transit[2].

While there is substantial evidence that sedentary lifestyles negatively impact mental and physical health, it is now a widely accepted fact that physical activity positively affects health. A moderate amount of physical activity is associated with a reduction in mortality, depression, reduced frequency of dementia, and switching from driving to more active modes can measurably reduce air pollution[3]. This is relevant to transportation and land use planners because it has been shown that a person can meet their daily physical activity needs by using

[1] Simcoe Muskoka District Health Unit. (2007). The Impact of the Built Environment on the Health of the Population: A Review of the Review Literature. Barrie, ON: Willams, M., & Wright, M.

[2] Frank, L. D., & Kavage, S. (2008). Urban planning and public health: a story of separation and reconnection. Journal Of Public Health Management And Practice, (3), 214.

[3] Litman, T. (2013). Transportation and Public Health. Annual Review Of Public Health, 34217-233. doi:10.1146/annurev-publhealth-031912-114503

active modes of transportation such as bicycling, walking, and even taking transit[4] [5]. In fact, the majority of trips happen within walking or cycling distance from the trip's origin[6]. In addition to transportation infrastructure additions and careful land use planning, educational campaigns and employer sponsored active transportation programs have been successful in spreading awareness and changing habits.

This literature review contains an annotated bibliography of 22 articles. Each article lists the author(s) and title, then an abstract. This is followed by direct quotes from text covering various aspects of active transportation and health. Imbedded in some of the quotes are footnotes, indicating a source the author cites.

[4] Killingsworth, R., De Nazelle, A., & Bell, R. (n.d). Building a new paradigm, improving public health through transportation. *Ite Journal-Institute Of Transportation Engineers*, *73*(6), 28-32.

[5] Dill, J. (2009). Bicycling for Transportation and Health: The Role of Infrastructure. Journal Of Public Health Policy, 30S95-S110. doi:10.1057/jphp.2008.56

[6] Sallis, J. F., Frank, L. D., Saelens, B. E., & Kraft, M. (2004). Active transportation and physical activity: opportunities for collaboration on transportation and public health research. *Transportation Research Part A: Policy & Practice*, *38*(4), 249. doi:10.1016/j.tra.2003.11.003

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## Todd Litman, *Transportation and Public Health*

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

**Findings:**

**Safety impacts of conventional transportation planning are often overlooked**
"Policies that make driving more convenient and affordable tend to increase per capita crash rates. Reducing congestion and increasing traffic speeds tend to increase crash severity. Automobile-dependent, sprawled land use development tends to increase per capita traffic casualty rates. Increasing the perception of vehicle and road safety encourages more intensive driving, which partly offsets crash-reduction benefits." P.221

**Physical activity associated with decreased mortality**
"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[7]." P.221

**Positive association between sedentary living, increased body weight, and related health risks**
"Research indicates that automobile travel is positively associated with sedentary living and increased body weight[8], whereas increased walking and cycling are associated with reduced obesity and related illnesses such as high blood pressure and diabetes[9] [10]." P.222

**Automobile dependence limits access to healthcare and is a barrier to disadvantaged populations**
"Automobile-dependent transport systems tend to limit access for physically, economically, and socially disadvantaged people (e.g., people who cannot drive because of a physical disability or

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[7] Woodcock J, Franco OH, Orsini N, Roberts I. 2010. Non-vigorous physical activity and all-cause mortality: systematic review and meta-analysis of cohort studies. Int. J. Epidemiol. 40:121–38

[8] Alliance for Biking and Walking. 2010. Bicycling and Walking in the U.S.: 2010 Benchmarking Report. Washington, DC: Alliance for Biking and Walking. http://www.peoplepoweredmovement.org/site/index.php/site/memberservices/C529

[9] Frank L, AndresenMA, Schmid TL. 2004. Obesity relationships with community design, physical activity and time spent in cars. Am. J. Prev. Med. 27(2):87–97

[10] Hoehner CM, Barlow CE, Allen P, Schootman M. 2012. Commuting distance, cardiorespiratory fitness,and metabolic risk. Am. J. Prev. Med. 42(6):571–78

who cannot afford a motor vehicle), which can contribute to health problems and increase health care costs[11]. One survey found that 4% of US children (3.2 million) either missed a scheduled health care visit or did not schedule a visit during the preceding year because of transportation restrictions[12]." P.222

**Association between walking and reduced stress and depression**

"Increased neighborhood walkability is associated with reduced symptoms of depression in older men[13], and reduced frequency of dementia in women and men[14]. In a study of 299 US older adults (mean age 78 years) Erickson et al.[15] found significantly higher rates of gray matter volume and cognitive ability in those who previously walked more than 72 blocks a week. High-quality public transit service can reduce commute stress compared with driving[16]." P.223

**Increased in distance of walking and cycling linked reduced traffic casualties**

In a typical situation, doubling the distances walked and cycled in an area increases pedestrian and cycling injuries by 32% but reduces risk to other road users, resulting in a net reduction in traffic casualties[17]. P.223

**Shifting from driving to active modes can reduce pollution from emissions**

Shifts from driving to active modes can provide proportionately large air pollution emission reductions because these modes tend to substitute for shorter urban vehicle trips that have high per-kilometer emission rates due to cold starts and congestion; therefore, a 1% shift from motorized to nonmotorized modes typically reduces emissions by 2–4%[18]. Such improvements also tend to increase physical activity and basic access[19]. P.223

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[11] Am. Public Transp. Assoc. (APTA). 2003. *The Benefits of Public Transportation: The Route to Better Personal Health*. Washington, DC: APTA. **http://www.apta.com/resources/reportsandpublications/Documents/better_health.pdf**

[12] Redlener I, Brito A, Johnson D, Grant R. 2006. *The Growing Health Care Access Crisis for American Children: One in Four at Risk*.New York:Children's Health Fund. **http://www.childrenshealthfund.org/sites/default/files/WhitePaper-May2007-FINAL.pdf**

[13] Berke EM, Gottlieb LM, Moudon AV, Larson EB. 2007. Protective association between neighborhood walkability and depression in older men. J. Am. Geriatr. Soc. 55(4):526–33

[14] Larson EB,Wang L, Bowen JD, McCormick WC, Teri L, et al. 2006. Exercise is associated with reduced risk for incident dementia among persons 65 years of age and older. *Ann. Intern. Med.* 144(2):73–81

[15] Erickson KI, Raji CA, Lopez OL, Becker JT, Rosano C, et al. 2010. Physical activity predicts gray matter volume in late adulthood: the Cardiovascular Health Study. *Neurology* 75:1415–22

[16] Wener RE, Evans GW. 2007. A morning stroll: levels of physical activity in car and mass transit commuting. *Environ. Behav.* 39(1):62–74

[17] 35. Jacobsen PL. 2003. Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Inj. Prev.* 9:205–9

[18] Grabow ML, Spak SN, Holloway T, Stone B, Mednick A, Patz JA. 2012. Air quality and exerciserelated health benefits from reduced car travel in the midwestern United States. *Environ. Health Perspect.* 120(1):68–76

[19] Sciara G-C, Handy S, Boarnet M. 2011. *Draft: Policy brief on the impacts of pedestrian strategies based on a review of the empirical literature*. Calif. Air Resour. Board, Sacramento. **http://www.arb.ca.gov/cc/sb375/policies/ped/ped_brief.pdf**

**Active transportation and physical fitness**
"Because most transit trips include walking and cycling links, transit improvements tend to increase physical fitness[20]." P.224

**Health benefits of parking and congestion pricing**
"Transport pricing reforms include efficient road and parking pricing (motorists pay directly for using roads and parking facilities, with higher prices under congested conditions), parking unbundling (parking is rented separately from building space, so occupants pay only for parking spaces they want) and cash out (travelers who are offered a subsidized parking space can instead choose its cash value if they use alternative modes), higher fuel prices, and distance-based vehicle insurance and registration fees (motorists pay in proportion to their annual vehicle travel). These pricing reforms can provide significant health benefits[21]." P.224

**"Smart" growth residents drive less and have lower traffic casualty rates**
"Smart growth residents typically drive 20–40% less than they would if located in automobile dependent sprawl[22]. Smart growth residents tend to have substantially lower per capita traffic casualty rates than do residents of automobile dependent sprawl[23]." P.225

**Roadway facilities impact mode share**
"More multimodal planning can significantly increase walking, cycling, and public transit travel and reduce automobile travel[24]. For example, walking and cycling more than doubled in nine US cities that invested in active transport programs[25], and urban regions with high-quality public transit systems tend to have 10–30% less per capita driving, and comparable reductions are observed in per capita traffic deaths and pollution emissions[26] [27]." P.228

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[20] Lachapelle U, Saelens BE, Sallis JF,ConwayTL. 2011. Commuting by public transit and physical activity: where you live, where you work, and how you get there. *J. Phys. Act. Health* 8(Suppl. 1):S72–82

[21] 52. Litman T. 2012. *Pricing For Traffic Safety: How Efficient Transport Pricing Can Reduce Roadway Crash Risk.* Transp. Res. Board Annu. Meet. Pap. 12–5310. Victoria, BC: Victoria Transp. Policy Inst. **http://www.vtpi.org/price_safe.pdf**

[22] Ewing R, Cervero R. 2010. Travel and the built environment: a meta-analysis. *J. Am. Plann. Assoc.* 76(3):265–94

[23] Ewing R, Schieber RA, Zegeer CV. 2003. Urban sprawl as a risk factor in motor vehicle occupant and pedestrian fatalities. *Am. J. Public Health* 93(9):1541–45

[24] Guo JY, Gandavarapu S. 2010. An economic evaluation of health-promotive built environment changes. *Prev. Med.* 50(Suppl. 1):S44–49

[25] Pucher J, Buehler R, Seinen M. 2011. Bicycling renaissance in North America? An update and reassessment of cycling trends and policies. *Transp. Res. A* 45(8):451–75

[26] Litman T. 2012. *Rail Transit in America: A Comprehensive Evaluation of Benefits*. Victoria, BC: Victoria Transp. Policy Inst. (VTPI). **http://www.vtpi.org/railben.pdf**

[27] Liu HF. 2007. Vehicle CO2 Emissions and the Compactness of Residential Development. Spec. Stud., Dec. 12th. Washington, DC: Natl. Assoc. Home Build.
**http://www.nahb.org/fileUpload_details.aspx?contentTypeID=3&contentID=86266&subContentID=125229**

**Tool for quantifying active transportation**
"The Active Transport Quantification Tool[28] describes how to value the vehicle cost savings, reductions in heart disease, diabetes risk, congestion, pollution and crash risk, and increased happiness from more active transport (walking and cycling)…" P.228

**Air pollution deaths**
"As previously mentioned, air pollution damages probably cause about the same number of deaths as do traffic crashes but cause smaller reductions in longevity because crash victims are younger, on average, than people who die from air pollution and cause little property damage." P.228

**Externalities of auto dependency**
"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." P.228

**Congestion is not the largest external cost but usually the most focused on**
"Conventional planning tends to focus on congestion costs (the additional travel time and vehicle operating expenses associated with traffic congestion), although it is actually modest compared with other automobile costs. Thus a congestion-reduction strategy that causes even small increases in crashes, sedentary living, or pollution exposure is probably not cost effective, but a congestion-reduction strategy becomes more cost-effective if it provides even small reductions in crashes, pollution, or sedentary living costs." P.229

**Health impacts big but under-considered**
"Health impacts tend to be relatively large compared with other impacts that tend to receive greater consideration in the planning process, such as traffic speeds, congestion delays, and vehicle operating costs." P.229

## John Pucher & Lewis Dijkstra, *Promoting Safe Walking and Cycling to Improve Public Health: Lessons from the Netherlands and Germany*

**Abstract:**

*Objectives*. We examine the public health consequences of unsafe and inconvenient walking and bicycling conditions in American cities and suggest improvements based on successful policies in The Netherlands and Germany.

*Methods*. Secondary data from national travel and crash surveys are used to compute fatality trends from 1975 to 2001 and fatality and injury rates for pedestrians and cyclists in The Netherlands, Germany, and the USA in 2000.

[28] Int. Counc. Local Environ. Initiat. (ICLEI). 2007. *Active Transportation Quantification Tool.* Melbourne, Aust.: Cities for Clim. Prot., ICLEI. **http://www.iclei.org/index.php?id=8394**

*Results*: Whereas walking and cycling account for less than a tenth of all urban trips in American cities, they account for a third of all trips in Germany and for half of trips in The Netherlands. American pedestrians and cyclists are much more likely to get killed than Dutch and German pedestrians and cyclists, both on a per-trip and per-km basis. They are also far more likely to be injured

*Discussion*: On the basis of Dutch and German experience, we propose a wide range of measures to improve the safety of walking and cycling in American cities, both to reduce fatalities and injuries and to encourage more walking and cycling, thus providing much needed physical exercise for increasingly overweight Americans.

**Findings:**

**Physical activity affects obesity rates**

"Many studies suggest that the lack of physical exercise is one important reason for the alarming trend toward increased obesity. Several articles and editorials in the leading medical and public health journals have explicitly advocated more walking and cycling for daily travel as the most affordable, feasible, and dependable way for people to get the additional exercise they need[29] [30] [31] [32] [33]." P.3

**Most trips are short enough to walk or bike but most people do not**

"Even in the sprawling metropolitan areas of the USA, 41% of all trips in 2001 were shorter than 2 miles, and 28% were shorter than one mile[34]. Bicycling can easily cover distances up to two miles and most people can walk at least a mile[35]. Yet Americans use their cars for 66% of all trips up to a mile long and for 89% of all trips between one and two miles long[36]." P.4

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[29] Dora C. A different route to health: implications of transport policies. *Brit Med J* 1999; 318:1686- 1689.

[30] Koplan J and Dietz W. Caloric imbalance and public health policy. *JAMA* 1999; 282:1579-1581.

[31] Carnall D. Cycling and health promotion. *Brit Med J* 320: 888.

[32] Wolff SP, Gilham CJ. Public health versus public policy? An appraisal of British urban transport policy. *Public Health* 1991; 105:217-228.

[33] Hillman M. Health promotion: the potential of non-motorized transport. In Fletcher T and McMichael AJ (eds). *Health at the Crossroads: Transport Policy and Urban Health*. London: Wiley and Sons, 1997.

[34] Pucher J and Renne J. Socioeconomics of urban travel: evidence from the 2001 NHTS. *Transportation Quarterly* 2003; 57 (3), forthcoming. Based on data from U.S. Department of Transportation, *2001 National Household Travel Survey*. Washington, DC: U.S. Department of Transportation, Federal Highway Administration; 2003. These calculations are for urban areas only but include all trip purposes and all means of transportation. The survey description and detailed data are accessible at: http://nhts.ornl.gov/2001/index.shtml

[35] Pucher J and Dijkstra L. Making walking and cycling safer: lessons from Europe. *Transportation Quarterly* 2000; 54 (3):25-50. Version without photos available as pdf file at: http://www.vtpi.org/puchertq.pdf

[36] Pucher J and Renne J. Socioeconomics of urban travel: evidence from the 2001 NHTS. *Transportation Quarterly* 2003; 57 (3), forthcoming.

**Elderly bike or walk MUCH more in Germany and the Netherlands than in the U.S.**
"As shown in Figure 2, walking increases with age in both The Netherlands and Germany, while cycling falls off only slightly. Indeed, the Dutch and Germans who are 75 and older make roughly half their trips by foot or bike, compared to only 6% of Americans aged 65 and older. While cycling is almost non-existent among the American elderly, it accounts for a fourth of all trips made by the Dutch elderly and for 7% of trips by the German elderly. Equally stunning, walking accounts for 48% of trips by Germans aged 75 and older and for 24% of trips by the Dutch aged 75 and older. That not only provides them with valuable physical exercise but also assures them a level of mobility and independence that greatly enhance their quality of life. It may also contribute to the longer life expectancy as well as healthy life expectancy in The Netherlands and Germany¾three years longer than in the USA[37]." P.8

**In the U.S. it is dangerous to use alternative modes**
"Per kilometer traveled, pedestrians were 23 times more likely to get killed than car occupants in 2001 (140 vs. 6 fatalities per billion km), while bicyclists were 12 times more likely than car occupants to get killed (72 vs. 6 fatalities per billion km)[38]. Walking and cycling in American cities are much more dangerous than in many other countries." P.10-11

**High injury and fatality rates in USA**
"As noted earlier, studies indicate that the Dutch and German police reports capture only about half of all serious injuries requiring hospitalization[39] [40]. Thus, the Dutch and German injury rates shown in Figure 3 should be roughly doubled to make them more comparable with the CDC rates for the USA. Even after such an upward adjustment, American pedestrians are about twice as likely to get injured as German pedestrians and four times as likely to get injured as Dutch pedestrians. American cyclists are at even greater risk: they are 8 times more likely to get injured than German cyclists and about 30 times more likely to get injured than Dutch cyclists." P.12

**More bikes but less fatalities in Germany and the Netherlands, less biking less fatalities in USA**

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[37] European Commission. *Eurostat: Key Data on Health 2000*. Luxembourg: Office des publications officielles des Communautes europeennes, 2001.

[38] The authors calculated fatality rates based on official mode-by-mode fatality and travel statistics of the U.S. Department of Transportation (National Highway Traffic Safety Administration and Federal Highway Administration). The total numbers of car occupant, cyclist, and pedestrian fatalities were derived from National Highway Traffic Safety Administration. *Traffic Safety Facts 2001*. Washington, DC: U.S. Department of Transportation, 2003. The total number of passenger km of travel by private motor vehicle, bicycle, and foot were calculated for the authors by Mary Ann Keyes of the Federal Highway Administration using unpublished data from the 2001 National Household Travel Survey.

[39] International Road Traffic and Accident Database. *Underreporting of Road Traffic Accidents Recorded by the Police, in International Comparison*. Bergisch-Gladbach, Germany: Organization for Economic Cooperation and Development, Road Research Transport Program, November 1994.

[40] Dutch Institute for Road Safety Research. *Victims, Road accident victims: general developments, official statistics and the real numbers* Leidschendam, The Netherlands, 1997. Accessible at: http://www.swov.nl/en/kennisbank/index.htm.

"Figure 4 shows that from 1975 to 2001, total pedestrian fatalities declined by 82% in Germany and by 73% in The Netherlands. Over the same period, cyclist fatalities declined by 64% in Germany and by 57% in The Netherlands. The drop in cyclist fatalities in Germany is especially impressive because it came during a boom in cycling there, with a doubling in the number of bike trips and 50% growth in the share of total trips made by bike[41]. By contrast, the 27% fall in cyclist fatalities in the USA was due almost entirely to the sharp decline in cycling by children[42] [43]."

**Solutions to calm traffic and increase alternative modes**

"As shown by the wide range of coordinated policies in The Netherlands[44] [45] and Germany[46], the necessary techniques and programs already exist and have been proven to work extremely well. They include better facilities for walking and cycling; traffic calming of residential neighborhoods; urban design sensitive to the needs of non-motorists; restrictions on motor vehicle use in cities; rigorous traffic education of both motorists and non-motorists; and strict enforcement of traffic regulations protecting pedestrians and bicyclists. American cities lack only the political will to adopt the same strategies." P.13-14

**Pedestrian deaths and vehicle speed**

"The British Department of Transport, for example, finds that the risk of pedestrian death in crashes rises from 5% at 20mph to 45% at 30mph and 85% at 40mph[47]." P.15

**Traffic calming in residential neighborhoods and safety**

"Area-wide traffic calming in Dutch neighborhoods has reduced traffic accidents by 20% to 70%.43 Traffic calming in German neighborhoods has reduced traffic injuries overall by 20% to 70% and serious traffic injuries by 35% to 56%.44 A comprehensive review of traffic calming impacts in Denmark, Great Britain, Germany, and The Netherlands found that traffic injuries fell by an average of 53% in traffic-calmed neighborhoods[48]." P.15

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[41] Pucher J and Dijkstra L. Making walking and cycling safer: lessons from Europe. *Transportation Quarterly* 2000; 54 (3):25-50. Version without photos available as pdf file at: http://www.vtpi.org/puchertq.pdf.

[42] Templin N. The bicycle loses ground as a symbol of childhood liberty. *The Wall Street Journal*, Sept. 10, 1996, pg. A-1.

[43] Pucher J, Komanoff C, and Schimek P. Bicycling renaissance in North America?: Recent trends and alternative policies to promote bicycling. *Transportation Research* A, 33 (7/8): 625-654. Accessible at: http://policy.rutgers.edu/papers.

[44] Van Vliet, Pieter and Schermers, Govert. *Sustainable Safety: A new approach for road safety in the Netherlands.* Rotterdam, the Netherlands: Ministry of Transport, Public Works and Water Management; Traffic Research Centre, 2000. Accessible at http://www.rws-avv.nl

[45] Ministry of Transport, Public Works and Water Management. *National Traffic and Transport Plan.* The Hague, The Netherlands: Ministry of Transport, Public Works and Water Management, 2000. Accessible at http://www.minvenw.nl

[46] German Ministry of Transport. *Nationaler Radverkehrsplan 2002-2012, FahrRad! Massnahmen zuer Foerderung des Radverkehrs in Deutschland*. Berlin: Bundesministerium fuer Verkehr, Bau- und Wohnungswesen, April 2002. Accessible at: http://www.bmvbw.de/Fahrradverkehr-.423.htm

[47] Surface Transportation Policy Project. *Mean Streets: Pedestrian Safety and Reform of the Nation's Transportation Law*. Washington, DC, 1997, table 4, pg. 14.

[48] Preston B. Cost-effective ways to make walking safer for children and adolescents. *Injury Prevention*, 1995, 1:187-190.

**Urban design affects trip length and walkability**
"In the United States, the separation of residential from commercial land uses increases trip distances and makes the car a necessity. Suburban cul-de-sacs further discourage walking and bicycling by making trips circuitous and excessively long. Residential roads often feed directly into high-speed traffic arteries, increasing the danger of any trips outside the neighborhood. The lack of sidewalks in most American suburbs further exacerbates the problem." P.16-17

**Education is crucial**
"Traffic education of children has high priority in both The Netherlands and Germany.46,47 By the age of 10, all school children have received extensive instruction on safe walking and bicycling practices. They are taught not just the traffic regulations but how to walk and bicycle defensively, to anticipate dangerous situations, and to react appropriately. That sort of safety education is completely lacking in the United States." P.17-18

**Neglect of alternative mode safety in the U.S. has made them dangerous**
"The neglect of pedestrian and bicycling safety has made these dangerous ways of getting around American cities. Walking and cycling can be made quite safe, however, as clearly shown by the much lower fatality and injury rates in The Netherlands and Germany. There is no good reason why American cities could not adopt many of the same measures to enhance safety. The necessary methods and technology are already available, with decades of successful experience in Europe." P.19

**Europe has high rates of biking and walking and lower rates of chronic diseases and they have higher life expectencies than USA**
"The European countries with the highest levels of walking and cycling have much lower rates of obesity, diabetes, and hypertension than the USA[49] [50]. The Netherlands, Denmark, and Sweden, for example, have obesity rates only a third of the American rate, while Germany's rate is only half as high[51]. Moreover, the average healthy life expectancies in those four European countries are 2.5 to 4.4 years longer than in the USA[52], although their per-capita health expenditures are only half those of the USA[53]." P.19

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[49] European Commission. *Eurostat: Key Data on Health 2000*. Luxembourg: Office des publications officielles des Communautes europeennes, 2001.

[50] World Health Organization. *Obesity in Europe: The Case for Action*. London: International Obesity Taskforce of the World Health Organization, September 2002. Accessible at: http://www.iotf.org/media/globalprev.htm.

[51] World Health Organization. *Obesity in Europe: The Case for Action*. London: International Obesity Taskforce of the World Health Organization, September 2002. Accessible at: http://www.iotf.org/media/globalprev.htm.

[52] European Commission. *Eurostat: Key Data on Health 2000*. Luxembourg: Office des publications officielles des Communautes europeennes, 2001.

[53] Organization for Economic Cooperation and Development. "Total expenditures on health per capita, 1960-2000, in US dollars, purchasing power parity." Washington, DC: OECD, 2002. Accessible at: http://www.oecd.org/xls/M00031000/M00031378.xls.

**Importance of education: Direct impact daily activity has on their health and longevity**
Unless individual Americans can be convinced that they will directly benefit from better walking and cycling conditions, politicians are unlikely to support the necessary policies. Self-interest is likely to be the strongest motivation to effect changes in travel behavior. Getting enough physical exercise is quite literally a matter of life and death. Health care professionals must convince their patients that walking and cycling on a regular basis for daily travel will help them live longer and healthier lives. P.19-20

**Awareness**
Only when the public and politicians become fully aware of the severity of the obesity problem—and the huge potential of walking and cycling to mitigate the problem—will public policies change enough to make a real difference. P.20

## L.D. Frank and S. Kavage, *Urban Planning and Public Health: A Story of Separation and Reconnection*

**Abstract:**
The built environment can influence public health largely because of the transportation choices that result from different approaches to community design.5–8 For years, urban planning researchers have been documenting associations between patterns of development and transportation behavior. The research has evolved considerably in recent years with the advent of Geographic Information Systems and faster, more adept computer and database systems. A number of literature reviews and meta-analyses have summarized this body of literature[54] [55] [56] [57] [58] [59] [60] [61] [62]. The reviews agree that all else being equal, households in "walkable communities"

[54] Ewing R, Bartholomew K, Winkelman S, Walters J, Chen D. *Growing Cooler: The Evidence on Urban Development and Climate Change*.Washington, DC: Urban Land Institute; 2007.

[55] Ewing R, Cervero R. Travel and the built environment: a synthesis. *Transportation Res Rec.* 2001;1780:87–114.

[56] Frank L. Land use and transportation interaction: implications on public health and quality of life. *J Plann Educ Res.* 2000;20(1):6–22.

[57] Boarnet M, Crane R. The influence of land use on travel behavior: specification and estimation strategies. *Transportation Res A.* 2001;35(9):823–845.

[58] Environmental Protection Agency. *Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation and Environmental Quality*. Washington, DC: US Environmental Protection Agency; 2001.

[59] Kuzmyak RJ, Pratt RH. Land use and site design. In: *Transit Cooperative Research Program Report 95, Traveler Response to Transport System Changes*. Washington, DC: Transportation Research Board; 2001:chap 15.

[60] Bento AM, Cropper ML, Mobarak AM, Vinha K. *The Impact of Urban Spatial Structure on Travel Demand in the United States*. Washington, DC: World Bank; 2003. World Bank Group Working Paper, No. 3007.

[61] TRB Committee on Physical Activity, Health, Transportation, and Land Use. *Does the Built Environment Influence Physical Activity? Examining the Evidence*. Washington, DC: Transportation Research Board/Institute of Medicine; 2005.

(see sidebar) have been shown in research to walk and bicycle *more* and drive *less* than households in sprawling, automobile-dependent locations. Although causal evidence at this point is limited, significant associations have been found in many different locations and at many scales of measurement.

The results are highly intuitive; especially at the extreme. **Live further away from work and nonwork destinations where the car is your only option and you drive more and walk less. Transit is not even an option.**

**Summary:**

**What Is a Walkable Community?**
The land use/transportation literature has consistently found a number of built environment characteristics that are associated with more walking, bicycling, and transit and less driving:
**Close-in location:** Neighborhoods that are centrally located mean that commute distances will likely be shorter, with more convenient transit service.
**Compactly developed:** Neighborhoods with higher residential densities put more people within walking distance of everyday goods and services.
**Mixed use:** Neighborhoods with a mix of homes, shops, and services and other destinations within walking distance facilitate walking for everyday errands.
**Interconnected street networks:** A "gridiron" street layout, as opposed to one dominated by cul–de sacs and wide arterials, allows more direct connections between destinations. This is especially important to encourage walking trips.
**Pedestrian-friendly design:** A landscape that is designed for pedestrians means narrower streets, wider sidewalks, easier and safer street crossings, and architecture that is easily accessible and visually engaging.

**Findings:**

**Findings from the land use/transportation literature about walking, bicycling, and taking transit**
"The land use/transportation literature has consistently found a number of built environment characteristics that are associated with more walking, bicycling, and transit and less driving:
**Close-in location:** Neighborhoods that are centrally located mean that commute distances will likely be shorter, with more convenient transit service. **Compactly developed:** Neighborhoods with higher residential densities put more people within walking distance of everyday goods and services. **Mixed use:** Neighborhoods with a mix of homes, shops, and services and other destinations within walking distance facilitate walking for everyday errands. **Interconnected street networks:** A "gridiron" street layout, as opposed to one dominated by cul–de sacs and wide arterials, allows more direct connections between destinations. This is especially important to encourage walking trips. **Pedestrian-friendly design:** A landscape that is designed for pedestrians means narrower streets, wider sidewalks, easier and safer street crossings, and architecture that is easily accessible and visually engaging." P.215

**Link between activity and obesity**

[62] Bagley MN, Mokhtarian PL. The impact of residential neighborhood type on travel behavior: a structural equation modeling approach. *Ann Reg Sci.* 2002;36:279–297.

"For each individual, body weight is generally determined by a combination of genetic makeup, energy consumed (what we eat) and energy expended (our activity level). Sedentary lifestyles combined with a prevalence of high-energy, high-fat, high-sugar foods have resulted in alarming increases in obesity and associated diseases." P.215

**Link between disease and obesity, healthcare costs**

"Diseases associated with obesity and low rates of physical activity—heart disease, obesity, high blood pressure—are currently among the leading causes of disability and death. Even for those who are not overweight, obesity has a huge impact on the healthcare system and related costs, through increasing healthcare costs and waiting times[63]." P.215

**Driving time and obesity**

"Our Atlanta study found that each additional hour spent in a car per day was associated with a 6 percent increase in the likelihood of obesity[64]. For public transit, the inverse is true—research indicates that because transit users are also walkers, transit may play an important role in facilitating physical activity (U. Lachapelle, MSc, and L. Frank, PhD, unpublished data, 2008)[65] [66] [67]." P.215-216

**Walkable neighborhoods and emissions**

"We found repeatedly that residents of more walkable environments generate significantly lower levels of both ozone precursors (volatile organic compounds and oxides of nitrogen) and CO[68] [69] [70]." P.216

**Trip types and emissions**

"Short motor vehicle trips in urban conditions tend to have relatively high per mile emission rates because of cold engine starts and traffic congestion, so reducing these trips can bring

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[63] Visscher T, Seidell J. The public health impact of obesity. Annu Rev Public Health. 2001;22:355–375.

[64] Frank L, Andresen M, Schmid T. Obesity relationships with community design, physical activity, and time spent in cars. Am J Prev Med. 2004;27(2):87–97.

[65] Frank L, Andresen M, Schmid T. Obesity relationships with community design, physical activity, and time spent in cars. Am J Prev Med. 2004;27(2):87–97.

[66] Weinstein A, Schimek P. Extent and correlates of walking in the USA. *Transportation Res Pt D*. 2007;12(8):548–563.

[67] Besser LM, Dannenberg AL. Walking to public transit: steps to help meet physical activity recommendations. *Am J Prev Med.* 2005;29(4):273–280.

[68] Frank L, Sallis JF, Conway T, Chapman J, Saelens B, Bachman W. Multiple pathways from land use to health: walkability associations with active transportation, body mass index, and air quality. *J Am Plann Assoc.* 2006;72(1):75–87.

[69] Frank L, Stone B Jr, BachmanW. Linking land use with household vehicle emissions in the central puget sound: methodological framework and findings. *Transportation Res Pt D.* 2000;5(3):173–196.

[70] Frank L, Chapman J. *Integrating Travel Behavior and Urban Form Data to Address Transportation and Air Quality Problems in Atlanta: Final Report*. 2004. Prepared for the Georgia Department of Transportation and Georgia Regional Transportation Authority. Atlanta, GA: Georgia Tech Research Institute.

relatively large net emission reductions. These short trips also have the most potential for replacement by walking and cycling." P.216

**Traffic fatalities, U.S.A.**
"In the United States, traffic crashes kill more than 40 000 people per year[71]." P.216

**Sprawl and traffic fatalities**
"Several recent studies have found that per capita traffic fatality rates tend to be higher in sprawling communities than in compact, mixed-use communities[72] [73]. This difference is likely a result of increased per capita vehicle travel, more driving by teenaged and elderly motorists because of poor travel options, and higher travel speeds and volumes." P.216-217

**Design vs. neighborhood preference on VMT**
"In our study in the Atlanta region, we were able to control for neighborhood preference and found that neighborhood walkability remained a significant predictor of miles driven and distances walked, even after adjusting for demographics and neighborhood preference[74]." P.217

**Latent demand for walking**
"Furthermore, there is recent evidence of latent demand for more walkable neighborhoods[75] [76]. These studies suggest that simply accommodating the existing demand would allow those who are currently located in auto-oriented environments to choose a more walkable one, thus lowering rates of vehicle travel and emissions." P.217

**Online tool**
"Standard planning metrics, such as residential density and vehicle per miles traveled, can be used as indicators in the absence of local data. We are developing such a planning tool as part of the HealthScape project in King County,Washington(**www.metrokc.gov/healthscape**). By applying research relationships from our research in King County to an existing sketch planning

[71] US Department of Transportation. Fatality analysis reporting system encyclopedia. http://www-fars.nhtsa.dot.gov/Main/index.aspx. Accessed January 14, 2008.

[72] Ewing R, Schieber R, Zegeer CV. Urban sprawl as a risk factor in motor vehicle occupant and pedestrian fatalities. Am J Public Health. 2003;93(9):1541–1545.

[73] Lucy WH. Mortality risk associated with leaving home: recognizing the relevance of the built environment. Am J Public Health. 2003;93(9):1564–1569.

[74] Frank LD, Saelens B, Powell KE, Chapman JE. Disentangling urban form effects on physical activity, driving, and obesity from individual pre-disposition for neighborhood type and travel choice: establishing a case for causation. Soc Sci Med. 2007;65(9):1898–1914

[75] Belden Russonello & Stewart. *2004 American Community Survey National Survey on Communities*. Washington, DC: Smart Growth America and National Association of Realtors; 2004.

[76] Levine J, Frank LD. Transportation and land-use preferences and residents' neighborhood choices: the sufficiency of compact development in the Atlanta region. *Transportation.* 2007;34(2):255–274.

model (I-PLACE3S, developed by the California Energy Commission), **it will be able to assess the impacts of differentland use scenarios on physical activity, walking, and obesity." P.218**

**Online tool**
"As part of an HIA process, the San Francisco Department of Public Health developed the Healthy Development Measurement Tool (**theHDMT.org**), a set of more than 100 indicators that can be used to assess of the effects of land use and transportation decisions on health." P.218

## Megan Williams and Myrna Wright, *The Impact of the Built Environment on the Health of the Population: A Review of the Review Literature*

**Abstract:**
This literature review has examined a large body of evidence and concludes that the built environment profoundly impacts the health of the population. Sprawling and fragmented communities have fostered car dependency, inactivity, obesity, loneliness, fossil fuel and resource consumption, and environmental pollution[77]. Addressing these health impacts of the built environment will be one of the most significant challenges of the 21st century as it encompasses chronic disease, environmental degradation and global warming. We are presented with an epidemic of our own making." (p.89) Recommendations follow.

**Findings:**

**Conclusive report that the built environment impacts health**
"Over the years, enough evidence has been collected to support this statement to the extent that Frank and Engelke have concluded: "The ways in which cities are designed and constructed have public health consequences." (p.193)[78]" P.2

**Conclusions from the Surgeon General's landmark 1996 Report on Physical Activity and Health**
"The published literature agrees that significant health benefits arise from regular physical activity. One of the landmark documents was the U.S. Surgeon General's 1996 *Report on Physical Activity and Health*, which reviewed the existing literature on the role of physical activity in preventing disease and concluded that ***the evidence was sufficiently strong to draw a causal relationship between physical activity and health outcomes***, including: o Lower mortality rates for both older and younger adults; o Lower risk for heart disease and stroke; o Prevention or delay of high blood pressure and among people with hypertension, lowering of blood pressure; o Decrease risk for colon cancer; o Lowered risk for type 2 diabetes (non-insulin dependent); o Weight loss and redistribution of body fat; o Increase in muscle mass; o Improvement of mood and relief of the symptoms of depression and anxiety; o Enhancement of psychological wellbeing and perceived health-related quality of life; and o Improved physical

[77] Jackson R. Environment meets health, again. Science 2007 Sep 3;315(5817):1137.

[78] Frank LEP. Multiple impacts of the built environment on public health: Walkable places and the exposure to air pollution. International Regional Science Review 2005;28(2):193- 216.

functioning among people with poor health. (United States Department of Health and Human Services, as cited in Jackson and Kochtitzky, 2001)" P.15-16

**Inactivity is as dangerous as smoking but many more people are inactive than smoke**
"It is estimated that obesity and its concomitant health problems rivals tobacco in its health impacts[79]. Sallis et al (2004) note that more than 70 per cent of American adults do not meet physical activity recommendations, whereas less than 20 per cent are smokers[80] and concluded that physical inactivity directly impacts more people than tobacco use does." P.18

**Link between obesity and sedentary lifestyle**
"While both increased food intake and physical inactivity have contributed to the problem of obesity, physical inactivity has been proposed as the major contributing factor according to a study from the British Medical Journal and highlighted in the text book *Urban Sprawl and Public Health*[81]. The study compared proxy measures of food intake and physical inactivity to obesity trends from 1950 to 1990. Food intake was measured in proxy as energy intake and fat intake. Physical inactivity was measured in proxy by car ownership and television viewing. When compared to obesity trends, the food intake proxy measurement hit a peak around 1970 and declined subsequently. On the other hand, **the physical inactivity proxy measurement increased along with obesity and has continued to increase.** The data indicated that as the years progressed, the number of cars per household increased as did the number of hours spent viewing television per week although television viewing did hit a plateau." P.19

**Obesity and diabetes**
"Being obese increases the risk of type 2 diabetes by forty-fold (Hu et al, in Frumkin et al, 2004) and diabetes is a major risk factor for amputations, blindness, kidney failure and The Impact of the Build Environment on the Health of the Population: A Review of the Review Literature heart disease[82]. A recent type 2 diabetes study found that weight loss and physical activity were more effective in controlling the disease than medication." P.19-20

**Obesity and sedentary lifestyle link**
"Brownson et al (2005) reviewed current patterns and longterm trends over the past 50 years to identify the contributing factors[83]. Researchers observed an overall decline in physical activity

[79] Bray R, Vakil C, Elliott D. Report on Public Health and Urban Sprawl in Ontario: A Review of the Pertinent Literature. Toronto, Ontario: Environmental Health Committee, Ontario College of Family Physicians; 2005 Jan 1.

[80] Sallis J, Frank L, Saelens B, Kraft M. Active transportation and physical activity: opportunities for collaboration on transportation and public health research.

[81] Frumkin H, Frank L, Jackson R. Urban Sprawl and Public Health: Designing, Planning, and Building for Healthy Communities. Washington, D.C.: Island Press; 2004.

[82] Jackson R, Kochtitzky C. Creating a Healthy Environment: The Impact of the Built Environment on Public Health. 2001. Sprawl Watch Clearinghouse monograph series 2001.

[83] Brownson RC, Boehmer TK, Luke DA. Declining rates of physical activity in the United States: what are the contributors? [Review] [57 refs]. Annual Review of Public Health 2005;26:421-43.

associated with one's employment, the maintenance and running of a home, and for self-powered transportation. In other words, the amount of physical activity necessary for everyday life has decreased. Additionally, there has been an increase in sedentary behaviour. Only the physical activity exerted during leisure time has remained the same or slightly increased." P.22

**Divergence from the grid**

"Criticism of the grid pattern began at the end of the nineteenth century as it was inappropriately associated with the social and economic problems in urban America, including the lack of open space, substandard housing, and the lack of light and fresh air in the city[84]."

**Alternative modes and car ownership**

"The current availability and convenience of a car obscures most opportunities to walk or bicycle to a destination. In fact, the probability of any self-powered transport is inversely related to the number of automobiles per household regardless of income level[85]."

**Density as a key factor in physical activity**

"Density is the most important factor influencing physical activity or automobile usage. It is defined as the number of people or jobs per unit of area, such as the number of people per acre or jobs per square mile. Density affects distances between destinations and the number of destinations that can be reached by walking and cycling. A concentration of jobs or households makes active transportation and public transit more viable and provides the critical mass needed to support retail development[86]." P.26

**Density and mode choice**

"Residents of sprawling regions make more trips as well as making longer trips[87]. Almost all travel is done by car until the residential density reaches 13 persons per gross acre (Frank and Pivo, as cited in Frank, Kavage & Litman 2007). The same study also found that an employment density of 75 employees per gross acre was needed in order to see increases in work-related transit use and walking." P.27

**Low-density makes non-car travel difficult**

"Additionally, low-density development reinforces automobile use[88]. Low-density development is only possible when almost everyone has a car. Low-density areas are inaccessible and unappealing to those without automobile access. Once built, such development encourages car

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[84] Frank L, Engelke P. How Land Use and Transportation Systems Impact Public Health: A Literature Review of the Relationship Between Physical Activity and Built Form. 2006.

[85] Brownson RC, Boehmer TK, Luke DA. Declining rates of physical activity in the United States: what are the contributors? [Review] [57 refs]. Annual Review of Public Health 2005;26:421-43.

[86] Frank L, Kavage S, Litman T. Promoting Public Health Through Smart Growth : Building Healthier Communities Through Transportation and Land Use Policies and Practices. SmartGrowth BC 2007 [cited 8-2-2007]; Available from: URL: http://www.smartgrowth.bc.ca/downloads/SGBC%5FHealth%20Report%20Final.pdf

[87] Gilbert ROC. Child- and Youth-Friendly Land-Use and Transport Planning Guidelines. The Centre for Sustainable Transportation; 2005.

[88] Gilbert ROC. Child- and Youth-Friendly Land-Use and Transport Planning Guidelines. The Centre for Sustainable Transportation; 2005.

use that in turn reinforces the place of the car in society, making more low-density development feasible and likely. Without the car, travel within low-density areas is difficult." P.27

**Connectivity and walking**
"The LUTAQH study found that walking increased by 14 per cent for each quartile increase in street connectivity. (King County ORTP, as cited in Frank, Kavage & Litman, 2007) While connectivity is best determined when communities are first planned, retrofitting is possible by adding connecting links with sidewalks and diagonal paths, removing barriers and improving maintenance of streets and sidewalks and reducing traffic volume and speed[89]." P.29

**Example of policy initiative to support walkability**
"The City Council of Edmonton, Alberta, approved a planning initiative called *Smart Choices* in 2004 which aims to accommodate growth while minimizing urban sprawl through intensified land development[90]." P.29

**Benefits of a gridded street network**
"Street networks influence the mode of travel and trip frequency through the ways in which trip origins and destinations are connected. Street networks are arranged using either a grid pattern or a transportation hierarchy pattern. The classic grid pattern consists of two sets of parallel streets crossing at right angles to form square or rectangular blocks. Grids are theoretically capable of increasing walking and biking trips in two ways. The grid pattern reduces trip distances as they have a large number of intersecting streets, thereby reducing the distance between trip origin and destination. Grid patterns also increase the number of route choices so that different routes can be made according to the desire for variety, safety and convenience[91]." P.30

**Sprawl and obesity**
In a 2003 study, Ewing et al (as cited in Atlanta Regional Health Forum, Atlanta Regional Commission, 2006) found that people living in counties characterized by sprawling development were likely to walk less, weigh more and have a greater prevalence of hypertension than did people living in compact communities, controlling for age, education, gender, race and ethnicity[92]. The same researchers looked at the impact of sprawl on its residents another way. They found that regardless of whether the residents walked for exercise or not, people living in

[89] Frank L, Kavage S, Litman T. Promoting Public Health Through Smart Growth: Building Healthier Communities Through Transportation and Land Use Policies and Practices. SmartGrowth BC 2007 [cited 8-2-2007]; Available from: URL: http://www.smartgrowth.bc.ca/downloads/SGBC%5FHealth%20Report%20Final.pdf

[90] Walkable Edmonton. Walkable Edmonton Toolkit. Walkable Edmonton; 2007.

[91] (54) Frank L, Engelke P. How Land Use and Transportation Systems Impact Public Health: A Literature Review of the Relationship Between Physical Activity and Built Form. 2006.

[92] (56) Atlanta Regional Health Forum (ARHF) ARCA. Land Use Planning for Public Health: The Role of Local Boards of Health in Community Design and Development. Bowling Green, Ohio: National Association of Local Boards of Health; 2006.

higher levels of sprawl were heavier[93]. The researchers postulated that this was a result of residents not being able to incorporate physical activity into their daily routine[94]. P.34

**Driving time and obesity**

Research on more than 10,500 people in the Atlanta area indicated that the more time a person spent in a car, the more obese s/he tended to be[95]. For every hour spent driving in a car, the likelihood of being obese increased by 6 per cent (Frank et al, SMARTRAQ, 2004 as cited in Atlanta Regional Health Forum and Atlanta Regional Commission, 2006). P.34

**People in compact, mixed-use communities weigh 10 lbs less than their counterparts in single-family subdivisions**

"Neighbourhoods with greater residential density and street plans that facilitated walking from place to place showed below-average rates of obesity[96]. The magnitude of the effect was not trivial. A typical white male living in a compact, mixed use community weighs about 4.5 kilograms (10 pounds) less than a similar man in a subdivision containing nothing but homes[97]." P.34

**Obese people do not self-select to live in suburbs; suburban form is what limits them from incorporating movement into daily activities**

"…research done by Saelens et al in 2003 found that there were no differences in minutes walked when walking for recreational exercise between high and low-walkability neighbourhoods. They did find that rates of utilitarian exercises, such as walking trips for errands, were higher in neighbourhoods that were rated as highly walkable[98]. An analysis of studies in six communities found that on average, residents in highly-walkable neighbourhoods took twice as many walking trips as people in less walkable neighbourhoods and that most of the increase was due to walking for errands or to go to work[99]. This research indicated that people who did not walk for exercise were not a self-selected group who choose to live in urban sprawl

[93] Atlanta Regional Health Forum (ARHF) ARCA. Land Use Planning for Public Health: The Role of Local Boards of Health in Community Design and Development. Bowling Green, Ohio: National Association of Local Boards of Health; 2006.

[94] Atlanta Regional Health Forum (ARHF) ARCA. Land Use Planning for Public Health: The Role of Local Boards of Health in Community Design and Development. Bowling Green, Ohio: National Association of Local Boards of Health; 2006.

[95] Atlanta Regional Health Forum (ARHF) ARCA. Land Use Planning for Public Health: The Role of Local Boards of Health in Community Design and Development. Bowling Green, Ohio: National Association of Local Boards of Health; 2006.

[96] Frank LD, Andresen M, Schmid T. Obesity relationships with community design, physical activity, and time spent in cars. American Journal of Preventive Medicine 2004;27(2):87- 96.

[97] Frank LD, Andresen M, Schmid T. Obesity relationships with community design, physical activity, and time spent in cars. American Journal of Preventive Medicine 2004;27(2):87- 96.

[98] Saelens BE, Sallis JF, Frank LD. Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. [Review] [70 refs]. Annals of Behavioral Medicine 2003;25(2):80-91.

[99] Saelens BE, Sallis JF, Frank LD. Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. [Review] [70 refs]. Annals of Behavioral Medicine 2003;25(2):80-91.

areas. Rather, living in a neighbourhood not conducive to walking for errands was what was contributing to their obesity[100]." P.35

**Regardless of preference for or aversion to walking, environment influences how much people walk**

"Dr. Frank concluded that people walked more in areas that facilitated walking, regardless of their preference of walking-related environments. People walked less in areas that did not facilitate walking. He also found that people living in an environment that discouraged walking were more likely to be obese regardless of their preference of walking-related environments. With walking, the living environment had more impact than personal preference. The design of the environment people lived in did impact the amount of walking. As well, the design of the environment lived in did impact the amount of obesity[101]." P.36

**Pedestrian and bicyclist street preference**

"Heavy traffic volume is a significant deterrent to walking and biking. In a study of San Francisco streets, Appleyard and Lintell (as cited in Frank and Engelke, 2006) **assessed the feelings of residents regarding privacy, social interaction, traffic hazard, environmental awareness, stress, noise and pollution to determine how traffic conditions affected the livability and quality of the street environment.** Three streets were chosen with varying traffic volumes. One street, with a traffic volume of 15,750 vehicles per day was classified as heavy volume, a second street with 8,700 vehicles per day was classified as moderate, and the third street with 2,000 vehicles per day was as light. Using a five-point satisfaction rating scale, **the heavy traffic volume street scored the worst and the light traffic volume street the best in all categories** - privacy, social interaction, traffic hazard, environmental awareness, stress, noise and pollution. The scores for the light street ranged between 1.2 and 2.6 (with 1 being most satisfied), while those for the heavy street ranged between 3.0 and 4.5 (with 5 being the most dissatisfied) with the scores for the moderate street always in-between those of the light and heavy streets." P.40

**Vehicle speed determines severity of collision injury**

"Vehicular speed is the second causal factor of traffic collisions, injuries and fatalities. There are higher numbers of fatalities resulting from traffic crashes with the increased speed of the vehicle at the time of impact. Where **speed limits exceed 60 km/hr**, about **two-thirds** of the **collisions that occurred caused fatalities** (Transport Canada, as cited by Bray, 2005). In comparison, in areas with posted **speed limits below 60 km/hr**, **70 per cent** of the **collisions involved injuries** and not fatalities[102]. Speed at impact determines whether the outcome is life, injury or death.

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[100] Bray R, Vakil C, Elliott D. Report on Public Health and Urban Sprawl in Ontario: A Review of the Pertinent Literature. Toronto, Ontario: Environmental Health Committee, Ontario College of Family Physicians; 2005 Jan 1.

[101] Frank L. Health Enabling and Disabling Effects Health Enabling and Disabling Effects of the Places we Live, Work, and Playof the Places we Live, Work, and Play. Healthy Eating and Active Living 2006 Conference 2006Available from: URL: http://www.mhp.gov.on.ca/english/health/HEAL/program.asp

[102] Bray R, Vakil C, Elliott D. Report on Public Health and Urban Sprawl in Ontario: A Review of the Pertinent Literature. Toronto, Ontario: Environmental Health Committee, Ontario College of Family Physicians; 2005 Jan 1.

Essentially, collisions at fast speed (exceeding 60 km/hr) usually result in death whereas collisions at slower speeds (below 60 km/hr) usually result in injuries." P.40-41

**Lower speeds and cars parked on the street determine severity of car collisions and pedestrian related crashes**
"Another study (Peterson et al, as cited by Ewing, Frank & Kreutzer, 2006) that looked at the risk of pedestrian injury found that injury increased by 7.6 times with an increase in the average speed of just 10 mph, from 20 to 30 mph. The authors concluded that measures that lower vehicle operating speeds should reduce the frequency and severity of traffic accidents. This study also found that the number of parked cars on the street was the second most influential factor in pedestrian injury." P.41

**Presence of other cyclists/pedestrians in an area affects their safety - Example: more bicyclists = more driver awareness of bicyclists**
"Some street environments encourage driver alertness and anticipation to exercise caution while other street environments are less engaging and discourage attentive driving. **Crashes between motorists and pedestrians or bicyclists are less likely when there are more people walking or bicycling** (Jacobsen, as cited by Ewing, Frank & Kreutzer, 2006). Several data sources show that in environments with many pedestrians or bicyclists, motorists come to expect them and adjust their behavior accordingly (Jacobson, 2003; Leden et al, 2000; Leden, 2002, as cited by Ewing, Frank & Kreutzer, 2006). However, **as walking and bicycling decline, driver awareness declines as well, making the street environment conditions even more dangerous for pedestrians[103].**" P.42

**SUVs are more deadly for pedestrians and cyclists than other cars**
"Comparing collisions in the United States found that at the same collision speed, **pedestrians hit by SUV's are twice as likely to die as pedestrians struck by passenger cars[104]**.(66) Other studies have demonstrated higher rates (up to four times greater) of severe injury and death among pedestrians involved in collisions with SUV's.(66) The increased height of SUVs and light trucks also presents an increased risk of injury to children in driveways, as it is often more difficult for drivers to see things around the vehicle (Simms, as cited in Toronto Public Health Department, 2006)." P.43

**Sprawl makes people have to drive more**
"The average distance driven varies remarkably depending on the degree of compactness or sprawl characterizing different American cites. In a sprawling city like Atlanta, the estimated driving distance is 35.1 miles/day on average (TTI, as cited by Bray, 2005) compared with more compact cities like Philadelphia, with 16.7 miles/day on average, Chicago with 19.7 miles/day on average and San Francisco with 21.1 miles/day on average." P.43

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[103] Frank L, Kavage S, Litman T. Promoting Public Health Through Smart Growth : Building Healthier Communities Through Transportation and Land Use Policies and Practices. SmartGrowth BC 2007 [cited 8-2-2007]; Available from: URL: http://www.smartgrowth.bc.ca/downloads/SGBC%5FHealth%20Report%20Final.pdf

[104] Toronto Public Health Department. Staff Report - The Impacts of Traffic on Health. Toronto Public Health Department; 2006.

**More time in cars means more accidents and the high speed arterial roads typical in suburban development mean that crashes are more severe (higher speeds)**
As people spend ever more time in cars, their risk of being in an accident increases[105]. The design of communities influences how reliant the residents are on the use of automobiles for transportation and, in turn, increased automobile use contributes to an increased likelihood of more motor vehicle crashes and pedestrian injuries. Additionally, roads connecting sprawling areas are designed to move vehicles as efficiently as possible – as many cars as possible and as fast as possible. The result is that when collisions occur they happen at higher speeds, and therefore are more severe[106]. P.43

**More density, mixed use, and centering means less traffic fatalities**
"What Ewing et al found was that three of the factors in metropolitan areas —density, mix, and centering — were significantly related to annual traffic fatalities per 100,000 residents when controlling for socio-demographic differences. Fewer fatalities per capita occurred in areas with higher density, a greater mix of homes, shops and workplaces, and a more centered the development pattern. This reduction in fatalities is due, in part, to fewer vehicle miles traveled per capita in compact metropolitan areas, and may also be due to lower average speeds. While this study was applicable to metropolitan areas, it may or may not be applicable to individual neighborhoods (Ewing et al, as cited by Ewing, Frank & Kreutzer, 2006)." P.44

**VMT critical factor in crashes**
"For each 1 per cent reduction in vehicle miles, total crash costs are reduced by 1.0 to 1.4 per cent (Litman, as cited by Ewing, Frank & Kreutzer 2006). When 10 street variables were tested, the second most significant determinant of accident rates was average daily traffic volume (Swift et al, as cited by Ewing, Frank & Kreutzer, 2006)." P.45

**3 objectives for reducing crashes/increasing pedestrian and bicycle activity**
"In order to reduce the number of fatal and non-fatal traffic accidents, actions should be taken that: • reduce traffic volumes and the vehicle miles traveled (VMT), • decrease vehicle speeds and the amount of time spent in a vehicle or vehicle hours traveled (VHT), or change the street environment." P.45

**Lane width correlated with and collision fatalities due to faster speeds**
"As streets get wider, vehicle speed gets faster. Among infrastructure variables, increases in lane widths accounted for over half of the total increase in fatalities and about one quarter of the increase in injuries." P.45

**Number of lanes affects vehicle speed and accident rates**

[105] Frank L, Kavage S, Litman T. Promoting Public Health Through Smart Growth : Building Healthier Communities Through Transportation and Land Use Policies and Practices. SmartGrowth BC 2007 [cited 8-2-2007]; Available from: URL: http://www.smartgrowth.bc.ca/downloads/SGBC%5FHealth%20Report%20Final.pdf

[106] Frank L, Kavage S, Litman T. Promoting Public Health Through Smart Growth : Building Healthier Communities Through Transportation and Land Use Policies and Practices. SmartGrowth BC 2007 [cited 8-2-2007]; Available from: URL: http://www.smartgrowth.bc.ca/downloads/SGBC%5FHealth%20Report%20Final.pdf

"The number of road lanes available also impacts driving speed. As the number of lanes increases, more accidents occur. On two-lane roads, prudent drivers set the pace and, others must follow but on multi-lane roads, aggressive drivers can pass slower drivers, and they tend to set the prevailing speed (Burden and Lagerwey, as cited by Ewing, Frank & Kreutzer, 2006). The conversion of an urban two-lane undivided road to four lanes typically produces a substantial increase in accident rates (Harwood, as cited by Ewing, Frank & Kreutzer, 2006)." P.46

**Trees decrease traffic crashes in urban areas - same with other fixed objects**
"Lee and Mannering (1999, as cited by Ewing, Frank & Kreutzer, 2006) investigated the effect of roadside trees. In rural areas, the presence of trees was associated with statistically-significant increases in the number of roadside crashes that occurred. However in urban areas, the presence of trees was associated with a decrease in the probability of a roadside crash. The number of sign supports was also associated with crash reductions, as were the presence of miscellaneous fixed objects, including mailboxes and telephone booths." P.48

**Parked cars are a safety buffer for pedestrians but are not good for car accidents**
"Parked cars act as a buffer between traffic and pedestrians and are a convenience to shoppers and residents. However, these benefits come at the expense of traffic safety. If parking is permitted, conflicts with parked cars produce about 40 per cent of total accidents on two-way major streets, 70 per cent on local streets, and a higher percentage on one-way streets (Box, as cited by Ewing, Frank & Kreutzer, 2006). The number of accidents increases with the parking turnover rate, meaning that land uses which generate high turnover will also generate more traffic accidents (Humphreys et al, as cited by Ewing, Frank & Kreutzer, 2006)." P.48

**4 way stops safer for pedestrians than signals**
"From a safety standpoint, all-way stops appear to outperform signals at moderate traffic volumes, say, up to 10,000 vehicles per day on the major street (Syrek, 1955; Ebbecke and Schuster, 1977; Bissell and Neudorff 1980, as cited by Ewing, Frank & Kreutzer 2006). One study found that pedestrian collisions declined by 25 per cent when traffic signals were converted to all-way stops at low-volume urban intersections (Persaud et al, 1997, as cited by Ewing, Frank & Kreutzer, 2006)." P.49

**6 design factors that affect bicycle use**
"The Federal Highway Administration (as cited in Frank and Engelke, 2006) summarizes the **six design factors believed to have the greatest effect on bicycle use**: • Traffic volume. Higher motor vehicle traffic volumes represent greater potential risk for cyclists and contribute to their sense of fear. Average motor vehicle operating speed. The average operating speed is more important than the posted speed since the two frequently are not the same. •Traffic mix. The regular presence of trucks and buses inhibits cycling. On-street parking. The presence of on-street parking increases the width needed in the adjacent travel or bike lane to accommodate bicycles. Sight distance. A lack of sight distance sufficient to allow motorists to slow or avoid bicyclists when passing causes safety problems. Number of intersections. Intersections create problems for cyclists and pedestrians, especially when bike lanes or separate paths are involved." P.49-50

**Pedestrian collisions two and one-half times more likely on street sections without sidewalks**

"One study found that pedestrian collisions were two and one-half times more likely on street sections without sidewalks than those with them (Tobey et al, 1983; Knoblauch et al, 1988, as cited by Ewing, Frank & Kreutzer, 2006)."[107] P.50

**Marked crosswalk with no other improvements associated with higher pedestrian crash rates**

"...on multi-lane roads with traffic volumes above about 12,000 vehicles per day, having a marked crosswalk alone (without other substantial improvements) was associated with higher pedestrian crash rates (after controlling for other site factors) compared to an unmarked crossing. However, raised medians provided significantly lower pedestrian crash rates on multi-lane roads, compared to roads with no raised median[108]." P.50

**Vehicle emissions**

"Vehicle emissions are caused by two processes: combustion and evaporation. During combustion, the burning fuel in a vehicle and the air around it experience oxidation. This process produces carbon monoxide, carbon dioxide, and in some cases sulphur oxides (SOx) and nitrogen oxides. Particulate matter is also the result of combustion. Visually, PM is the smoke that comes out of tailpipes and smokestacks. It is composed of small particles that vary in size and that contain such elements as organic chemicals, ammonium, sulfates, nitrates, carbon and other metals. The smaller the particles, the easier they are to enter into human lungs and compromise health." P.54

**Air quality and health**

"Poor air quality contributes to mortality, cancer, cardiovascular disease and birth defects[109]." P.55

**Air quality and respiratory problems**

The biggest impact of air pollution, however, is on respiratory health. Resulting health outcomes include bronchitis, asthma, reduced lung function and cardiac-related respiratory problems[110]. P.56

**Children and air pollution**

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[107] Tobey et al, 1983; Knoblauch et al, 1988, as cited by Ewing, Frank & Kreutzer, 2006.
(Ewing R, Frank L, Kreutzer R. Understanding the Relationship Between Public Health and the Built Environment: A Report Prepared for the LEED-ND Core Committee. Washington, DC: LEED for Neighbourhood Development Partnership; 2006.)

[108] Zegeer et al, as cited by Ewing, Frank & Kreutzer, 2006. (Ewing R, Frank L, Kreutzer R. Understanding the Relationship Between Public Health and the Built Environment: A Report Prepared for the LEED-ND Core Committee. Washington, DC: LEED for Neighbourhood Development Partnership; 2006.)

[109] Frumkin H, Frank L, Jackson R. Urban Sprawl and Public Health: Designing, Planning, and Building for Healthy Communities. Washington, D.C.: Island Press; 2004.

[110] Campbell M, Pengelly D, Bienefeld M. Air Pollution Burden of Illness in Toronto: 2004 Summary. Toronto: Toronto Public Health; 2004.

”Studies have also shown that children are particularly vulnerable to health impacts from air pollution. Frumkin et al (2004) suggest that this is due to the following factors:
• Physical development – small lungs, narrow airways and rapid breathing mean that children inhale a greater amount of air than adults.
• Play – outdoor play and recreation activities place children in areas where pollution levels are highest, and exposure to ozone is most likely.
• Asthma – asthma rates are high among children. ... Asthma is affected by pollutants, particularly ozone and particulate matter. It has been known for some time that air pollution makes asthma symptoms worse; however, recent studies suggest that exposure to air pollution may lead to the development of asthma[111].” P.56

**VMT is affected by the built environment**
“One of the key determinants of poor air quality is known as VMT, or vehicle miles travelled. VMT has increased over the years, due to the increased number of cars on the road and to community design and land use development. A 2001 study by the U.S. Environmental Protection Agency found that the biggest determinant of the length of a trip in miles (VMT), as well as the duration of a trip in hours (VHT), is the built environment.” P.61

**Kids who are hospitalized for respiratory problems more likely to live less than one quarter of a kilometer of a busy roadway than other hospitalized kids**
”In a study by Lin et al (2002, as cited in McKeown, 2006) of hospitalized children in New York State, the researchers found that those children who were in the hospital for asthma, compared to those who were in for reasons other than respiratory-related illness, were more likely to live less than onequarter of a kilometre away from busy roadways that carried truck traffic and other vehicles with high amounts of miles travelled.”[112] P.61

**Density and VMT**
”In a major American study that looked at density as a variable of the built environment, Holtzclaw (1994, as cited in Ewing et al, 2006) found that compared to low density communities, high density neighbourhoods with mixed land use, pedestrian access and public transit services produced about 30 per cent fewer VMTs. In a 2000 follow-up to the 1994 study, Holtzclaw et al (2002, as cited in Ewing et al, 2006) found that a doubling in the density of an area resulted in reduced VMT by as much as 43 per cent, and that higher density was correlated with less vehicle ownership. This study concluded that four variables play a key role in the number of vehicles that people own and the total amount of miles that people drive: density, access to transit, household income and household size.” P.64

**Density and VMT**
”Increasing density, however, could also produce some negative effects. As some of the literature suggests, a more compact community can result in a small area with a high volume of

[111] Government of Canada. Children's Health and the Environment in North America: A First Report on Available Indicators and Measures. Country Report: Canada. 2006.

[112] Lin et al (2002, as cited in McKeown, 2006.
(McKeown D. Toronto Staff Report: The Impacts of Traffic on Health. Toronto: Toronto Public health; 2007.)

traffic and congestion. This can result in negative health impacts to residents The Impact of the Build Environment on the Health of the Population: A Review of the Review Literature 65 who are exposed to traffic emissions due to living in close proximity to busy roadways[113]." P.64-65

**How far people will walk for public transit**

"What is a reasonable distance for convenient access to public transit? Studies in the U.S. have shown that although 70 per cent of people will walk 500 feet for a normal daily trip, 40 per cent will walk 1,000 feet and 10 per cent will walk half a mile (Unterman 1990, as cited in Ewing et al, 2006), this distance increases for people who walk to a public transit stop (a quarter mile for a bus and up to half a mile for a train) (Frank, Stone and Bachman, as cited in Ewing et al, 2006)." P.65

**Two case studies (Portland, OR, and Montgomery County, Maryland) that show expanding public transit options has positive effects both on ridership and on employment opportunities**

"In a study that looked at a traffic impact model for Portland, Oregon, it was concluded that public transit trips to work would almost double if the transit system in that city was expanded (1000 Friends of Oregon, 1997, as cited in Ewing et al, 2006). These results were replicated in another modeling study in Montgomery County, Maryland. There it was found that with expanded transit infrastructure, along with development that was centred around the transit system, the County could double over 30 years the number of employment opportunities and households within the acceptable traffic congestion levels, inferring that public transit would be a highly used mode of transportation (Replogle, 1993, as cited in Ewing et al, 2006)." P.65

**Tolls as a tool for reducing SOVs, example from London**

"Several other strategies have been found effective in increasing public transit use, thereby reducing private vehicle use. One such example is the tolls imposed on vehicles entering the central area of London, England (an area of about 20 kilometres in size) in 2003. During the weekday, vehicles going into the city centre were charged a flat fee. The result of this fee was a 20 per cent increase of kilometres traveled by buses within the fee zone, as well as 25 per cent increase in bus use and a 29 per cent decrease in vehicle kilometres traveled. Overall, these changes resulted in a reduction of NOx and PM emissions by 12 per cent, and CO2 by 19 per cent. (Beevers 2004, as cited in McKeown, 2006)." P.66

**Tennessee example of people having lower emissions rates in the downtown street grid area with density than the city's suburbs**

"In a study looking at the location of two existing and similar communities near Nashville, Tennessee, it was found that the community that was closer to downtown Nashville, and that had a street grid pattern and a higher density, had emission rates 30 per cent lower than the low density neighbourhood located closer to the suburbs (Allen, 2003, as cited in Ewing et al, 2006)." P.66

[113] Ewing R, Frank L, Kreutzer R. Understanding the Relationship Between Public Health and the Built Environment: A Report Prepared for the LEED-ND Core Committee. Washington, DC: LEED for Neighbourhood Development Partnership; 2006.

**The physical environment has a measurable effect on mental and physical health**
"In research by Kaplan and Kaplan (1989, as cited in Maller et al, 2005) it was concluded that: "**People with access to nearby natural settings have been found to be healthier overall than other individuals**."(p.47)(92) Overall health impacts in this research were not just physical. They included such mental health **indicators as increased levels of job and homelife satisfaction and satisfaction with "life in general**".(p.47) Further, Maller et al (2005) cite several studies conducted between 1987 and 2001 that indicate **the human connection to the natural environment is not only vital for good physical health in terms of meeting basic needs (such as food, air, shelter and water), but that it is also essential for human mental health by fulfilling a plethora of emotional, spiritual and psychological needs** (Wilson, 1984; Katcher & Beck, 1987; Friedmann & Thomas, 1995; Roszack, et al 1995; Frumkin, 2001; Wilson, 2001). More specifically, Rohde and Kendle (1994, as cited in Maller et al 2005) concluded in their review of the literature that: "…**the psychological response to nature involves feelings of pleasure, sustained attention or interest, 'relaxed wakefulness**', and diminution of negative emotions, such as anger and anxiety.)(p.48)[114]" P.73

**Sprawl and the sense of isolation, mental health**
"Suburbs are characterized by neighbourhoods that are spread out, in which people drive more often than they walk; stores and services that are boxy and impersonal; and large residential lots that separate neighbours and create vast distances between homes, schools, shops and services. These characteristics of a neighbourhood can often lead to a person experiencing feelings of isolation and alienation. Many sprawl areas have little or poorly serviced public transit systems, making jobs and services hard to get to without access to a car. This can lead to further feelings of isolation. For some, these factors can also contribute to a lack of cohesion and connectivity to the community. Their sense of "community" or "belonging" is lost when they do not know their neighbours, can't shop at local stores, or must spend most of their day in a car commuting to work, robbing them of time at home and in their neighbourhood. As Frank et al (2005) state: "A connected and supportive community can both prevent and mitigate the impact of mental health disorders."(p.34)[115]" P.75

**Driving causes stress**
"Bray et al (2005) cite more recent studies that show traffic stress to be associated with depression and lower overall health status (Gee and Takeuchi, 2003 & 2004). Curbow (1999) found that several traffic-related factors, such as exposure to vehicle fumes, traffic volume, visual distractions on the road, and the anxiety and stress that results from driving in heavy traffic, can lead to increased blood pressure and headaches, and in some cases, incidents of road rage. Frumkin (2002, as cited in Bray et al, 2005) reported that driving can even impact negatively on relations with family, friends and coworkers who can be the ones to feel the effects of a frustrated and anxious driver. He hypothesizes that drivers who come home from long

[114] Maller C, Townsend A, Brown P, St.Leger L. Healthy nature healthy people: 'Contact with nature' as an upstream health promotion intervention for populations. Health Promotion International 2005 Dec 22;21(1):45-54.

[115] Frank L, Kavage S, Litman T. Promoting Public Health Through Smart Growth: Building Healthier Communities Through Transportation and Land Use Policies and Practices. SmartGrowth BC 2007 [cited 8-2-2007]; Available from: URL: http://www.smartgrowth.bc.ca/downloads/SGBC%5FHealth%20Report%20Final.pdf

commutes feeling angry and disgruntled do not just restrict their negative feelings to their cars, but bring home their frustration and let it out on their loved ones. Social and family relationships may be compromised as the result." P.77

**Policy actions that can enhance mental health**
It is possible to design communities and make land use decisions that will enhance, rather than hinder, overall population mental health. Based on what is written on this topic in the literature actions to achieve this can include:
• Provide open space and park areas within the urban environment that are easily accessible to all residents and visitors of a community, but particularly located
near schools, workplaces and housing developments[116].
• Ensure that communities Include meeting places and common areas that address all stages of the life cycle[117].
• Increase community safety features and initiatives to induce more social interaction among neighbours and increase physical activity[118]." P.81

**Less driving brings more sense of community, which impacts mental health**
"Frank et al (2005) state that walking in a neighbourhood can increase contact with neighbours, provide more eyes on the street, and thus prevent crime, and can instill a greater sense of community pride and cohesion. "Practices that decrease time spent The Impact of the Build Environment on the Health of the Population: A Review of the Review Literature driving and increase pedestrian activity, social interactions and commercial activity in a neighbourhood can probably also increase social capital."(p.35)[119] Freeman (2001) adds that if social capital is to increase then communities must be designed to be less car-oriented and more walkable, which is dependent on good public transportation system planning. "Developing more transit oriented neighbourhoods would likely enhance neighbourhood social ties, either by attracting individuals who are inclined to form such ties or by causing individuals already residing there to form them."(p.74)[120]" P.87-88

## Ross A. Hammond and Ruth Levine, *The Economic Impact of Obesity in the United States*

[116] Maller C, Townsend A, Brown P, St.Leger L. Healthy nature healthy people: 'Contact with nature' as an upstream health promotion intervention for populations. Health Promotion International 2005 Dec 22;21(1):45-54.

[117] International City & County Management Association. Active Living and Social Equity:
Creating Healthy Communities for All Residents. Washington, D.C.: ICMA; 2005 Jan 1.

[118] International City & County Management Association. Active Living and Social Equity: Creating Healthy Communities for All Residents. Washington, D.C.: ICMA; 2005 Jan 1.

[119] Frank L, Kavage S, Litman T. Promoting Public Health Through Smart Growth: Building Healthier Communities Through Transportation and Land Use Policies and Practices. SmartGrowth BC 2007 [cited 8-2-2007]; Available from: URL: http://www.smartgrowth.bc.ca/downloads/SGBC%5FHealth%20Report%20Final.pdf

[120] Freeman L. The effects of sprawl on neighborhood ties. American Planning Association
Journal 2001;67(1):69-77.

**Abstract:**
Over the past several decades, obesity has grown into a major global epidemic. In the United States (US), more than two-thirds of adults are now overweight and one-third is obese. In this article, we provide an overview of the state of research on the likely economic impact of the US obesity epidemic at the national level. Research to date has identified at least four major categories of economic impact linked with the obesity epidemic: direct medical costs, productivity costs, transportation costs, and human capital costs. We review current evidence on each set of costs in turn, and identify important gaps for future research and potential trends in future economic impacts of obesity. Although more comprehensive analysis of costs is needed, substantial economic impacts of obesity are identified in all four categories by existing research. The magnitude of potential economic impact underscores the importance of the obesity epidemic as a focus for policy and a topic for future research.

**Findings:**

**Obesity causes health problems**
"Obesity is linked with higher risk for several serious health conditions, such as hypertension, type 2 diabetes, hypercholesterolemia, coronary heart disease (CHD), stroke, asthma, and arthritis. Direct medical spending on diagnosis and treatment of these conditions, therefore, is likely to increase with rising obesity levels." P.285-286

**Definition of obesity**
"The most common definitions of obesity are based on body mass index (BMI), defined as weight in kilograms divided by height in meters squared. Obesity in adults is generally defined as a BMI of 30.0 or greater, with BMI of 25.0–29.9 categorized as overweight" P.286

**Obese individuals have higher health care costs over time**
"The obese (BMI [greater than or equal to] 30) had 36% higher average annual health care costs than the healthy-weight group, including 105% higher prescription costs and 39% higher primary-care costs. The overweight (BMI 25–29) had 37% higher prescription costs and 13% higher primary-care costs than the healthyweight group[121] [122] [123]."

**Obesity is a risk factor for other health problems**
"obesity is a risk factor for hypertension, hypercholesterolemia, and diabetes, which are themselves risk factors for CHD and stroke." P. 286

**Increased mortality among obese individuals offsets their increased medical costs somewhat but not much**

[121] Gorsky R, Pamuk E, Williamson D, Shaffer P, Koplan J. The 25-year health care costs of women who remain overweight after 40 years of age. Am J Prev Med. 1996;12:388–394.

[122] Ogden CL, Carroll MD, Curtin LR, et al. Prevalence of overweightand obesity in the United States, 1999–2004. JAMA. 2006;295(13):1549–1555.

[123] Thompson D, Edeslberg J, Kinsey KL, Oster G. Estimated economic costs of obesity to US business. Am J Health Promot. 1998;13(2):120–27.

Allison et al18 examine whether any of the direct medical costs of obesity estimated in previous studies might be offset by increased (early) mortality associated with obesity. They conclude that increased mortality may lower costs somewhat, though inclusion of this factor does not affect the qualitative conclusion that such costs are likely substantial[124]." P.287

**Weight gain in females affects GPA**
"There is a consistent negative relationship between weight and GPA among females, though the magnitude is not very large. The point estimate for white females from the OLS regressions suggests that a 50% increase in BMI would lead to a 6.6% decline in GPA, and a 50 lb weight gain would lead to a 0.17 point decline in GPA. Obese white females had a 0.182 point lower GPA on average relative to their nonobese counterparts. Sabia notes that while the size of the weight gains discussed is large, even a 0.2 point drop in GPA translates to a drop of eight percentiles. The results for nonwhite females are roughly similar in size and significance, with an even lower relative mean GPA among the obese group. Among males, the only significant correlation is for nonwhites: the individuals in the obese group had a 0.18 point lower mean GPA than those in the nonobese group." P.292

**Obese individuals spend substantially more on healthcare than non-obese people**
"Relative medical spending for the obese may be as much as 100% higher than for healthy weight adults, and nationwide "excess" medical spending may amount to as much as $147 billion annually for adults and $14.3 billion annually for children." P.294

**Productivity costs related to obesity are high**
"significant productivity costs are linked with obesity. Productivity effects may fall into at least four different categories (absenteeism, presenteeism, disability, and premature mortality). Several of the studies reviewed focus on only a subset of these effects, and there is extensive variation in cost estimates." P.294

## P. L. Jacobsen, *Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling*

**Abstract:**
Objective: To examine the relationship between the numbers of people walking or bicycling and the frequency of collisions between motorists and walkers or bicyclists. The common wisdom holds that the number of collisions varies directly with the amount of walking and bicycling. However, three published analyses of collision rates at specific intersections found a non-linear relationship, such that collisions rates declined with increases in the numbers of people walking or bicycling.

[124] Allison DB, Zannolli R, Narayan KM. The direct health care costs of obesity in the United States. Am J Public Health. 1999;89(8):1194–1199.

Data: This paper uses five additional data sets (three population level and two time series) to compare the amount of walking or bicycling and the injuries incurring in collisions with motor vehicles.
Results: The likelihood that a given person walking or bicycling will be struck by a motorist varies inversely with the amount of walking or bicycling. This pattern is consistent across communities of varying size, from specific intersections to cities and countries, and across time periods.
Discussion: This result is unexpected. Since it is unlikely that the people walking and bicycling become more cautious if their numbers are larger, it indicates that the behavior of motorists controls the likelihood of collisions with people walking and bicycling. It appears that motorists adjust their behavior in the presence of people walking and bicycling. There is an urgent need for further exploration of the human factors controlling motorist behavior in the presence of people walking and bicycling.
Conclusion: A motorist is less likely to collide with a person walking and bicycling if more people walk or bicycle. Policies that increase the numbers of people walking and bicycling appear to be an effective route to improving the safety of people walking and bicycling.

**Findings:**

**Inverse relationship between the number of ppl biking and walking and deaths and injuries**
"The likelihood that a given person walking or bicycling will be struck by a motorist varies inversely with the amount of walking or bicycling. This pattern is consistent across communities of varying size, from specific intersections to cities and countries, and across time periods." P.205

**More collisions with less bicyclists. For pedestrians, number of cars is an important factor**.
"Ekman examined numbers of pedestrians, bicyclists, and motorists, and serious conflicts among them at 95 intersections in Malmö, Sweden. He found that after adjusting for the number of bicyclists, the number of conflicts/bicyclist was twice as great at locations with few bicyclists compared with locations with more. In fact, the number of conflicts/bicyclist decreased abruptly with more than 50 bicyclists/hour. With pedestrians, Ekman found that although the number of conflicts/pedestrian was largely unaffected by numbers of pedestrians, the conflict rate was still affected by numbers of motorists.[125]" P.205

**Motorists most likely adjust to seeing more ppl and drive with them in mind.**
"It seems unlikely that people walking or bicycling obey traffic laws more or defer to motorists more in societies or time periods with greater walking and bicycling. Indeed it seems less likely, and hence unable to explain the observed results. Adaptation in motorist behavior seems more plausible and other discussions support that view. Todd reported three studies showing "motorists in the United States and abroad drive more slowly when they see many pedestrians in the street and faster when they see few"[126]." P.208

[125] Ekman L. On the treatment of flow in traffic safety analysis—a non-parametric approach applied on vulnerable road users. Bulletin 136. Lund, Sweden: *Institutionen för Trafikteknik, Lunds Tekniska Högskola*, 1996.

[126] Todd K. Pedestrian regulations in the United States: a critical review. *Transportation Quarterly* 1992;46:541–59.

**More people, less collisions**
"A motorist is less likely to collide with a person walking and bicycling when there are more people walking or bicycling. Modeling this relationship as a power curve yields the result that at the population level, the number of motorists colliding with people walking or bicycling will increase at roughly 0.4 power of the number of people walking or bicycling. For example, a community doubling its walking can expect a 32% increase in injuries (20.4 = 1.32)." P.208

**Key, easily quotable, points**
"• Where, or when, more people walk or bicycle, the less likely any of them are to be injured by motorists. There is safety in numbers.
• Motorist behavior evidently largely controls the likelihood of collisions with people walking and bicycling.
• Comparison of pedestrian and cyclist collision frequencies between communities and over time periods need to reflect the amount of walking and bicycling.
• Efforts to enhance pedestrian and cyclist safety, including traffic engineering and legal policies, need to be examined for their ability to modify motorist behavior.
• Policies that increase walking and bicycling appear to be an effective route to improving the safety of people walking and bicycling." P.209

## Ugo Lachapelle and Lawrence D. Frank, *Transit and Health: Mode of Transport, Employer-Sponsored Public Transit Pass Programs, and Physical Activity*

**Abstract:**
Increased provision of transit service and policy incentives that favor transit use can support a physically active lifestyle. We used the SMARTRAQ travel survey in metropolitan Atlanta, Georgia (in 2001–2002) to assess whether transit and car trips were associated with meeting the recommended levels of physical activity by using walking as a means of transportation. Additionally, we assessed associations between walking and using an employer-sponsored public transit pass. We controlled for demographics, neighborhood density, presence of services near workplaces, distance from home to transit, and car availability in our sample of 4,156 completed surveys. Walking distances from origin to destination were derived by a geographical information system and categorized as: no walking, moderate walking, or meeting recommendation (walkingX2.4km (1.5 miles) a day, approximatelyX30 min). In a multinomial logistic regression controlling for other covariates, transit trips were associated with an odds ratio (OR) of 3.87 (confidence interval (CI) 95%, 2.93–5.11) of meeting recommendation. In a multinominal logistical regression controlling for other covariates, transit users were associated with meeting recommendation, OR 2.23 (CI 95%, 1.27–3.90).

**Findings:**

**Low density less walking, Transit users living close to transit were more likely to be moderate walkers.**
"Living in a lower density neighborhood was significantly and negatively associated with being a moderate walker and with meeting recommendation after adjusting for other variables in the

model. Living within 450m (0.28 miles) of a bus stop or rail station was not associated with walking when only transit users were considered. However, transit users living between 450 and 1,000m (0.6 miles) of transit were more likely to be moderate walkers than those living farther away from transit." P.S83

**Employer-sponsored transit pass positively associated with meeting physical activity recommendation**
Having an employer-sponsored transit pass had a positive relationship with meeting the physical activity recommendation, but not with being a moderate walker. It may be that those who benefit from a sponsored transit pass leave home more frequently without a car, make shopping and leisure detours between transit and destination, work in locations that are denser and better served by transit, and, as a result, adopt a lifestyle that involves walking considerable distances." P.S87-S88

**Sponsoring a transit pass is a good deal for employers and employees**
"Sponsored transit pass programs are attractive to both employer and employee because they are tax-free to employees and tax-deductible for the employer. Furthermore, they may reduce demand on parking space for employers and contribute to employee retention[127]." P.S88

**People may live in less transit-serviced areas but then take transit to work in an area where they can walk to amenities during the day/lunchtime etc.**
"Motorized modes of transport and trips taken may act as mediators in the relationship between the built environment and walking. Employer-sponsored pass users and other transit users do not all reside in higher-density areas. Some transit users may live in medium-density areas adequately served by transit, but gain access, through a transit trip, to higher-density areas where multiple services are available within short walking distances. These individuals might be reported as frequent walkers living in low-density, disconnected areas, and may have decreased the impact and significance of residential neighborhood effect in previous studies. Inversely, car users living in a highly walkable area may record little walking if their work destination is not walkable and not accessible by transit." P.S88-S89

**Incentives coupled with infrastructure to get more transit ridership**
"To reduce car travel, walkable developments must provide an alternative to car use for long-distance regional travel. Along with land use policies and transportation infrastructure, we found that transportation incentives supporting transit use may offer a synergistic means of improving population health through active lifestyles. Changing land use is difficult and will likely not be enough. Making transit incentives more broadly available may increase the proportion of people meeting the physical activity recommendation." P.S91

**Good wrap up sentence- employer sponsored pass positively correlated with physical activity and from there health.**
"The significant and positive relationship between having access to an employer-sponsored transit pass, using the pass, and meeting the physical activity recommendation suggests public

[127] Transportation Research Board. Analyzing the Effectiveness of Commuter Benefits Programs. Washington, DC: Transit Cooperative Research Program; 2005, Available at http://onlinepubs.trb.org/Onlinepubs/tcrp/tcrp_rpt_107.pdf, accessed 14 August 2008.

health benefits of transit passes and that working in a walkable environment is associated with health-promoting behaviors." P.S91

## Urban Design 4 Health, Inc. and The American Public Health Association, *The Hidden Health Costs of Transportation*

**Abstract:**

Our dependence on automobiles and roadways has profound negative impacts on human health: decreased opportunities for physical activity, and increased exposure to air pollution, and the number of traffic crashes. The health costs associated with these impacts, including costs associated with loss of work days and wages, pain and suffering, and premature death, may be as high as several hundred billion dollars. An investment in a "healthier" transportation system is critical. Providing convenient alternatives, encouraging active modes of transport, and a establishing a transportation system that fosters connectivity and social interaction can not only offset health impacts and costs, but generate health benefits…Much more work is needed in the area of health evaluation and cost assessment in transportation policy. Investments in healthier transportation are also critically needed. A few key policy changes can help realize both of these objectives.

**Findings:**

**Negative, and expensive, effects of transportation on health**

"Our dependence on automobiles and roadways has profound negative impacts on human health: decreased opportunities for physical activity, and increased exposure to air pollution, and the number of traffic crashes. The health costs associated with these impacts, including costs associated with loss of work days and wages, pain and suffering, and premature death, may be as high as several hundred billion dollars." Ex-1

**Good summary of the land use and transportation paradigms we have embraced for the last 50+ years and where we are now as a result.**

"Since the 1950s our country has prioritized road building and the private auto when funding transportation, with proportionately little investment in transit, bicycle and pedestrian infrastructure[128]. The U.S. is, therefore, a country of drivers – despite recent downward trends in driving, over 80 percent of the country's workers drove or rode in a car to work in 2007[129], and in 2008 the average American drove nearly 10,000 miles. Investments in highways and roads have clearly provided the U.S. and its residents with benefits – convenience and comfort, economic opportunities, access and mobility – and a high degree of independence. However, our

[128] Homburger, W. Fundamentals of traffic engineering. Berkeley, CA: Institute of Transportation Studies, University of California, Berkeley, 1996. Available at: http://www.bts.gov/publications/transportation_statistics_annual_report/2008/html/chapter_04/table_04_04.html

[129] Puentes R, Tomer A. 2008. The Road…Less Traveled: An Analysis of Vehicle Miles Traveled Trends in the U.S. Washington, DC: Brookings Institution. p. 8.

auto dependent lifestyles have also impacted our health and our environment in many ways. Traffic crashes cause over 40,000 deaths a year. Thirty-five million people live within 300 feet of a major roadway, and are at higher risk of respiratory illness due to exposure to traffic-related air pollution[130]. About one-third of adults are estimated to be obese, and another third are overweight[131], due in part to sedentary lifestyles and the lack of opportunity for everyday physical activity. The mobility benefits of our current investment paradigm have also been inequitably dispersed—low-income, non-driving and ethnic minority populations are less likely to realize the benefits from road investment, and often suffer more of the adverse impacts[132]." P.1

**The federal transportation bill is an opportunity to rethink what we value and can help get more active transportation projects funded.**
"Negotiations over the federal transportation bill will shape transportation spending from top to bottom, and every indication is that the bill is a key opportunity not just to get more funding for health and safety programs, but to totally re-think the transportation funding process. Investment should shift toward transit, pedestrian and bicycling infrastructure in order to facilitate healthy, equitable and environmentally sound mobility." P.8

**We should have health-related criteria for federal transportation funding**
"A national set of health-related policy objectives needs to be part of the criteria for federal transportation funding decisions. Performance-based transportation funding would allocate more funds to projects and efforts that support healthy communities and active transportation, and give transportation planning agencies an incentive to put forth more health-promoting transportation investments." P.8

## The Healthy Transportation Network, *Bicycle and Pedestrian Transportation Training for Caltrans Staff*

**Abstract:**
The purpose of this Report is to provide an overview of some of the primary bicycle- and pedestrian-related technical training strategies and opportunities provided by Caltrans to its staff, and to make recommendations where appropriate. The Report's ultimate goal is to improve the availability, quality and safety of bicycle and pedestrian transportation in California by supporting and assisting Caltrans in fully implementing its active (non-motorized) transportation policies, including Complete Streets.

**Findings -** Examples of promotional campaigns and programs that were successful:

[130] Environmental Protection Agency. Available at: http://epa.gov/airscience/quick-finder/near-roadway.htm; accessed June 30, 2009.

[131] Ogden, C.L., M.D. Carroll, L.R. Curtin, M.A. McDowell, C.J. Tabak, and K.M. Flegal. 2006. Prevalence of Overweight and Obesity in the United States. Journal of the American Medical Association 295(13):1549-1555.

[132] Robert D. Bullard and Glenn S. Johnson. Just Transportation: Dismantling Race and Class Barriers to Mobility. Gabriola Islands, British Columbia, Canada: New Society Publishers, 1997.

**Bicycle planning and design course**
"Bicycle Planning and Design: In this consultant designed and delivered course, students learn the critical elements of planning and design for bicycle circulation. The course examines broad legal and policy issues, community-wide planning, policy needs, and detailed designs for bicycle systems and facilities. Included is a half-day guided bicycle tour through the city of Davis and the UC Davis campus." P.12

**Designing safe, accessible pedestrian facilities course**
"Designing Safe, Accessible Pedestrian Facilities: Communities across California are asking for more emphasis on walkability, with facilities that are safe and comfortable for all pedestrians, including those who are disabled. This new course covers principles and good practices, including how to plan, design, and operate a wide range of pedestrian-friendly facilities, including sidewalks, crosswalks, and other public spaces adjoining or intersecting the vehicular transportation system. Application of current standards and guidelines is emphasized. Case studies and in-class exercises supplement lectures." P.12

**Complete Streets learning modules**
"Complete Streets – Learning Modules: Caltrans' web-based training includes Designing Streets for Pedestrian and Bicycle Safety, Multi-modal 01 Introduction and is available online at http://www.dot.ca.gov/hq/tpp/offices/ocp/learning_modules.html" P.12

## Richard E. Killingsworth, Audrey de Nazelle, and Richard H Bell, *Building a New Paradigm, Improving Public Health through Transportation*

**Abstract:**
This feature describes the emerging active living movement, explains the potential health benefits that can result from a transportation system that supports walking and bicycling, articulates the role transportation professionals can play in improving public health and recommends what can be done to create and support an active transportation system. It identifies significant relationships between the built environment and travel choices, progress in building healthier communities and a need for better methods, data and improved multidisciplinary collaboration and decision-making.

**Findings:**

**Active transportation probably more effective than organized health programs**
"Furthermore, integrating additional walking and bicycling into a daily routine may be a better public health strategy than traditional structured and organized programs." P.29

**Tools and programs that can integrate physical activity concerns**
"Concerns about physical activity can be integrated easily in tools and programs used in transportation planning, such as community impact assessments and context-sensitive design." P.30

**Policies etc that help promote active transportation options and health as a transportation performance measure**
"• multidisciplinary collaboration;
• improved community participation;
• careful and informed community design;
• updated policies at the federal, state, or local government level or for employers and lenders (such as zoning, street standards, building codes, incentives for desirable development and redevelopment, funding flexibility, parking policies and school site location);
• targeted programs (such as health promotion programs, walk-toschool initiatives and walking clubs); and
• creative funding arrangements (such as incentives for housing construction near transit and location-efficient mortgages)." P.31

**Factors that make people more likely to walk**
"In many cases, the research and anecdotal evidence also show that people
are more likely to walk or bike if it is convenient, safe and enjoyable and if there are places to go and things along the way to capture the attention and sense of imagination." P.31

## Palma Chillon, Kelly R. Evenson, Amber Vaughn, and Dianne S. Ward, *A Systematic Review of Interventions for Promoting Active Transportation to School*

**Abstract:**
Background: Active transportation to school is an important contributor to the total physical activity of children and adolescents. However, active school travel has declined over time, and interventions are needed to reverse this trend. The purpose of this paper is to review intervention studies related to active school transportation to guide future intervention research.
Methods: A systematic review was conducted to identify intervention studies of active transportation to school published in the scientific literature through January 2010. Five electronic databases and a manual search were conducted. Detailed information was extracted, including a quantitative assessment comparing the effect sizes, and a qualitative assessment using an established evaluation tool.
Results: We identified 14 interventions that focused on active transportation to school. These interventions mainly focused on primary school children in the United States, Australia, and the United Kingdom. Almost all the interventions used quasi-experimental designs (10/14), and most of the interventions reported a small effect size on active transportation (6/14).
Conclusion: More research with higher quality study designs and measures should be conducted to further evaluate interventions and to determine the most successful strategies for increasing active transportation to school.

**Findings**:

**Active transportation to school = physical activity for children and adolescents**
"Active transportation to school is an important contributor to the total physical activity of children and adolescents. However, active school travel has declined over time, and interventions are needed to reverse this trend." P.1

**Findings for how effective various interventions were**
"1) Existing interventions to promote active transportation to and from school are heterogeneous, due to the size, scope, and focus of the intervention and measurements.
2) Interventions with appropriate school, parent, and community involvement and that work toward a specific goal (i.e., increasing active transportation) seemed to be more effective than interventions that were broader in focus.
3) Intervention quality was often low as measured by the EPHPP tool.
4) Interventions evidenced a small but promising effectiveness in increasing active transportation to school." P.15

## Jennifer Dill, *Bicycling for Transportation and Health: The Role of Infrastructure*

**Abstract:**
This paper aims to provide insight on whether bicycling for everyday travel can help US adults meet the recommended levels of physical activity and what role public infrastructure may play in encouraging this activity. The study collected data on bicycling behavior from 166 regular cyclists in the Portland, Oregon metropolitan area using global positioning system (GPS) devices. Sixty percent of the cyclists rode for more than 150 minutes per week during the study and nearly all of the bicycling was for utilitarian purposes, not exercise. A disproportionate share of the bicycling occurred on streets with bicycle lanes, separate paths, or bicycle boulevards. The data support the need for well-connected neighborhood streets and a network of bicycle-specific infrastructure to encourage more bicycling among adults. This can be accomplished through comprehensive planning, regulation, and funding.

**Findings:**

**Biking has the potential to replace more vehicle trips than walking and it's good for us**
"While most of the focus on ''active living'' has been on walking, bicycling may have a greater potential to substitute for motorized vehicle trips because of its faster speed and ability to cover greater distances. Bicycle commuting has been shown to be an activity that meets recommended intensity levels[133] and to be related to lower rates of overweight and obesity[134]." P.S95

**Factors that dissuade people from biking**
"US studies consistently find that women are less likely to bicycle than men[135] [136] [137] [138] [139]. One explanation is that some studies find that women are more concerned about safety, particularly

[133] 1. de Geus B, De Smet S, Meeusen R. Determining the intensity and energy expenditure during commuter cycling. Br J Sports Med. 2007;41:8–12.

[134] Wen LM, Rissel C. Inverse associations between cycling to work, public transport, and overweight and obesity: findings from a population based study in Australia. Prev Med. 2008;46:29–32.
[135] 12. Plaut PO. Non-motorized commuting in the U.S. Transp Res Part D – Transp Environ. 2005;10:347–56.

[136] 13. National Highway Traffic Safety Administration, and Bureau of Transportation Statistics. National Survey of Pedestrian and Bicyclist Attitudes and Behaviors: Highlights Report. Washington, DC: U.S. Department of Transportation; 2003.

from vehicle traffic[140] [141]. In the United States, bicycling rates also decline with age[142]. Several researchers have found that bike lanes and paths are correlated with higher rates of bicycling or willingness to cycle[143] [144] [145] [146] [147] [148]. However, cities need to know what type of infrastructure will be most effective."

**Bicyclists value bike lanes and paths**

"Simple stated preference studies usually find that people prefer bike paths and lanes or indicate that having such infrastructure would encourage them to bicycle more[149] [150]. Some studies present respondents with two options, trading off a higher quality facility (e.g., a dedicated bike lane) with a longer travel time. At least two such studies have found that bicyclists value bike lanes and off-street paths[151] [152]." P.S97

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[137] 14. Dill J, Voros K. Factors affecting bicycling demand: initial survey findings from the Portland, Oregon, region. Transp Res Rec. 2007;2031:9–17.

[138] 15. Shafizadeh K, Niemeier D. Bicycle journey-to-work: travel behavior characteristics and spatial analysis. Transp Res Rec. 1997;1578:84–90.

[139] 16. Moudon AV, Lee C, Cheadle AD, Collier CW, Johnson D, Schmid TL, et al. Cycling and the built environment, a U.S. perspective. Transp Res Part D – Transp Environ. 2005;10:245–61.

[140] 17. Health Canada. 1998 National Survey on Active Transportation; Summary Report. Go for Green; 1998. Available at http://safety.fhwa.dot.gov/ped_bike/docs/bike_flash.pdf, accessed 30 October 2008.

[141] 18. Garrard J, Rose G, Lo SK. Promoting transportation cycling for women: the role of bicycle infrastructure. Prev Med.2008;46:55–9.

[142] National Highway Traffic Safety Administration, and Bureau of Transportation Statistics. National Survey of Pedestrian and Bicyclist Attitudes and Behaviors: Highlights Report. Washington, DC: U.S. Department of Transportation; 2003.

[143] Pucher J, Komanoff C, Schimek P. Bicycling renaissance in North America? Recent trends and alternative policies to promote bicycling. Transp Res Part A – Policy Practice. 1999;33:625–54.

[144] Pucher J, Dijkstra L. Promoting safe walking and cycling to improve public health: lessons from the Netherlands and Germany. Am J Public Health. 2003;93:1509–16.

[145] Federal Highway Administration. National Bicycling and Walking Study, Case Study No. 1: Reasons Why Bicycling and Walking are Not Being Used More Extensively as Travel Modes. Washington, DC: U.S. Department of Transportation; 1992.

[146] Cervero R, Duncan M. Walking, bicycling, and urban landscapes: evidence from the San Francisco Bay Area. Am J Public Health. 2003;93:1478–83.

[147] Dill J, Carr T. Bicycle commuting and facilities in major U.S. cities: if you build them, commuters will use them. Transp Res Rec. 2003;1828:116–23.

[148] Antonakos CL. Environmental and travel preferences of cyclists. Transp Res Rec. 1994;1438:25–33.

[149] Federal Highway Administration. National Bicycling and Walking Study, Case Study No. 1: Reasons Why Bicycling and Walking are Not Being Used More Extensively as Travel Modes. Washington, DC: U.S. Department of Transportation; 1992.

[150] Antonakos CL. Environmental and travel preferences of cyclists. Transp Res Rec. 1994;1438:25–33.

[151] Tilahun NY, Levinson DM, Krizek KJ. Trails, lanes, or traffic: valuing bicycle facilities with an adaptive stated preference survey. Transp Res Part A – Policy Pract. 2007;41:287–301.

**Bike commuters differ from infrequent bike users in their preferences**
"One study found that bicycle commuters diverted very little from the shortest path and preferred not to ride on paths or trails[153]. A national survey found that frequent bicyclists preferred bike lanes rather than paths. Infrequent bicyclists were more likely to want more bike paths rather than lanes[154]." P.S97

**Mixed use and trip linking on bikes**
"participants were linking trips together, stopping somewhere on the way home from work, for example. This is made more feasible by Portland's policies and regulations that support mixing land uses, including commercial and residential uses. A well-connected network of bicycle-friendly infrastructure would also facilitate such linking of trips." P.S104

**Bicyclists place almost equal value on taking the shortest route and traveling on bike paths/lanes**
"The preference for traveling on bike paths and boulevards is consistent with the priority the bicyclists placed on routes that avoid streets with lots of vehicle traffic. However, the participants placed almost equal importance on minimizing trip distances. Without a well-connected network of bike lanes, paths, and boulevards, along with low-traffic neighborhood streets without specific bicycle infrastructure, meeting these two priorities simultaneously would be difficult." P.S104-S105

**Biking can allow a person to meet daily recommended physical activity**
"The study demonstrated that bicycling for transportation can be used by adults to meet the recommendations for daily physical activity." P.S105

**Infrastructure that would have the largest impact on biking**
"A network of different types of infrastructure appears necessary to attract new people to bicycling. Simply adding bike lanes to all new major roads is unlikely to achieve high rates of bicycling. For people concerned with safety and avoiding traffic, a well-connected network of low-traffic streets, including some bicycle boulevards, may be more effective than adding bike lanes on major streets with high volumes of motor vehicle traffic." P.S106

**Bike infrastructure is more useful when people can use it to trip chain (mixed use). Use zoning to help with this.**
"The bicycle infrastructure in Portland appears to work, in part, because of a supporting land use and street network structure. The areas within Portland where the highest levels of bicycling

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[152] Stinson M, Bhat C. Commuter bicyclist route choice: analysis using a stated preference survey. Transp Res Rec. 2003;1828:107–15.

[153] Aultman-Hall L, Hall FL, Baetz BB. Analysis of Bicycle Commuter Routes Using Geographic Information Systems: Implications for Bicycle Planning. Transp Res Rec. 1998;1578:102–10.

[154] Bureau of Transportation Statistics. How Bike Paths and Lanes Make a Difference. BTS Issue Brief. Washington, DC: Bureau of Transportation Statistics; 2004.

occur also have a well-connected street grid and mix of land uses. This allows bicyclists to link their trips together in an efficient manner. The grid street patterns allows the installation of bike boulevards that provide options to bicycling on major streets with more traffic, without increasing travel distances too much. The older parts of many US cities have this same supportive structure. For new development, street connectivity standards and zoning that allows or even mandates a mix of land uses can create such an environment." P.S106

### L. D. Frank, *Many Pathways from Land Use to Health: Associations between Neighborhood Walkability and Active Transportation, Body Mass Index, and Air Quality*

**Abstract:**
The literature shows single-use, low density land development and disconnected street networks to be positively associated with auto dependence and negatively associated with walking and transit use. These factors in turn appear to affect health by influencing physical activity, obesity, and emissions of air pollutants. We evaluated the association between a single index of walkability that incorporated land use mix, street connectivity, net residential density, and retail floor area ratios, with health-related outcomes in King County, Washington.
We found a 5% increase in walkability to be associated with a per capita 32.1% increase in time spent in physically active travel, a 0.23-point reduction in body mass index, 6.5% fewer vehicle miles traveled, 5.6% fewer grams of oxides of nitrogen (NOx) emitted, and 5.5% fewer grams of volatile organic compounds (VOC) emitted. These results connect development patterns with factors that affect several prevalent chronic diseases.

**Findings:**

**3 ways low density land use can adversely affect health**
"This article examines the following three pathways by which single-use, low density land use patterns can adversely affect health:
1. If the built environment reduces opportunity for active transportation, this may reduce total physical activity, and potentially increase risk for chronic disease.
2. If the built environment stimulates increased time spent in vehicles, it may reduce physical activity, and both of these may contribute to obesity, potentially increasing risk for chronic disease.
3. If the built environment stimulates increased vehicular travel, this may increase per capita vehicle emissions, and these may increase exposure to pollutants and risk of respiratory and cardiovascular ailments." P.75-76

**Confirmation that people in walkable areas walk more, creating positive externalities for themselves and others**
"We used comparable methods to discover that people living in more walkable neighborhoods (characterized by mixed use, connected streets, high residential density, and pedestrian-oriented retail) did more walking and biking for transportation, had lower BMIs, drove less, and produced less air pollution than people living in less walkable neighborhoods." P.82

**Promoting walkablility isn't enough to create a "healthy" place. Factors such as pollution are also crucial to address. P.84**

**Many regulations and guidelines favor less walkable land use patterns, producing negative health outcomes**
"A wide range of zoning, development, and transportation regulations and guidelines favor less walkable land use patterns (Schilling & Linton, 2005). Our findings are consistent with literature suggesting current laws and regulations are producing negative health outcomes (Frumkin et al., 2004; Hirschhorn, 2004), and support assessing the health impacts of actions that shape the built environment (Cole, Shimkhada, Fielding, Kominski, & Morgenstern, 2005)[155] [156] [157] [158]." P.85

## Kristin Hendricks, Risa Wilkerson, Christine Vogt, and Scott TenBrink, *Transforming a Small Midwestern City for Physical Activity: From the Sidewalks Up*

**Abstract:**
This project focused on implementing 5 "P"s (Preparation, Promotion, Programs, Physical Projects, and Policy) to promote active lifestyles in this small town (p.691). The community created a Walkable Communities Task Force which included representatives from the city engineering department, local hospital, public school administration, etc (p.692) and carried out a variety of activities to promote walkability.

**Findings:**

**Promotional components were used to generate interest in walkability, earn media attention, and introduce individuals to "try-it-out" events.**
"Jackson area elementary schools participate in **International Walk to School Day** as a way to kick-off a larger Safe Routes to School program at their schools and raise awareness about walking to school." P.292

**Promotional components were used to generate interest in walkability, earn media attention, and introduce individuals to "try-it-out" events.**
"A city-wide **Smart Commute Day** with interbusiness competitions and educational sessions about biking safety and other related topics was started as a promotional event to encourage use of walking, biking, and transit to work." P.292

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[155] Schilling, J. S., & Linton, L. S. (2005). The public health roots of zoning: In search of active living's legal genealogy. American Journal of Preventive Medicine, 28(1 Suppl. 2), 96-104.

[156] Frumkin, H., Frank, L. D., & Jackson, R. (2004). *The public health impacts of sprawl*. Washington, DC: Island Press.

[157] Hirschhorn, J. S. (2004). Zoning should promote public health. *American Journal of Health Promotion, 18*{3), 258—260.

[158] Cole, B. L., Shimkhada, R., Fielding, J. E., Kominski, G., & Morgenstern, H. (2005). Methodologies for realizing the potential of health impact assessment. *American Journal of Preventive Medicine, 28*(4), 382-389.

**Promotional components were used to generate interest in walkability, earn media attention, and introduce individuals to "try-it-out" events.**
"Other **promotional activities** during the first years of the program include the creation of quarterly newsletters, a monthly spot on the local cable channel, a new website focused on the project (www. fitnesscouncil.org), and the presence of the project at popular community events (ie, running races, county fair, vintage car shows, and festivals). Each of these promotional activities help raise awareness about walking and biking in the community and encourage people to either support physical projects or enroll in one of the larger programs aimed at more long-term behavior change (eg, ongoing Safe Routes to School or worksite programs)." P.292

**Programs for working-age adults**
"In addition to the companies that took part in the Smart Commute Day promotional event, one area worksite piloted "Foot Energy," a worksite-based program. The Foot Energy pilot was conducted at a community mental health agency located on the outskirts of the city limits with about 50 employees. The company's wellness committee partnered with the Fitness Council to implement the program. The Foot Energy program created individualized maps and active transportation plans for workers, made changes at the worksite to support active living (eg, lockers, bike racks), and started a "Company Bikes" program where staff could check-out a bike to use during the day for meetings and errands." P.292

**Prisoner reentry program that teaches parolees to maintain a bike, gives them donated bikes, etc (increasing their access to transportation)**
"In an effort to expand the adult audience receiving the active living message, another program for adults was developed in conjunction with the Michigan Prisoner Reentry Initiative (MPRI). Lack of a license or a vehicle leads to many parolees having no access to transportation to get to work and run errands. As part of a larger set of support services to new parolees, the partnership collects donated bikes, teaches parolees how to fit and maintain a bike, and provides helmets and bicycling accessories. In addition, parolees are offered an on-street riding skills training class. This program is an opportunity to introduce the practical benefits of active transportation to a previously unreached audience." P.292-293

**Apply for funds for infrastructure that can help support the SR2S program**
"A major area of physical projects work is around schools involved in the Safe Routes to School program. By working with city, village, and township governments, new sidewalks, crosswalks, bike racks, crossing pedestrian signs, median islands, and other improvements are installed around school campuses in key areas. Taking advantage of the new Federal Safe Routes to School program, each school with a Safe Routes to School program has applied for several larger projects that include large sidewalk segments and trail sections that will make the routes to school safer and encourage walking." P.293

**Media campaign**
"To show support of bike lanes to government officials the partnership designed a media campaign (newspaper, radio, billboards) that educated people about the use of bike lanes and culminated with hundreds of residents signing an online petition stating their support of bike lanes in the community. While not a direct policy change, the support of the public added further

credibility to work by the partnership and served for the first time as a formal advocate base for establishing local policies to create bike lanes." P.693

**In Jackson, it worked to have both physical and policy/programmatic interventions implemented in the same time frame**

Local intervention organizers are often caught in a "chicken and egg" question of whether physical activity change can be promoted to increase the demand for better environmental design or whether environmental improvements must be completed before people will even consider behavior change. Jackson's experience suggests that positive results are achieved when programs and promotions advance at the same time as work on physical projects and policy level interventions.

## P. Insall, *Active Travel: Transport Policy and Practice for Health*

**Abstract:**

Past transport policies have tended to prioritise private motorised transport above health enhancing, low-emission active travel – walking and cycling. Decision makers, most of whom are drivers themselves, suffer from the 'windscreen perspective' and have difficulty seeing the issues around transport policy in a clear way. As a result, policy and investment planning still lean towards the car.

However, a range of factors now all point towards active travel for local trips. Climate change, peak oil, security of energy supply, road safety, noise and local air pollution all back up the arguments in favour of active travel as an easy and accessible way to incorporate physical activity into daily life. As forms of physical activity, walking and cycling offer valuable protection against cardiovascular disease, various forms of cancer, type 2 diabetes, depression and other forms of mental ill-health, while also helping to maintain bone strength and fitness. Over the past decade, the evidence has accumulated and public health policy is now firmly in favour of active travel.

It is also now clear that there is great potential to shift large numbers of sedentary, motorised trips to active travel, with all the health and other benefits that would bring. Britons are using motorised transport for large numbers of short journeys, many of which could easily be walked or cycled.

The move of public health back into local government offers a real opportunity to influence transport policies and practice. Public health teams may be able to develop collaboration with their transport colleagues. The capital budgets of local authority transport departments can be used to improve the walking and cycling environment, while public health revenue funds could support

**Findings:**

**Benefits of active transportation**

"• It is an easy and accessible way for individuals to incorporate physical activity into their daily lives, reducing their risk of a number of diseases and improving their health (Hillsdon et al. 2005). It does this by:

– Helping to maintain a healthy weight in combination with an energy-controlled diet as part of a

healthy lifestyle (Shaw et al. 2006);
– Reducing cardiovascular disease risk. Higher cardiorespiratory fitness has been shown to reduce the risk of pre-mature death associated with obesity, even in the obese (Blair 2007). Physical activity improves insulin sensitivity, blood lipid and lipoprotein profile, body composition, inflammation, blood pressure and the autonomic nervous system (Lee et al. 2010; Gibson-Moore 2012);
– Protecting against many forms of cancer. Physical activity can be important at all stages of cancer progression, from pre-diagnosis to treatment to end-of-life care or rehabilitation in survival (BNF 2011);
– Helping to prevent type 2 diabetes in both the general population and in those with impaired insulin sensitivity by increasing insulin sensitivity and maintaining glucose tolerance (Hardman & Stensel 2003);
– Protecting against depression (Camacho et al. 1991) and other forms of mental ill-health such as dementia and Alzheimer's disease particularly in old age. Physical inactivity has been identified as a potentially important, modifiable risk factor for Alzheimer's disease (Barnes & Yaffe 2011). In addition, aerobic exercise interventions to increase cardiorespiratory fitness have been shown to coincide with improvements in cognitive capacity associated with being able to remain independent and retain a high quality of life in later years (Angevaren et al. 2008);
– Building and maintaining bone strength and protecting against falls by improving balance and strength (Hardman & Stensel 2003);
• It emits virtually no carbon dioxide (CO2). Climate change is leading to extreme weather events, mass migration, crop failures, disease migration and the other consequences of a changing climate. Note that climate change is itself a major public health issue (DH 2010) and is linked to international relations and security (BMJ Group 2011).
• It uses minimal amounts of petrochemicals. Global fossil fuel stocks have passed the point of 'peak oil', and petrochemicals are increasingly expensive and difficult to extract. Security of energy supply is a growing strategic, concern across the globe.
• It improves quality of life. More people walking and cycling in any environment means more social interaction and is associated with wellbeing, whereas higher levels of motor traffic are associated with community severance and isolation (Appleyard & Lintell 1972; Sauter & Hüttenmoser 2006)[159] [160] [161] [162] [163] [164] [165] [166] [167].»

[159] Hillsdon M, Foster C, Naidoo B et al. (2005) The effectiveness of public health interventions for increasing physical activity among adults: a review of reviews. Evidence briefing. 2nd edn. Available at: http://www.nice.org.uk/aboutnice/whoweare/aboutthehda/hdapublications/p103.jsp, (accessed 31 Jan 2012).

[160] Shaw KA, Gennat HC, O'Rourke P et al. (2006) Exercise for overweight or obesity. Cochrane Database of Systematic Reviews (4): CD003817.

[161] Blair SN (2007) Physical inactivity: a major public health problem. Nutrition Bulletin 32: 113–7.

[162] Lee DC, Artero EG, Sui X et al. (2010) Mortality trends in the general population: the importance of cardiorespiratory fitness. Journal of Psychopharmacology (Oxford, England) 24 (Suppl.): 27–35.

[163] Gibson-Moore H (2012) Can physical activity improve the health of the overweight without weight loss. Nutrition Bulletin 37: 148–51.

**Investing in active travel is good value, better than motorized transport investments**
"Investment in active travel is very good value. For example, using the UK DfT's 'Cost Benefit Analysis' methodology, walking and cycling schemes regularly return benefit to cost ratios (BCRs) of over 10:1, while the DfT regard a BCR of 2:1 as a good return on investment, and some motor transport schemes go ahead with even lower rates of return (NAO 2011)[168]." P.63

**Investing in motorized transport is actually a BAD investment**
"In 2009, the Cabinet Office report summed the costs associated with our current approach to transport, including cost of congestion, physical inactivity, CO2 emissions, other pollutants, noise and accidents, to £38–48 billion in England (Cabinet Office 2009a)[169]." P.63

**Motivational and informational active transportation programs proven effective and to get a good return on the investment, example in England**
"• Our Personalised Travel Planning (PTP) Programme has addressed more than 300 000 households (some 650 000 individuals) over the past decade, consistently reducing private motorised travel by up to 14%. PTP gets more people walking and cycling, and health eco-nomic modelling carried out for the National Institute for Health and Clinical Excellence (NICE) suggests that as a public health intervention it is excellent value (NICE 2012)[170]."

**Example in England of successful bike-to-school program**
"• Our work in schools gives children the skills and confidence to cycle regularly to school. In 2011, our staff worked within 1400 schools with 340 000 children, mainly in England; across the programme, cycling daily to school, a figure that has doubled since the launch of the programme. Bike It is expanding rapidly and will have reached around half a million children in 2012." P.65

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[164] BNF (British Nutrition Foundation) (2011) Physical activity and cancer: Prof John Saxton. Available at: ttp://nutrition.org.uk/attachments/502_3.Physical%20activity%20and%20cancer_Prof%20John%20Saxton.pdf (accessed 16 November
2012).

[165] Hardman AE & Stensel DJ (2003) Physical Activity and Health: The Evidence Explained. Routledge: New York.

[166] Camacho TC, Roberts RE, Lazarus NB et al. (1991) Physical activity and depression: evidence from the alameda county study. American Journal of Epidemiology 134: 220–31.

[167] DH (2010) 2009 Annual report of the Chief Medical Officer. Available at: http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/@ps/documents/digitalasset/dh_114012.pdf (accessed 15 November 2012).

[168] NAO (National Audit Office) (2011) Department for transport: local authority major capital schemes. Available at: http://www.nao.org.uk/publications/1012/local_authority_major_capital.aspx (accessed 15 November 2012).

[169] Cabinet Office (2009a) An analysis of urban transport. Available at: http://webarchive.nationalarchives.gov.uk/+/http://www.cabinetoffice.gov.uk/media/308292/urbantransportanalysis.pdf (accessed 15 November 2012).

[170] NICE (2012) Public health programme: walking and cycling: local measures to promote walking and cycling as forms of travel or recreation: health economic and modelling report. Available at: http://www.nice.org.uk/nicemedia/live/13428/589 5/58985.pdf (accessed 15 November 2012).

**Example of active travel consortium in England**
"• We lead the Travel Actively consortium. This comprises all of the walking and cycling groups working at national level, which has together delivered 50 associated projects across England, providing information and support in school, community and workplace settings. Travel Actively has helped two million people, in communities, universities and workplaces get more active through walking and cycling (ATC 2012)." P.65

**You need both infrastructure and programming to successfully promote active transportation**
"...experience shows that the greatest impact will be realized where we can integrate capital works, to make the environment more supportive to walking and cycling, with the information and motivational projects that encourage and support more people to choose active travel more often. These latter programmes (known in the transport field as 'soft measures') can be focused on the most deprived areas and communities. The ideal scenario is for an integrated package of environmental measures to make active travel easier to choose, and support to help individuals make the choice (Sustrans 2011b), aimed particularly at those most in need; a form of what Marmot has called 'proportionate universalism'. This approach can raise levels of physical activity across a population while the targeted elements 'flatten the curve' and improve health equality[171]." P.65

**S. Ryan, D. E. Sidelinger, S. Saitowitz, D. Browner, S. Vance, and L. McDermid, *Designing and Implementing a Regional Active Transportation Monitoring Program Through a County-MPO-University Collaboration***

**Abstract:**
**Purpose** This article describes a unique effort underway in San Diego County to establish a regional nonmotorized data collection system in support of long-range planning for bicycle and pedestrian systems, and physical activity promotion and monitoring.
**Design** Case study of a novel approach to siting a regional active travel data collection program. Setting. San Diego County, California. Subjects. None. Intervention. Installation of 54 automated bicycle and pedestrian counting units at 35 sites across San Diego County.
**Measures**. Equipment siting criteria including population density, employment density, median household income, planned bicycle network, and planned land uses. Analysis. Mapping, stakeholder input, site visits.
**Results**. A comprehensive network of 76 sites identified and proposed for long-range implementation.

[171] Sustrans (2011b) House of Lords science and technology committee behaviour change – travel mode choice interventions to reduce car use in towns and cities (Submission from Sustrans) (January 2011). Available at: http://www.sustrans.org.uk/assets/files/policy/Lords%20S%20and%20T%20Committee%20Behaviour%20Change%20Sustrans%20Response.pdf (accessed 15 November 2012).

**Conclusion**. This research establishes a siting methodology that holds promise for replication in other regions. San Diego's counting program is one of the most comprehensive automated data collection systems of any region in the United States.

**Findings:**

**Non-motorized counts programs are usually run by volunteers or advocacy organizations. These programs can be successful, however relying on less formalized counts keeps non-motorized modes marginalized and not a seriously considered or funded transportation option. Interagency collaboration helps integrate it into mainstream planning**
"Planning and implementation of the San Diego counting program grew out of collaboration between the County of San Diego Health and Human Services Agency (HHSA) chronic disease staff, San Diego State University (SDSU) city planning researchers, and SANDAG transportation planning professionals. The multidimensional, multidisciplinary effort created a critical foundation of funding availability, méthodologie rigor, and connection to mainstream planning and programming. Each of these facets is necessary for establishing a viable nonmotorized counting program." P.S105

**In order to understand the impacts of bicycling and walking you have to be able to monitor/measure the activity**
"A key justification for the successful grant application stemmed from arguments that the effectiveness of physical activity interventions, especially related to planning for bicycle and pedestrian travel, cannot be understood unless there is systematic measurement of cycling and walking" P.S105

**Equipment**
"Eco-Counter equipment (Lannion, France) was selected on the basis of three criteria: (1) automated tipload and transfer of the count data to a Web-based server, which precludes the need to conduct field visits for data uploads, (2) capability to count in-street cyclists and distinguish them from automobiles, and (3) previous research showing relatively high levels of accuracy." P.S105

**Methodology**
"Three products were purchased from Eco-Counter: the Zelt, the Pyro, and the Eco-Multi. Each of these technologies records counts at 15-minute intervals and the data are uploaded daily via modem to a Web-based server. The Zelt is used for in-street bicycle counting; the Pyro for pedestrian counting, and the Eco-Multi is used for bicycle and pedestrian counting on separated paths. The Zelt and Eco-Multi are installed permanently, collecting continuous, 24 hour data. The Pyro also collects continuous, 24-hour data, but is mobile." P.S105-S106

**Intended project outcome: to perform before-after analysis, to enhance understanding of active travel, and overall to treat biking and walking like real forms of transportation so they can get funding and attention**
"The design and implementation of this regional active transportation monitoring program reflect the synergy and positive outcome that can be achieved when public health professionals, planning professionals, and academic researchers collaborate to enhance our understanding of

active travel. The multidisciplinary approach was necessary to spearhead innovation grounded in ongoing regional transportation and land use planning and programs. The data will support trend analysis, before after analysis, and overall monitoring of
active travel impacts resulting from implementation of SANDAG's regional bicycle network and smart growth land development projects." P.S111

**J. F. Sallis, L. D. Frank, B. E. Saelens, and M. Kraft, *Active Transportation and Physical Activity: Opportunities for Collaboration on Transportation and Public Health Research***

**Abstract:**
Physically inactive lifestyles are a major public health challenge, and research in the transportation field on influences on the choice to walk and bike may provide guidance toward solutions. In the interests of promoting effective collaboration among the transportation, planning, and health fields, the current paper was written to fulfill three purposes. The first purpose was to summarize the transportation and planning studies on the relation between community design and non-motorized ("active") transport and to interpret these studies from a health perspective. The second purpose was to summarize studies from the health literature that examine the relation between physical environmental variables and leisure-time physical activity that have relevance for transportation research. The third purpose was to promote more collaboration among transportation, planning, and health investigators by identifying opportunities for transdisciplinary research.

**Findings:**

**Most trips happen within potential walking or biking distance and could be planned for accordingly**
"Although the concepts of proximity and connectivity are familiar to transportation professionals, these factors also are pertinent to understanding an individual s overall level of physical activity. For instance, approximately 83% of all ‘‘trips’’ (each instance of moving from a point of origin to a destination) are short, for non-work purposes, and occur relatively close to home (Ross and Dunning, 1997). The majority of non-work trip destinations are within walking or cycling distance of trip origins (e.g., home) and are therefore of interest to the physical activity, air quality, and transportation planning fields." P.252

**Although historically land use planning has occurred with health goals in mind, active transportation has been engineered out of the average post-WWII built environment**
"Although there is a long history of transportation and land use planning based on health, safety, and public welfare considerations, contemporary concerns about physical activity expand on these traditions and raise new issues of relevance to transportation researchers and practitioners. Plainly stated, the hypothesis is that land uses and transportation policy and infrastructure that have been dominant since World War II favor automobile use so heavily that most people have little or no ability to walk or cycle for transportation. This appears to be an historic and dramatic shift away from millennia of experience in which walking was the major form of transport. Current reliance on personal vehicle use, along with other factors contributing to more sedentary

lifestyles (e.g., application of technology to work and entertainment), has engineered physical activity for non-exercise purposes out of many Americans  lives." P.255

**Bicycle and pedestrian facilities close to homes associated with increased physical activity**
"Availability of recreational facilities near homes appears to be related to adults' physical activity. The self-reported presence of convenient physical activity facilities has been associated with exercise in adults (Sallis et al., 1989), has predicted increases in walking over time without intervention (Hovell et al., 1992), and has predicted adoption of vigorous exercise for men (Sallis et al., 1992a). An objective measure of density of exercise facilities around participants' homes was positively related to exercise levels, even after adjustment for age, sex, and education level (Sallis et al., 1990). Although the most common setting for physical activity was the neighborhood street network, proximity of a variety of recreational facilities was related to their use (Giles-Corti and Donovan, 2002). Presence and characteristics of trails have been associated with physical activity (Brownson et al., 2000; Troped et al., 2001). These studies imply that building recreational facilities near homes can promote leisure-time physical activity. It can be hypothesized that placing the facilities within walking or cycling distance of homes could reduce driving to recreational destinations[172] [173] [174] [175] [176] [177] [178]." P.257, 260

**Children are more physically active when they have access to parks close to home**
"Childhood physical activity studies have implications for the transportation field. For example, preschool children were more physically active when there were places nearby where they could play, such as parks (Sallis et al., 1993; Blommaert et al., 1981). Ensuring that playspaces are within walking distance to homes could be expected to both increase children s physical activity and reduce the necessity for parents to drive children to recreational opportunities. There is growing evidence that elementary and middle school children are dependent upon parental transportation to physical activity settings (Sallis et al., 1992b; Hoefer et al., 2001)." P.260

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[172] Sallis, J.F., Hovell, M.F., Hofstetter, C.R., Faucher, P., Elder, J.P., Blanchard, J., Caspersen, C.J., Powell, K.E., Christenson, G.M., 1989. A multivariate study of determinants of vigorous exercise in a community sample. Preventive Medicine 18, 20–34.

[173] Hovell, M.F., Hofstetter, C.R., Sallis, J.F., Rauh, M.J.D., Barrington, E., 1992. Correlates of change in walking for exercise: An exploratory analysis. Research Quarterly for Exercise and Sport 63, 425–434.

[174] Sallis, J.F., Alcaraz, J.E., McKenzie, T.L., Hovell, M.F., Kolody, B., Nader, P.R., 1992a. Parent behavior in relation to physical activity and fitness in 9-year-olds. American Journal of Diseases of Children 146, 1383–1388.

[175] Sallis, J.F., Hovell, M.F., Hofstetter, C.R., Elder, J.P., Caspersen, C.J., Hackley, M., Powell, K.E., 1990. Distance between homes and exercise facilities related to the frequency of exercise among San Diego residents. Public Health Reports 105, 179–185.

[176] Giles-Corti, B., Donovan, R.J., 2002. The relative influence of individual, social and physical environment determinants of physical activity. Social Science and Medicine 54, 1793–1812.

[177] Brownson, R.C., Housemann, R.A., Brown, D.R., Jackson-Thompson, J., King, A.C., Malone, B.R., Sallis, J.F., 2000. Promoting physical activity in rural communities: walking trail access, use, and effects. American Journal of Preventive Medicine 18, 235–241.

[178] Troped, P.J., Saunders, R.P., Pate, R.R., Reininger, B., Ureda, J.R., Thompson, S.J., 2001. Associations between selfreported and objective physical environmental factors and use of a community rail-trail. Preventive Medicine 32, 191–200.

**Active transportation and lower BMI and healthier blood lipid profiles**
"European and Asian studies have documented significant relationships between greater active commuting or transit use frequency and positive health indicators, including lower body mass index, healthier blood lipid profiles, and lower blood pressure associated with active commuting. Many of these associations persisted after controlling for individuals leisure time physical activity and other factors influencing health (e.g., smoking status). These findings suggest that people's utilitarian active travel have similar health benefits as more traditionally-studied leisure exercise." P.260

**Active transportation improves cardio-respiratory fitness, which protects from heart disease and premature death.**
"Studies have documented increased prevalence and frequency of active commuting to work (Mutrie et al., 2002) and improvements in active commuters cardio-respiratory fitness (Hendriksen et al., 2000; Vuori et al., 1994). Because cardiorespiratory fitness protects from heart disease and premature death (USDHHS, 1996), these studies show that active community to work has important health benefits." P.260

**Segregating land uses means more emissions and lowers the population's overall physical activity levels**
"Zoning, along with other development regulations, control local land use decisions that have long been legally underpinned by public health, safety, and public welfare (Euclid V Ambler Realty 1926) (Randle, 1989). Current approaches to zoning often result in the segregation of uses, and mandate increased trip distances between destinations (Pendall, 1999). Increased trip distance harms public health in two ways. First, it increases air pollution through increased trip lengths, usually by automobile. Second, as shown consistently in the present review, separated land use reduces walking and cycling for transportation and contributes to low population levels of physical activity.[179] [180]" P.263

## Lawrence D. Frank, PhD, Martin A. Andresen, MA, Thomas L. Schmid, PhD, *Obesity Relationships with Community Design, Physical Activity, and Time Spent in Cars*

**Abstract:**
Background: Obesity is a major health problem in the United States and around the world. To date, relationships between obesity and aspects of the built environment have not been evaluated empirically at the individual level.

Objective: To evaluate the relationship between the built environment around each participant's place of residence and self-reported travel patterns (walking and time in a car), body mass index (BMI), and obesity for specific gender and ethnicity classifications.

[179] Randle, W., 1989. Professors, reformers, bureaucrats, and cronies: The Players in Euclid v. Ambler. In: Haar, C., Kayden, J. (Eds.), Zoning and the American Dream: Promises Still to Keep. Planners Press, American Planning Association, Chicago.

[180] Pendall, R., 1999. Do growth controls cause sprawl? Environment and Planning–B: Planning and Design 26, 555–571.

Methods: Body Mass Index, minutes spent in a car, kilometers walked, age, income, educational attainment, and gender were derived through a travel survey of 10,878 participants in the Atlanta, Georgia region. Objective measures of land use mix, net residential density, and street connectivity were developed within a 1-kilometer network distance of each participant's place of residence. A cross-sectional design was used to associate urban form measures with obesity, BMI, and transportation-related activity when adjusting for sociodemographic covariates. Discrete analyses were conducted across gender and ethnicity.
The data were collected between 2000 and 2002 and analysis was conducted in 2004.

Results: Land-use mix had the strongest association with obesity (BMI_30 kg/m2), with each quartile increase being associated with a 12.2% reduction in the likelihood of obesity across gender and ethnicity. Each additional hour spent in a car per day was associated with a 6% increase in the likelihood of obesity. Conversely, each additional kilometer walked per day was associated with a 4.8% reduction in the likelihood of obesity. As a continuous measure, BMI was significantly associated with urban form for white cohorts. Relationships among urban form, walk distance, and time in a car were stronger among white than black cohorts.

Conclusions: Measures of the built environment and travel patterns are important predictors of obesity across gender and ethnicity, yet relationships among the built environment, travel patterns, and weight may vary across gender and ethnicity. Strategies to increase land-use mix and distance walked while reducing time in a car can be effective as health interventions.

**Findings:**

**Physical activity could help reduce obesity-related illnesses**
"Modest but attainable increases in the level of physical activity, especially for those who are currently inactive or sedentary, could have important positive health effects. For instance, one estimate predicts that these diseases would be reduced by almost one third if the most inactive portions of the population increased their activity levels[181]." P.87

**Driving and obesity**
"Time spent in the car as a passenger or driver was positively associated with obesity, and an additional 60 minutes per day in the car translated into an additional 6% odds of being obese." P.90

**Link between driving and obesity**
"Time spent in the car as a passenger or driver was positively associated with obesity, and an additional 60 minutes per day in the car translated into an additional 6% odds of being obese changes appear small, the relative decrease in the actual probabilities of obesity fell by approximately 24% and 35%, respectively. This test suggests that increased land use mix is

[181] Powell K, Blair S. The public health burdens of sedentary living habits: theoretical but realistic estimates. Med Sci Sports Exerc 1994;26:851–6.

associated with a greater overall reduction in the probability of obesity among blacks than whites." P.91

**Urban form seems to have different strengths of association among different genders and races**
"The strongest association between urban form and BMI was for white males. Mean BMI for white males decreased significantly as mix, density, and connectivity increased." P.92

**Number of destinations increases with greater land use mix**
"The average household with a land use mix of 0.15 had 18 nonresidential destinations, whereas the average household with a land use mix of 0.30 had 67 nonresidential destinations in its 1-kilometer buffer. Commercial destinations increased from 13 to 51, respectively. In this study, land use mix was clearly the most important aspect of the built environment related to obesity. The change in land use mix from 0.15 to 0.30, although a substantial increase, was not outside policy control in certain areas of the Atlanta region." P.94

**Beyond land use mix, access to healthy food may contribute to levels of obesity**
"Access to food may also play an important role. Based on income levels, poorer areas of cities have fewer food establishments, restaurants, and grocery stores that serve healthy foods,34 and supermarkets, a source of a variety of healthy foods, are four times more prevalent in white neighborhoods than in black neighborhoods[182]." P.94

## Mark Hamer and Yoichi Chida, *Active Commuting and Cardiovascular Risk: A Meta-Analytic Review*

**Abstract:**
Objective. Leisure time physical activity is inversely associated with cardiovascular risk, although evidence for the protective effects of active commuting is more limited. The present review examines evidence from prospective epidemiological studies of commuting activity and cardiovascular risk.
Methods. Meta-analytic procedures were performed to examine the association between commuting physical activity and cardiovascular risk. Several cardiovascular endpoints were examined including mortality, incident coronary heart disease, stroke, hypertension and diabetes.
Results. We included eight studies in the overall analysis (173,146 participants) that yielded 15 separate risk ratios (RR). The overall meta analysis demonstrated a robust protective effect of active commuting on cardiovascular outcomes (integrated RR=0.89, 95% confidence interval 0.81–0.98, p=0.016). However, the protective effects of active commuting were more robust among women (0.87, 0.77–0.98, p=0.02) than in men (0.91, 0.80–1.04, p=0.17).
Conclusions. Active commuting that incorporates walking and cycling was associated with an overall 11% reduction in cardiovascular risk, which was more robust among women. Future studies should investigate the reasons for possible gender effects and also examine the importance of commuting activity intensity.

[182] Morland K, Wing S, Roux AD, Poole C. Neighborhood characteristics associated with the location of food stores and food service places. Am J Prev Med 2002;22:23–9.

**Findings:**

**Short bouts of physical activity spaced throughout the day can help a person achieve recommended daily activity levels**
"Accumulated bouts of physical activity such as commuting may also be an effective way to achieve recommended guidelines of a 30-min activity per day. A number of studies have demonstrated benefits for accumulated bouts of short duration exercise over the day as oppose to one continuous session (e.g., Park et al., 2006; Murphy et al., 2002). For example, four 10 min bouts of walking were more effective in lowering daytime ambulatory blood pressure than a continuous 40 min session in pre-hypertensive adults (Park et al., 2006)." P.10-11

**Activity and lower cancer risk**
"...the present results are consistent with findings that demonstrate active commuting is protective against all cause mortality (Andersen et al., 2000). In addition, recent studies suggest a protective effect against certain types of cancer (Hou et al., 2004; Matthews et al., 2005)." P.11

**Promoting behavioral changes**
"Various approaches have been adopted to encourage active commuting, including publicity programs, extending cycling networks and financial incentives, with the most successful deemed to be targeted behavioural change. Given that worksite health promotion programs can have a positive impact on risk factors (Engbers et al., 2005), initiatives in the workplace that encourage activemcommuting, such as provision for showering facilities and secure bicycle racking, may also be beneficial." P.12

**Bengt Kayser, *Determinants of Active Commuting***

**Abstract:**

In this issue of Preventive Medicine Bringolf-Isler et al. (Bringolf-Isler et al., 2008) report on factors associated with active commuting to school in more than 1000 children aged 6–14 years in a German-speaking, a French-speaking, and a bilingual area in Switzerland. This study design naturally allows for separating cultural from other determinants of self transportation. Switzerland may be a small country with a socio-economically homogenous population but it nevertheless has different language regions with subtle differences in culture.

The authors recommend that, in order to keep active commuting levels high, the route to school should remain relatively short and safe. They also underline the importance of taking cultural differences into account, as exemplified by the differences found between German- and French-speaking sub-populations, even though the origin of the cultural effect remains poorly understood (Stamm and Lamprecht, 2005). Limiting factors of the study are its crosssectional design precluding conclusions on causality and the lack of objective measures of physical activity levels (the study used parental questionnaires).

**Findings:**

**Active transportation to school**
"The authors recommend that, in order to keep active commuting levels high, the route to school should remain relatively short and safe." (Single page summary, no page number)

## Todd Litman, *Integrating Public Health Objectives in Transportation Decision-Making*

**Abstract:**
This perspective explores how transportation decision-making can better support public health objectives, including reduced crashes and pollution emissions and increased physical activity. Conventional transportation planning tends to overlook negative health impacts resulting from increased motor vehicle travel and potential health benefits from shifts to alternative modes. Raising the priority of health objectives supports planning reforms that result in a more balanced transportation system. Integrating health objectives into transportation planning may be a cost-effective way to improve public health.

**Findings:**

**Transdisciplinary communication helps illuminate the full spectrum of active transportation benefits**
"By focusing on a narrow set of objectives, planners tend to undervalue solutions that provide additional benefits. For example, a transportation agency may undervalue a congestion reduction strategy that increases nonmotorized travel by ignoring health benefits, whereas a public health agency may undervalue a program that increases walking and cycling by ignoring congestion reduction benefits." P.103

**It has become safer to drive, however people now drive much more than in previous decades, so the total deaths do not show much of a decrease. Driving less would likely reduce traffic fatalities.**
"When road risk is measured per vehicle-mile, increased mileage is not considered a risk factor and traffic reductions are not considered a safety strategy. From this perspective, an increase in total crashes is not a problem provided that there is a comparable increase in vehicle travel. By emphasizing per-mile crash rates, conventional transportation planning undervalues the potential safety benefits of strategies that reduce total vehicle mileage." P.104

**Although vehicles emit fewer pollutants than they did previously, the increase in vehicle mileage has offset these pollution reductions.**
"It is common to hear claims that vehicle emissions have declined 90% or more as the result of vehicle emission control technologies such as electronic ignition and catalysts, but this is an exaggeration. Such declines only apply to certain tailpipe emissions measured by standard tests. Tests do not reflect real driving conditions (they underestimate out-of-tune engines and hard accelerations), and vehicles produce additional harmful emissions not measured in these tests, such as toxics and particulates from road dust, tires, and break linings. Increased vehicle mileage has offset much of the reduction in per-mile emissions." P.104

**Potential policy solutions**
"• Facility investment and design features that improve walking, cycling, and public transit (e.g., improved sidewalks, crosswalks and paths, and roadway traffic calming).
• Programs to encourage use of alternative modes (such as walking, cycling, ride sharing, public transit, and telework), such as employee trip reduction programs at worksites and campus transportation management programs at colleges.
• Financial incentives such as road and parking pricing, pay-as-you-drive vehicle insurance, and Parking Cash Out, which reduce motor vehicle traffic.
• "Smart growth" land use policies (i.e., more compact, mixed, multimodal land use patterns) that help create more accessible and walkable communities." P.105

**Crashes are deemed most costly, however congestion reduction can have a greater impact when one adds up a variety of benefits**
"If roadway capacity expansion reduces congestion costs by 10% but increases total crash costs by 2% due to additional vehicle travel and higher traffic speeds, it is probably not worthwhile overall since crash costs are approximately five times greater in magnitude than congestion costs, and therefore a 1% increase in total crashes costs offsets a 5% reduction in total congestion costs. However, a congestion reduction strategy provides far greater total benefits if it causes even small reductions in crashes, pollution, or sedentary lifestyles in a community." P.107

**Transportation decisions impact health and it is important to plan with health in mind**
"Conventional transportation planning gives relatively little consideration to indirect health impacts caused by increased motor vehicle travel. As a result, planners tend to understate the health costs of decisions that favor automobile travel. Giving health a higher priority in transportation planning would increase emphasis on mobility management strategies, particularly those that increase nonmotorized travel." P.107-108

## Ari Rabl and Audrey de Nazelle, *Benefits of Shift from Car to Active Transport*

**Abstract:**
There is a growing awareness that significant benefits for our health and environment could be achieved by reducing our use of cars and shifting instead to active transport, i.e. walking and bicycling. The present article presents an estimate of the health impacts due to a shift from car to bicycling or walking, by evaluating four effects: the change in exposure to ambient air pollution for the individuals who change their transportation mode, their health benefit, the health benefit for the general population due to reduced pollution and the risk of accidents. We consider only mortality in detail, but at the end of the paper we also cite costs for other impacts, especially noise and congestion. For the dispersion of air pollution from cars we use results of the Transport phase of the ExternE project series and derive general results that can be applied in different regions. We calculated the health benefits of bicycling and walking based on the most recent review by the World Health Organization. For a driver who switches to bicycling for a commute of 5km (one way) 5 days/week 46 weeks/yr the health benefit from the physical activity is worth about 1300 h/yr, and in a large city (4500,000) the value of the associated reduction of air pollution is on the order of 30 h/yr. For the individual who makes the switch, the

change in air pollution exposure and dose implies a loss of about 20 h/yr under our standard scenario but that is highly variable with details of the trajectories and could even have the opposite sign. The results for walking are similar. The increased accident risk for bicyclists is extremely dependent on the local context; data for Paris and Amsterdam imply that the loss due to fatal accidents is at least an order of magnitude smaller than the health benefit of the physical activity. An analysis of the uncertainties shows that the general conclusion about the order of magnitude of these effects is robust. The results can be used for cost-benefit analysis of programs or projects to increase active transport, provided one can estimate the number of individuals who make a mode shift.

**Findings:**

**The wide range of physical activity (PA) benefits**
"In addition to mortality, PA also reduces the incidence of a wide range of morbidity endpoints, especially coronary heart disease, stroke, hypertension, and type 2 diabetes; PA is also associated with significantly lower rates of colon and breast cancer, as well as improved mental health(US DHHS,2008)." P.123

**Bicyclists can be more exposed to air pollutants than drivers; however, the health benefits outweigh these potential harms**
"The data show that the change in exposure of individuals who leave their car to bicycle or to walk is extremely variable from one case to another. However, as our calculations will show, this does not matter since the health impact of such changes is entirely negligible compared to the overall benefits of the physical activity." P.124

**The benefits of physical activity outweigh the costs of urban cyclist's air pollution exposure**
"The concern about pollution exposure of bicyclists, often evoked in the context of bicycling in cities, is unfounded when compared to the benefits of the cycling activity; of course, such exposure should be minimized as far as is practical. Accidents can be a more serious problem and more should be done to reduce the risks." P.128

**The benefits of shifting from driving to bicycling are also found for those who shift to taking public transportation**
"The conclusions about the relative magnitude of the effects also hold for individuals who switch from driving to walking. Incidentally the role of physical activity (walking to the station, standing, climbing stairs to the subway) is not negligible when people switch from driving to public transportation and the associated benefits may well outweigh the increased exposure to PM that has been observed in subways and many buses." P.130

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