# The Hidden Health Costs of Transportation




# EXECUTIVE SUMMARY

Transportation investments and the systems that are developed from them shape lives and communities. The transportation system is a complex web of highways, sidewalks, bike paths, trains and bus services that connect people to each other as well as to places of work, play, prayer, medical care, and shopping. Transportation policies and decisions influence land use and how communities and neighborhoods are designed and built—whether sprawling and disconnected, or central and connected.

The combustion engine and the creation of the highway system increased mobility and access to goods and services. However, investments in highways have come at the expense of other transportation modes. Over the years this has led to a heavier reliance on vehicles and roadways and less on walking, bicycling and transit use. Further, suburban development has resulted in communities that are away from town centers and public transit and require a near-total reliance on the automobile for transport and access.

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.

Health impacts and costs have typically not been considered in the transportation policy, planning, and funding decision-making process. There are few standards or models for estimating health costs. However, existing research can be used to estimate the population at risk, the magnitude of the health impact, and the health costs associated with those impacts. Growing recognition of the connection between transportation, land development and health has resulted in some studies and examples where health impacts and costs have been considered and assessed. These examples not only demonstrate that health costs should be a significant factor in decision-making, but also show that calculating such costs is indeed possible.

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.

## *Policies that*

- Encourage federal planning, funding practices, and decision making to include health impacts, costs and benefits
- Support development of healthy communities, active transport and incentives for transportation investments that support health
- Promote measurement and evaluation of health, safety and equity in planning and development processes
- Fund research to evaluate health impacts and costs of transportation and land use actions

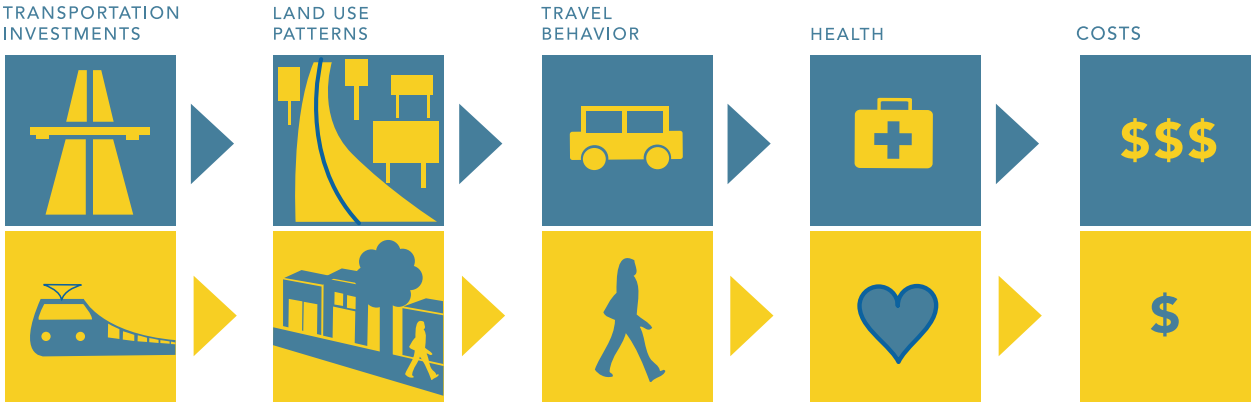
Such policies must be integrated into transportation policy—especially national transportation policy. The upcoming reauthorization of the federal highway transportation bill provides an important opportunity to advocate for healthier and more active transporation systems.

A report prepared by Urban Design 4 Health, Inc. and the American Public Health Association, February 2010.

# 1 Overview: Health Costs Associated with Transportation

Transportation investments, and the transportation systems that emerge from them, shape lives and communities. Highways, sidewalks, bike paths, trains and bus service connect people to friends and family, jobs, shopping, school, and countless other activities. These transportation systems also shape the design of the buildings and neighborhoods that they link together. Transportation systems and neighborhood design together determine the out of pocket cost, convenience, and comfort of different travel options.[1,2] The travel choices we make on a daily basis—whether we get around via active or sedentary, polluting or non-polluting modes of travel—are a product of these investment and development decisions (see Table 1).

**TABLE 1 HOW TRANSPORTATION IMPACTS HEALTH AND EQUITY COSTS**




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.[3] 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,[4] 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 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.[5] About one-third of adults are estimated to be obese, and another third are overweight,[6] 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.[7]

Total health care spending in the U.S. is already astronomical, and increasing rapidly, with estimated spending of $2.4 trillion in 2008, $3.1 trillion in 2012, and $4.3 trillion by 2016.[8] The health impacts of traffic crashes, air pollution, and physical inactivity alone add hundreds of billions of dollars in costs—costs of health care, lost

**TABLE 2 THE COST OF TRANSPORTATION-RELATED HEALTH OUTCOMES**

The consequences of inactivity, obesity, exposure to air pollution, and traffic crashes in the U.S. are staggering when viewed in terms of cost. Fortunately, with certain policy changes, these costs are largely preventable.

| The National Health Costs of… | $$ (Billions) | Estimate Includes | Source |
|---|---|---|---|
| Obesity and overweight | $142 | • Healthcare costs<br>• Lost wages due to illness & disability<br>• Future earnings lost by premature death | National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. Statistics Related to Overweight and Obesity: The Economic Costs.<br><br>Available at: http://win.niddk.nih.gov/statistics/index.htm |
| Air pollution from traffic | $50-80 | • Health care costs<br>• Premature death | Federal Highway Administration. 2000. Addendum to the 1997 Federal Highway Cost Allocation Study Final Report, May 2000.<br><br>Available at: www.fhwa.dot.gov/policy/hcas/addendum.htm |
| Traffic crashes | $180 | • Healthcare costs<br>• Lost wages<br>• Property damage<br>• Travel delay<br>• Legal/administrative costs<br>• Pain & suffering<br>• Lost quality of life | AAA. Crashes vs. Congestion? What's the Cost to Society? Cambridge, MD: Cambridge Systematics, Inc.; 2008.<br><br>Available at: www.aaanewsroom.net/assets/files/20083591910.crashesVscongestionfullreport2.28.08.pdf |

All cost estimates adjusted to 2008 dollars.

work days and productivity, and pain, suffering and premature death. The costs of obesity account for approximately nine percent of total U.S. health care spending,[9] and add an estimated additional $395 per year to per-person health care expenses.[10] A portion of these costs are attributable to auto-oriented transportation and land use development that inadvertently limit opportunities for physical activity and access to healthy food. Traffic crashes cost us $180 billion yearly,[11] and the health costs of transportation-related air pollution are between $50 and $80 billion.[12] Most often, these potential health costs are not included in the transportation decision-making process and policy framework. These "hidden" health costs of transportation decisions are stacking up to a level that can no longer be ignored. If they are not factored into the decision-making process, these costs will continue to grow and undermine the country's economic health and our quality of life.


## Transportation Policy and Planning is at a Crossroads with Health

Our current system of federal transportation policy, planning and funding is a holdover from the initial structure set up to implement the U.S. interstate highway system in the Eisenhower era. Although the federal highway system is by most accounts complete, the planning and funding structure remains largely the same—with little accountability and few funding programs that tie into to broader national policy goals. The majority of highway

and transit funding is distributed to transit agencies and state Departments of Transportation (DOTs) through formula grants regardless of the anticipated performance or cost-effectiveness of the project.[13] The federal government does not require a consistent methodology for environmental impact analysis, transportation modeling, or cost-benefit analysis for agencies seeking federal highway funding—and while this approach allows agencies to tailor analyses to fit their needs, it makes it impossible to compare potential project effectiveness at a national level. It also means that health impacts, costs and benefits are often left off the table when projects are being considered.

The methods used to select transportation projects typically provide, at best, an incomplete accounting of a project's potential health costs and benefits. A Government Accountability Office survey of state DOTs and transit agencies found that although assessments of costs and benefits often play some role in the decision-making process, formal cost-benefit analysis is rare, and "not necessarily the most important factor" in project selection.[13] Although there are no data on how frequently health costs and benefits are included in cost-benefit analyses, these results indicate that more thorough accounting systems are needed to bring health into the decision-making process.[13]

The scope and process for project evaluation will vary widely depending on the project and its location. Typically any cost-benefit analysis for transportation will include the costs of construction, right of way acquisition, operation and maintenance, travel time savings, and any revenues generated such as tolls. The monetary costs and benefits to health are rarely included. The decision to leave out any single impact area may be made because of budget and time constraints, because the impacts are perceived as difficult to measure, or because evidence is perceived as new or limited. However, such decisions have the result of inflating the benefits of roadway projects and underestimating the benefits of transit, bicycle and pedestrian projects. It is safe to assume that if even some of the costs listed below were to be considered in the transportation planning process, the decisions made would be very different.

- **INDIRECT IMPACTS AND INDUCED TRAFFIC.** The indirect impacts of transportation investment on land development (for example, a new road that fuels development on the fringes of an urban area) and transportation ("induced traffic") are typically externalized (not included). This also means the exclusion of a number of other costs: the impacts of indirect land development on physical activity and obesity, the cost of the additional infrastructure (local roads, water and sewers, schools, fire, police services) necessary to serve indirect land development, and the impact of induced traffic on health and the environment (incremental air pollution, noise, climate change and water pollution costs).

- **SCOPE OF COSTS ESTIMATED.** The scope of costs that are included in estimates may be limited. For example, the costs of pain and suffering and other intangible costs are frequently left out of cost-benefit analyses due to the desire for a more "conservative" approach. However, an approach that uses the precautionary principle to avoid harmful action—and therefore accounts for all potential costs of an action—may actually be the most conservative and health-protective approach.[14,15]

- **OBESITY AND PHYSICAL ACTIVITY IMPACTS, COSTS AND BENEFITS.** Because research on the link between transportation, the built environment and physical activity/obesity is relatively new, there have been limited opportunities to integrate it into current transportation planning processes, and there are no requirements within the planning process to do so. However, there is a large and growing body of available evidence linking transportation and land use patterns to physical activity and obesity, and physical activity and obesity to costs.

- **OTHER HEALTH IMPACTS, COSTS AND BENEFITS.** Other health impacts of transportation investment can include noise, water quality, mental health and/or stress, equity and social capital or social cohesion. Noise and water quality impacts are typically documented in a project's environmental impact assessment, but impacts on health in particular, and the costs/benefits of those impacts, are not usually calculated. The link between transportation investment and mental health, stress and social cohesion impacts is less established, with little research on which to base cost estimates. It may be reasonable to recognize and discuss potential impacts qualitatively while continuing to perform research and develop best practices on which impacts and costs can be based. In terms of equity impacts, analytical and accounting methods should examine the population directly affected by the investment, as well as the potential for differential impacts on different vulnerable subgroups within the larger study area population. Evaluation should consider impacts, costs and benefits with respect to not only low-income and ethnic minority groups, but to young, elderly and disabled people, who are typically left out of impact assessments.

- **TRAFFIC CRASHES AND AIR POLLUTION EXPOSURE.** Although the analytical methods and tools exist to measure the impacts and costs of traffic crashes and air pollution exposure, these factors are frequently not accounted for in cost-benefit analysis.

Transportation investments are inevitably a political endeavor, and decisions are often made for reasons other than objective and technical evidence. However, the stronger the evidence over the need and the benefits/costs of a particular investment, and the more that planners are able to conceive, articulate, and promote investments that address an array of established health concerns, the greater the chance that health-promoting projects will be funded.


## Calculating the Health Costs of Transportation

More work is needed to develop "health cost analysis" and to ensure that health is considered in the cost-benefit analysis of transportation planning, policy and decision making. Several models have been developed and are being used, and a large amount of data and research exists that can be used as the basis for the analysis. However, there are no standard methods, models or specific guidelines for these calculations, although federal agencies frequently have standards for impacts (for example, the Clean Air Act standards are health based) and costs that can be applied to a cost analysis. With any assessment, a number of assumptions will need to be made.

Calculating health costs of changes in investment or policy decisions will require different sets of data, models and considerations for each scenario. There are three basic steps in a cost analysis: determining the affected population, the health impacts on that population, and the cost of those health impacts.

The following examples are conceptual and show how health costs or benefits can be calculated for changes in pedestrian safety, air pollution and physical activity. These examples are drawn from the work of other researchers, and detail the methods and approaches they used to arrive at the estimates.

## Traffic Safety Case Study

The San Francisco Department of Public Health estimated how plans for growth in five San Francisco neighborhoods would impact pedestrian injuries from motor vehicle collisions.[16,17]

1 **DETERMINING AFFECTED POPULATION:** The population in five San Francisco neighborhoods that were being studied for increased residential development.

2 **DETERMINING HEALTH IMPACTS:** A citywide analysis was used to determine which factors were most highly correlated with pedestrian–vehicle injury collisions.[18] These factors included traffic volume, proportion of arterial streets without public transit service, land area, proportion of households without cars, proportion of residents commuting via walking or public transit, and total number of residents. These results were applied to projected increases in population and traffic in each of the neighborhood plans in order to estimate the change in pedestrian injury collisions, resulting in a projected increase of 17 percent, or 32 additional collisions in those five neighborhoods each year.

To estimate the health impacts of these pedestrian injury crashes, the distribution of pedestrian crashes by severity for the City of San Francisco over a five-year period was applied to the additional projected crashes (see first column in Table 3).[19]

3 **DETERMINING HEALTH COSTS:** California Highway Patrol estimates of traffic injury costs were the basis of the health costs calculation, as shown in the table's second column. The cost factors include cost of property damage, lost earnings, medical and legal expenses, and costs of pain and lost quality of life, and were adjusted for inflation.[20] These estimates are also conservative, in that they assume only one pedestrian is injured per vehicle collision.

**TABLE 3 THE COST OF TRAFFIC CRASHES IN FIVE SAN FRANCISCO NEIGHBORHOODS**

| | Citywide Crash Distribution (5-year average) | CHP value per accident | Estimated existing crashes | Estimated cost of existing crashes | Projected additional crashes with new development | Estimated cost of additional crashes with new development |
|---|---|---|---|---|---|---|
| Fatalities | 3% | $ 2,709,000 | 28.3 | $ 76,664,700 | 0.96 | $ 2,600,640 |
| Severe injuries | 10% | $ 180,000 | 94.2 | $ 16,956,000 | 3.2 | $ 576,000 |
| Visible injuries | 36% | $ 38,000 | 339.1 | $ 12,885,800 | 11.52 | $ 437,760 |
| Pain complaints | 51% | $ 20,000 | 480.4 | $ 9,608,000 | 16.32 | $ 326,400 |
| Total | 100% | -- | 942 | $ 116,114,500 | 32 | $ 3,422,400 |

## Air Pollution Case Study

Researchers from California State University-Fullerton calculated the health cost savings of meeting federal standards for fine particulates and ozone in California's South Coast and San Joaquin Valley regions.[21]

1. **DETERMINING AFFECTED POPULATION:** Researchers used a computer model to estimate the population currently exposed to unsafe levels of air pollution in both regions.

2. **DETERMINING HEALTH IMPACTS:** Research results from the scientific literature on air pollution were used to estimate the health impacts on the affected population. The researchers calculated impacts both for current conditions and for a scenario in which air quality standards were met.

3. **DETERMINING HEALTH COSTS:** In the cost estimating step, other research findings and federal standards were used to calculate the cost of premature death, medical expenses due to illness and hospitalization and lost wages, and the value of avoided illness (where possible, these rates were adjusted for California income levels and current year [2007] dollars). These rates were applied to each of the health impacts that would be avoided by meeting the standards.

The study did not separate out the impacts of motor vehicle air pollution from other sources of air pollution – however, we know vehicles contribute significantly to air pollution. In the San Joaquin Valley, on-road motor vehicles make up 58 percent of oxides of nitrogen (NOx) emissions, one of the major contributors to ozone, and 11 percent of fine particulates.[22] In the South Coast region, on-road motor vehicles make up 53 percent of NOx emissions and about 15 percent of fine particulates.

**TABLE 4 HEALTH SAVINGS FROM MEETING AIR QUALITY STANDARDS**

| | **San Joaquin** | **South Coast** (Los Angeles, Orange, Riverside and San Bernardino counties) |
|---|---|---|
| Costs of air pollution (per year) | $1,600 per person | $1,250 per person |
| Savings if air quality standards were met (per year) | $6 billion regionwide | $22 billion regionwide |

## Physical Activity Case Study

Researchers from the University of California-Irvine, University of Wisconsin-Milwaukee and University of Texas-Austin calculated cost savings from reductions in coronary heart disease deaths and overall mortality due to increases in walking inspired by more walkable urban design.

1. **DETERMINING AFFECTED POPULATION:** Portland, Oregon metro region

2. **DETERMINING HEALTH IMPACTS:** Using travel diary data for the Portland, Oregon region, researchers first determined which of the following urban design characteristics were significantly correlated with

physical activity: street connectivity, retail employment density, total employment density, population density and proximity to downtown Portland. The results of the analysis were applied to two scenarios: a "low change" scenario that increased each urban design value from the regional median to the 75th percentile, and a "high change" scenario that increased each to the 95th percentile. To calculate health benefits, researchers assumed that a change in urban design would impact 5,000 people—a significant, but not unusual change roughly the size of a transit station area or a neighborhood. Existing research on the impact of physical activity on mortality rates[23] was used to calculate the number of lives saved per year for each scenario and each urban form characteristic.

3 **DETERMINING HEALTH COSTS:** To estimate health cost savings, monetized values of human life from previously published sources were applied. The lower value of human life ($2.47m[24]) was applied to the "low change" scenario, whereas the higher value ($7.98m[25]) was applied to the "high change" scenario. The final values therefore had a wide distribution because they reflected both the differing assumptions for value of life, and the differences in lives saved for each scenario.

In addition to demonstrating that there are substantial monetary benefits due to additional physical activity associated with more walkable urban design, the results show the potential value of changing a single urban design characteristic (for instance, a regulation that increases allowable development densities) or making a combination of changes (for example, by adding the benefits of increasing street connectivity and retail development together). These results can therefore be useful for policy analysis by incorporating the potential benefit from reduced mortality into existing methods for benefit/cost analysis.

**TABLE 5 ESTIMATED COST SAVINGS FROM WALKABLE URBAN DESIGN**

| Land Use/Urban Design Characteristics | Change in Amount of Walking (Miles, Over a Two-Day Period) | | Number of Persons Who Will Move from First to Second Tertile of Physical Activity | | Annual Lives Saved | | Present Discounted Value (in Dollars) | |
|---|---|---|---|---|---|---|---|---|
| | Low (median–75th percentile) | High (median-95th percentile) | Low | High | Low | High | Low | High |
| Street connectivity (intersection density) | 0.3816 | 1.1844 | 22.79 | 78.59 | 0.0456 | 0.1572 | $2,255,107 | $23,205,007 |
| Retail employment density (retail jobs/ 0.0652 square mile) | 0.0652 | 0.9734 | 4.72 | 62.09 | 0.0094 | 0.1242 | $466,574 | $18,331,955 |
| Total employment density (jobs/1.0648 square mile) | 0.0019 | 1.0648 | 1.57 | 66.02 | 0.0031 | 0.1320 | $155,525 | $19,492,206 |
| Population density (persons/square mile) | 0.2581 | 0.549 | 15.72 | 28.29 | 0.0314 | 0.0566 | $1,555,247 | $8,353,802 |
| Distance to central business district (miles) | –0.8108 | –2.5054 | 45.58 | 209.05 | 0.0912 | 0.4181 | $4,510,215 | $61,725,318 |


# Factoring Health Costs into Future Transportation Policy Is Critical

The current process by which transportation funding decisions are made generally does little to consider the long-term costs and benefits to health, safety and equity. Our system of transportation investment has resulted in many benefits for the U.S. and its residents, but today's growing, aging and urbanizing population has different needs and expectations for a transportation system. 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. Evaluative methods and project selection practices should reflect goals of accountability and tractability as well as national policy objectives.

## Recommendations for Future Transportation Policy and Investment

1. A considerable increase in transportation investments is needed to offer more balanced and affordable modes of transport including biking, walking and public transit. Currently 80% of federal transportation funding goes toward building highways and improving road infrastructures, and approximately 20% goes toward public transit and motor vehicle safety programs.
2. Federal planning and funding practices need to more fully account for impacts, costs and benefits to health, throughout the planning and decision-making processes. It may be necessary to develop new methods and approaches for health cost accounting, or to fund new areas of research on the health impacts of transportation investments. By internalizing potential health costs, decisions can be made based on a full understanding of the cost tradeoffs to the public, rather than ignoring or trying to guess at what the costs might be.
3. 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.
4. Research funding should be allocated to document the health costs of transportation investments and develop and apply evidence-based tools that account for the health impacts of such investments. These tools can range from the simple and qualitative to more robust quantitative approaches. Existing tools for modeling or scenario planning can be modified to include health outcomes. Such efforts, which use evidence-based feedback to inform project development, are critical. Funding should be made available to test these tools across a range of geographic settings, study area sizes, demographic populations, and project types.

HIA

**Health Impact Assessment** :: HIA is a "combination of procedures, methods, and tools by which a policy, program, or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population."

# REFERENCES


1 Frank, LD. 2004. Economic Determinants of Urban Form: Resulting Trade-offs Between Active and Sedentary Forms of Travel. American Journal of Preventive Medicine 27(3S):146-153.

2 Boarnet M, Greenwald M and McMillan T. 2008. Walking, Urban Design, and Health: Toward a Cost-Benefit Analysis Framework. Journal of Planning Education and Research 27:341-358.

3 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

4 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.

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

6 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.

7 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.

8 Keehan, S. et al. 2008. Health spending projection through 2017. Health Affairs. Web Exclusive W146:21. February 28.

9 Finkelstein, EA, Fiebelkorn, IC, Wang, G.2003.National medical spending attributable to overweight and obesity: How much, and who's paying? Health Affairs W3: 219-226.

10 Sturm R. 2002. The Effects Of Obesity, Smoking, And Drinking On Medical Problems And Costs. Health Affairs, March/April: 245-253.

11 AAA. Crashes vs. Congestion Report. What's the Cost to Society? Cambridge, MD: Cambridge Systematics, Inc.; 2008. Available at: www.aaanewsroom.net/assets/files/20083591910.crashesVscongestionfullreport2.28.08.pdf. Adjusted to 2008 dollars.

12 Federal Highway Administration. 2000. Addendum to the 1997 Federal Highway Cost Allocation Study Final Report, May 2000. Available at: www.fhwa.dot.gov/policy/hcas/addendum.htm; Adjusted to 2008 dollars.

13 United States Government Accountability Office. 2008. Surface Transportation. Restructured Federal Approach Needed for Focused, Performance-Based, and Sustainable Programs. GAO-08-400.

14 Frank LD, Kavage S. 2008. Urban Planning and Public Health: A Story of Separation and Reconnection, Journal of Public Health Management & Practice 14(3): 214-220.

15 Litman, Todd. Transportation Cost and Benefit Analysis II. Victoria, British Columbia:, Canada: Victoria Transport Policy Institute 2009. Available at: http://www.vtpi.org/tca/tca08.pdf

16 Wier M, Bhatia R, Weintraub J. 2007. Predicting Pedestrian Injury Collisions in San Francisco, California: An Area- level Model. San Francisco, CA: San Francisco Department of Public Health. Available at: www.sfphes.org

17 Bhatia R, Wier M, Weintraub J. 2007. Impacts of Urban Land Use Development on Pedestrian-Motor Vehicle Collisions: An Application of the San Francisco Pedestrian Injury Model to Five Neighborhood Plans. San Francisco, CA: San Francisco Department of Public Health. Available at: www.sfphes.org

18 This model has since been refined as detailed in: Wier M, Weintraub J, Humphreys E, Seto E, Bhatia R. 2009. An area-level model of vehicle-pedestrian injury collisions with implications for land use and transportation planning. Accident Analysis & Prevention 41:137-145.

19 Ragland DR, Markowitz F, MacLeod KE. 2003. An Intensive Pedestrian Safety Engineering Study Using Computerized Crash Analysis. Berkley, CA: Institute of Transportation Studies: UC Berkeley Traffic Safety Center publication UCB-TSC-RR-2003-12. Available at: http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1010&context=its/tsc; accessed on June 25, 2009.

20 U.S. Department of Transportation, Federal Highway Administration. Motor Vehicle Accident Costs. Technical Advisory T 7570.2. October 31, 1994. Available at: http://www.fhwa.dot.gov/legsregs/directives/techadvs/t75702.htm

21 Hall J, Brajer V. 2008. The Benefits of Meeting Clean Air Standards in the South Coast and San Joaquin Valley Air Basins. Fullerton, CA: California State University Fullerton Institute for Economic and Environmental Studies. November 2008. For more information on the health impacts of air pollution. Available at: http://www.arb.ca.gov/research/health/health.htm

22 California Air Resources Board. 2006. Emissions Inventory for the San Joaquin Valley Air District – California Emissions Forecasting System (CEFS) Emissions by Summary Category. Available at: http://www.arb.ca.gov/app/emsinv/fcemssumcat2007.php. Web query accessed on May 15, 2009.

23 Leon, A. S., J. Connett, D. R. Jacobs, and R. Rauramaa. 1987. Leisure-time physical activity levels and risk of coronary heart disease and death: The Multiple Risk Factor Intervention Trial. Journal of the American Medical Association 258 (17): 2388-2395.

24 Mrozek, Janusz R., and Laura O. Taylor. 2002. What determines the value of life? A meta-analysis. Journal of Policy Analysis and Management 21(2): 253-270.

25 U.S. Environmental Protection Agency. 2000. Guidelines for preparing economics analyses. Washington, DC: U.S. Environmental Protection Agency.

# ACKNOWLEDGEMENTS

*The following are recognized for the development of this report.*

**URBAN DESIGN 4 HEALTH, INC ::** Sarah Kavage, Special Projects Manager; Lawrence Frank, President; and Heidi Smets, Graphics www.urbandesign4health.com

**AMERICAN PUBLIC HEALTH ASSOCIATION ::** Tracy Kolian, Senior Policy Analyst www.apha.org

**ZEIGLER/DACUS ::** Ben Dacus, Director of Creative Services www.zeiglerdacus.com

The development of this report was supported through a grant provided by the **Convergence Partnership Fund.**

## About APHA

The American Public Health Association is the oldest and most diverse organization of public health professionals in the world and has been working to improve public health since 1872. The Association aims to protect all Americans and their communities from preventable, serious health threats and strives to assure community-based health promotion and disease prevention activities and preventive health services are universally accessible in the United States. APHA is committed to health equity and a healthy global society. The Association's broad array of public health professionals are champions of and advocate for healthy people and communities.

---

American Public Health Association

800 I Street NW
Washington, DC 20001
(202) 777-APHA (2742)
www.apha.org

Protect, Prevent, Live Well



February 2010