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"Efficiency - Equity - Clarity"

Quantifying the Benefits of Non-Motorized Transport for Achieving TDM Objectives

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ABSTRACT
This paper examines the degree to which non-motorized travel (walking and cycling) help achieve Transportation Demand Management (TDM) objectives, including congestion reduction, road and parking facility cost savings, consumer cost savings, and various environmental and social benefits. The potential of non-motorized travel as a transportation mode is considered. Potential barriers and problems associated with increased walking and cycling are examined. Specific pedestrian and bicycle transportation encouragement strategies are discussed. This paper updates and expands on the paper "Quantifying Bicycling Benefits for Achieving TDM Objectives," published in *Transportation Research Record*, No. 1441 (Nonmotorized Transportation Around the World), 1994, pp. 134-140.

Note: Unless stated otherwise, cost values in this paper are in 1996 U.S. dollars.

I. Introduction

There are two general approaches to address transportation problems. One is to increase transportation system capacity. The other, called Transportation Demand Management (TDM), is to use existing capacity more efficiently. TDM includes a variety of strategies to encourage travelers to use the most efficient mode for each trip.[1] TDM is often the most cost effective solution when all impacts are considered, and is increasingly used to address various transportation problems.

This paper explores two questions. First, it examines the benefits that result when walking and cycling substitute for automobile travel. It focuses on the benefits that are normally associated with TDM program objectives, such as traffic congestion, infrastructure cost savings and pollution emission reductions. Note that this does not represent the full benefits of improved bicycling and walking conditions, which also includes recreational and tourist benefits, improved exercise and health, and the benefits these modes provide as basic mobility (for example, by providing mobility when somebody cannot drive an automobile).

Second, it discusses strategies to encourage pedestrian and bicycle transport. Many TDM programs focus on transit and ridesharing as the main alternatives to driving, although there is increasing recognition that walking and cycling are also important, on their own for short trips and to provide access to transit and rideshare vehicles. There are a number of specific strategies to encourage more non-motorized transportation which can be incorporated in TDM programs. This report is intended to provide TDM planners a summary of pedestrian and bicycle planning issues and resources.

II. Non-Motorized Transportation Benefits

TDM program objectives include reduced traffic congestion, roadway costs savings, reduced parking problems and parking facility cost savings, user cost savings, and a variety of social and environmental benefits. Transportation improvements, including TDM programs, should be evaluated taking into account all potential benefits and costs. Recent studies provide estimates of total motor vehicle costs, including external and non-market costs.[2] These estimates are used in this paper to calculate potential savings for a shift from driving to non-motorized travel for a typical 2-1/2 mile (4 km) trip under three road conditions: urban peak, urban off-peak, and rural trips.[3] Cost estimates can be modified as needed to reflect conditions in a particular community.

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[1] Todd Litman, *Potential TDM Strategies*, VTPI (Victoria; www.vtpi.org), 1999.
[2] Todd Litman, *Transportation Cost Analysis: Techniques, Estimates and Implications,* VTPI (www.vtpi.org), 1999; Mark Delucchi, "Total Cost of Motor-Vehicle Use," *Access* (http://violet.berkeley.edu), No. 8, Spring 1996, pp. 7-13; Pendakur, Badami and Lin, "Nonmotorized Transportation Equivalents in Urban Transport Planning," *Transportation Research Record 1487* (www.nas.edu/trb), 1995, pp. 49-55.
[3] In many cases a walking or cycling trip will replace a longer automobile trip. For example, a consumer may choose between walking to a nearby store or driving to a store across town.

A. Congestion Reduction

Traffic congestion increases travel time, vehicle operating costs, stress and air pollution.[4] Walking normally produces no traffic congestion. To analyze bicycle congestion impacts, road conditions are divided into four classes:

1. *Uncongested roads and separated paths.*
   Bicycling on uncongested roads causes no traffic congestion.

2. *Congested roads with space for bicyclists.*
   Bicycling on the road shoulder (common on highways), a wide curb lane (common in suburban areas and newer urban streets), or a designated bike lane contributes little to traffic congestion except at intersections and driveways where other vehicles' turning and lane shifting maneuvers may be delayed. Table 1 summarizes congestion impacts of bicycling by road width, although traffic volume and intersection design are also factors.

Table 1 **Passenger-Car Equivalents for Bicycles by Lane Width**[5]

	< 11 ft. Lane	**11-14 ft. Lane**	**> 14 ft. Lane**
Riding With Traffic	1.0	0.2	0.0
Riding Against Traffic	1.2	0.5	0.0

3. *Narrow, congested roads with low speed traffic.*
   Bicycling on a narrow, congested road when the rider can safely keep up with traffic (common on some urban streets) probably contributes slightly less to congestion than an average car, due to a bicycle's smaller size.

4. *Narrow, congested roads with moderate to high speed traffic.*
   Bicycling on a narrow, congested road when the rider is unable to keep up with traffic can contribute to traffic congestion, depending on how easily faster vehicles can pass.

Congestion is reduced when automobile drivers shift to bicycling under the first three conditions. Only under condition 4 does a shift from driving to bicycling fail to reduce congestion. This represents a small portion of bicycle transport mileage because most bicyclists avoid riding under such conditions, and bicycling is forbidden on urban freeways where congestion costs are usually highest.[6]

Estimated Benefits: Cost estimates for urban peak-period driving range from 5¢ to 30¢ per vehicle mile.[7] This analysis estimates that a shift from driving to non-motorized travel under urban peak conditions provides average congestion cost savings of 16¢ per mile. A shift from driving to walking or bicycling is estimated to provide congestion reduction benefits worth an estimated **40¢** per urban peak trip, and **4¢** per urban off-peak trip. No congestion benefit is assumed for rural travel.

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[4] David Schrank & Tim Lomax, *Mobility Study-1982 to 1996*, TTI (http://mobility.tamu.edu/study), 1998.
[5] *Policy on Geometric Design for Streets and Highways*, AASHTO (www.aashto.org), 1990.
[6] John Forester reaches a similar conclusion in *Bicycle Transportation*, MIT Press (Cambridge), 1983.
[7] Herbert Mohring and David Anderson, "Congestion Costs and Congestion Pricing," *Buying Time*, Humphrey Institute (Minneapolis; www.hhh.umn.edu), 1996.

B. Roadway Cost Savings

Road costs are a function of vehicle size, weight, speed, and, in some regions, studded tire use. These costs average about 3.5¢ per mile for automobiles, with higher costs for heavier vehicles.[8] Bicycles impose minimal roadway costs. Walking imposes minimal roadway costs but uses sidewalks. Sidewalks can be considered to represent "basic mobility" facilities, since they are used by motorists exiting their vehicles as well as by pedestrians on longer trips. Once sidewalks are constructed there is minimal marginal cost to their use by pedestrians. Although many people assume that roads are fully funded through motor vehicle user fees such as fuel taxes, local roads (which pedestrians and bicyclists use most) are mostly funded by local taxes, which residents pay regardless of their travel. Reduced automobile use reduces local government roadway costs.

Estimated Benefits: Shifts from driving to walking or bicycling are estimated to provide roadway cost savings of **10¢** per trip for urban driving and **5¢** per trip for rural driving.

C. Parking Cost Savings

Parking is a major cost of automobile use, and a major subsidy to driving. 80% of commuters and an even greater portion of shoppers use free parking.[9] Typical urban parking facility cost estimates range from $50 to $100 per month, or about $2.00 to $4.00 per day.[10] Bicycle parking costs less. Up to 20 bicycles can be stored in the space required for one automobile, and bicycles are often stored in otherwise unused areas. Pedestrians require no parking (except, perhaps, umbrella stands).

Estimated Benefits: Parking cost savings for drivers shifting to non-motorized travel are estimated here at **$1.50** per urban peak trip ($3.00 per day for commuter parking), **25¢** for urban off-peak trip (short term parking for shopping and errands), and **5¢** per rural trip.

D. User Savings

Walking has minimal incremental user cost. Bicycles are inexpensive to own and operate. People who already own both an automobile and a suitably equipped bicycle save the difference in variable costs. If increased bicycling allows a household to own fewer or less expensive motor vehicles, greater savings can be enjoyed.

Time is another user cost. Although bicycles compete favorably in door-to-door travel times with automobiles for some trips, walking and bicycling are generally slower than driving. This implies increased user costs. However, many people enjoy walking and bicycling and appreciate its aerobic exercise. Any additional travel time for walking and bicycling that results from improved facilities or financial rewards (such as cashing out free parking) should not be considered a cost if these are voluntary travel choices.

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[8] *1997 Federal Highway Cost Allocation Study*, USDOT (www.ota.fhwa.dot.gov).

[9] Donald Shoup, "Cashing Out Free Parking," *Journal of American Planning Association*, June 1994.

[10] Douglass Lee, *Full Cost Pricing of Highways*, National Transportation Research Center (Cambridge), Jan. 1995; Mark Delucchi, *Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991*, Vol. 6, Institute of Transportation Studies (Davis), UCD-ITS-RR-96-3 (6), 1997.

Estimated Benefits: Automobile operating costs average about 12¢ per mile,[11] with 50% higher costs for peak period urban driving due to stop-and-go conditions. Costs per mile are double for the short trips replaced by walking and cycling due to high fuel and maintenance costs from cold starts. Variable walking and bicycling costs are estimated at 1¢ per mile. Savings are estimated at **85¢** per urban peak trip, and **55¢** per urban off-peak or rural trip. Greater savings are possible when non-motorized travel improvements allow a household to own fewer or cheaper cars.

E. Air Pollution

Walking and bicycling produces virtually no air pollution. Per mile air pollution reductions are large because bicycling usually replaces short, cold start trips for which internal combustion engines have high emission rates, so each 1% of automobile travel replaced by bicycling decreases motor vehicle air pollution emissions by 2% to 4%.[12]

Estimated Benefits: Automobile air pollution costs are estimated to average 1¢ to 13¢ per automobile mile.[13] Many monetized estimates include only a limited portion of total air pollution costs (for example, many ignore particulate pollution), so a relatively high value is appropriate. A conservative estimate is 5¢ per mile for urban peak driving, 4¢ for urban off-peak and 1¢ for rural driving. Since motor vehicle emissions are higher for short trips due to cold starts, per mile emission reductions are doubled, yielding savings of **$.25** per urban peak trip, **$.20** per urban off-peak trip and **$.05** per rural trip.

F. Noise

Vehicle noise imposes disturbance and discomfort. Estimates of noise costs range from 0.2¢ to 5¢ per vehicle mile, depending on location and type of vehicle.[14] Noise costs are greatest on residential streets, where a change in traffic volumes of just a few hundred vehicles per day can significantly affect property values.[15] Since non-motorized travel tends to replace driving on such noise sensitive, residential streets, and peak-period trips occur during early morning when noise sensitivity is high, a reasonable value is **10¢** for peak urban trips, **5¢** for off-peak urban trips, and **2¢** per rural trip.

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[11] Jack Faucett Associates, *The Costs of owning and Operating Automobiles, Vans and Light Trucks, 1991*, FHWA (Washington DC), 1992. Based on estimated costs for fuel, fuel taxes, tires, parking and tolls, and maintenance for an "intermediate" size car.

[12] Charles Komanoff and Cora Roelofs, *The Environmental Benefits of Bicycling and Walking*, National Bicycling and Walking Study Case Study No. 15, USDOT, January 1993, FHWA-PD-93-015

[13] Ken Small and Camilla Kazimi, "On the Costs of Air Pollution from Motor Vehicles," *Journal of Transport Economics and Policy*, January 1995; Donald McCubbin and Mark Delucchi, *Social Cost of the Health Effects of Motor-Vehicle Air Pollution*, Institute of Transportation Studies (Davis), August 1996.

[14] Kjartan Sæ lensminde, *Environmental Costs Caused by Road Traffic in Urban Areas*, Institute for Transport Economics (Oslo), 1992; Dr. Peter Bein, *Monetization of Environmental Impacts of Roads*, B.C. Ministry of Transportation and Highways (Victoria, www.th.gov.bc.ca/bchighways), 1997.

[15] Gordon Bagby, "The Effects of Traffic Flow on Residential Property Values," *Journal of the American Planning Association*, January 1980, pp. 88-94.

G. Road Safety

Motor vehicles impose external accident costs (i.e., uncompensated accident damages on other road users).[16] A shift from driving to non-motorized travel reduces these costs (although it may increase risks to those who make the shift, as discussed later).

Estimated Benefits: Several studies indicate that motor vehicle external accident costs average 2¢ to 12¢ per automobile mile, depending on vehicle type and driving conditions.[17] Net benefits of a shift from driving to walking or cycling are estimated to average **15¢** per urban peak trip, **12¢** per urban off-peak trip, and **10¢** per rural trip.

H. Regional Economic Development

Public trails and a shift from driving to non-motorized travel can provide regional economic development benefits. Public trails can stimulate tourist activity, increase property values, and help attract certain types of industries, particularly knowledge-based businesses with employees who place a high value on amenities such as environmental quality, access to greenspace, and outdoor recreation opportunities.[18]

Reduced automobile use tends increases local employment and business activity since most economic inputs to driving (vehicles, parts and fuel) are imported from outside the region.[19] The table below shows the regional income and jobs created by various consumer expenditures. Automobile provide far less than general consumer expenditures, indicating that money saved by reduced driving tends to provide net economic development benefits.

Table 2 **Regional Economic Impacts of $1 Million Expenditure**[20]

Expenditure Category	Regional Income	Regional Jobs
Automobile Expenditures	$307,000	8.4
Non-automotive Consumer Expenditures	$526,000	17.0
Transit Expenditures	$1,200,000	62.2

This table shows economic impacts of consumer expenditures in Texas.

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16 Ted Miller, *The Costs of Highway Crashes*, FHWA (Washington DC), Publ. No. FHWA-RD-055, 1991.

17 Rune Elvik, "The External Costs of Traffic Injury: Definition, Estimation, and Possibilities for Internalization," *Accident Analysis and Prevention*, Vol. 26, No. 6, 1994, pp. 719-732; Jansson, "Accident Externality Charges," *Journal of Transport Economics and Policy*, January 1994, p. 31-42.

18 *Economic Impacts of Protecting Rivers, Trails and Greenway Corridors*, U.S. National Park Service (www.nps.gov/pwro/rtca/econ_index.htm), 1995; *The Economic and Social Benefits of Off-Road Bicycle and Pedestrian Facilities*, Technical Brief, National Bicycle and Pedestrian Clearinghouse, No. 2 (www.bikefed.org), 1995.

19 Todd Litman and Felix Laube, *Automobile Dependency and Economic Development*, VTPI (www.vtpi.org), 1998.

20 Jon Miller, Henry Robison & Michael Lahr, *Estimating Important Transportation-Related Regional Economic Relationships in Bexar County, Texas*, VIA Metropolitan Transit (San Antonio), 1999, available at www.vtpi.org.

Estimated Benefits: Although often significant, these benefits are too variable to be quantified on a per-trip basis.

I. Additional Environmental and Social Benefits

Automobile use and automobile dependency contribute to several additional problems: water pollution, suburban sprawl and reduced wildlife habitat,[21] reduced community interaction,[22] and decreased mobility for non-drivers.[23] Each of these imposes costs on society. Non-motorized transportation reduces these costs.

Estimated Benefits: It is difficult to quantify these benefits, but a rough minimum estimate can be made using transit subsidies as a benchmark. U.S. public transit service receive financial subsidies that average about $1.15 per trip. The American Public Transit Association lists 10 justifications for these subsidies.[24] Four are already considered (reduced traffic congestion, safety, reduced air pollution and economic development) and two do not necessarily apply to walking and cycling (creation of jobs and increased productivity from existing transit investments). Three benefits do apply to walking and bicycling: *rational urban development, mobility for non-drivers* and *mobility during crises*. Although more research is needed to develop better estimates of these benefits, it seems reasonable to recognize the potential of increased bicycling to discourage urban sprawl, provide mobility to non-drivers and enhance urban environments as representing at least 20% of the subsidy currently provided transit service, equal to **23¢** per trip.

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[21] Robert Burchell, et al., *The Costs of Sprawl – Revisited*, TCRP Report 39, Transportation Research Board (www.nas.edu/trb) 1998.
[22] Donald Appleyard. *Livable Streets,* University of California Press, Berkeley, 1981.
[23] Elmer Johnson, *Avoiding the Collision of Cities and Cars*, American Academy of Arts and Sciences (Chicago), 1993.
[24] American Public Transit Association, *1992 Transit Fact Book.* Washington DC.

III. Non-Motorized Transportation Potential

A. Current and Potential Usage

It may be difficult to determine the number of non-motorized trips in an area because they are often underrecorded in travel surveys and traffic counts. Some travel surveys exclude non-motorized trips altogether, and when included, walking and cycling trips are often undercounted because they include many short, non-work and recreational trips, and trips by children, all of which tend to be overlooked. Automatic traffic counters do not record non-motorized travel and manual counts usually focus on arterial streets, ignoring side streets and paths that may be popular walking and cycling routes. Most trips involve non-motorized links that are often ignored in traffic counts. Trips classified as "auto" or "transit" are usually "walk-auto-walk," or "walk-transit-walk" trips, yet the walking component is often not counted, even if it takes place on a roadway.

The 1995 National Personal Transportation Survey indicates that walking and bicycling account for 5.2% and 0.8% of personal trips respectively.[25] Only 7% of walking trips and 8% of cycling trips are to work, a far smaller portion than for motorized travel, so surveys that focus on commute trips are particularly likely to undercount non-motorized travel. Table 3 illustrates the distribution of household trips between non-motorized and motorized modes by geographic category.

Table 3 **Household Trips Per Day By Mode**[26]

	Rural	Suburban	Urban	Average
Walk	0.4	0.4	1.8	0.6
Bicycle	0.1	0.1	0.1	0.1
Total Non-Motorized	*0.5*	*0.5*	*1.9*	*0.7*
Transit	0.3	0.3	1.1	0.4
Auto Passenger	3.5	2.7	2.8	2.7
Auto Driver	7.8	6.6	6.3	6.4
Total, All Modes	*12.2*	*10.1*	*12.1*	*10.1*

Several North American cities have non-motorized travel rates that are much higher than the national average, including Palo Alto, California; Madison, Wisconsin; Boulder, Colorado; and Eugene, Oregon.[27] Walking and cycling transportation are even more common in some relatively wealthy European cities, as shown in Table 4. High levels of non-motorized travel in such geographically diverse communities, and lower levels in otherwise similar areas, indicate that transport policies and community attitudes are more important than geography or climate in determining bicycle use.

[25] *1995 National Personal Transportation Survey*, FHWA (www-cta.ornl.gov/cgi/npts).
[26] *1995 National Personal Transportation Survey*, USDOT (www-cta.ornl.gov/cgi/npts).
[27] Andy Clarke, "The United States of America," Chapter in *The Bicycle and City Traffic*, Ed. Hugh McClintock, Belhaven Press (London) 1992.

Table 4 **Transportation Mode Split (percent of total trips)**[28]

Urban Area	Car	Public Transit	Bicycle	Walk
Austria	39	13	9	31
Canada	*74*	*14*	*1*	*10*
Denmark	42	14	20	21
France	54	12	4	30
Germany	52	11	10	27
Netherlands	44	8	27	19
Sweden	36	11	10	39
Switzerland	38	20	10	29
United Kingdom	62	14	8	12
U.S.	*84*	*3*	*1*	*9*
Amsterdam (NL)	38	15	21	26
Leeds (UK)	60	25	2	13
Bristol (UK)	66	14	6	14
Munich (Germany)	36	25	15	24
Dresden (Germany)	43	21	8	28

New transportation planning models are now available that can help predict the amount of walking and bicycling that occurs in an area.[29] These indicate that various community design features can increase the portion of non-motorized travel. Residents in neighborhoods with suitable street environments tend to walk and bicycle more,[30] ride transit more,[31] and drive less than comparable households in other areas.[32] One study found that walking is three times more common in a community with pedestrian friendly streets than in otherwise comparable communities that are less conducive to foot travel.[33] Transportation demand management strategies, such as parking price reforms (either increased parking prices or parking "cash out", in which non-drivers receive the cash equivalent of parking subsidies) and various types of road pricing can significantly reduce motor vehicle use – how much of this represents shifts to non-motorized travel depends on local conditions.

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[28] John Pucher and Christian Lefèvre, *The Urban Transport Crisis*, MacMillan (London), 1996, pp. 16-17.

[29] Christopher Porter, John Suhrbier and William Schwartz, *Forecasting Bicycle and Pedestrian Travel: State of the Practice and Research Needs*, TRB Annual Meeting (www.nas.edu/trb), 1999; *Bicycle/ Pedestrian Trip Generation Workshop*, FHWA (www.tfhrc.gov/safety/pedbike/pbworkshop.htm), 1996.

[30] Rhys Roth, *Getting People Walking: Municipal Strategies to Increase Pedestrian Travel*, WSDOT (Olympia; www.wsdot.wa.gov/ta/t2/t2pubs.htm), 1994.

[31] Anastasia Loukaitou-Sideris, *Retrofit of Urban Corridors: Land Use Policies and Design Guidelines for Transit-Friendly Environments*, University of California Transportation Center (Berkeley), #180, 1993.

[32] Parsons Brinckerhoff, *The Pedestrian Environment*, 1000 Friends of Oregon (Portland; www.friends.org), 1993.

[33] Anne Vernez Moudon, *et al.*, *Effects of Site Design on Pedestrian Travel in Mixed Use, Medium-Density Environments*, Washington State Transportation Center (www.wsdot.wa.gov/ta/t2/t2pubs.htm), 1996.

There is considerable latent demand for non-motorized travel. That is, people would walk and bicycle more if they had suitable conditions. Two-thirds of U.S. urban trips are less than five miles, distances suitable for bicycling.[34] A Harris survey indicates that 17% of adults would sometimes bicycle commute if secure storage and changing facilities were available, 18% would bicycle commute if employers offer financial incentives, and 20% would bicycle commute if they could ride on safe bike lanes.[35] Table 5 summarizes the results of a recent Canadian public survey, indicating high levels of interest in cycling and walking for transportation. These and other surveys indicate that non-motorized travel could increase significantly with appropriate support and encouragement.[36]

Table 5 **Active Transportation Survey Findings**[37]

	Cycle	**Walk**
Currently use this mode for leisure and recreation.	48%	85%
Currently use this mode for transportation.	24%	58%
Would like to use this mode more frequently.	66%	80%
Would cycle to work if there "were a dedicated bike lane which would take me to my workplace in less than 30 minutes at a comfortable pace."	70%	
Portion of Canadian adults who could realistically increase their use of these modes for transportation.	29%	61%
Support for additional government spending on bicycling facilities.	82%	

34 John Fegan, "National Bicycling and Walking Study: Results and Recommended Actions," *The Bicycle: Global Perspectives*. Papers presented at the Velo City Conference, Sept. 13-17, 1992, Montreal.
35 "A Trend On the Move: Commuting by Bicycle." *Bicycling Magazine*, Rodale Press, April 1991.
36 Charles Komanoff and Cora Roelofs, *The Environmental Benefits of Bicycling and Walking*, National Bicycling and Walking Study Case Study No. 15, USDOT, January 1993, FHWA-PD-93-015.
37 Environics, *National Survey on Active Transportation*, Go for Green, (www.goforgreen.ca), 1998.

B. Barriers to Increased Non-Motorized Transportation[38]

This section discusses various barriers to increased non-motorized travel.

1. *Perceived Accident Risk*

Accident risk is a deterrent to non-motorized transportation, although the actual risk for a particular type of trip is uncertain, since reliable travel data are not available. A British study found that fear of both accidents and street crime are significant deterrents to walking for transportation.[39] Table 6 summarizes estimated accident fatality risk for various modes, indicating that walking is only slightly more hazardous than driving, while cycling is about 2.5 times more hazardous, when measured per trip. A survey of Toronto bicycle commuters estimates that cycling has an injury rate 26-68 times that of automobile travel, with particularly high risk on paths and trails, and for inexperienced cyclists.[40]

Table 6 **Fatalities per 100 Million Passengers in Britain (1992)**[41]

	Per Trip	Per Hour	Per Km
Motorbike	100	300	9.7
Air	55	15	0.03
Pedalcycle	12	60	4.3
Foot	5.1	20	5.3
Car	4.5	15	0.4
Van	2.7	6.6	0.2
Rail	2.7	4.8	0.1
Bus	0.3	0.1	0.04

The health risk from non-motorized travel is less than these estimates indicate because:[42]

- Non-motorized travel imposes minimal risk to other road users.
- Non-motorized transport encourages land use patterns that reduce travel distances over the long term.
- Bicycling offers significant health benefits that offset accident risk.[43] According to a government report, "*Regular walking and cycling are the only realistic way that the*

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[38] *Reasons Why Bicycling and Walking Are and Are Not Being Used More Extensively as Travel Modes*, National Bicycling and Walking Study report #1, USDOT, FHWA (Washington DC), 1992; John Pucher, "Bicycling Renaissance in North America: Recent Trends and Alternative Policies to Promote Bicycling," *Transportation Research A*, Vol. 33, Nos. 7/8, September/November 1999, pp. 625-254.

[39] Social Research Associates, *Personal Security Issues in Pedestrian Journeys*, UK Department of the Environment, Transport and the Regions (London; www.mobility-unit.detr.gov.uk/psi), 1999.

[40] Lisa Aultman-Hall and M. Georgina Kaltenecker, "Toronto Bicycle Commuter Safety Rates, *Accident Analysis and Prevention*, Vol. 31 1999, pp. 675-686.

[41] Royal Society for Prevention of Accidents, "Fasten Your Safety Belts," *The Economist*, 11/1/1997, p. 57.

[42] Charles Komanoff and Cora Roelofs, *The Environmental Benefits of Bicycling and Walking*, National Bicycling and Walking Study Case Study No. 15, USDOT, January 1993, FHWA-PD-93-015.

[43] *Benefits of Bicycling and Walking to Health*, National Bicycling and Walking Study #14, USDOT, FHWA (Washington DC), 1992; *Physical Activity: An Agenda for Action*, National Forum for Coronary Heart Disease Prevention (London), 1995.

population as a whole can get the daily half hour of moderate exercise which is the minimum level needed to keep reasonably fit."[44] A sedentary lifestyle has a cardiovascular risk equal to smoking 20 cigarettes a day.[45] One study concludes that heart disease would decline 5-10% if one-third of short trips shifted from driving to bicycling.[46]

[44] Physical Activity Task Force, *More People, More Active, More Often*, UK Department of Health (London), 1995; *Charter on Transport, Environment and Health,* World Health Organization (www.who.dk), 1999.
[45] Ian Roberts, Harry Owen, Peter Lumb, Colin MacDougall, *Pedalling Health—Health Benefits of a Modal Transport Shift*, Bicycle Institute of South Australia (www.science.adelaide.edu.au), 1996.
[46] *Bike For Your Life*, Bicycle Association & Cyclists' Public Affairs Group (London), 1995.

Active Transportation as an Investment (by John Z. Wetmore)

Health researchers recommend devoting about 30 minutes, or about 2% of each day, in moderate exercise, such as walking or cycling. Is this time a worthwhile investment?

The GAM83 mortality table used by insurance actuaries gives the probability of dying within one year for an X-year-old, for X from 5 to 110 ("Qx" for short). This table indicates that the expected value of age-at-death for an 18-year-old male alive today is 77.8, or 59.8 more years. An 18-year old male would need to live 102% of 59.8 = 61.0 years, or age at death 79.0 to offset a 30 minute a day exercise investment. That is, it is worthwhile to invest 2% of each day if it reduces the probability of death by 11% for later ages.

Each Qx can be multiplied by a constant "C" that represents a reduction in the risk of dying (e.g., if Q76 = 4.9% and C = 0.8 then Q76 = 4.9% * 0.8 = 3.92%). The objective is to find C such that the expected age at death increases from 77.8 to 79.0. As it turns out, C is 0.89.

According to the Honolulu Heart Study (www.agenet.com/watchful_walking_adds.html), the probability of death for 61 to 81 year old males is about 50% less for those who walk two miles per day. Taking C times Q61 through Q81 and leaving alone Q5 through Q60 and Q82 through Q110. C turns out to be 0.84. That is, 30 minutes daily exercise is a worthwhile investment if the probability of death is 16% lower for ages 61 to 81 and unchanged for all other ages. The observed reduction of 50% is much better than the break-even point of 16% reduction.

Not only that, but many people consider time spent on moderate exercise enjoyable. The result is a double return on investment: health and enjoyment.

Changes in pedestrian and bicyclist behavior could reduce current crash risk. A American Society of Civil Engineers study concluded that a combination of increased helmet use, bicyclist education, improved night lighting, and education of motorists regarding bicycling could have reduced the 1990 bicyclist fatality rate per mile by 2/3 (see box below). Roadway improvements that reduce traffic speeds and provide appropriate facilities for pedestrians and cyclists could reduce risk further.[47]

Based on this analysis, a responsible bicyclist who follows traffic rules is estimated to have a per trip crash fatality rate approximately equal to that of non-interstate automobile occupants, and poses a minimal accident risk to other road users, resulting in a reduction in overall fatalities compared with motor vehicle driving. Walking can have even lower risks. There is no evidence that shifting travel from driving to non-motorized travel is a public health risk, especially if safety education and facility improvements are provided.

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[47] C.N. Kloeden, A.J. McLean, V.M. Moore and G. Ponte, *Travelling Speed and the Risk of Crash Involvement*, NHMRC (Adelaide, Australia; http://plato.raru.adelaide.edu.au/speed/index.html), 1998; Jack Stuster and Zail Coffman, *Synthesis Of Safety Research Related To Speed And Speed Limits*, FHWA No. FHWA-RD-98-154 (www.tfhrc.gov/safety/speed/speed.htm), 1998; Todd Litman, *Traffic Calming Benefits*, Costs and Equity Impacts, VTPI (www.vtpi.org), 1999.

Bicycle Fatality Reduction Strategies
Based on American Society of Civil Engineers' Human Powered Transport Subcommittee analysis of 1990 bicyclist behavior and additional sources as noted. Risk factors overlap and are therefore not cumulative.

	Potential Fatality Reduction
1. Teaching riders to avoid common mistakes.	50% or more.
2. Helmet use.	40% to 50%.
3. Eliminating intoxicated bicyclists.	16% or more.
4. Eliminate intoxicated automobile drivers.[48]	16%
5. Enforcing nighttime lighting requirements.	10% or more.
6. Teaching motorists to share the road with bicyclists.	5% or more.
7. Infrastructure improvements.	Significant

2. Roadway Hazards and Bottlenecks[49]

Many roadway conditions present problems for pedestrians and cyclists. Common problems and barriers include:

- Non-existent, incomplete, and poor quality sidewalks and crosswalks.
- Roads and bridges with heavy vehicle traffic and inadequate lane space for cyclists.
- Highways and other roadways with rough pavement, potholes, draingrates or other surface irregularities along the right lane and shoulder.
- Wide roads and intersections that are difficult for pedestrians to cross.
- Rough railroad tracks crossing a roadway (particularly if at an angle).
- Missing trail network links where they would be suitable, such as between a residential area and a public trail, school or shopping mall, or between two dead-end residential streets.
- Traffic signals that provide inadequate time for pedestrians to cross or are not activated by bicycles.

A community pedestrian and bicycle planning program can reduce these problems. Some of them can be addressed at minimal cost by incorporating appropriate design standards into scheduled road construction and land development projects.

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[48] National Highway Traffic Safety Administration, *Traffic Safety Facts 1992; Pedalcyclists*, USDOT, 1993, Washington DC, GPO:1993-343-273:80101.
[49] AASHTO, *Guide for the Development of Bicycle Facilities*, American Association of State Highway and Transportation Officials (Washington DC; www.aashto.org), 1991; Suzan Anderson Pinsof and Terri Musser, *Bicycle Facility Planning*, Planners Advisory Service, American Planning Association (Chicago; www.planning.org), 1995.

3. *Cultural and Institutional Bias*

Walking and bicycling are often considered travel modes of last resort. Bicycles have traditionally been considered a child's toy. On the other hand, walking and cycling are popular forms of recreation and are increasingly recognized as legitimate forms of travel. However, even were communities are beginning to reinvest in non-motorized travel, pedestrian and bicycle conditions are usually poor due to decades of neglect by transportation institutions.

Non-motorized travel tends to be under-supported by transportation agencies and professionals. Pedestrian and bicycle projects are ineligible for many transportation funds. Only a small portion of federal, state and provincial transportation funding is spent on non-motorized transportation. Few local transportation agencies fund walking and bicycling facilities in proportion to walking and cycling trips. Non-motorized planning is given relatively little attention in North American traffic engineering curricula.[50] Decision makers often argue that bicycle use must increase before more resources can be invested in bicycle programs, creating a chicken-and-egg quandary. These institutional barriers must be overcome before bicycle transport can achieve its full potential.

Similarly, transportation agency and funding practices tend to favor roadway investments and automobile travel over TDM and non-motorized travel modes.[51] Least-cost (or "integrated") transportation planning can help overcome this bias.[52] It means that demand management strategies are considered as alternatives to any capacity expansion project, and implemented whenever they are more cost effective, taking into account all costs.

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[50] Mac Elliott, "Bicycle Transportation Education in the US Universities 1991," In *The Bicycle: Global Perceptions.* Velo City Conference proceedings, Sept.13-17, 1992, Montreal.

[51] Todd Litman, *Transportation Market Distortions*, VTPI (www.vtpi.org), 1999.

[52] ECONorthwest and PBQD, *Evaluation of Transportation Alternatives; Least-Cost Planning: Principles, Applications and Issues*, Metropolitan Planning Tech. Rpt. #6, FHWA (Washington DC), 1995; *The Integrated Transport Planning Beginner's Handbook*, International Institute for Energy Conservation (Washington DC; www.iiec.org), January 1996.

IV. Non-Motorized Transportation Encouragement Strategies[53]

Many TDM programs include walking and bicycle encouragement features, although they often receive less support than transit and rideshare promotion. For example, half of employers participating in Southern California's commute trip reduction program provided employee bike racks, and 26% provided shower and locker facilities, but only 32% offered financial incentives for non-motorized commutes, lower than the 68% for transit riders and 41% for carpooling.[54] Specific pedestrian and bicycle encouragement strategies suitable for TDM programs are described below.

A. *Commute Trip Reduction (CTR) Programs.*

Commute Trip Reduction (CTR) programs provide individual commuters with resources and incentives to reduce their vehicle trips. This often involves shifting parking subsidies and traffic management resources to supporting alternative travel modes. Automobile reductions of 10-30% are common. Examples include:

- Employer "Commuter Choice" and similar programs.[55]
- Colleges and universities that provide discounted transit passes to students and staff, support ridesharing and non-motorized travel, and reduce parking subsidies.[56]
- Grade through high schools that encourage parents and students to use alternative modes.[57]
- Trip reduction programs for government agencies.[58]

B. *Transportation Price Reforms*

Most of the costs of automobile use are either external or fixed, which results in greater motor vehicle use than would occur under a more optimal market.[59] A number of revenue-neutral price reforms could encourage vehicle owners to make greater use of alternative travel modes, including walking and bicycling.[60]

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[53] *What Needs to be Done to Promote Bicycling and Walking*, National Bicycling and Walking Study, reports #3 and #4, USDOT, FHWA (Washington DC) 1993; Todd Litman, *Potential TDM Strategies*, VTPI (www.vtpi.org), 1999.

[54] Genevieve Giuliano, Keith Hwang & Martin Wach, "Employee Trip Reduction in Southern California: First Year Results." *Transportation Research A*, 1993, No.2. pp.125-137.

[55] Commuter Choice Program, Transportation Air Quality Center, USEPA (www.epa.gov/oms/traq); Philip Winters and Daniel Rudge, *Commute Alternatives Educational Outreach*, National Urban Transit Institute, Center for Urban Transportation Research, USF (Tampa; www.cutr.eng.usf.edu), 1995.

[56] For examples visit websites for the University of Washington U-PASS program at www.washington.edu/upass, and the University of British Columbia's TREK program at www.trek.ubc.ca.

[57] "Active and Safe Routes to School" (Ottawa; www.goforgreen.ca); Way To Go! School Program, (www.waytogo.icbc.bc.ca); SUSTRANS Safe Routes to School Project (www.sustrans.co.uk/srts).

[58] Nancy Skinner and Stuart Cohen, *Commuting in the Greenhouse; Automobile Trip Reduction Programs for Municipal Employees*, International Council for Local Environmental Initiatives (www.iclei.org), 1996.

[59] Todd Litman, *Socially Optimal Transport Prices and Markets*, VTPI (www.vtpi.org), 1996.

[60] Todd Litman, Charles Komanoff and Douglas Howell, *Road Relief; Tax and Pricing Shifts for a Fairer, Cleaner, and Less Congested Transportation System in Washington State*, Energy Outreach Center (Olympia; www.eoc.org), 1998.

C. *Transportation Efficient Land Use Policies*

Current zoning laws and development policies result in low-density, automobile-oriented land use patterns. Alternative practices that encourage more mix and proximity of activities can help create land use patterns that are more suitable for alternative travel.[61] For example, more flexible zoning laws allow retail businesses and employment centers to locate closer to residential areas, and public policies can encourage more schools, parks and post offices to be located within walking and cycling distance of residences. Walking and bicycling can also be encouraged by a more connected street network (minimal dead-ends and cul de sacs), narrow streets, and more human-scale development.[62]

D. *Traffic Calming*

Traffic calming includes a number of strategies that control vehicle traffic volumes and speeds, and improve road conditions for pedestrians and cyclists.[63] This can be used to create a network of bicycle routes that give priority to bicycle traffic, but restrict automobile traffic in terms of speeds and volumes. This can provide a number of benefits, including increased use of non-motorized travel modes.[64]

E. *Pedestrian and Bicycle Facility Improvements*

High-quality multi-use paths can increase non-motorized travel on a corridor. Such trails are often highly valued by communities.[65] Better planning can improve the quantity and quality of pedestrian facilities, such as paths, sidewalks and crosswalks.[66]

Nearly all communities with high levels of bicycle transportation have extensive networks of bicycle paths and lanes. One study found that each mile of bikeway per 100,000 residents increases bicycle commuting 0.075 percent.[67] However, a poorly designed or maintained bicycle facility can be more dangerous than none at all.[68]

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[61] Reid Ewing, *Best Development Practices; Doing the Right Thing and Making Money at the Same Time*, Planners Press (Chicago; www.planning.org), 1996.

[62] *Residential Streets*, American Society of Civil Engineers (Washington DC), 1990; Project for Public Spaces, Inc. *Transit-Friendly Streets: Design and Traffic Management Strategies to Support Livable Communities*, TCRP Report 33, Transportation Research Board (Washington DC; www.nas.edu/trb), 1998.

[63] TAC *Canadian Guide To Traffic Calming*, Transportation Association of Canada (Ottawa; www.tac-atc.ca/programs/calming/calming.htm), 1999; PTI, *Slow Down You're Going Too Fast*, Public Technology Incorporated (http://pti.nw.dc.us/task_forces/transportation/docs/trafcalm).

[64] Todd Litman, *Traffic Calming Costs, Benefits and Equity Impacts*, VTPI (www.vtpi.org), 1997.

[65] *Economic and Social Benefits of Off-Road Bicycle and Pedestrian Facilities*, National Bicycle and Pedestrian Clearinghouse, Technical Assistance Series, No. 2, September 1995.

[66] Ellen Vanderslice, *Portland Pedestrian Design Guide*, and *Pedestrian Master Plan*, Pedestrian Transportation Program, City of Portland (503-823-7004; pedprogram@syseng.ci.portland.or.us), 1998; *Pedestrian Facilities Guidebook: Incorporating Pedestrians Into Washington's Transportation System*, Washington State Department of Transportation (Olympia; www.wsdot.wa.gov/ta/t2/t2pubs.htm), 1997.

[67] Arthur C. Nelson and David Allen, *If You Build Them, Commuters Will Use Them; Cross-Sectional Analysis of Commuters and Bicycle Facilities*, Transportation Research Board, #970132, 1997.

[68] Hugh McClintock. *The Bicycle and City Traffic.* Belhaven Press, London, 1992.

Developing urban bicycle lanes often involves a tradeoff with on-street parking. There are three justifications for choosing bicycle lanes over automobile parking in such situations:

1. *Equity*. Local roads are funded through local taxes that residents pay regardless of their travel patterns.[69] It is only fair that bicyclists receive a share of road space and funds.
2. *Priority*. Mobility is the primary function of public roads, and is the justification for devoting public land and financial resources to them. Vehicle storage (i.e., on-street parking) can be considered a less important function than traffic movement, since offstreet parking can be supplied by private firms. Since bicycle lanes can improve traffic flow for both bicyclists and motor vehicles, such facilities deserve higher priority than on-street parking.
3. *Parking efficiency*. Reduced automobile parking capacity that results when on-street parking spaces are converted to bike lanes can be offset if the bike lanes result in reduced automobile trips. For example, if 80 automobile parking spaces are converted to bike lanes which results in an average daily shift of 100 commute trips from automobile to bicycle, there would be a net *gain* of 20 parking spaces.

F. *Roadway Improvements*[70]

Some bicycle improvements are relatively inexpensive. These include pothole filling, paving short stretches of road shoulder, installing curb cuts, paving short paths and smoothing railroad crossings. Some communities establish "spot improvement" programs.[71] Some arterials lanes can be converted to bicycle lanes with no reduction in traffic capacity.[72] Many highway agencies and local governments now specify that all highways and arterials without curbs have a smooth shoulder of 1-3 metres wherever possible, in part to more safely accommodate cyclists.[73]

G. *Bicycle Parking and Showers.*[74]

Long-term parking must keep bicycles and accessories safe from theft and protected from weather. Convenient short-term parking is important near commercial areas. Racks must be well designed to hold the bike frame (rather than just the wheels) and accommodate a wide range of bicycles and lock types. Bicycle commuters may need showers and lockers, especially those who wear professional clothes or ride long distances in hot, humid or rainy climates. Bike parking standards are incorporated in some municipal zoning laws.

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[69] Todd Litman, *Whose Roads?*, VTPI (www.vtpi.org), 1996.

[70] John Williams, Bruce Burgess, Peter Moe and Bill Wilkinson, *Implementing Bicycle Improvements at the Local Level*, FHWA, Report FHWA-RD-98-105, 1998.

[71] Michael Dornfeld. "Bicycle Spots Safety Improvement Program." In *The Bicycle: Global Perspectives*. Velo City Conference proceedings, Sept. 13-17, 1992, Montreal.

[72] Dan Burden and Peter Lagerwey, *Road Diets; Fixing the Big Roads*, Walkable Communities (www.walkable.com), 1999.

[73] A.M. Khan and A. Bacchus, "Bicycle Use of Highway Shoulders," *Transportation Research Record 1502*, 1995, pp. 8-21; Michael Ronkin, *Reasons for Highway Shoulders*, Oregon DOT (available at www.walkable.org).

[74] BCM bicycle parking information (www.users.thecia.net/users/bcom/lawlegis/parking.htm). *Bicycle Parking Facilities Guidelines*, City of Portland (www.trans.ci.portland.or.us/Traffic_Management)

H. *Encouragement and Safety Programs*

Employers, bicycle clubs, and other organizations can promote pedestrian and bicycle transportation, sponsor promotional events and contests, distribute safety information and support safety campaigns. A map that highlights preferred bicycle routes can encourage bicycle transportation, especially beginning riders. Bicycle safety programs are most effective at the community level, especially if they involve law enforcement officials.

I. *Bicycle-Transit Integration*[75]

Bicycling and transit are complementary modes. Bicycling is ideal for making short trips in low traffic areas, while transit is most efficient on longer trips on congested corridors. Bicycles are widely used to access transit stations in many parts of the world. Such intermodal bicycle trips can be encouraged by providing secure bicycle storage at transit stations and park-and-ride lots, by allowing bicycles to be carried on buses and trains, and by promoting bicycling along with other efficient modes.

Table 7 summarizes the travel impacts of these strategies. Some strategies only affect a portion of total travel (for example, Commute Trip Reduction programs only affect commute travel at participating worksites), so their total impacts depend on how widely they are implemented. No single TDM strategy can solve all transportation problems, but a combination of these strategies can have significant impacts, shifting 10-30% of automobile travel to non-motorized modes, and providing support for public transit, ridesharing and more transportation-efficient land use.

Table 7 **Travel Impacts of Strategies to Encourage Non-Motorized Travel**

Strategy	Potential Travel Impacts
Commute Trip Reduction Programs	Can significantly reduce automobile commute trips. The portion that shifts to non-motorized travel depends on local conditions.
Transportation Price Reform	Can significantly reduce automobile trips. The portion that shifts to non-motorized travel depends on local conditions.
Land Use Policy Reform	Can significantly reduce automobile trips over the long term.
Traffic Calming	Can cause a moderate reduction in automobile trips and increase non-motorized over the medium and long term.
Pedestrian & Bicycle Facilities	Can significantly increase walking and cycling over the medium term. Not all of the increased non-motorized travel substitutes for automobile trips.
Roadway Improvements	Can moderately increase walking and cycling over the medium term. Not all of the increased non-motorized travel substitutes for automobile trips.
Bicycle Parking & Showers	Can moderately increase cycling where implemented.
Encouragement & Safety Programs	Can moderately increase walking and cycling over the medium term. Not all of the increased non-motorized travel substitutes for automobile trips.
Bicycle-Transit Integration	Can moderately increase cycling where implemented.

"Significant" = greater than 5% "Moderate" = 1-5%

[75] Transit Cooperative Research Program *TCRP Synthesis 4, Integration of Bicycles and Transit*, Transportation Research Board (www.nas.edu/trb), 1994.

Calculating Optimum TDM Program Investments

Table 8 summarizes the potential benefits of a shift from driving to walking or bicycling for a typical trip under Urban Peak, Urban Off-Peak and Rural conditions. Note that this analysis focuses on "economic" benefits of reduced automobile use. It does not include benefits to users and society that may result from increased walking and bicycling for recreation, or benefits to pedestrians and cyclists from improved travel conditions.

Table 8 **Estimated Benefits of Shift From Driving To Bicycling (dollars per trip)**

	Urban Peak	**Urban Off-Peak**	**Rural**
Congestion	$0.40	$0.04	$0.00
Road Costs	0.10	0.05	0.05
Parking	1.50	0.25	0.05
User Costs	0.85	0.55	0.55
Air Pollution	0.25	0.20	0.05
Noise	0.10	0.05	0.02
Road Safety	0.15	0.12	0.10
Additional Environmental & Social	0.23	0.23	0.23
Totals	*$3.58*	*$1.49*	*$1.05*

Using these estimates, the following formula can be used to determine the maximum investment justified for TDM programs that achieve a shift from SOV travel to walking or bicycling:

Optimal Investment/Year = (Benefits/Trip x Modal Shift)/Year

Example: Table 9 shows the maximum funding justified for a TDM program per one percentage point shift from driving to walking or bicycling in a hypothetical urban or suburban community with 10,000 commuters and 35,000 non-commute trips each day, based on estimated benefits in Table 1. In this case up to $179,000 could be spent for each percent of commute trips, and $190,348 for each percentage point of non-commute trips shifted from driving to non-motorized travel.[76]

Table 9 **Maximum Funding Per 1-Point Modal Shift for Hypothetical Bicycle Encouragement Program**

	Commute Trips	**Non-Commute Trips**
Trips per day	20,000	35,000
Days per year	250	365
Benefits per trip	$3.58	$1.49
Calculation	20,000 x 250 x 3.58 x .01	35,000 x 365 x 1.49 x .01
Totals	*$179,000*	*$190,348*

[76] For an application of this model see Pro. Arthur C. Nelson, *Private Provision of Public Pedestrian and Bicycle Access Ways; Public Policy Rationale and the Nature of Public and Private Benefits*, paper presented at the Transportation Research Board Annual Meeting, January 1995.

Summary

Non-motorized transportation provides many benefits, including internal benefits (to people who walk and bicycle) and external benefits (to others), as indicated in Table 10. Shifting travel from automobile to walking and bicycling is estimated to provide economic benefits worth $1.05 to $3.58 per trip shifted, depending on conditions, not including improved health and enjoyment to users. A conventional analysis that focuses on just one or two objectives (such as traffic congestion or emission reductions) will tend to undervalue shifts to non-motorized travel.

Table 10 **Benefits of Increased Non-Motorized Travel**[77]

Internal Benefits	External Benefits
	Reduced congestion
	Reduced road and parking facility expenses
Financial savings	Reduced accidents
Health benefits	Reduced pollution
Increased mobility for non-drivers	Resource conservation
Enjoyment	Increased travel choices (reduced automobile dependency)

Non-motorized transportation can help achieve TDM objectives, both alone and by supporting other TDM strategies. Improved walking and cycling conditions supports transit and rideshare use, and more efficient land use patterns that reduce the need to travel.

There are several specific ways to encourage walking and cycling. Although many communities are implementing some of these strategies, few are implementing all or even most of them. Most communities could significantly increase non-motorized transportation using strategies that are feasible, cost effective and fair. Much greater support for walking and cycling is probably justified in most communities when all benefits are considered.

[77] Todd Litman, *Guide to Calculating TDM Benefits*, VTPI (Victoria; www.vtpi.org), 1997.

V. Resources

American Trails (www.outdoorlink.com/amtrails) fosters communication among trail users.

America WALKs (www.webwalking.com/amwalks) is a coalition of walking advocacy groups.

Association for Commuter Transportation (Washington DC; 202-393-3497; http://tmi.cob.fsu.edu/act/act.htm) is a non-profit organization supporting TDM programs.

Bicycle Federation of America (www.bikefed.org) provides a variety of resources related to bicycle and pedestrian planning and advocacy.

The **Pedestrian and Bicycle Information Center** (www.bicyclinginfo.org) provides a variety of technical information on non-motorized transport planning and programs.

Dan Burden and Peter Lagerway, *Road Diets Free Millions for New Investment*, Walkable Communities (www.walkable.org), 1999.

Dan Burden, *Street Design Guidelines for Healthy Neighborhoods*, Center for Livable Communities, Local Government Commission (Sacramento; www.lgc.org/clc), 1999.

Center for Urban Transportation Research (http://cutr.eng.usf.edu) provides TDM materials.

Commuter Choice Program (www.epa.gov/oms/traq) provides information, materials and incentives for developing employee commute trip reduction programs.

Environment Canada **Green Lane** program (www.ec.gc.ca/emission/5-1e.html) promotes TDM and other strategies for reducing transportation environmental impacts.

Go For Green, The Active Living & Environment Program (www.goforgree.ca) provides many resources to promote non-motorized transportation.

National Institute of Health (www.nih.gov) has information on the health benefits of exercise.

Oregon Bike and Pedestrian Planning (www.odot.state.or.us/techserv/bikewalk/obpplan.htm) is an example of bicycle and pedestrian planning at its best.

Partnership for a Walkable America (http://nsc.org/walk/wkabout.htm) promotes the benefits of walking and supports efforts to make communities more pedestrian friendly.

The **Institute of Transportation Engineers** (Washington DC; www.ite.org) has extensive technical resources on TDM, transportation planning and traffic calming.

The **TDM Resource Center** (www.wsdot.wa.gov/Mobility/TDMhome.html) and **Northwest Technology Transfer Center** (www.wsdot.wa.gov/TA/T2) provide TDM resources.

Transportation Association of Canada (Ottawa; www.tac-atc.ca) provides a variety of resources related to transportation planning and TDM.

Transportation for Livable Communities (www.tlcnetwork.org) is a resource for people working to create more livable communities by improving transportation.

Turner-Fairbank Highway Research Center (www.tfhrc.gov), Pedestrian and Bike Planning.

UK **Health Education Authority** (www.hea.org.uk) has excellent material to promote “transport exercise” and better integration of non-motorized transport in public health programs.

Walkable Communities, Inc. (www.walkable.org) works with communities to create more people-oriented environments.

John Williams, Bruce Burgess, Peter Moe and Bill Wilkinson, *Implementing Bicycle Improvements at the Local Level*, FHWA (www.bikefed.org/local.htm).

The **WSDOT Bicycle Website** (www.wsdot.wa.gov/hlrd/Sub-defaults/Bicycle-default.htm) provides extensive information and examples of Washington's outstanding cycling programs.

Here are related reports available from VTPI:

Whose Roads? Defining Bicyclists' and Pedestrians' Right to Use Public Roads

Evaluating Traffic Calming Benefits, Costs and Equity Impacts

Pavement Busters' Guide

Potential TDM Strategies

Traffic Calming Benefits, Costs and Equity Impacts

Transportation Cost Analysis; Techniques, Estimates and Implications

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The Victoria Transport Policy Institute appreciates feedback, particularly suggestions for improving our products. After you have finished reading this report please let us know of any:

- Typographical errors or confusing wording.
- Concepts that were not well explained.
- Analysis that is inappropriate or incorrect.
- Additional information, ideas or references that could be added to improve the report.

Thank you very much for your help.

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