Impacts of Pedestrian Strategies on Passenger Vehicle Use and Greenhouse Gas Emissions

Policy Brief

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Policy Brief on the Impacts of Pedestrian Strategies on Passenger Vehicle Use and Greenhouse Gas Emissions

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Policy Description

Strategies that improve the walking environment have the potential to also reduce vehicle trips and vehicle miles traveled (VMT), both by supporting walking as a replacement for driving and by enhancing pedestrian access to transit. Many different strategies can be used to increase opportunities for walking, as summarized in Table 1. The most direct approach is to expand or improve pedestrian infrastructure, including sidewalks, off-street paths, intersections, and separated street crossings. Other street improvements, such as street trees and lighting, enhance comfort and security for pedestrians and may, thereby, encourage walking. Traffic calming techniques that reduce vehicle speeds or reduce both vehicle speeds and volumes also enhance comfort and security for pedestrians, again potentially encouraging walking. The last two categories of strategies are programs to promote walking and to promote changes in travel behavior more generally.

Table 1. Strategies to Increase the Level of Walking in Communities

Category	Examples
Pedestrian infrastructure expansion and improvement	Sidewalks: sidewalk widenings, repair and maintenance programs, ADA retrofits Off-street paths: hike-bike trails, pedestrian cut-throughs Intersections: raised pedestrian crossings, intersection "neck-downs," pedestrian islands, pedestrian signals Separated crossings: pedestrian bridges, pedestrian tunnels
Street improvements to enhance security and comfort	Street trees and landscaping Street furniture: benches, trash cans Street lighting Aesthetic improvements: pavement treatments, graffiti removal programs
Traffic calming techniques to reduce vehicle speeds	Speed humps and bumps Chicanes (landscaped areas or other features creating swerves in an otherwise straight street) Neck-downs (extensions of street corners that narrow the space for cars and reduce the distance for pedestrians crossing the street)
Traffic calming techniques to reduce vehicle speeds and volumes	Traffic diverters Partial/full street closures Home zones (residential streets designated as play areas with 10mph speed limits) Car-free zones
Programs to promote walking	Safe Routes to School plans (http://www.saferoutesinfo.org) Walking School Bus Walk to School Day
Programs to promote travel behavior change	Trip reduction programs Individualized marketing Travel awareness programs

See http://www.walkinginfo.org/ for further explanations of these strategies and terms.

Impacts of Pedestrian Strategies

Walking for any purpose will have an impact on VMT only if it replaces travel by car. In most cases, walking for utilitarian purposes (i.e. as a mode of travel to a destination) impacts VMT, but walking only for recreational purposes will not.

While many studies examine the effect of the built environment in general on walking, relatively few provide evidence on the effect of pedestrian strategies more specifically on walking, and fewer yet provide evidence on the effect of pedestrian strategies on VMT. This assessment excluded studies that address larger scale characteristics of the built environment that influence walking, including street network connectivity, land use mix, density, and regional accessibility, because the effects of these strategies on VMT are summarized in separate briefs (see http://arb.ca.gov/cc/sb375/policies/policies.htm). The identified studies instead examine one of three aspects of the walking environment:

- Street characteristics: measures of sidewalk width, sidewalk coverage, or sidewalk length
- Pedestrian environment quality: composite measure of several characteristics of the walking environment such as sidewalks, street crossings, and topography
- Neighborhood type: a simple classification reflecting many characteristics of the neighborhood, including the pedestrian environment

Many studies focus on recreational walking or do not distinguish between recreational and utilitarian walking. Only studies that provide evidence for utilitarian walking are included in this brief. Walking is measured in several different ways, including the probability of walking mode choice, the number of walking trips, daily walking miles, and daily walking time. One study examines non-vehicle mode choice, mixing walking with bicycling and transit use (Cervero and Kockelman, 1997). A few studies provide evidence on the effect of pedestrian strategies on vehicle travel, measured either as the number of vehicle trips or VMT.

Effect size

The findings are summarized in three tables. Table 2 shows effects on walking of sidewalk characteristics and pedestrian environment quality. Table 3 shows effects on walking of neighborhood type. Table 4 shows effects on vehicle travel of sidewalk characteristics.

Most studies show a relatively small effect of sidewalk characteristics on walking, ranging from 0.09 percent to 0.27 percent increases in walking per 1 percent increase in sidewalk coverage, length, or width (Table 2). The study by Rodriguez and Joo (2004) is a notable outlier, with a 1.23 percent increase in walking mode choice for commute trips for a 1 percent increase in sidewalk coverage. Because this study focuses on university students and employees in a small city, the results are not likely to be relevant to most communities. The effects for pedestrian environment quality are about the same as for sidewalk characteristics, ranging from 0.12 percent for work trips to 0.18

percent for non-work trips.

Table 2. Impact of Pedestrian Strategy on Walking

Study	Study Location	Study Year	Results		
			Sidewalk Characteristics or Pedestrian Environment Quality Variable	*Walking Variable*	*Increase in Walking Variable for 1% Increase in Pedestrian Strategy Variable*
Cervero & Kockelman (1997)	SF Bay Area, CA	1990	Average sidewalk width	Non-private vehicle choice for non-work trips	0.09%
Rodriguez & Joo (2004)	Chapel Hill, NC	1997	Proportion of route with sidewalks	Walk mode choice (commute trips)	1.23%
Fan (2007)	Raleigh-Durham, NC	2006	Sidewalk length	Daily walking time per person	0.12%
Ewing et al. (2009)	Portland, OR	1994	Sidewalk coverage	Walk mode choice	0.27%
Cervero & Kockelman (1997)	SF Bay Area, CA	1990	Walking quality factor*	Non-private vehicle choice for non-work trips	0.18%
				Non-private vehicle choice for work trips	0.12%

*Effect size is per 1 standard deviation increase in walking quality factor.

Another set of studies examines differences in walking for different types of neighborhoods (Table 3). The results show that residents of traditional and new urbanist neighborhoods walk much more often than residents of conventional suburban neighborhoods. These effects are probably the result of better sidewalks and other aspects of the walking environment, as well as larger scale aspects of the built environment, such as density, land use mix, connectivity, and regional accessibility. Land use mix and street network connectivity are especially important for walking because together they determine distances from homes to potential destinations. Studies show that distance to destinations is one of the strongest predictors of walking for utilitarian purposes. For example, one study shows that a 1 percent decrease in the distance to the nearest store is associated with a 0.56 percent increase the frequency of walking to the store (Cao, et al. 2006).

It is worth noting that while all these studies show a positive effect of pedestrian strategies on walking, increased walking does not necessarily mean decreased driving. Handy and Clifton (2001) found that 72 percent of walking trips to a store replaced driving trips, but the rest did not. The estimated savings in VMT per person was 2.1 miles per month, on average.

Table 3. Impact of Neighborhood Type on Walking

Study	Study Location	Study Year	Results		
			Neighborhood Type	*Walking Variable*	*Increase in Walking Variable for Neighborhood Type Relative to Conventional Suburban*
Handy & Clifton (2001)	Austin, TX	1995	Traditional neighborhood	Walk trips to store per person	120%
Khattack & Rodriguez (2005)	Chapel Hill, NC	2003	New Urbanist neighborhood	Walk trips per household	306%
Cao, et al. (2009)	Northern California	2003	Traditional neighborhood	Non-work walk trips per person	44%

The few studies that examine the association between sidewalk characteristics and vehicle travel also show much smaller effects on vehicle travel than seen for walking (Table 4). Kitamura, et al. (1998) found that the presence of sidewalks in the neighborhood was associated with a 0.14 percent decrease in vehicle trips. Another study found that a 1 percent increase in the ratio of sidewalks-to-streets was associated with a 0.05 percent decrease in VMT (Frank et al., 2011). Other studies found no effect or almost no effect of sidewalk width or length (Cervero and Kockelman, 1997; Fan, 2007). A study conducted in Portland, OR found that a 1 percent increase in the quality of the pedestrian environment was associated with a 0.19 percent decrease in VMT (Parsons Brinkerhoff 1993). Not surprisingly, neighborhood types, reflecting the quality of the pedestrian environment, as well as larger scale aspects of the built environment, have a much greater impact on VMT, as summarized in Ewing and Cervero (2010). Studies show substantial declines in VMT for traditional and new urbanist neighborhoods, ranging from 20 percent to 34 percent.

Table 4. Impact of Sidewalk Characteristics on Vehicle Travel

Study	Study Location	Study Year	Results		
			Pedestrian Strategy Variable	*Vehicle Travel Variable*	*Decrease in Vehicle Travel Variable for 1% Increase in Pedestrian Strategy Variable*
Parsons Brinkerhoff (1993)	Portland, OR	1985	Pedestrian Environment Factor (PEF)[1]	Vehicle miles traveled	-0.19%
Kitamura, et al. (1997)	SF Bay Area, CA	1993	Presence of sidewalks in neighborhood (yes vs. no)	Number of vehicle trips	-0.14%
Cervero & Kockelman (1997)	SF Bay Area, CA	1990	Sidewalk width	Vehicle miles traveled	No effect

Study	**Study Location**	**Study Year**	**Results**		
			Pedestrian Strategy Variable	*Vehicle Travel Variable*	*Decrease in Vehicle Travel Variable for 1% Increase in Pedestrian Strategy Variable*
Fan (2007)	Raleigh-Durham, NC	2006	Sidewalk length	Vehicle miles traveled per person	-0.02%
Frank, et al. (2011)	Puget Sound Region	2006	Sidewalk-to-street ratio	Vehicle miles traveled per household	-0.05%

[1] See pages 3-4 of the accompanying Technical Background Document on Impacts of Pedestrian Strategies

Evidence Quality

Most studies are cross-sectional and thus demonstrate associations between pedestrian strategies and levels of walking rather than direct evidence that the strategies will increase walking. The studies mostly do not account for self-selection, that is, the possibility that walking-inclined individuals choose residential locations with better walking environments. The studies use different measures of the walking environment and even different measures of walking. While these limitations make it impossible to identify an accurate range of effect sizes, it is worth noting that all studies show a positive, non-zero effect on walking.

Caveats

All studies cited here focus on metropolitan regions as a whole, or on the urban core or suburban areas within those regions. It is likely that small-scale strategies to improve walking will have larger effects in environments that are already conducive to walking. The effect sizes are likely to be smaller for rural areas where destinations are farther apart. In most communities, walking represents a small share of all daily travel, so that even large percentage increases in walking may lead to small percentage decreases in driving. Furthermore, some new walking trips may replace trips by transit or bicycling rather than driving.

Greenhouse Gas Emissions

No studies provide direct evidence of the impact of pedestrian strategies on greenhouse gas (GHG) emissions. Translating increases in walking into GHG emissions reductions requires two steps: translating increases in walking into reductions in VMT, and converting reductions in VMT into reductions in GHG emissions. An increase in pedestrian trips does not necessarily translate into a 1-to-1 decrease in vehicle trips. The resulting reduction in GHG emissions also depends on the nature of the VMT eliminated (e.g. speeds, acceleration, deceleration, times vehicle is started) and the types of vehicles owned by individuals who switch from driving to walking. Apart from those particular considerations, one would generally expect the percentage GHG emissions reduction to be similar to the VMT reduction, if vehicle fleet composition and driving patterns are unchanged. While the pattern of such changes in response to pedestrian strategies has not been documented, it is reasonable to expect that policies that reduce VMT will also lead to reductions in GHG emissions.

Co-benefits

Pedestrian strategies have the potential to produce many important co-benefits, particularly with respect to health. Walking as a mode of transportation represents an important source of physical activity, critical in addressing obesity, cardio-vascular disease, and other important health problems. Walking is also a relatively affordable means of transportation. Strategies such as traffic calming may help to improve safety and livability for all residents of a community, not just pedestrians. Investments in pedestrian facilities, particularly off-street paths, may increase property values and promote economic development. The benefits of walkable communities are well-documented in the literature (Talen, 2013).

Examples

Cities throughout the U.S. have adopted strategies to increase walking. In recent years, public health officials have urged adoption of many of these efforts. The University of North Carolina-Chapel Hill's Active Living by Design program, for example, works with local organizations to improve walking conditions in their communities (http://www.activelivingbydesign.org/). In California, the Local Government Commission provides resources on planning for active living (http://www.lgc.org/issues/healthycommunities/activeliving.html). Many other state and national organizations provide similar support. The impacts of pedestrian improvements and other pedestrian strategies are rarely evaluated, however.

References

Cao, X., Handy, S.L., and Mokhtarian, P.L. (2006). The influences of the built environment and residential self-selection on pedestrian behavior: Evidence from Austin, TX. *Transportation*, 33(1), 1-20.

Cao, X., Mokhtarian, P.L. and Handy, S.L. (2009). The relationship between the built environment and nonwork travel: A case study of northern California. *Transportation Research Part A*, 43(5), 548–559.

Cervero, R. and Kockelman, K. K. (1997). Travel Demand and the 3 Ds: Density, Diversity, and Design. *Transportation Research D, 2*(3), 199-219.

Ewing, R. and Cervero, R. (2010). Travel and the Built Environment. *Journal of the American Planning Association, 76*(3), 265-294.

Ewing, R. and Cervero, R. (2001). Travel and the Built Environment: A Synthesis. Transportation Research Record (1780), 87-114.

Ewing, R., Greenwald, M. J., Zhang, M., et. al. (2009). *Measuring the Impact of Urban Form and Transit Access on Mixed Use Site Trip Generation Rates -- Portland Pilot Study*. Washington, D.C.: U.S. Environmental Protection Agency.

Fan, Y. (2007). The Built Environment, Activity Space, and Time Allocation: An Activity-based Framework for Modeling the Land Use and Travel Connection. (Unpublished doctoral dissertation.) University of North Carolina.

Frank, L., Greenwald, M., Kavage, S. and Devlin, A. (2011). An Assessment of Urban Form and Pedestrian and Transit Improvements as an Integrated GHG Reduction Strategy. WSDOT Research Report WA-RD 765.1, Washington State Department of Transportation. Available: http://www.wsdot.wa.gov/research/reports/fullreports/765.1.pdf

Handy, S. and Clifton, K. (2001). Local Shopping as a Strategy for Reducing Automobile Travel," *Transportation*, 28(4), 317-346.

Khattak, A.J., and Rodriquez, D. (2005). Travel behavior in neotraditional neighborhood developments: A case study in USA. *Transportation Research A*, 39(6), 481–500.

Kitamura, R.,Laidet, L. and Mokhtarian, P. (1997). A Micro-Analysis of Land Use and Travel in Five Neighborhoods in the San Francisco Bay Area. *Transportation,* 24: 125–158.

Parsons Brinckerhoff Quade Douglas (1993). *The Pedestrian Environment,* Report prepared for the 1000 Friends of Oregon, Portland, OR.

Rodriguez, D. A. and Joo, J. (2004). The Relationship between Non-motorized Mode Choice and the Local Physical Environment. *Transportation Research D, 9*(2), 151-173.

Saelens, B. E. and Handy, S. L. (2008). Built Environment Correlates of Walking: A Review *Medicine & Science in Sports and Exercise, 40*(7S), S550-S566.

Talen, E. (2013). The Walkable Neighborhood: A Literature Review. *International Journal of Sustainable Land Use and Urban Planning*, 1(1), 42-63.

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