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

Technical Background Document

Susan Handy and Gian-Claudia Sciara, University of California, Davis
Marlon Boarnet, University of Southern California

September 30, 2014

Policy Brief: http://www.arb.ca.gov/cc/sb375/policies/ped/walking_brief.pdf

Technical Background Document:
http://www.arb.ca.gov/cc/sb375/policies/ped/walking_bkgd.pdf

California Environmental Protection Agency
Air Resources Board

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

Susan Handy and Gian-Claudia Sciara, University of California, Davis
Marlon Boarnet, University of Southern California

Study Selection

This review focused on studies that provide evidence of the effect of pedestrian strategies on walking and/or vehicle miles of travel (VMT). It relied on the extensive review by Ewing and Cervero (2010) to identify relevant studies and for estimates of effect sizes, as noted below. Other reviews also provided important insights, particularly Ewing and Cervero (2001), Heath, et al. (2006), and Saelens and Handy (2008).

The reviewed studies examine three aspects of the walking environment: sidewalk characteristics, pedestrian environment quality, and neighborhood type. Studies that address the more macro-scale aspects of the built environment that may influence walking infrastructure, including street network connectivity, land use mix, density, and regional accessibility are excluded. The potential of these characteristics for reducing VMT are addressed separately in the briefs addressing land-use related policies.

Many studies focus on recreational walking or do not distinguish between recreational and utilitarian walking. The review includes only studies that focus on walking for utilitarian purposes (i.e. as a mode of travel to a destination) and excludes those that examine walking solely as a form of recreation or physical exercise. 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). Four studies provide evidence on the effect of pedestrian strategies on vehicle travel, measured either as number of vehicle trips or VMT.

Studies by Parsons Brinkerhoff (1993), Fan (2007), Ewing, et al. (2009), and Frank, et al., (2011) are included even though they are not published in the peer-review literature, because of the limited number of studies that provide evidence of the effect of sidewalk characteristics on either utilitarian walking or VMT.

Effect Size, Methodology and Applicability Issues

Sources for the estimated effect sizes are shown in Tables 1, 2, and 3. Ewing and Cervero (2010) conducted a thorough review of the literature on the relationship between the built environment and travel behavior. They report elasticities as the change in walking or VMT for a 1 percent increase in the measure of the built environment. In many cases, Ewing and Cervero estimated the elasticities or proportional increase based on data presented in the published paper or from additional data acquired from the authors of the paper and are thus not reported in the published paper. For this reason, the effect sizes in the Ewing and Cervero report are used, and only the statistically significant effect sizes reported by Ewing and Cervero as being statistically significant are included.

Table 1: Walking Effect Sizes for Sidewalk Characteristics and Walking Environment Quality

Study	**Sidewalk Characteristics or Pedestrian Environment Quality Variable**	**Walking or vehicle travel measure**	**Results**		
			Elasticity	*Source*	*Data Source*
Cervero & Kockelman (1997)	Average sidewalk width: based on sample of 20 block faces within each neighborhood	Non-private vehicle choice for non-work trips	0.09	Ewing and Cervero, 2010 Table A-9	Region-wide household survey, for 50 neighborhoods in SF Bay Area
Rodriguez & Joo (2004)	Sidewalk coverage: percentage of shortest route to campus with sidewalk	Walk mode choice (commute trips)	1.23	Ewing and Cervero, 2010 Table A-9	Survey of UNC students, faculty, staff
Fan (2007)	Sidewalk length: ratio of sidewalk length to total street length within block group	Daily walking time per person	0.12	Ewing and Cervero, 2010 Table A-9	Region-wide household survey in Triangle region of North Carolina
Ewing et al. (2009)	Sidewalk coverage: mileage of sidewalks per centerline mile of streets within neighborhood	Walk mode choice	0.27	Ewing and Cervero, 2010 Table A-9	Region-wide household survey in Portland, OR, for 52 mixed-use neighborhoods in Portland, OR
Cervero & Kockelman (1997)	Walking quality factor (see text)	Non-private vehicle choice for non-work trips	0.18	Cervero & Kockelman (1997) Table 14	50 case study neighborhoods in SF Bay Area
		Non-private vehicle choice for work trips	0.12		

Table 2: Walking Effect Sizes for Studies of Neighborhood Type

Study	Neighborhood Type	Walking or vehicle travel measure	Results		
			Proportional Increase	*Source*	*Data Source*
Handy & Clifton (2001)	Traditional neighborhood (see text)	Walk trip to store per person	1.20	Ewing and Cervero, 2010 Table A-12	Survey of households in 6 neighborhoods
Khattack & Rodriguez (2005)	New Urbanist neighborhood (see text)	Walk trips per household	3.06	Ewing and Cervero 2010 Table A-12	Survey of households in 2 neighborhoods
Cao, et al. (2009)	Traditional neighborhood (see text)	Non-work walk trips per person	0.44	Ewing and Cervero, 2010 Table A-12	Survey of households in 8 neighborhoods

Table 3: VMT Effect Sizes for Studies of Sidewalk Characteristics

Study	Pedestrian strategy measure	Vehicle travel measure	Results		
			Elasticity	*Source*	*Notes*
Parsons Brinkeroff (1993)	Pedestrian Environment Factor (PEF)	Vehicle miles traveled	-0.19	Ewing and Cervero, 2001 Table 8	Region-wide household survey in Portland, OR
Kitamura, et al. (1997)	Presence of sidewalks in neighborhood: yes or no, as reported by survey participants	Number of vehicle trips	-0.14	Ewing and Cervero, 2001 Table 8	Survey of residents of 5 neighborhoods
Cervero & Kockelman (1997)	Average sidewalk width: based on sample of 20 block faces within each neighborhood	Vehicle miles traveled	No effect	Ewing and Cervero, 2010 Table A-3	Data from region-wide household survey, for 50 case study neighborhoods in SF Bay Area
Fan (2007)	Sidewalk length: ratio of sidewalk length to total street length within block group	Vehicle miles traveled per person	-0.02	Ewing and Cervero, 2010 Table A-3	Region-wide household survey in Triangle region of North Carolina
Frank, et al. (2011)	Ratio of sidewalk length to street length within 1 km buffer of home	Vehicle miles traveled per household per day	-0.05	Frank, et al., 2011 Table 4.4	Region-wide household survey in Puget Sound Region

The quality of the pedestrian environment has been measured in two different ways in the studies cited here. The Pedestrian Environment Factor (PEF) was created for the Portland region. It is a simple combination of ease of street crossing, sidewalk continuity, street connectivity, and topography (Parsons Brinkerhoff, 1993). Each of these elements was scored for each neighborhood on a 3-point scale, and each element was equally weighted in determining the overall score as a simple sum of the ratings on the four elements. In contrast, Cervero and Kockelman (1997) used factor analysis to develop a “walking quality” factor as a function of sidewalk provisions, street light provisions, block length, planted strips, lighting distance, and flat terrain. Each element is weighted based on its association with the other elements, as determined through the factor analysis.

The effects for walking quality are about the same as the effects for sidewalk characteristics. In studies that use a composite measure of the walking environment, it is not possible to translate the results into the effects of specific strategies. The similarity in results for the composite measures and the sidewalk characteristics suggests that sidewalks may be the most important component of the walking environment. However, other studies have found associations between walking and other aspects of the walking environment, for example, pedestrian amenities such as benches and trees (Hoehner, et al., 2005).

In studies that compare walking or VMT in different types of neighborhoods, “traditional” neighborhoods or “new urbanist” neighborhoods are typically compared to conventional suburban neighborhoods. The traditional neighborhoods have generally been built before World War II, with a gridded street network, narrower streets, neighborhood stores, and detached garages, among other characteristics. The new urbanist neighborhoods have been built in the last decade or two but designed to resemble traditional neighborhoods. The conventional suburban neighborhoods have been built after World War II, with a cul-de-sac street pattern, wider streets, separated from shopping areas, and attached garages, among other characteristics.

The cited studies are cross-sectional and thus demonstrate associations between pedestrian strategies and levels of walking or VMT rather than direct evidence that the strategies will increase walking or decrease VMT. The studies use a variety of statistical techniques to estimate the relationship between the pedestrian strategy and walking or VMT, while controlling for other factors, such as socio-economic characteristics. Other than Boarnet, et al. (2005), no studies were identified that directly estimate the effect of pedestrian strategies on utilitarian walking or VMT by measuring travel patterns before and after the completion of an infrastructure project.

Several of the studies do not account for self-selection, that is, the possibility that walking-inclined individuals choose residential locations with better walking environments. As a result, they may overstate the effect of pedestrian strategies on walking or VMT. The studies by Cao, et al. (2009), Fan (2007), and Kitamura, et al. (1997) control for self-selection using responses from survey participants to questions about factors affecting their choice of neighborhood. All studies except Parsons

Brinkerhoff (1993) control for socio-economic characteristics.

Increased utilitarian walking does not necessarily translate into reduced driving. Handy and Clifton (2001) asked survey participants to think about the last time they walked to the store. For this trip, the participants were then asked to speculate on what they would have done had they not been able to walk that day. The results show that 64 percent of participants would have driven to the same store and 8 percent would have driven to a different place, suggesting that these trips replaced driving trips. Thirteen percent would have stayed at home and 2 percent would have taken transit; these trips do not replace driving trips.

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. 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.

References

Boarnet, M.G., Greenwald, M., and McMillan, T. (2008). Walking, urban design, and health: Toward a cost-benefit analysis framework. *Journal of Planning Education and Research,* 27(3), 341–358.

Boarnet, M. G., Day, K., Anderson, C., McMillan, T., and Alfonzo, M. (2005). California's Safe Routes to School Program: impacts on walking, bicycling, and pedestrian safety. *Journal of the American Planning Association, 71*(3), 301-317.

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

Greenwald, M.J., and Boarnet, M.G. (2001). The built environment as a determinant of walking behavior: Analyzing non-work pedestrian travel in Portland, Oregon. *Transportation Research Record*, 1780, 33–43.

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

Heath GW, Brownson RC, Kruger J, et al. (2006). The effectiveness of urban design and land use and transport policies and practices to increase physical activity: a systematic review. *Journal of Physical Activity and Health*, 3:S55–76.

Hoehner, C. M., Brennan Ramirez, L. K., Elliott, M. B., Handy, S. L. and Brownson, R. C. (2005). Perceived and Objective Environmental Measures and Physical Activity among Urban Adults. . *American Journal of Preventative Medicine,* 28, 105–116.

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.

Acknowledgments

This document was produced through an interagency agreement with the California Air Resources Board with additional funding provided by the University of California Institute of Transportation Studies MultiCampus Research Program on Sustainable Transportation and the William and Flora Hewlett Foundation.