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Pedestrian-Friendly Environments and Active Travel for Residents of Multifamily Housing: The Role of Preferences and Perceptions

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Abstract

This article examines the relationship of the built environment to physical activity in suburban multifamily housing developments in a medium-sized city, testing Alfonzo's (2005) model of decisions regarding active travel. All complexes were within one-quarter mile of a shopping area with a major grocery store, but varied in pedestrian friendliness. Survey data were gathered on travel behavior to the stores, sociodemographic characteristics, preferences for an "active" environment, and perceptions of the extent to which their environment promoted activity. Multilevel analyses showed that residents in more pedestrian-friendly areas had significantly more active travel and less driving travel, indicating a substitution, rather than a supplementation, effect. Results remained when preferences for an "active" environment were controlled and, in most cases, when perceptions of the environment were

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controlled. It is suggested that Alfonzo's model of decisions regarding walking behavior be amended to include direct influences of urban form on travel behavior.

Keywords

active travel, pedestrian-friendly design, obesity, multifamily housing

In the United States, the fields of urban planning and public health have common historical roots. In the late 19th and early 20th century, they worked together to combat the many health-related problems of large and growing cities. Although practitioners and scholars in these areas later went their separate ways, they have recently rejoined efforts to focus on a new health crisis: the growing rates of obese and overweight people. Recent estimates indicate that 26% of all adults in the United States are obese (measured as a body mass index [BMI] of 30.0 or greater) and well over a third are overweight (a BMI of 25 to 30). The prevalence of obesity in the United States is higher than that for any other industrialized society and is related to growing rates of chronic conditions such as hypertension, heart disease, and diabetes. Although dietary patterns certainly contribute to increased rates of both overweight and obesity, low levels of physical activity are the other major contributory factor (Hu, Li, Colditz, Willett, & Manson, 2003; Mokdad et al., 2003; Ogden et al., 2006; Wells, Ashdown, Davies, Cowett, & Yang, 2007).

A growing body of literature, within both public health and planning, has documented the relationship of the built environment to physical activity. Although the magnitude of the effect varies somewhat from one study to another, researchers have consistently found that the physical environment in which people live is related to the degree to which they are physically active. People who live in areas with characteristics such as a more highly gridded street network, well-maintained sidewalks, illuminated pathways, safety from crime, attractive surroundings, and proximity to desired destinations are more likely to use active modes of transportation, such as walking or biking. Importantly, the impact of these pedestrian-friendly environments is independent of individual-level characteristics that may otherwise influence activity patterns (Cervero & Duncan, 2003; Doyle, Kelly-Schwartz, Schlossberg, & Stockard, 2006; Frank et al., 2006; Frost et al., 2010; Lee, Ewing, & Sesso, 2009; Lopez, 2004; Saelens & Handy, 2008; Sallis et al., 2009). This article continues this tradition by examining the relationship of pedestrian-friendly environments to actual behavior, controlling for a number of individual level and site-related factors.

Our exploration of this relationship supplements existing literature in several ways. First, it focuses on multifamily housing developments. Multifamily housing is a widespread, but often overlooked, example of dense development located near commercial areas throughout suburbia. This housing type often acts as a buffer between commercial strip malls and adjoining single-family home neighborhoods. It has been the largest growing housing market in the United States since 1970 and currently comprises one in five units in suburbia. Unlike New Urbanism projects, which have garnered extensive scholarly attention, these developments are typically not the result of cumbersome master planned community designs. Instead, they are generally built under zoning codes and processes that are fairly uniform throughout the nation and common elements of most suburban areas (Larco, 2009, 2010b). We examine the way in which variation in the built environment of these multifamily developments is related to travel behavior to the nearby commercial areas. We know of no other study that has focused on this growing and important element of suburban housing.

Second, our work may be seen as testing key elements of Alfonzo's (2005) socioecological model of walking behavior, which is the most common form of adult physical activity. Her model describes how environmental factors, such as pedestrian-friendly design, influence individuals' decisions to walk. However, she suggests that this influence is indirect, moderated by life-cycle circumstances as well as individuals' perceptions of their environment. Our analysis considers the impact of both of these categories of intervening variables. Specifically, we test Alfonzo's implicit hypothesis that there is no direct relationship between pedestrian-friendly design and walking behavior—that once individual characteristics and perceptions are controlled the statistical relationship of design elements and walking behavior will diminish or disappear.

Finally, our analysis addresses two somewhat controversial issues related to the efficacy of policies regarding the built environment. First, disagreement exists over the extent to which active trips will substitute for motorized trips, supplement them, or, perhaps, lead to even more trips by both active and nonactive modes. Evidence is still incomplete, but some authors suggest, based on analyses of data from large geographic areas, that the supplementation pattern may be more likely to appear (Crane, 1996; Guo, Bhat, & Cooperman, 2007). By focusing on travel to a single destination for all respondents within a given development and by using multiple dependent measures, we are able to develop a more precise test of whether variations in the built environment are related to a substitution or a supplementation effect.

The second area of controversy within the field involves the issue of self-selection and the extent to which greater levels of activity within more pedestrian-friendly environments simply reflect a tendency for people who prefer active travel to select these environments (Bhat & Guo 2007; Handy, 1996). Some evidence indicates that the impact of the built environment on walking behavior is independent of individuals' preferences related to their neighborhoods and environments (e.g., Handy, Cao, & Mokhtarian, 2006), but it is important to see whether these results can be replicated, especially within the far less studied area of multifamily housing developments.

To summarize, we examine the travel behavior of residents of multifamily housing developments to nearby shopping areas. We examine the extent to which residents of more pedestrian-friendly complexes engage in more active travel to nearby stores, controlling for a variety of other factors that could influence travel behavior, including individuals' sociodemographic characteristics and other characteristics of their apartment complexes and the nearby stores. We also examine the extent to which active travel substitutes for or supplements motorized travel to a specific destination, and the extent to which the relationship between environmental characteristics and travel behavior is altered when respondents' preferences regarding their housing location and their perceptions of their environment are controlled.[1] Thus, our analysis tests Alfonzo's (2005) model, which suggests that the influence of a pedestrian-friendly environment on active behavior is diminished when individuals' perceptions and circumstances are controlled.

Methodology

Setting and Sample

The setting for our study was a medium sized city in the Pacific Northwest with employment primarily in health care, education, government, and manufacturing. The city is the county seat, with a population of about 150,000 and situated near another city with a population of about 57,000. In all, 88% of the population is White, and the largest ethnic minority group is Hispanic, comprising just less than 9% of the population. Average incomes are lower than in the state or nation, and the poverty rate is slightly higher than the national and state figures.

The 14 multifamily housing developments included in the study were selected by analyzing county Geographic Information System (GIS) tax parcel data, aerial photographs of the city, and unit count data gathered directly from development sites. Developments were selected if they were in a suburban location, defined as being away from the center of the city, if units were rented rather than owned, and if there were at least 50 units within the development.[2] In addition, all sites had to be located near a local commercial area that included "pedestrian magnets" as defined by Leadership in Energy and Environmental Design (LEED) criteria (U.S. Green Building Council, 2005). These "pedestrian magnets" include amenities such as banks, grocery stores, post offices, restaurants, and commercial offices. The shopping area was a contiguous commercial cluster, typically an individual strip mall or a series of strips. Each shopping area included a large, full-service grocery store, and at least 15 additional shops within walking distance, "as the crow flies," to the multifamily housing development. A feasible walking distance was considered to be approximately a quarter mile (see Agrawal, Schlossberg, & Irvin, 2008; Southworth, 2005). These selection criteria helped ensure that there was relatively little variation in the characteristics of the nearby stores. In addition, as described below, we controlled for related variables in our analysis to provide further rigor to our tests.[3] All of the households within these 14 complexes comprised the population for the study.

Procedures

A written survey was sent to all households in the sites. Standardized survey distribution strategies, including an introductory post card, a survey mailing, a follow-up postcard, and then a second survey mailing, were used (Dillman, 2006). The survey asked questions about residents' travel habits, how they chose their modes of transportation and current place of residence, and barriers to walking and biking. All study sites were surveyed simultaneously to avoid differences in weather, fuel costs, and day length that might affect their responses. The surveys were distributed in March, and the time period had an even mix of sun and rain with daytime temperatures typically ranging between the mid 50°F up into the 70° F. In general, this area of the country has mild but wet winters, a mix of wet and dry springs and falls, and mild, dry, and pleasant summers, making walking and biking feasible throughout the year.

The survey was received by a total of 1,493 households, and 229 surveys were returned, representing a 15.3% response rate. Although this response rate is not high, it is similar to that obtained in other mail-out, mail-back surveys of the general population (Cao, Mokhtarian, & Handy, 2009; Sommer & Sommer, 1997). The administration of the survey and all coding and cleaning of the data were conducted under the supervision of one of the authors. For this analysis, people who did not have a car (12% of all respondents) were not included. We omitted these respondents to ensure that our sample only included people who potentially had a choice to drive or use active transportation to get to the nearby shopping area. Our analysis sample included 191 people for whom we had data on all of our variables.

Measures

Mode of travel. Our measures of mode of travel to the shopping area were derived from a question that asked respondents to reflect on their travel patterns in the last month and report how often they traveled "to your local commercial area in an average week" by driving, bike, walking, and bus. The first page of the survey included a map of the area surrounding their complex showing both the complex and the shopping area so that this reference would be clear to them. In addition, the survey included explicit definitions of walking and biking: "throughout this survey, the word 'walk' is used to refer to walking and wheelchair use. The word 'bike' is used to refer to any other nonmotorized transportation with wheels (bicycle, skateboard, rollerblades, etc.)."

Over four fifths (83%) of the respondents reported driving to the shopping area at least once in an average week and slightly less than two thirds (65.4%) reported walking. In total, 10% reported biking to the area at least once, but less than 3% ($n = 5$) reported taking the bus. Because both biking and walking involve an active mode of transportation, these responses were grouped together and we focused on (a) the number of trips that the respondents reported taking by biking and walking, (b) the number of trips they reported taking by driving, and (c) the percentage of all trips to the shopping area that were by biking and walking. Including measures of the use of both active and inactive modes is needed to determine the extent to which active travel substitutes for or simply supplements an inactive mode of travel to the shops. We also analyzed the percentage of trips that were by driving but, as would be expected given how few trips were by bus, the other mode of transportation, the results were simply the opposite of those with the percentage of trips by an active mode. Our results with this dependent measure are available on request from the authors.

Table 1 gives descriptive statistics for all of the measures in our analysis. Results for the three dependent measures are in the first section. There is substantial variability on all measures. For instance, on average, respondents reported walking or biking to nearby stores slightly more than two times each week, although values varied from none to a maximum of 11. The

Table 1. List of Variables and Descriptive Statistics

	Minimum	Maximum	*M*	*SD*
Dependent variables				
Number of bike and walking trips to shopping area	0	11	2.3	2.4
Number of driving trips to shopping area	0	7	3.1	2.5
% of all trips to shopping area that are active (bike or walking)	0	100	38.9	36.6
Site-level variables				
Pedestrian-friendly measure	39.5	98.2	80.4	18.3
Distance to shopping area (feet)	269.1	1,556.5	937.3	380.8
Density of apartment complex (units/acre)	9.3	38	19.7	6.6
Size of shopping area (number of units)	16	160	56.3	53.3
Individual-level variables				
Male (proportion)	0	1	0.29	0.46
Non-Hispanic White (proportion)	0	1	0.84	0.37
30 to 45 years (proportion)	0	1	0.27	0.45
45 years and older (proportion)	0	1	0.38	0.49
College graduate (proportion)	0	1	0.57	0.50
Postgraduate work (proportion)	0	1	0.14	0.34
Employed or student (proportion)	0	1	0.73	0.45
Child under 18 in home (proportion)	0	1	0.31	0.47
Income US$30,000 and up (proportion)	0	1	0.43	0.50
Preference for an active environment	1	5	2.93	1.40
Perceived walkability to shops	1	5	4.03	1.10

Note: $N = 191$. Site-level statistics were calculated with individuals as the unit of analysis.

average number of driving trips was slightly higher (mean of 3.1 trips per week). On average, respondents reported that they walked or biked about 39% of the time that they visited their nearby shopping area.

Site-level measures. We measured the pedestrian-friendly design of the linkage of the developments and the nearby shopping areas with objective measures obtained through systematic, quantitative observations based on good resolution aerial photographs of the housing developments with a graphic scale. The measure had three components: (a) external route directness, tapping the extent to which the distance from the development to the shopping area differed from the shortest possible distance; (b) presence of a protected pedestrian path, measuring the percentage of the distance from the complex to the shopping area that was protected from traffic; and (c) external street type, tapping the extent to which pedestrians would have to travel along and/or cross major arterials and collectors to reach the shopping area (Larco, 2010a; Larco & Johnson, 2009) (See Appendix for details). These indicators each ranged from 1 to 100 and were highly correlated (Cronbach's $\alpha = .73$), so the scores were summed and averaged. The resulting scale could theoretically vary from 1 to 100, with higher values indicating a development that had more direct access to the shopping area, greater protection of the route from traffic, and less busy streets along the path; in other words, a route that would be considered to be more friendly to pedestrian and bicycle traffic. As shown in the second section of Table 1, values on this measure ranged from 39 to 98, with a mean of 80. Thus, on average, the respondents lived in sites with that were relatively pedestrian friendly, but there was ample variation between the sites.

Three other site-related measures that might affect travel patterns were used as control variables. The first was the walking distance from the center of each development to the front door of the grocery store in the shopping area, measured in feet. This was included to control for the possibility that any effect of the pedestrian-friendly environment might actually be the result of distance to and from the shops. The second was the density of the development (total number of apartment units divided by the size of the complex in acres), which was included to control for any impact of the size of the development on travel patterns. The third site level control was the number of commercial establishments in the shopping area, controlling for the potential attractiveness of the commercial development.[4] Statistics regarding these indicators are also in the second section of Table 1 and indicate substantial variability. The average distance of the sites from the shopping areas ranged from 269 feet to more than 1500 feet, with a mean of 937. Similarly, there was variation in the density of the developments, ranging from just 9 units per acre to 38 units per acre (mean = 19.7). Finally, there was variation in the size of the shopping areas, ranging from 16 establishments to 160, with an average of 56.

Individual-level variables. We used several individual-level control variables in our analysis, paralleling Alfonzo's (2005) theoretical model. Seven involved individual, sociodemographic and life-cycle characteristics of the residents that might influence their travel patterns, and these were all measured by categorical, dummy variables. The first was gender, with 1 = *male*, 0 = *female*. Race–ethnicity was measured by a dummy variable with one indicating non-Hispanic White. Slightly less than a third of our sample (29%) was male and the vast majority (84%) was non-Hispanic Whites. Age was measured with two dummy variables: one contrasting ages 45 and older with other respondents and the other contrasting those between 30 and 44 with others. Thus, the omitted category was people younger than 30. All ages were represented, with the sample fairly evenly distributed among the three groups. Education was also measured with two dummy variables. One contrasted those who had completed college with others, whereas the other contrasted those with postgraduate work with others. The omitted category was people who had not finished college. The respondents were well educated, with over half being college graduates and an additional 14% holding graduate degrees. Employment status was captured by a dummy variable with 1 indicating *employed or a student* and 0 indicating *unemployed or retired*.[5] Almost three fourths were employed or students. Household composition was measured by a dummy variable with 1 indicating that a child under 18 lived in the household. Slightly less than a third fell in this category. Finally, income was measured by a dummy variable, with one assigned to those earning $30,000 or more a year. Slightly less than half had incomes above this level. There were few missing values on the control variables and these appeared to be randomly distributed. To maximize sample size systematic decision rules were used for assignment of missing values.[6,7]

In comparison to all residents of the city (as reported by the U.S. Census Bureau's mid-decade American Community Survey), the respondents were slightly less well educated, had lower average incomes, were less likely to have children in the home, were more often women, and were more often members of an ethnic minority. These differences mirror those found in other analyses of residents of multifamily housing, which tend to indicate that they are relatively less privileged, on average, than others in their community (Larco, 2009, 2010b).

We measured respondents' preference for an active living environment by a question that asked them to report how important the "ease of walking or biking to stores and restaurants" was to them when they chose their "current home." The question was embedded within a series of questions asking about factors related to their location choice, but we focused on this item because of its clear relation to our dependent measures. Answers could vary from 1, indicating not important at all, to 5, indicating very important. Responses ranged throughout the entire one to five scales, with an average at the midpoint of three.

Finally, we measured respondents' perception of the actual characteristics of their environments by a question that asked respondents to rate, on a scale of 1-5, "the ease of walking and biking between your apartment complex and the local commercial area," with 1 indicating *not easy* and 5 indicating *very easy*.[8] Responses to perceptions of walkability from their apartment to the nearby shopping area also ranged through the entire scale, but were, on average, relatively high (4.0 on a 5 point scale).

Analysis Plan

We used mixed modeling to examine the relationship between the pedestrian-friendly nature of the developments and travel behavior while controlling for respondents' individual characteristics, their preferences for an active environment, their perceptions of their environments, and characteristics of the sites other than walkability. Mixed models are particularly appropriate for analyzing multilevel data, such as those regarding behaviors of people in different sites. In these models, a "random variable" is used to control for differences between sites (often termed the level 2 entity) while calculating regression coefficients regarding the relationship of variables from both individuals and the sites to travel behavior. The random variable is roughly equivalent to having a separate intercept in the regression equation for each site. The coefficients associated with the various individual and site-related variables are then calculated while this between-site variance is controlled. The analysis also allows one to calculate the amount of variance in the dependent variable that occurs between sites (Raudenbush & Bryk, 2002; Singer, 1998).

We examined six incrementally more complex models: (1) an "intercept only" or base line model, which included no predictor variables other than the differences between sites (akin to a simple analysis of variance); (2) a model that added the pedestrian-friendly measure; (3) a model that added the individual sociodemographic variables; (4) a model that added the importance respondents attached to being able to walk to businesses and restaurants; (5) a model that added respondents' perceptions of the extent to which their environment was pedestrian friendly; and (6) a model that added the measures of distance to the shopping area, density of the development, and size of the shopping area. Each of these models is important in testing the issues outlined above. The first model allows us to assess the amount of variance in travel behavior between the different sites, whereas the second examines the extent to which this travel behavior is related to our measure of a pedestrian-friendly environment. Models 3, 4, and 5 directly examine hypotheses based on Alfonzo's model and the possibility that individuals' life-cycle circumstances, preferences, and perceptions moderate the relationship between the built environment and active travel. The final model examines the extent to which relationships remain constant when other characteristics of the site, such as density of the apartment complex or the size of the nearby shopping area, are controlled. We examined the relative fit of these models with model fit statistics and then looked at the fixed coefficients associated with the best fitting models.

We examined the extent to which active travel substitutes for or supplements inactive modes for traveling to the shopping area by comparing results between the dependent variables. Theoretically, one would expect that a substitution effect would result in a positive relationship between a pedestrian-friendly environment and active travel, but a negative relationship between such an environment and driving. If a pedestrian-friendly environment had a supplemental effect, we would expect a positive relationship with the number of active trips and no, or a potentially positive, relationship with the number of driving trips. Including a measure of the percentage that active travel comprises of total travel provides another way to examine the substitution versus supplemental effect. For instance, the number of active trips might increase with a more pedestrian-friendly environment (a positive relationship with the number of active trips), but if the effect were merely supplemental and driving trips also increased, there would be little relationship of a pedestrian-friendly environment with the percentage of trips that were active.

Finally, we illustrated the results by examining the mean values of the dependent variables for mutually exclusive values of our measures of preference for an active environment and perceptions of their environment with categories based on the actual, measured characteristics of their environment.[9]

Results

The mixed model results for each of the dependent measures are given in Tables 2 to 4. The bottom part of each table gives the random coefficients and fit statistics, whereas the top sections report the fixed effects coefficients. The random effects for the intercept test the null hypothesis that the differences between the intercepts, or average values for each site, equal zero. For Model 1, this is equivalent to a simple analysis of variance, and for subsequent models the results would be comparable to those obtained with an analysis of covariance adding the variables indicated for a given model. For the number of active trips and the percentage of all trips that were active (Tables 2 and 4) these values were statistically significant for Model 1 (the intercept only model), but not for the subsequent models, all of which included the measure of a pedestrian-friendly environment. Thus, as hypothesized, when the measure of a pedestrian-friendly environment was added to the models (in Model 2) there were no longer significant differences between the developments in the active travel of residents. In contrast, the random coefficient associated with the intercept was not significant in Model 1 for the analysis

Table 2. Mixed Models Regressing Number of Biking and Walking Trips on Individual and Site Characteristics

	Model 3			Model 4 (adding preferences)			Model 5 (adding perceptions)		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	SE	*p*
Fixed effects coefficients									
(Constant)	−1.6	1.3	.26	−3.2	1.1	.01	−3.9	1.1	.003
Individual-level variables									
Male	1.8	0.4	<.0001	1.5	0.3	<.0001	1.5	0.32	<.0001
Non-Hispanic White	0.9	0.4	.03	1.0	0.4	.01	1.0	0.0	.01
30 to 45 years	−0.1	0.4	.90	0.0	0.4	.93	−0.1	0.4	.80
Over 45 years	−0.3	0.4	.55	−0.3	0.4	.38	−0.3	0.4	.43
College graduate	0.1	0.4	.87	0.0	0.3	.92	0.1	0.3	.79
Postgraduate education	0.1	0.5	.84	0.2	0.5	.72	0.1	0.5	.82
Employed or student	0.1	0.4	.72	0.2	0.4	.50	0.1	0.3	.78
Child in household	1.0	0.4	.01	0.9	0.3	.01	0.6	0.3	.06
Income over $30K	−0.5	0.4	.18	−0.4	0.3	.22	−0.4	0.3	.20
Active Environment Important	—	—	—	0.7	0.1	<.0001	0.6	0.1	<.0001
Perceived walkabililty	—	—	—	—	—	—	0.5	0.1	.001
Site-level variable									
Pedestrian-friendly environment	0.03	0.01	.04	0.02	0.01	.03	0.02	0.000	.17

(continued)

Table 2. (continued)

	Random effects		Fit statistics			
	Intercept	Residual	−2 log likelihood (LL)	Change in LL	*df*	*p*
Random effects and fit statistics						
Model 1	0.93*	5.08****	868	—	—	—
Model 2	0.54	5.10****	865	3.7	1	<.10
Model 3	0.72	4.22****	832	32.4	9	<.001
Model 4	0.31	3.47****	790	42.3	1	<.001
Model 5	0.24	3.31****	771	18.4	1	<.001
Model 6	0.20	3.29****	777	−5.8	2	*ns*

Note: The change in log likelihood data were calculated by subtracting the −2 log likelihood value for a more complex model to the next less complex model (e.g., Model 2 to Model 1, Model 3 to Model 2, etc.). Degrees of freedom refer to the number of variables added in the more complex model. *T*-ratios may be computed by dividing the β coefficient by the standard error. Correlation ratio (η) = .15.
*$p < .05$. **$p < .01$. ***$p < .001$. ****$p < .0001$.

Table 3. Mixed Models Regressing Number of Driving Trips on Individual and Site Characteristics

	Model 3			Model 4 (adding preferences)			Model 5 (adding perceptions)		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
Fixed effects coefficients									
(Constant)	6.5	1.1	<.0001	7.6	1	<.0001	7.7	1.1	<.0001
Individual-level variables									
Male	–0.9	0.4	.02	–0.7	0.4	0.047	–0.8	0.4	.05
Non-Hispanic White	–0.5	0.5	.23	–0.7	0.4	.13	–0.6	0.4	.14
30 to 45 years	0.4	0.4	.37	0.4	0.4	.33	0.4	0.4	.33
Over 45 years	–0.4	0.4	.38	–0.3	0.4	.53	–0.3	0.4	.55
College Graduate	–0.4	0.4	.34	–0.3	0.4	.40	–0.3	0.4	.36
Postgraduate education	–1.5	0.6	.01	–1.4	0.5	.01	–1.4	0.6	.01
Employed or student	0.6	0.4	.17	0.5	0.4	.20	0.5	0.4	.19
Child in household	0.1	0.4	.83	0.2	0.4	.55	0.3	0.4	.45
Income over $30K	–0.1	0.4	.7	–0.3	0.4	.44	–0.2	0.4	.49
Active Env. Imp.	—	—	—	–0.5	0.1	<.0001	–0.5	0.1	.0001
Perceived walkability	—	—	—	—	—	—	–0.1	0.2	.52
Site-level variable									
Pedestrian-friendly environment	–0.03	0.01	.001	–0.03	0.01	.004	–0.03	0.01	.01

(continued)

Table 3. (continued)

	Random effects		Fit statistics			
	Intercept	Residual	–2 log likelihood (LL)	Change in LL	*df*	*p*
Random effects and fit statistics						
Model 1	.27	5.95****	889	—	—	—
Model 2	.00	5.77****	877	11.8	1	<.001
Model 3	.00	5.11****	854	23.3	9	<.025
Model 4	.00	4.67****	836	17.3	1	<.001
Model 5	.00	4.70****	829	7.4	1	<.01
Model 6	.00	4.59****	833	–4.0	2	*ns*

Note: The change in log likelihood data were calculated by subtracting the –2 log likelihood value for a more complex model to the next less complex model (e.g., Model 2 to Model 1, Model 3 to Model 2, etc.). Degrees of freedom refer to the number of variables added in the more complex model. *T*-ratio may be computed by dividing the b coefficient by the standard error. Correlation ratio (h) = .04.

*$p < .05$. **$p < .01$. ***$p < .001$. ****$p < .0001$.

Table 4. Mixed Models Regressing Percentage of Trips to Shopping Area that Are by Active Mode on Individual and Site Characteristics

	Model 3			Model 4 (adding preferences)			Model 5 (adding perceptions)		
	b	*SE*	*p*	*b*	*SE*	*p*	*b*	*SE*	*p*
Fixed effects									
(Constant)	–35.2	15.2	.04	–63.8	12.7	.0003	–70.4	12.9	.0001
Individual level variables									
Male	22.8	5.5	<.0001	18.4	4.6	<.0001	18.4	4.5	<.0001
Non-Hispanic White	8.0	6.4	.21	11.1	5.3	.04	10.6	5.3	.06
30 to 45 years	–2.5	6.3	.69	–3.0	5.2	.57	–3.6	5.1	.48
Over 45 years	1.1	6.2	.86	–2.1	5.1	.59	–2.1	5.1	.68
College Graduate	4.5	5.5	.41	3.0	4.5	.51	4.0	4.5	.37
Postgraduate education	7.6	8.1	.35	7.2	6.7	.29	6.8	6.6	.31
Employed or student	–2.9	5.9	.62	–1.3	4.9	.79	–3.0	4.9	.54
Child in household	10.1	5.6	.08	6.5	4.7	.17	3.9	4.7	.41
Income above US$30K	–9.7	5.2	.07	–6.4	4.3	.14	–6.5	4.3	.14
Active Env. Imp.	—	—	—	13.4	1.4	<.0001	12.5	1.4	<.0001
Perceived walkability	—	—	—	—	—	—	5.2	2	.01
Site-level variable									
Pedestrian-friendly environment	0.8	0.1	<.0001	0.6	0.1	<.0001	0.5	0.1	<.0001

(continued)

Table 4. (continued)

	Random effects		Fit statistics			
	Intercept	Residual	−2 log likelihood (LL)	Change in LL	*df*	*p*
Random effects and fit statistics						
Model 1	161.8*	1168****	1904	—	—	—
Model 2	13.34	1150****	1890	14.2	1	<.001
Model 3	5.40	1019****	1866	24.2	9	<.01
Model 4	1.00	693****	1792	74.3	1	<.001
Model 5	0.00	672****	1767	24.7	1	<.001
Model 6	0.00	666****	1784	−16.8	2	*ns*

Note: The change in log likelihood data were calculated by subtracting the –2 Log Likelihood value for a more complex model to the next less complex model (e.g., Model 2 to Model 1, Model 3 to Model 2, etc.). Degrees of freedom refer to the number of variables added in the more complex model. *T*-ratio may be computed by dividing the β coefficient by the standard error. Correlation ratio (η) = .12.
$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. $^{****}p < .0001$.

of number of driving trips, indicating that the average number of driving trips was similar across the complexes. However, when the measure of a pedestrian-friendly environment was added, in the second model, the random coefficient for the intercepts dropped to zero, indicating that, as with the other two dependent variables, variation in travel behavior between the complexes disappeared when the nature of the environment was considered.

The random effects for the residual test the null hypothesis that differences between individuals equal zero. This effect is significant for all models, indicating that, as would be expected, the variables that we examine cannot explain all the variation in individuals' travel behavior. The correlation ratio (η^2 and given in the footnotes to the tables) is a descriptive measure, calculated from the two random effects for the intercept only model (Model 1) and tells the percentage of variation that is between the developments, rather than between individuals. These values range from .04, for the analysis of number of driving trips, to .15 for the analysis of the number of walking and biking trips. Taken together, these findings indicate that up to 15% of the variation in respondents' travel behavior to their nearby shopping area is related to the developments in which they live. The least variation is explained in the number of driving trips, but over 10% of the variation in the number of active trips ($\eta^2 = .15$) and the percentage of all trips that are active ($\eta^2 = .12$) is between the developments rather than between the individuals.

The fit statistics provide additional information to determine which of the models best fit the data. The −2 log likelihood ratios have a chi-square distribution and can be compared from one model to the next to see if a given model provides a better fit to the data. These comparisons are shown in the "Change in LL" column in the second section of the tables. As hypothesized, Model 3, which added the measures of individual sociodemographic characteristics, had a significantly better fit than Model 2, and Models 4 and 5, which added the measures of the importance individuals attached to living in an active development and perceptions of walkability, also provided significantly better fits. In contrast, Model 6, which added the other site level characteristics (density of the development, distance from the development to the shopping area, and the size of the shopping area) did not have a better fit.

In short, the results indicate that Model 5, which includes the measure of a pedestrian-friendly environment, individuals' sociodemographic characteristics, preference for an active environment, and their perception of ease of walking to the nearby shops, provided the best fit to the data for all of the dependent measures. Adding other site characteristics, including the distance to the shopping area, its size, and/or the density of the apartment complex, did not improve model fit. Knowing the extent to which a multifamily development is well connected to the shopping area was sufficient to explain differences between complexes in how much residents used active modes of travel or driving to get to their nearby shopping area.

Magnitude of effects and testing Alfonzo's model. The top sections of Tables 2 to 4 give the fixed effects coefficients for Models 3, 4, and 5 for each of the dependent variables. Including coefficients for each of these models allows us to see the way in which the relationship of pedestrian-friendly environment to travel alters when individuals' preferences for an active environment and their perceptions of their own environment are controlled. Recall that Alfonzo's model suggests that the relationship of a pedestrian-friendly environment to travel behavior should become much smaller when these variables were controlled because they serve as moderating variables. To conserve space, fixed effects for the two preliminary models (the intercept-only, baseline model, and the model that only included the scale that measured the pedestrian-friendly nature of the environment) as well as those for Model 6, which did not significantly add to the fit, are not reported.

Coefficients for the number of active trips are in the top section of Table 2 and indicate that males, non-Hispanic Whites and those with a child in the household made significantly more active trips to the nearby shopping area. In addition, respondents who indicated that living in an active environment was important in choosing their home and those who perceived that their environment was more walkable were more likely to walk or bike to the shops. As hypothesized, those who lived in more pedestrian-friendly areas were more likely to walk or bike to their nearby shops. This was statistically significant in Models 3 and 4 ($p = .04$ and $p = .03$, respectively), but declined to insignificance ($p = .17$) in Model 5, when perceptions of walkability were added to the model.

Coefficients for the models when the number of driving trips was the dependent variable are in the top section of Table 3. The results indicate that males and those with postgraduate education had significantly fewer driving trips to the shops. In addition, those who attached more importance to living in an active environment had significantly fewer driving trips. However, in contrast to the results with the number of active trips, the perception of walkability was not significantly related to the number of driving trips. In addition, the relationship of living in a more pedestrian-friendly complex to fewer driving trips remained statistically significant and approximately the same magnitude in all three models. (Variations in the significance level across models results from changes in the standard errors, which are hidden by the rounded numbers in the table.)

Finally, the fixed effects coefficients in the top section of Table 4 report results when the dependent variable was the percentage of individuals' trips that were by an active mode. Results indicate that males had a significantly higher percentage of their trips by active modes, and, when the importance attached to an active environment was added to the model, non-Hispanic Whites had a significantly higher percentage of their trips by active mode. Respondents who rated an active environment as more important and those who believed that it was very easy to walk to the nearby shops also had a higher percentage of trips by active mode. However, even when these variables were controlled, the relationship of living in a more pedestrian-friendly complex to a larger percentage of active trips was highly significant and unchanged in magnitude.

Descriptive results: The magnitude of selection effects and perceptions. Table 5 displays average values of the dependent variables for respondents with different reported preferences for an active environment and different perceptions of the walkability of their sites for those living in areas that were objectively determined to be both less and more pedestrian-friendly. The values in the top lines of each section of Table 5 show that, on average, people who attached more importance to living in an active environment took more active trips to their nearby shops, drove less often to the stores, and had a higher percentage of their trips by an active mode than those who attached less importance to this type of location. At the same time, however, within each of the preference categories, people who lived in more pedestrian-friendly developments had more active trips, fewer driving trips, and a higher percentage of their trips by active means.[10] In general, the impact of a pedestrian-friendly environment on travel behavior was about the same as, or even greater than, the impact of the difference between seeing an active environment as important or having neutral views. For instance, respondents in the more pedestrian-friendly complexes who expressed neutral feelings regarding living in an active environment had, on average, more active trips and fewer driving trips than those who lived in less pedestrian-friendly areas but rated an active environment as important.

The descriptive results examining the role of perceptions of the environment, in the bottom rows of each section, varied slightly across the dependent variables, although all results illustrate the importance of pedestrian-friendly design. Respondents who perceived that it was easy to walk to the nearby shops and those in the more pedestrian-friendly environments had more active trips and a higher percentage of trips that were active, and these impacts were independent of each other. Results related to the number of driving trips were slightly different. As hypothesized, residents of the less pedestrian-friendly

Table 5. Travel Behavior by Pedestrian-Friendly Nature of Complex, Preference for an Active Environment, and Perceived Ease of Walking

	Less pedestrian friendly	More pedestrian friendly
Number of trips by walking or biking		
Preference for an active environment		
Not important (1-2)	0.5	1.4
Neutral (3)	1.7	2.5
Important (4-5)	2.3	3.7
Perceived ease of walking to shops		
Not easy (1-3)	0.7	1.3
Easy (4-5)	2.1	2.9
Number of trips by driving		
Preference for an active environment		
Not important (1-2)	4.4	3.9
Neutral (3)	4.2	2.5
Important (4-5)	3.9	1.9
Perceived ease of walking to shops		
Not easy (1-3)	3.7	3.4
Easy (4-5)	4.7	2.6
Percentage of trips that are active		
Preference for an active environment		
Not important (1-2)	4.3	21.1
Neutral (3)	21.2	45.9
Important (4-5)	32.8	69.8
Perceived ease of walking to shops		
Not easy (1-3)	12.8	29.1
Easy (4-5)	22.7	50.0

Note: Expressed preferences for living in an active environment were combined as follows: Categories 1 and 2 (not at all important and not important, $n = 76$), Category 3 (neutral, $n = 46$), and Categories 4 and 5 (important and very important, $n = 69$). The measure of perceived ease of walking to the nearby shopping area was combined into two categories: 1 with scores 1-3 (not easy to the midpoint) and 2 with scores of 4 and 5 (very easy). The measure of a pedestrian-friendly environment was divided into two mutually exclusive groups: sites with scores between 39 and 58 (less friendly, $n = 43$) and sites with scores between 78 and 98 (more friendly, $n = 148$).

complexes made more driving trips than those in the more friendly areas. However, in these less friendly areas, those who perceived it was easy to walk made even more driving trips than other residents, a result that was opposite to that in the more pedestrian-friendly areas. On average, residents in the less pedestrian-friendly areas drove to the nearby shops more often than those in the more pedestrian-friendly areas no matter how they perceived the environment.[11]

Summary and Discussion

This study used data from a mail out-mail back survey of residents of 14 different multifamily housing complexes in a medium size city. Like multifamily complexes throughout the country, these developments were situated in locations that serve as a buffer between commercial areas and single-family housing. Thus, all of the complexes were situated within about one-quarter mile of a retail center that included a major grocery store. The complexes varied, however, in the extent to which their design allowed "pedestrian-friendly" access to these stores. Based on a growing literature within public health and planning, we hypothesized that residents in the more pedestrian-friendly areas would be more likely to walk or bike to the nearby shops. Our analysis provided strong support for this hypothesis. Respondents who lived in the more connected complexes were significantly more likely to walk or bike to the shopping area. They were also significantly less likely to drive there, and a higher percentage of their trips were by active mode.

Alfonzo's (2005) model of influences on walking behavior suggests that individuals' sociodemographic and life-cycle characteristics, as well as their perceptions of their environment, moderate the impact of the built environment. Our analysis found that the relationship of the built environment to travel behavior was not diminished with the introduction of sociodemographic or life-cycle characteristics or preferences for an active environment. Thus, our results suggest that these factors do not moderate the influence of urban form on travel behavior, but serve as additional contributory factors. These findings regarding the independent influence of a pedestrian-friendly environment and preferences for an active environment also replicate the work of others who have discounted the role of self-selection as a sole explanation for decisions regarding travel behavior (e.g., Handy et al., 2006).

In partial support of Alfonzo's model, our analysis did find that individuals' perceptions of the ease of walking to their shopping area served as a moderating factor in the analysis of the number of walking or biking trips, but not in the analysis of the number of driving trips or the percentage of trips that were active. Examination of descriptive results indicated that this resulted from greater active travel among residents of the less connected complexes who perceived that it was easy to walk or bike to the nearby shops.[12] Among those who perceived that walking was not easy, the pedestrian-friendly nature of the complexes still mattered: those who lived in the friendlier complexes had on average almost twice as many active trips to the nearby shops as residents of the less friendly areas (1.3 vs. 0.7). Thus, our results suggest that, at least for this sample, positive perceptions of walkability can moderate the impact of less pedestrian-friendly environments, to at least some extent, but negative perceptions cannot. More generally, our results suggest that Alfonzo's model could be modified to suggest that sociodemographic and life-cycle characteristics, preferences for an active environment, and perceptions of one's environment do not fully moderate the impact of urban design factors on decisions regarding travel behavior. A more appropriate model might be one in which these elements remain as important influences on decisions but in which elements of urban design can also have direct effects.

In addition to examining Alfonzo's model and the issue of self-selection, our results address questions related to the "substitution effect" for travel. Our general pattern of results, with more walking and biking accompanied by less driving in the more pedestrian-friendly sites, suggests that the active mode of transportation substituted for driving behavior in trips to the nearby shops for these respondents. Our results also indicate that the negative impact on driving was somewhat greater than the positive impact on active travel.

It should, of course, be stressed that our evidence for this substitution effect is limited to trips to a nearby local commercial area. It could be suggested that this provides a more precise test of the substitution effect by limiting the comparisons to a common destination. We also limited our sample to developments and shopping areas that had similar amenities, and our analysis controlled for characteristics of both the developments and the shopping areas. Our analysis cannot, of course, address the extent to which the differences between the developments were related to alterations in other types of travel behavior including trips to additional destinations that were paired with stops at the shopping area.

The magnitude of our results would probably not be described as trivial. The average network (walking or biking) distance to the shopping areas from the complexes was a little more than 1600 feet, resulting in almost two thirds of a mile for a round trip. An additional one to two trips a week for a resident would translate into almost an extra mile of walking each week. Health researchers note that even modest increases in activity can translate into health benefits. Similarly, two fewer driving trips a week to the nearby shopping area translates into fewer emissions, less consumption of fossil fuel, and lower costs for the residents.

It should be remembered that our sample focused on travel between two set locations—home apartment complexes and adjacent shopping areas. This added control to our analysis through having a common destination and route. It also, by definition, focused on what has been called "utilitarian walking," or purposeful, rather than leisure-oriented activity. Rodriguez, Khattak, and Evenson (2006) found that such utilitarian physical activity, but not other types of physical activity, was more common in New Urbanist areas than in traditional areas; and other research suggests that variations in the built environment may be more likely to influence utilitarian trips than leisure walking (Rodriguez et al., 2006; Saelens & Handy, 2008; but also see Cao et al., 2009). We suggest that such travel should not be dismissed as trivial, for greater activity is important no matter when or where it occurs.

Moreover, this type of travel may be the most effective one on which to focus policy efforts, for it might have the greatest chance of success. In general, our findings have implications for planners and policy makers, for they show the ways in which different environments within the same city can promote variations in individuals' behavior that are statistically significant and substantively important.[13] As noted earlier, multifamily housing has received relatively little scholarly attention, but is home to almost 20% of all suburban residents and comprises over 9 million units in this country (Larco, 2009, 2010b). Thus, policies that promote pedestrian-friendly environments could potentially impact large numbers of people.

In addition, there is no indication from our results that the improved pedestrian amenities resulted in lower levels of traffic to the nearby stores. People in both highly pedestrian friendly and less friendly complexes visited their nearby shopping areas with about equal frequency; they simply varied in how they typically traveled there. Thus, we have no reason to expect that business people would oppose the development of more pedestrian-friendly areas and, in fact, might find ways to use it to enhance business.

Finally, future research into this area needs to be conducted to address obvious limitations to our work, such as its focus on just one community, one time point, one type of housing, and a relatively limited number of variables. It would be important to replicate our results looking at developments in different areas of the country. It would also be important to extend our analyses to include single-family homes that are adjacent to commercial areas. Finally, it would be important to explore, in greater detail, the ways in which individual sociodemographic factors relate to travel behavior.

Appendix

Measuring Pedestrian-Friendly Design

Our measure of the pedestrian-friendly design of the linkage between apartment complexes and nearby shopping areas had three components: (a) external route direction, (b) protected pedestrian path, and (c) external street type. Each component could range theoretically from 1 to 100. Descriptions of computations are given below and full details of the connectivity audit that includes these measures are available in Larco & Johnson (2009). In the description below, the term "commercial area" refers to the nearby shopping area, "egress point" refers to exits from the apartment complex, "front door" refers to the entrance to the shopping center that is closest to the egress point, "direct path" refers to a straight line or "as the crow flies" path from the egress point to the front door, and "pedestrian path" refers to the path that a pedestrian would have to follow to go from the egress point to the front door. All of these elements can be determined in a high resolution aerial photograph with graphic details.

External Route Direction—Defined as the extent to which the distance from the development to the commercial area differs from the shortest possible distance. Thus, it measures the total "extra" distance that pedestrian must travel as a result of an indirect path or deficient connections from the development to the shopping area. The indicator is based on two measurements: the direct or straight-line distance (A) and the pedestrian path distance (B) and involves five steps:

1. Divide the pedestrian path distance by the straight line distance $(B/A) = R$,
2. Find the maximum value of R for the set of complexes ($R_{\max}$),
3. Divide R by $R_{\max}$ ($R/R_{\max}$) to reduce the range of values to fall between 0 and 1,
4. Subtract from 1 ($1 - [R/R_{\max}]$) so that a higher score indicates greater walkability, and
5. Multiply by 100 to transform the indicator to a 0 to 100 scale.

$$\text{ERD} = 100 \times [1 - (R/R_{\max}) \tag{1}$$

Protected Pedestrian Path—Defined as the extent to which the pedestrian path from the development to the commercial area is protected from auto traffic. Thus, it measures how well protected a pedestrian is on the journey from the development to the commercial area. The indicator is based on two measurements: the total pedestrian path distance (B in the measure above) and the distance of the pedestrian path that is unprotected (U). A protected path is defined as an area that has a planting strip or on-street parking separating the sidewalk and the street, whereas an unprotected path does not have any buffer between the sidewalk and the roadway. The calculation involves three steps:

(continued)

Appendix (continued)

1. Subtract the unprotected path distance (U) from the total distance (B; B – U) to get the actual distance that is protected,
2. Divide this difference by B, the total distance [(B – U)/B] to convert to a proportion of the total distance that is protected; and
3. Multiply by 100 to change to a 0 to 100 scale.

$$\text{PPP} = [\ (\text{B} - \text{U})/\ \text{B}] \times 100 \tag{2}$$

External Street Type—This measure determines the street types that pedestrians must travel along or cross to travel from the development to the commercial node. Following conventions in the field of planning and transportation, streets are categorized as major arterials, minor arterials, major collector, neighborhood collector, and local. City websites typically define the category in which each street lies. To create the measure the shortest pedestrian path (B) is mapped. Ten measures are recorded: the number of streets in each of the five categories that are traveled along and the number of streets of each type that are crossed to get from the egress point to the front door. The following codes are used:

Major Arterial: Traveled (+5)
Major Arterial: Crossed (+5)
Minor Arterial: Traveled (+4)
Minor Arterial: Crossed (+4)
Major Collector: Traveled (+3)
Major Collector: Crossed (+3)
Neighborhood Collector: Traveled (+2)
Neighborhood Collector: Crossed (+2)
Local: Traveled (+1)
Local: Crossed (+1)

A score is calculated for each development by multiplying the number of each type of streets by the score (e.g., *one major arterial traveled* = 5, *one local street crossed* = 1). The indicator is calculated with three steps:

1. Add the calculated codes resulting in a sum (S), with higher values indicating heavier auto traffic,
2. Divide this sum by 30, a value arbitrarily taken as a theoretical maximum (obtained by adding all the possible codes; S/30), a procedure that converts the indicator to a proportion;

3. Subtract this value from 1 to reverse the ordering so that a higher score indicates a route with less traffic [1 – (S/30)]; and
4. Multiply by 100 to alter to a scale ranging from 1 to 100.

$$PPP = 100 \times [1 - (S/30)] \tag{3}$$

Authors' Note

Any opinions and conclusions expressed are the responsibility of the authors.

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Notes

1. Throughout our discussion we generally use the term "pedestrian-friendly environment" in the way that other authors have also used terms such as "connectivity," "walkability," and "active environment." All who use these terms assume that environments that are more connected enhance the probability that individuals will be physically active and, thus, walk more to their destinations.
2. Some of the developments included within the study were situated immediately adjacent to other developments, as part of a cluster of multifamily housing. If a development with fewer than 50 units was part of such a cluster it was included within the study. As noted below, controls for size and density of developments did not alter our findings.
3. As further confirmation that the sites were equivalent, we used the web-based "Walk Score" rating system, based on "as the crow flies" proximity, number, and variety of neighboring commercial development (www.walkscore.com3) to determine scores for each complex. Values on this measure did not differ significantly between the complexes.
4. We also included size of the development, as measured by the number of units, as a control variable and obtained results equivalent to those reported here.
5. The decision to group students and employed workers and those who were retired and unemployed reflected the desire to distinguish residents who were absent from their homes for at least part of every day from those who would be more likely to be there. We also wanted to maintain adequate sample size within the categories.

6. For the measures of having children in the home and employment status, people who did not answer the question ($n = 10$ for number of children and $n = 3$ for employment status) were assigned a value of zero, assuming they had no children at home and/or that they were not employed. For the measure of education, a regression-based estimation procedure was used, with income, gender, and age as predictor variables ($n = 8$).
7. Correlations among the sociodemographic variables were low to moderate. The only correlations surpassing .30 were age 30 to 45 with presence of children (.33) and age 45 plus with employment status (–.33). Not surprisingly, given these low correlations, the associations between these sociodemographic variables and the dependent variables were very similar in the multivariate models to the zero-order measures.
8. Five respondents did not answer the question regarding their preference for an active environment and two did not answer the question regarding their perception of the environment. There was no systematic relation to other missing data. To preserve the sample size, the missing cases were set to the mean (2.93 for preference for active living and 4.0 for perception of the ease of walking to the shopping area).
9. We also used the fixed effect coefficients from the mixed models to calculate the expected values of the dependent variables if all individual sociodemographic characteristics were equal (at the mean) and for varying levels of the preference for an active environment, perceptions, and the measure of a pedestrian-friendly environment. The results were substantively identical to those reported in the text, and are available from the authors on request.
10. We also calculated two-way analyses of variance for each of these relationships. The results indicated that the two effects were significant, but independent of each other (no significant interactions) for all analyses with preferences.
11. Two-way analyses of variance with these relationships indicated no significant interaction effect and only significant main effects for the number of active trips and the percentage of trips that were active. The interaction effect was significant for the analysis with perceptions and the number of driving trips.
12. Note that among those who perceived it was easy to walk to the shops, those in the more pedestrian-friendly areas still had more active trips on average (mean = 2.9) than those who lived in the less friendly areas (2.1), again illustrating the impact of pedestrian-friendly design.
13. A number of the apartment complexes in our set of more "pedestrian-friendly developments" were built after the city implemented zoning changes that required significantly more attention to pedestrian amenities, illustrating that communities can enact code changes that facilitate such environments.

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