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Trips to Strips: Walking and Site Design in Suburban Multifamily Housing

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ABSTRACT *With over nine million units in the country, suburban multifamily housing is a widespread and overlooked example of density located within walking distance of commercial development in suburbia. This paper reports on resident demographics, attitudes, and perceptions as they relate to mode choice in 14 suburban multifamily sites in Eugene, Oregon. Through site analysis and resident surveys, this study shows that residents of well-connected suburban multifamily housing developments walk or bike for nearly half of their trips to the local commercial area (LCA). In addition, residents of well-connected multifamily developments reported walking to their LCA 60% more (one more trip per week) than residents of less-connected developments who took a similar number of total trips. Quantifying the degree to which site design, and specifically connectivity, makes a difference in residents' mode choice is a first step towards increasing the amount of active transportation in these areas. The results of this research provide planners and designers a basis for re-evaluating suburban multifamily site design and zoning codes.*

Introduction

The lack of active travel in suburbia, which is dominated by auto trips, is a topic that has garnered national attention. Research on this topic merges concerns about sedentary lifestyles with an investigation into the most prevalent form of development in the United States: suburbia. An increase in active travel has been correlated with improved health, lower body mass index, improved productivity (in the form of fewer sick days taken by individuals), and increased independence (Frank et al. 2006). Areas with more-connected street networks correlate with increased physical activity (Saelens et al. 2003; Frank et al. 2005; McGinn et al. 2007), lower obesity rates (Booth, Pinkston, and Poston 2005), and increased walking and biking (Frank et al. 2006; Ewing and Cervero 2010). Active transport can also result in reduced vehicle miles travelled and can contribute to lower greenhouse-gas emissions, reduced traffic, decreased environmental impacts, and economic savings to individuals and municipalities.

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Many of the studies related to active travel and development focus directly on the question of how the built environment affects mode choice. Researchers have identified a series of variables—summarized as the “Seven D’s”—that play a role in mode choice and walking behaviour: density, diversity of land uses, design, distance to transit, destination access, demand management (mostly in terms of auto and parking use), and demographics (Cervero and Kockelman 1997; Lee and Moudon 2006a; Ewing and Cervero 2010).

The role these variables have in determining walking behaviour is a topic of debate. Studies have shown that diversity of land uses, the concentration and accessibility of commercial destinations, and reduced distances between origins and destinations are consistently related to increased walking trips (Moudon et al. 1997; Lee and Moudon 2006a; Moudon et al. 2007; Saelens and Handy 2008; Cao, Mokhtarian, and Handy 2009; Ewing and Cervero 2010; Boarnet et al. 2011). Residential density, however, seems to have a fairly inconsistent relationship to walking behaviour, with higher densities sometimes but not always resulting in increased walking (Forsyth et al. 2007; Ewing and Cervero 2010; Forsyth and Krizek 2010).

Similarly, measures of connectivity, or the general directness of routes between destinations and origins in an area, have also had mixed results in terms of their relationships to increased walking behaviour. Ewing and Cervero’s meta-analysis found one of the key measures of connectivity—intersection/street density—to be the most salient variable in predicting walking trips, while Saelens and Handy’s meta-analysis showed an inconclusive effect for connectivity measures (Saelens and Handy 2008; Ewing and Cervero 2010).

Some of the inconsistency in the findings related to density and connectivity may be explained by the fact that many studies group utilitarian and recreational walking trips. Studies that have separated the two have found a significant relationship between utilitarian walking trips, density, and connectivity (Giles-Corti and Donovan 2002; Saelens et al. 2003; Badland and Schofield 2005; Lee and Moudon 2006b; Forsyth et al. 2007, 2009). In contrast, studies looking specifically at recreational walking have shown less of a relationship to these factors, while the aesthetic quality of the environment, safety, and convenience to recreational facilities have shown a more significant relationship (Ball et al. 2001; Giles-Corti and Donovan 2002).

One of the issues complicating research on connectivity and walking specifically has been the definition of the transportation network in many studies (see discussion of this in Saelens and Handy 2008; Ewing and Cervero 2010; Forsyth and Krizek 2010). Because of the difficulty of producing pedestrian network maps, the typical coincidence of street networks and pedestrian networks, and the prevalence and ease of acquiring street network GIS data, studies have often used the street network as a proxy for the pedestrian network. While these street maps may adequately represent pedestrian routes in some conditions, in others they leave off substantial portions of the pedestrian network—especially in suburban areas with large commercial, institutional, or multifamily lots (Chin et al. 2008; Larco 2009).

Putting this complicating issue aside, studies have generally shown similar determinants of travel behaviour in both urban and suburban areas (Forsyth et al. 2007; Moudon et al. 2007; Ewing and Cervero 2010). While this would seem to suggest that typical suburban development—with its low residential density, general lack of mixed use, and spread-out and disconnected pattern—would not seem to support much walking, that has not been the case. Studies looking at mode choice in suburbia have found substantial amounts of walking occurring in typical suburban development—particularly around commercial centres (Moudon et al. 1997; Hess et al. 1999; Handy and Clifton 2001; Larco 2009; Boarnet et al. 2011).

The current study builds on these previous ones and looks specifically at the mode choice of residents living within suburban multifamily housing. Suburban multifamily housing is a widespread and often overlooked example of dense development in suburbia, typically built at densities of 12 to 30 units per acre. This housing type is often located near commercial areas and acts as a buffer between commercial strip malls and adjoining single-family-home neighbourhoods. It has been the fastest-growing housing market in the United States since 1970 and currently comprises one in five units in suburbia (US Census Bureau 1973–2010). This housing type is often rental property and often takes the form of scattered two- or three-story buildings interspersed with long runs of parking lanes and lots (Hess 2005; Larco 2010). This development typology is typically not the result of cumbersome master-planned community designs, but instead is often built under common zoning codes and processes across the country.

While the current planning approach regarding suburban multifamily housing has been to locate it near arterials and to use it as a buffer between single-family housing and commercial uses, the actual site design of the vast majority of these developments continues to adopt the detached and enclaved single-family-home development pattern (Larco 2009). Walls or green buffers may surround entire developments, with only one or two egress points from the complex, and walking paths may be minimal or non-existent. This design negates any potential synergy between suburban multifamily housing developments and nearby commercial development and creates areas that are overwhelmingly auto-dominated, often uninviting, and with minimal connections between uses.

Contrary to what is typically considered the norm in suburbia, suburban multifamily housing is a widespread example that incorporates levels of density and diversity that could support concentrated active travel. Large numbers of suburban Americans live in homes that are very near to commercial areas and could invite the types of interactions with commercial developments envisioned by the advocates of mixed use; but the enclaved design of much of this housing is a barrier.

This study investigates the potential for increased active travel in suburbia by looking at suburban multifamily residents' mode choice for trips to their local commercial area (LCA). Building on earlier studies, this study investigates the specific condition of suburban multifamily housing and the hypothesis that increased connectivity in these dense developments increases residents' use of active travel modes.

To test this hypothesis, we created a system for analyzing connectivity in these large-lot, often streetless developments. Then, within a single municipality 14 sites that ranged in degrees of connectivity were selected and travel surveys were conducted among residents in these sites. Finally, statistical analysis was conducted to describe overall travel patterns to the LCAs for the well-connected and less-connected sites and to control for differences in demographic characteristics of residents between sites.

The findings of this study show that there is a large proportion of active transportation from suburban multifamily housing developments to LCAs and that the proportion of active trips is significantly correlated with the degree of connectivity between the developments and their LCAs. The impact of connectivity on active travel is independent of the straight-line distance from the development to the LCA and of residents' socio-demographic characteristics. Given that creating better connected suburban multifamily developments is relatively inexpensive and carries with it substantial health, environmental, and social benefits, zoning and land use policy should encourage and enforce strong connectivity between suburban multifamily developments and LCAs.

Study Design

This study focused on suburban multifamily developments within Eugene, a mid-size city in western Oregon with employment primarily in health care, education, government, and manufacturing. Study sites for this investigation were selected by analyzing a combination of county GIS tax parcel data, aerial photographs of the city, and unit count data gathered directly from development sites. Criteria for initial site selection included suburban location, multifamily housing typology, rental property status, and a minimum development size of 30 units.

As the purpose of this study was to analyze individuals' travel routes, it was necessary to have standard destinations for each development. This study employed the concept of "pedestrian magnets" as the qualifying criteria for destinations and referred to the description provided by the US Green Building Council's Leadership in Energy and Environmental Design (LEED) programme. According to the LEED-NC 2005 reference publication, pedestrian magnets fall in two categories: commercial and community (US Green Building Council 2005, 33–37). To examine the relationships between multifamily housing and commercial activities, commercial magnets (which include destinations like banks, grocery stores, post offices, and restaurants) were employed as the control criteria.

To balance shopping opportunities between sites, the local commercial area of each study site was specifically analyzed. The LCA was defined as a contiguous commercial cluster, typically an individual strip mall or a series of strips. Each LCA included a large grocery store and at least 15 additional shops within walking distance from the multifamily housing development. Walking distance was assumed to be approximately one-quarter mile (Southworth 2005; Agrawal and Irvin 2008). This distance was measured "as the crow flies" in order to capture an idealized walkable catchment area for each site. While this distance was held relatively constant between study sites, the lower the external connectivity of a development, the larger the additional actual distance between a site and the LCA.

Each site's Walk Score was rated via the web-based tool at http://www.walkscore.com. This rating assigned a value between 1 ("not walkable") and 100 ("walker's paradise") to each site based on "as the crow flies" proximity, number, and variety of neighbouring commercial developments. All of these measures were used to ensure a reasonable equality between the sites' pedestrian draw, allowing us to isolate each site's connectivity as a critical variable.

Connectivity and Suburban Multifamily Housing

From the list of sites that met the initial criteria described above, five were eliminated because they were part of a New Urbanist, master-planned development with vertical mixed use and did not represent typical suburban multifamily typologies, because they were student housing managed by a local university, or because they were assisted living facilities that had exclusively elderly populations. The university and elderly housing sites were eliminated out of concern that these populations may be making respectively more or less trips than the typical suburban multifamily resident, regardless of the qualities of the built environment. This left 14 developments that we then categorized based on their level of connectivity. To evaluate this level, connectivity measures were developed that were specific to large-lot suburban multifamily housing development.

While a large amount of research involving street connectivity measures in suburban development exists (see Handy, Paterson, and Butler 2003 for a discussion of these measures), many of the measures have centred on single-family-home development typologies. This development type results in smaller lot parcels where each lot is required to access a right of way. Within this model, much of the pedestrian infrastructure is often related to the streets themselves. Chin et al. (2008) demonstrated that even in these single-family neighbourhoods, using streets as a proxy for pedestrian networks can greatly under-represent actual connectivity levels. This issue is made even more acute in suburban multifamily housing development.

Suburban multifamily housing is different from single-family housing developments in that it is typically large-lot development where the multiple units within the lot are not required to have direct access to a right of way. These developments are often arranged around parking lots and have parking lanes (wide access lanes lined with perpendicular parking) in lieu of streets. Pedestrian and bicycle infrastructure is often non-existent, and when it is present it is often designed to take residents from their units to their cars and not necessarily to other buildings on site or to adjacent developments (Moudon and Hess 2000; Larco 2009).

Even streets with sidewalks are often not ideal travel paths for pedestrians travelling to local commercial areas, because primary access to multifamily developments is often through high-speed and high-traffic arterials. Connections to commercial strip development often occur through these streets and then through parking lots, requiring pedestrians and cyclists to traverse large, auto-dominated expanses.

Because of these differences in suburban multifamily development and typical strip mall development, it was necessary to develop measures of connectivity that did not rely solely on the street networks and that incorporated measures of protection from auto traffic. To this end, the nine connectivity measures described in Table 1 were developed. These measures take into account connectivity internal to suburban multifamily developments, pass-through connectivity between developments, and external connectivity between the housing developments and nearby commercial development. These connectivity measures were reviewed and modified by national experts in connectivity research as well as local and state land use and transportation planners.

For each study site, a numeric score for each measure was generated and the site was then ranked relative to the other sites in the study. To create a composite measure we compiled these individual scores and created an overall connectivity measure for each site. The differentiation between well-connected and less-connected developments was established at a natural break in the continuum of connectivity and was then verified via discussions with land use and transportation planners. Typical well-connected and less-connected site plans

Table 1. Connectivity measurement criteria

Type of connectivity	Measurement	Description
Internal	1. Continuous pedestrian circulation network—building to building	Percentage of buildings connected by a continuous pedestrian path
	2. Continuous pedestrian circulation network—internal network to development egress point	Percentage of egress points connected by a continuous pedestrian path
	3. Pedestrian network node density	Number of pedestrian network segments divided by number of nodes
	4. Pedestrian route directness	Crow-flies distance between furthest residence and the egress point to commercial node, divided by network distance between these two points
	5. Pedestrian friendliness of the automobile realm	Broken down by type of internal vehicular circulation (e.g. parking lots vs. parking lanes vs. actual street)
Pass-through	6. Access point distribution	Ratio of the largest segment of perimeter without access points outside site to the total length of perimeter
External	7. External route directness	Crow-flies distance between closest egress point to commercial node and the entrance to the largest store, divided by network distance between these two points
	8. Protected pedestrian path	Measure of length of path buffered from traffic (green buffer, cars, etc.), divided by total length of path
	9. External street type	Broken down by traffic counts and street designation (arterial, collector, neighbourhood collector).

are compared in Figures 1 and 2. Final groupings for well-connected and less-connected developments are shown in Table 2.

As shown in the table, within the grouping of well-connected and less-connected study sites there is a range of development sizes and characteristics. Compared as two groups, however, each grouping is similar in the ranges and averages of number of units, acreage, proximity to commercial development, and amount and type of commercial development near study sites. The Walk Score of study sites varied between 52 and 82, with less-connected sites scoring a slightly higher average than the well-connected sites. It is important to note that at the time this original analysis was done, the Walk Score tool did not evaluate connectivity, only straight-line distances to commercial sites and the number and variety of these sites. The slightly higher rating for less-connected sites suggests that these sites have (some combination of) more commercial sites and closer commercial sites than the well-connected developments. Study sites were geographically dispersed around the city, and all included similar surrounding morphology typical to suburban development (low-density single-family homes, arterial roads, and strip malls).

One primary difference between the two groups was the age of the developments. This difference was due to a change in zoning in 2001 that led to a

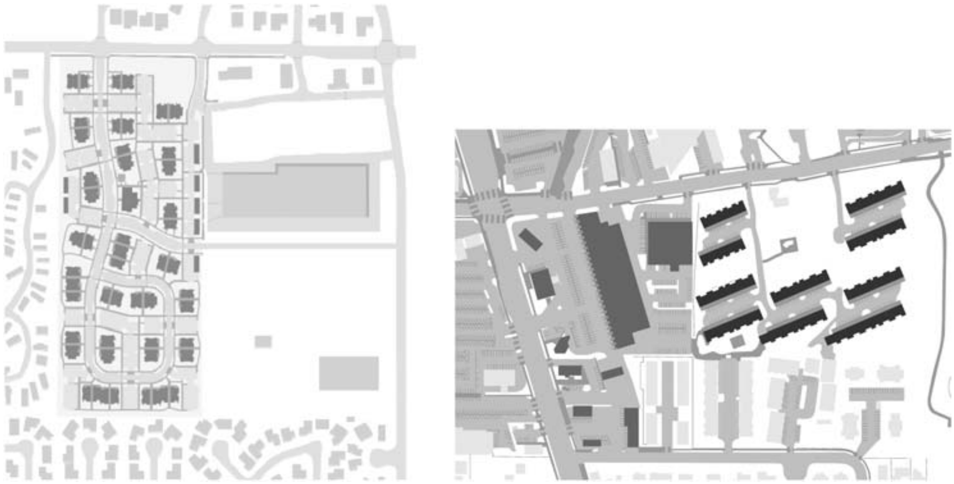

Figure 1. A well-connected site design (Heron Meadows, left) has extensive internal pedestrian networks, directly connects to adjacent properties in multiple locations, and is organized around legible streets. A less-connected site design (Riviera Village, right) has no direct connection to adjoining property, only connects to a fast-moving arterial, is organized around parking, and has a limited internal pedestrian network.

change in the degree of connectivity of multifamily developments in the city. The code change included changes to street network requirements, parking design, and pedestrian infrastructure. This change resulted in most of the well-connected developments having been built after 2001 and most of the less-connected developments before that, in essence allowing us to evaluate the impact this policy change has had on active travel. One significant ramification we expected given the age difference between well- and less-connected developments was a difference in the income levels of the two resident groups, because newer developments tend to command higher rents. The analysis below describes how we controlled for this variable.

Figure 2. A well-connected site (Sheldon Village, left) has buildings organized along a legible street with on-street parking, sidewalks, and direct connections to commercial development (seen on right part of image). The less-connected site (Woodland Creek, right) has haphazardly arranged buildings that front a large parking area. Sidewalks are discontinuous or do not exist at all, and the only connection outside this development is to the arterial.

Table 2. Characteristics of case study multifamily housing developments, Eugene, OR

Development name	Connectivity score	Size (acres)	Total units	Density (total units/acre)	Straight line distance to LCA (feet)	Network distance to LCA (feet)	# of comm. establishments in LCA	LCA size (acres)	Walk Score™
Well connected									
Heron Meadows	74	16.02	300	18.73	810.0	971.0	16	1.27	60
The crossings	69	5.94	208	17.24	575.9	819.6	27	22.06	52
Parkside apartments	61	14.17	254	17.92	1322.6	1470.9	27	22.06	54
Sheldon Village	48	3.05	73	23.96	402.5	516.6	38	17.5	74
Green Leaf Village	46	2.02	36	17.79	793.8	2799.0	60	32.67	66
Apple orchard	44	2.21	40	18.13	661.2	2763.4	60	32.67	69
Average	57	7.24	151.83	18.96	761.0	1556.8	35.25*	20.88*	62.50
Less connected									
Santa Clara place	34	3.05	60	19.68	1214.2	1405.2	49	31.51	72
Woodland Creek	30	5.91	58	9.82	1210.7	2185.3	160	76.21	82
Oak Meadow	27	8.72	120	13.76	1304.8	2280.9	160	76.21	78
Oak lane	27	3.4	129	37.97	1556.5	2103.0	160	76.21	78
Riviera Village	23	13.97	162	1.6	672.5	1206.7	31	7.23	63
Applewood	22	5.36	104	19.4	801.2	1795.4	61	27.78	63
Richardson bridge	16	3.44	32	9.31	708.3	2039.1	160	76.21	78
Firwood	2	3.75	90	23.98	269.1	661.0	26	16.97	74
Average	23	5.95	94.375	18.19	967.1	1709.6	65.40*	31.94*	73.5
Total average	**37.36**	**6.50**	**119.00**	**18.52**	**878.80**	**1644.08**	**52.00***	**27.02***	**68.79**

Notes: *Repeated data for same LCA was only used once in calculating averages

Survey Design and Methodology

To understand the travel habits of residents in suburban multifamily developments, an instrument called the Multifamily Housing Travel Survey was developed and sent to residents of the 14 case study sites. The survey asked questions about residents' travel habits, how they choose their modes of transportation, and barriers to walking and biking. The survey included 27 questions, divided into 6 sections: transportation modes and frequency; transportation choices; ease of walking and biking; housing choice; personal information; and a final section consisting of a mapping exercise. The survey was received by a total of 1493 residents in March 2009. Standardized survey distribution strategies were used, including an introductory postcard, a survey mailing, a follow-up postcard, and then a second survey mailing.

All study sites were surveyed simultaneously, to avoid differences in weather, fuel costs, and day length. The survey period had an even mix of sun and rain, with daytime temperatures typically ranging from the mid-50s up into the 70s (°F). In general, this area of Oregon 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.

A total of 229 surveys were returned, representing a 15.3% response rate (130 out of 848 [15.3%] from well-connected sites and 99 out of 645 [15.3%] from less-connected sites). The final analysis excluded individuals who did not have access to a car and hence used active transportation by necessity and not by choice. Incorporating this filter left 198 respondents in the analysis.

Given this response rate, the representativeness of survey participants was evaluated by comparing their demographics (sex, family type, and race) to the overall demographics of the study sites using 2010 census block data. In addition, using ESRI's Online Business Analyst software, the incomes of the survey respondents were compared to the incomes of residents living within a 0.15-mile radius of the study sites. Block data were used instead of broader geographic designations for this analysis to limit the number of single-family residents included, because previous studies have shown that suburban multifamily housing residents represent a significantly different demographic from the surrounding single-family residents (Larco 2010). Comparison showed that survey respondents were similar to the surrounding population in terms of family type and race. Respondents were more often women (typical of survey studies of this type) and were slightly less affluent than the surrounding population. These results showed no serious evidence of response bias.

Results

Demographics

Table 3 compares the demographic characteristics of survey respondents. Related to the difference in age of developments, as expected, residents of the well-connected developments were often economically better off than residents of less-connected developments. Respondents from the well-connected developments also tended to be younger and slightly more educated than residents of less-connected developments. Also, there was a slightly larger percentage of residents in less-connected developments who described their households as "Married/-partner with children". Both groups, however, were similar in regard to gender

Table 3. Demographic characteristics of residents (Shown as percentages)

Characteristic	All	Well connected	Less connected
Age			
18–29	35.4	41.9	24.3
30–45	26.8	27.4	25.7
46 and older	37.9	30.6	50.0
Income			
Less than $30,000	56.6	48.4	70.3
$30,000–$50,000	27.6	32.0	20.3
$50,000–$70,000	10.7	13.9	5.4
$70,000–$90,000	3.6	4.1	2.7
More than $90,000	1.5	1.6	1.4
Gender			
Male	29.2	32.2	24.3
Female	70.8	67.8	75.7
Household type			
Single with no children	37.1	38.9	34.6
Single with children	16.1	15.3	17.3
Married/partner with No children	17.7	16.7	19.2
Married/partner with children	16.9	12.5	23.1
Multiple adults (either related or unrelated) with No children	8.9	13.9	1.9
Multiple adults (either related or unrelated) with children	3.2	2.8	3.8
Race			
American Indian or Alaska native	1.6	2.5	0.0
Native Hawaiian or Pacific Islander	1.1	0.8	1.4
Asian	3.2	3.4	2.9
Black or African American	2.1	1.7	2.9
Latino/Hispanic	4.8	3.4	7.1
White/Caucasian (Non-Hispanic)	87.2	88.1	85.7
Education			
High school	29.5	24.4	38.0
College	56.8	58.0	54.9
Post graduate	13.7	17.6	7.0
	$n = 198$	$n = 124$	$n = 74$

and race. As with income, the analysis described below controlled for age, race, gender, education, and family type.

Trips and Modes

Survey respondents were asked to reflect on the previous month and report how often they had travelled to their local commercial area by driving, walking, and biking in a typical week. The local commercial area was defined for residents through a map showing their development, nearby streets, and the border of what we were considering to be each site's LCA. Walking was defined as including wheelchair use, while biking was defined as including any other non-motorized transportation with wheels (bicycle, skateboard, rollerblades, etc.).

Residents reported a substantial number of active transportation trips across both well-connected and less-connected developments. As shown in Table 4,

Table 4. Percentage of trips per week by travel mode

	Mean percentage of trips made by mode		
Mode	Both	Well connected	Less connected
Driving	60.5	54.0	71.1*
Walking	35.7	43.0	23.7**
Biking	3.0	1.7	5.1
Biking or walking	38.7	44.7	28.8
	$n = 197$	$n = 123$	$n = 74$

Notes: $^{*}p < .05$, $^{**}p < .01$

across all sites more than a third (38.7%) of all trips to the LCA are active transportation trips, with a large majority of those being walking trips.

In addition, travel mode use and connectivity were significantly associated. Residents of well-connected sites were significantly less likely to drive to the LCA than residents of less-connected sites. Just over half (54.0%) of the trips to the LCA were driving trips for residents of well-connected sites, versus 71.1% for residents in less-connected sites. A significantly larger percentage of trips (43.0%) are walking trips in well-connected sites, nearly double the rate for less-connected sites (23.7%). The development with the highest percentage of active transportation trips was Sheldon Village, with 72.0% of all trips, and the lowest was Richardson Bridge, with only 12.5%. It is important to note that all of these figures exclude individuals who did not have access to a car and therefore under-represent the total amount of active travel actually occurring in these developments.

Although not reaching significance, a surprising finding given the strong reporting of active transportation in well-connected sites is that there is more biking occurring in the less-connected sites than in well-connected sites. It can be hypothesized that this may be because these sites had environments and conditions that were hostile for pedestrian trips, but were still acceptable for biking trips. If this is the case, we may be seeing a shift where some would-be walking trips become biking trips in these circumstances. This is a topic for future study.

A second way of analyzing the trip data is by looking at travel modes based on individuals as opposed to trips. Looking at the data this way gives a sense of how mode choices are distributed among residents. It could have been that the active transportation trips shown in Table 4 were being done by the same *number* of individuals in each site, just to a different degree, therefore focusing any benefits of increased active transport on a small population. This, however, is not the case.

Table 5 again shows significantly more walking and biking in the well-connected sites, with almost three-quarters of residents in these sites (73.2%) using active transport to the local commercial area at least once a week, compared to only 58.1% of residents in less-connected sites. In other words, the well-connected sites are associated with *more individuals* seeing and using active transport as a viable form of transport to their local commercial area. In addition, one-fifth of residents in well-connected sites *only* walk or bike to their local commercial area, compared to only 9.5% of residents in less-connected sites. Well-connected sites also have significantly more residents (44.4%) who “mostly walk”—that is, walk for *at least* half of their total trips to the LCA—than less-connected sites (24.3%).

Table 5. Resident travel mode by site connectivity

	Percentage of residents who use the specified travel mode in a typical week (columns do not add up to 100% because residents may be part of multiple travel mode categories)		
Travel mode used	Both	Well connected	Less connected
Ever walk	65.2	72.6	52.7**
Ever bike	9.6	6.5	14.9*
Ever walk or bike	67.5	73.2	58.1*
Walk or bike only	16.2	20.3	9.5*
Ever drive	82.8	78.2	90.5*
Drive only	32.5	26.8	41.9*
Mostly walk	36.9	44.4	24.3**
Mostly drive	58.1	51.6	68.9*
	$n = 198$	$n = 124$	$n = 74$

Notes: $*p < .05$, $**p < .01$

These are residents for whom active transportation is their default mode of travel to the LCA.

A third way of analyzing this travel data is by looking at total trips taken to the LCA. As shown in Table 6, the total number of trips to the LCA is not significantly different between well- and less-connected sites, with both groups having an average of just over five trips to the LCA per week. Residents of well-connected sites, however, reported nearly one additional walking trip per week (average of 2.4) compared to less-connected sites (average of 1.5). This difference represents a 60% increase in walking trips, without a significant change in total trips to the LCA.

Ascertaining whether these walking trips are substituting for driving trips is a complicated task which is beyond the data gathered in this study. Previous studies have shown that even when active travel trips increase, this is often increasing total trips and not substituting one mode for another (Handy and Clifton 2001; Ewing and Cervero 2010). The data here show no significant increase in total trips to the LCA, but this does not include broader information about trips to other areas and therefore is suggestive rather than conclusive. Either way, increasing the active travel mode split can have substantial health, productivity, and social benefits for residents and in itself can give reason to re-evaluate suburban multifamily housing connectivity and site design.

Table 6. Number of trips by travel mode in a typical week

Travel mode	Both	Well connected	Less connected
Drive	3.1	2.9	3.5
Walk	2.0	2.4	1.5*
Bike	0.2	0.1	0.2
Total trips by all modes	5.4	5.6	5.2
	$n = 198$	$n = 124$	$n = 74$

Notes: $*p < .05$, $** p < .01$, $***p < .001$

Discussion

Given that residents of well-connected developments have a higher percentage of active transport trips to their local commercial area, two questions arise. First, why are we seeing these differences; is it truly explained by differences in levels of site connectivity? Second, what should planners, architects, and developers do about this?

Not Because of Demographics

Several control variables were looked at, including age, income, gender, and education, that might explain differences in travel mode choice between the well-connected and less-connected developments. Control variables relating to differences in study site size and distance to the LCA were also considered. Size was measured by both acreage and number of units, while distance was measured both "as the crow flies" and by pedestrian/street network distance. In multiple combinations of variables, site connectivity consistently showed the best fit with resident mode choice, suggesting that neither demographic differences, nor differences in distance to LCA, nor size of study site was responsible for resident mode choice. Only gender was significantly related to number and percentage of trips, with males making more active trips and having a higher percentage of their trips being active. Independent of this, everyone, both male and female, was more active in the well-connected complexes.

Similar Attitudes

The study also looked at whether residents had self-selected to live in well- or less-connected developments based on their inclinations to drive, walk, or bike. In the survey, we asked residents about their top three reasons for driving and their top three reasons for walking and biking. As shown in Tables 7 and 8, both groups had identical rankings of the top three reasons for both questions. Top reasons given for driving included (from most to least cited) combining of trips to the LCA with other driving trips, having too much to carry, and preferring to drive if the weather was bad.

Top reasons for walking and biking included health benefits (over 90% of all respondents ranked this in their top three), environmental benefits, and economic benefits. These answers showed strong similarity in regard to residents' interest in practicality and convenience as well as health, environmental, and economic concerns.

The survey also included questions regarding which housing factors residents had found critical in choosing their current residence. As shown in Table 9, residents of both well-connected and less-connected developments were identical in the ranking of the three most important factors: rent price, characteristics of the residence itself (size, number of rooms, look), and safety from crime—while housing factors related to active travel consistently ranked at the bottom of this list. This suggests that active travel was not a critical aspect of housing choice for residents of either group.

In summary, the survey responses showed no significant differences between the residents of well-connected and less-connected developments in terms of demographics, attitudes towards walking or driving, or reasons for choosing their housing.

Table 7. Driving factors and site connectivity

Driving factors	Percentage of residents ranking factor as first, second, or third most important reason: Both	Well connected	Less connected
I often combine trips to my local commercial area with trips to other destinations that require a car.	68.2	68.8	67.4
There is too much for me to carry, so I can't walk or bike.	62.0	67.6	52.7
I do not like to walk or bike in bad weather.	50.6	57.6	39.2*
I don't have enough time to walk or bike.	29.3	29.6	28.7
I don't feel safe walking or biking because of vehicle traffic.	25.5	20.4	34.0
I have to cross too many busy streets between my home and my local commercial area.	15.3	12.3	20.4
Crime in the area keeps me from walking and biking.	9.7	6.2	15.4
The distance from my residence to my local commercial area is too far for me to walk or bike.	6.9	8.0	5.1
I don't like the look or feel of the walking/biking route to my local commercial area.	4.4	3.1	6.8
Having to go through parking lots within my apartment complex prevents me from biking or walking.	3.9	3.1	5.1
There is no direct walking or biking path to my local commercial area.	3.2	4.1	1.7
There are no sidewalks, crosswalks, or bike lanes to walk or bike on.	1.9	1.1	3.4
	$n = 160$	$n = 100$	$n = 60$

Notes: $*p < .05$, $**p < .01$, $***p < .001$

Different Perceptions of the Built Environment

If residents do not have significant differences in their attitudes towards various travel modes, do they perceive differences in the characteristics of how their environment supports active travel? Findings from the survey indicated that perceptions regarding the ease of walking and biking are significantly associated with the level of connectivity around a development. Residents in well-connected developments are significantly more likely to report that it is easy to walk to their LCA than residents in less-connected sites. As shown in Table 10, over half (54.5%) of the residents in well-connected sites thought the walk/bike to the LCA was "very easy", versus only 30.6% of residents in less-connected sites.

To further investigate the effect of the built environment on travel behaviour, the survey asked residents if modifications to their environment would change their travel choices. Table 11 shows a significant association between resident responses and site connectivity. Nearly twice the percentage of residents in less-

Table 8. Walking/biking factors and site connectivity

Walking/biking factors	Percentage of residents ranking factor as first, second, or third most important reason		
	Both	Well connected	Less connected
Walking or biking is better for my health.	91.5	92.1	90.6
Walking or biking is better for the environment.	70.8	72.3	67.7
I want to save money	58.4	56.4	61.8
It is faster to walk or bike to my local commercial area that it is to drive.	22.9	26.7	15.5
Parking at my local commercial area is difficult.	12.5	13.9	9.9
I often combine trips that involve walking or biking, and my local commercial area is on my way.	9.8	8.9	11.7
I enjoy seeing and meeting other people when I walk and bike.	8.6	3.0	19.8***
I do not have access to a car.	8.5	7.9	9.5
Parking in my complex is difficult.	5.9	6.9	3.8
	$n = 153$	$n = 101$	$n = 52$

Notes: $*p < .05$, $**p < .01$, $***p < .001$

connected sites (38.9%), compared to residents of well-connected sites (19.8%), reported that improving the ease and convenience of the walking and biking trip to their LCA would increase the amount they engaged in active transportation. On average, 26.9% of residents reported that improving the physical environment

Table 9. Housing factors and site connectivity

Housing factors	Percentage of residents ranking factor as first, second, or third most important reason		
	Both	Well connected	Less connected
Rent price	78.8	76.3	83.5
Characteristics of residence itself (size, number of rooms, look)	59.6	65.7	48.7*
Safety from crime	48.5	44.9	54.9
Proximity to place of work	34.6	28.4	45.7*
Amenities within apartment complex (pool, gym)	20.0	23.4	13.8
Ease of walking or biking to stores and restaurants	18.7	22.4	12.2
Ease of walking or biking to public transportation	17.7	18.1	16.8
Ease of walking or biking to open space or park	15.5	15.6	15.3
Ease of walking or biking to neighbourhood school	6.6	5.2	9.1
	$n = 185$	$n = 119$	$n = 66$

Notes: $*p < .05$, $**p < .01$, $***p < .001$

Table 10. Perception of ease of walking and biking

	Percentage of residents reporting specified ease of walking to LCA		
	Both	Well connected	Less connected
1 (not easy)	3.6	2.4	5.6*
2	6.7	4.9	9.7*
3	19.5	14.6	27.8*
4	24.6	23.6	26.4*
5 (very easy)	45.6	54.5	30.6*
	$n = 197$	$n = 123$	$n = 74$

Notes: $*p < .05$, $** p < .01$

would affect their decision to use active travel, supporting the hypothesis that the physical environment plays a critical role in resident mode choice.

All of these results show that while the two groupings of residents may not have significant differences in their attitudes towards different travel modes, they do perceive differences in how their environment supports active travel, and these differences are associated with differences in site connectivity.

Lessons for Planners and Designers (Policy, Planning, and Design)

A central finding of this study is simply that a substantial amount of active travel does happen in suburban areas—specifically within suburban multifamily housing located near commercial centres. Planners, architects, and developers often characterize suburbs as largely devoid of active travel (Larco 2009), and therefore make planning and design decisions that disregard pedestrian and bicycle transport. This study should give reason to re-evaluate previous perceptions of suburban travel and should encourage planners, architects, and developers to include active transport as a component of suburban travel. Simply putting active travel "on the radar" is the critical first step.

The next step is evaluating *which* changes to suburban environments, and specifically multifamily environments, are needed to improve connectivity and support a broader range of travel modes. Of the residents who said changes in the built environment would change their travel behaviour, the survey also asked which changes these residents saw as most critical. This issue was broken into two scales, one about changes within multifamily developments and another about changes between these developments and the local commercial area.

Table 11. "Would you walk or bike to the LCA more if it were made easier or more convenient to do so?"

	Percentage of residents giving specified answer		
	Both	Well connected	Less connected
Yes	26.9	19.8	38.9***
No, already convenient	57.5	70.2	36.1***
No, wouldn't influence my decision	15.5	9.9	25.0***
	$n = 197$	$n = 123$	$n = 74$

Notes: $*p < .05$, $**p < .01$, $***p < .001$

Table 12. Important factors for increasing walking and biking *within* apartment complex

Walking/biking factors	Percentage of residents ranking factor as first, second, or third most important reason: Both	Well connected	Less connected
Reduce speed and number of cars	60.6	62.1	59.1
Improve the look and feel (such as trees, benches, landscaping) of the route from my residence to a public street	57.2	67.2	48.4
Separate pedestrian path from vehicular traffic with trees, grass, and/or parked cars	53.3	54.0	53.0
Provide places to walk or bike (such as sidewalks, bike lanes, crosswalks)	46.9	45.1	48.2
Create a more direct path for walking or biking from my residence to a public street	35.9	26.9	43.9
Reduce obstacles (such as parking lots, fences, walls) between my unit and a public street	29.5	31.4	28.0
Other	16.6	13.4	19.4
(None were significant at .05)	$n = 52$	$n = 24$	$n = 28$

In response to questions about potential improvements within their complexes, as shown in Table 12, reducing the speed and number of cars, improvements to the look and feel of the route to public streets, and separating pedestrians from vehicular paths were the highest-ranked factors for both groups of residents. The largest difference between the two groups was the ranking of the perceived need to create more direct paths to public streets. As expected, more residents of less-connected developments ranked this as a top-three factor than did residents of well-connected developments. This finding is intuitive given that less-connected developments will, by definition, have more circuitous routes and hence longer routes to destinations.

Questions regarding potential improvements between apartment complexes and LCA's again showed general consistency between both groups; both ranked "reducing the speed and number of cars" as the top factor (Table 13). The second most critical factor was different between the two groups, with residents of less-connected developments favouring improved places to walk or bike (such as sidewalks, bike lanes, and crosswalks) and residents of well-connected developments favouring the separation of pedestrian paths from vehicular traffic with trees, grass, and/or parked cars. This difference is understandable given that the connectivity audits showed that less-connected developments had fewer sidewalks. Having a place to walk naturally precedes a need to have that place be protected from traffic. Residents of both groups ranked creating a more direct path for walking or biking as the third most critical factor. Aside from the difference noted above, the ranking of all factors was fairly similar in all of these questions.

Recommended Changes

As can be seen from this series of resident responses, the largest barriers to more active travel in and around suburban multifamily housing developments are the

Table 13. Important factors for increasing walking and biking *between* apartment and LCA

Walking/biking factors	Percentage of residents ranking factor as first, second, or third most important reason		
	Both	Well connected	Less connected
Reduce speed and number of cars	55.3	52.2	58.3
Provide places to walk or bike (such as sidewalks, bike lanes, crosswalks) from development to local commercial area	51.1	43.5	58.3
Create a more direct path for walking or biking from my development to my local commercial area	51.1	52.2	50.0
Improve the look and feel (such as trees, benches, landscaping) of the route between my development and my local commercial area	44.7	43.5	45.8
Separate pedestrian path from vehicular traffic with trees, grass, and/or parked cars	44.7	52.2	37.5
Reduce obstacles (such as parking lots, fences, walls) between my development and local commercial area	29.8	26.1	33.3
Other	23.4	30.4	16.7
(None were significant at .05)	$n = 52$	$n = 24$	$n = 28$

presence and speed of cars, as well as the lack of connectivity. To rectify these barriers, planners and designers need to encourage developments that reduce the dominance of the automobile and increase the comfort and connectivity of the pedestrian network. This includes providing places to walk and bike, reducing trip lengths, and protecting pedestrians from auto traffic.

The results of this study, combined with additional site analysis, as well as workshops and interviews with planners, architects, and developers throughout the country, led to the identification of three critical categories of site design that can improve the pedestrian environment in suburban multifamily housing developments. These categories, described in further detail below, are: (1) providing a robust and designated pedestrian path; (2) providing a multimodal, defined street network instead of parking lanes and lots; and (3) maximizing connection points to adjacent development. None of these suggestions is revolutionary in terms of current thinking regarding pedestrian environments; rather, they are the result of focusing such thinking on the suburban multifamily housing typology. It should be noted that while the second category can have cost implications, the first and third involve minimal costs to new projects. (These and other findings, as well as the methodology that led to them, are described in full in Larco et al. [2010]).

1. Provide Robust and Designated Pedestrian Networks

Typically, suburban multifamily housing site designs include either no designated sidewalks, or a pedestrian network that is truncated, or does not touch all

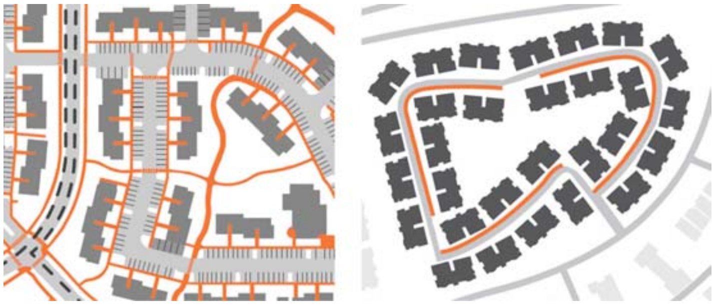

Figure 3. A robust pedestrian network linking all buildings and access points (left), compared to a single loop and discontinuous pedestrian path that does not connect all buildings nor any access points (right).

destinations, or is simply a ring around a large site that inhibits easy movement internally and to development access points (Figure 3).

The first step is simply to include designated and continuous pedestrian paths that connect every destination and all access points to the development. Next, much like connectivity standards described for streets (Handy, Paterson, and Butler 2003), the pedestrian network should maximize the number of connection points between paths as well as the variety of routes available within the development. A robust network will typically work at a finer scale than the street network and will ensure that residents have a safe, convenient, and efficient route to any destination.

Finally, the path should be made both attractive and usable. This includes creating buffers between paths and automobile zones as well as marking crossings at roads or parking areas. It also includes incorporating trees and landscape, as well as providing areas to rest or simply sit and observe the surroundings.

2. Provide a Multimodal, Defined Street Network Instead of Parking Lanes or Lots

Suburban multifamily housing development is typified by enclaved designs that ignore adjacent properties and connect only to arterials or collector streets. The primary circulation path for automobiles is through parking lanes and parking lots that encourage higher speeds, are hostile to pedestrians, and are often disorienting (Figure 4).

Automobile circulation should, where possible, be organized along defined streets that incorporate a variety of modes, create a legible system of blocks, and are designed to encourage local, low-speed travel. Parking can be incorporated along the street as well as within short series of parking pods that limit through traffic. With this, buildings can also be organized along the street to help define it and maintain "eyes on the street" (Figure 5).

3. Maximize Connection Points to Adjacent Development

A key component of reducing travel distances and encouraging walking and biking is to create direct connections between suburban multifamily developments and adjacent properties. Often, existing developments have only one or two connections outside of the development and these are typically concentrated along the property edge that runs along a local arterial or collector. This creates

Figure 4. Development organized around a defined, multimodal street network that includes on-street parking, buffers from moving cars, and buildings facing the street (left), compared to a more typical development organized along wide, auto-dominated parking lanes (right).

large "access shadows" that limit movement between the development and a large proportion of adjacent properties (Figure 6).

Wherever possible, suburban multifamily developments should include connections to adjacent properties. This means not only maximizing the number of connections, but also distributing them around the property so that access shadows are minimized (Figure 7). Ideally, these connections would be via multimodal street designs, but in truth pedestrian connections are often seen as much more politically feasible than vehicular ones. These connections should be encouraged and, in regard to neighbouring commercial property, should connect as closely as possible to the pedestrian strip in front of stores.

To implement these suggestions, planners will not only have to add code provisions that support active travel, they will also have to modify current provisions and practices that discourage it. Zoning codes throughout the country often include provisions such as mandated buffers between dissimilar uses as well as limitations on direct connections between developments (especially to commercial areas). These codes also often lack provisions for pedestrian networks, required connections to adjacent development, bicycle infrastructure, and street design. The result is that many suburban multifamily developments are

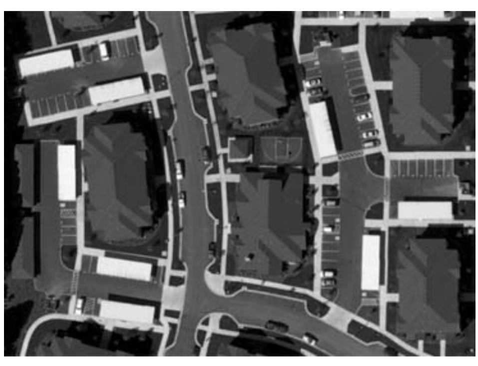

Figure 5. Parking pods (along the right and left sides of the image) provide additional parking off the street network. Pods are limited in size and do not allow through traffic. Also notice the robust street network that serves the buildings, street, and parking areas in this development.

Figure 6. Simple and direct connections between multifamily housing development and commercial strips allow easy access for residents (left). Typical development patterns disconnect these uses (right).

dominated by parking, have little infrastructure that supports active travel, and have few or no connections to adjacent properties.

In addition to changes in code, there is a need to modify the suburban planning processes and culture that perpetuate enclaved design solutions. Following engrained suburban development practices, planners often review and evaluate proposed suburban multifamily housing projects without sufficient attention to adjoining development. Plan reviews are often based on documents that only show land use designations and not the actual site designs of adjoining property, preventing any evaluation of potential connections between properties. Continuing an ethos of enclaved developments, these planning practices and culture have become barriers to connectivity themselves (see Larco 2009 for a discussion of barriers to creating more-connected suburban multifamily housing). To capitalize on the latent potential for active travel in and around suburban multifamily developments, planners will have to re-evaluate not only their codes but their processes as well.

Figure 7. A distribution of access points allows direct movement and connection to a number of different areas, including streets and a nature trail. Typical developments incorporate only a single connection to an arterial or collector street.

Conclusion

The results of this study show that, contrary to common perceptions, there is a substantial amount of pedestrian activity in and around suburban multifamily developments and that better-connected sites result in more active travel. The amount of this travel, however, and the percentage of individuals engaged in it are dependent on site connectivity. Suburban multifamily development patterns have followed the typical enclaved site design strategies seen throughout suburbia. These site design strategies are, quite literally, barriers to capitalizing on the potential health, economic, environmental, and social benefits of fostering more active travel in suburbia. These results should give planners and designers reason to improve suburban multifamily site connectivity and should lead to a re-evaluation of local zoning and design guidelines.

While this study focused on active transport from suburban multifamily housing to local commercial areas, the results suggest that there may be additional latent active transport in suburbia that involves travel to neighbouring housing, to other destinations such as parks, schools, offices, or simply through suburban multifamily lots. In looking at these types of trips, researchers should give attention to the pass-through connectivity of large-lot developments such as suburban multifamily housing. A lack of direct connections across sites may be an impediment to travel paths with both sources and destinations outside of the sites in question.

Further study of existing travel patterns in these areas of suburbia and the effects of connectivity on mode choice there is a critical next step in understanding the full potential of active travel in suburbia.

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