Site Design and Pedestrian Travel

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Research findings are summarized regarding the relationship between site design and pedestrian travel in mixed-use, medium-density environments, and recommendations are set forth for improving pedestrian facilities in suburban neighborhoods. A quasi-experimental method is used to study pedestrian volumes into 12 neighborhood commercial centers in the central Puget Sound region. Sites were matched for population density, land use mix, and income, but they varied in terms of neighborhood site design as measured by block size, and by the length and completeness of sidewalk systems. Urban sites with small blocks and extensive sidewalk systems were found to have, on average, three times the pedestrian volumes of suburban sites with large blocks and short, incomplete sidewalk systems. There are, however, many suburban pedestrians, with volumes varying between 50 and 103 people per hour walking into the suburban commercial centers studied. The majority of suburban pedestrians use streets with sidewalks where available. Also, suburban pedestrians are more likely both to jaywalk and to use crosswalks than their urban counterparts. People under age 18 and people of color were overrepresented in suburban pedestrian populations compared with their makeup in the local residential population. These findings point to the importance of providing facilities to improve pedestrian safety for people who cannot or do not want to drive in such areas. Recommendations include completing sidewalk networks, creating walkways to connect all building entrances to public sidewalks, and increasing the opportunities for pedestrians to cross streets safely.

This paper summarizes the findings of research regarding the effects of neighborhood site design on pedestrian travel in mixed-use, medium-density environments (*1*). It also sets forth recommendations for determining and prioritizing the implementation of pedestrian facility improvement programs in suburban neighborhoods.

The work is a contribution to a growing body of research that has examined the impact of land use and urban form on travel behavior. Population density, income, land use mix and intensity, and the types and extent of transportation infrastructure are all variables that have been shown to have statistically significant relationships to total vehicle miles traveled, and to travel mode choice, especially to the use of single-occupant vehicles (*2–9*). In aggregate, this work has helped shape policies that require the consideration of land use and urban form in the allocation of transportation infrastructure funding at both the national and regional levels.

The 1990 Nationwide Personal Transportation Survey shows that walking as the sole mode used accounts for more than 7 percent of person trips in U.S. metropolitan areas, substantially more than any other mode except private automobile (*10*). Walking also remains an important means of transport for the 9 percent of U.S. households without cars, for people who live in households with limited access to a car for much of the day (because there are more adults than vehicles), and for the many more people who are too young, too old, or not capable of driving a motor vehicle (*10*). Furthermore, walking is not only environmentally friendly, but it is also a healthful means of transportation (*11*). Finally, walking means "people on the streets," conveying the indirect benefit of safe and pleasant environments (*12*). The provision of walkable environments therefore promises to address a range of contemporary socioeconomic issues spanning from transportation and air quality to personal health.

The research findings presented here focus on pedestrian volumes and pedestrian behavior in 12 neighborhoods. The neighborhoods or sites studied are selected to be similar in terms of their population densities, their land use mix, and, to the extent possible, their incomes. They were also were selected to have very different pedestrian environments, with half the neighborhoods having very extensive pedestrian facilities and the other half having very limited pedestrian facilities.

RESEARCH DESIGN AND DEFINITIONS

A quasi-experimental method was used to study pedestrian volumes and behaviors in 12 neighborhoods around small commercial centers sites in the central Puget Sound region. The project's methodology has been explained in detail elsewhere (*1,13*) and is only briefly summarized here. The following describes control, independent, and dependent variables used in the study.

Control Variables

Neighborhoods or sites used in the research are selected to control for four basic variables identified by previous research as affecting pedestrian trip volumes:

- Gross population density, with higher densities establishing a larger pool of potential pedestrians;
- Land use type and mix defining origins and destinations for pedestrian travel;
- Income, with higher income related to automobile access and less pedestrian travel; and
- A pedestrian travel catchment area defined by a 0.8-km (0.5-mi) radius and containing the above variables in an area of 202 ha (500 acres).

Study areas were defined on the basis of U.S. census blocks, and population and housing data are from this source. Income data are only illustrative, however, because they are available only at the census-block-group level or above, a spatial unit that often poorly matched the sites based on their land use patterns (*13*). Land use variables were measured from field observations.

The land use characteristics of all 12 sites create a high potential to support pedestrian travel. Each site has a gross residential den-

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sity of approximately 25 people per hectare (10 people per acre) or greater, creating an average of 6,000 people living in multifamily housing (apartments and condominiums) and single-family houses. This population lives within 0.8 km (0.5 mi) of a neighborhood commercial center oriented toward convenience retail services.

Independent Variables

Selected sites differ in that half exhibit design characteristics that are supportive of pedestrian travel while the other half do not. This difference in neighborhood site design constitutes the study's independent variable in the study. To facilitate discussion, the six sites with supportive design characteristics are termed "urban," and the six sites with site design characteristics that are not supportive of pedestrian travel are termed "suburban." In this study, therefore, the distinction between urban and suburban establishes sets of sites defined by two types of pedestrian environment. The terms do not necessarily correspond to distinctions between central-city and non-central-city locations. Figure 1 illustrates the measurable characteristics of the pedestrian environments found in urban versus suburban sites

Urban sites have the following site design characteristics:

- A mean block size of 1.1 ha (2.7 acres), the equivalent of a 91- by 122-m (300- by 400-ft) block;
- A complete and continuous public sidewalk system on both sides of all streets, averaging 60.5 km (37.6 mi) in total length per site; and
- On-street parking as well as off-street parking in small lots.

Suburban sites have the following site design characteristics:

- A mean block size of 12.8 ha (32 acres), the equivalent of a 305- by 396-m (1,000- by 1,300-ft) block;

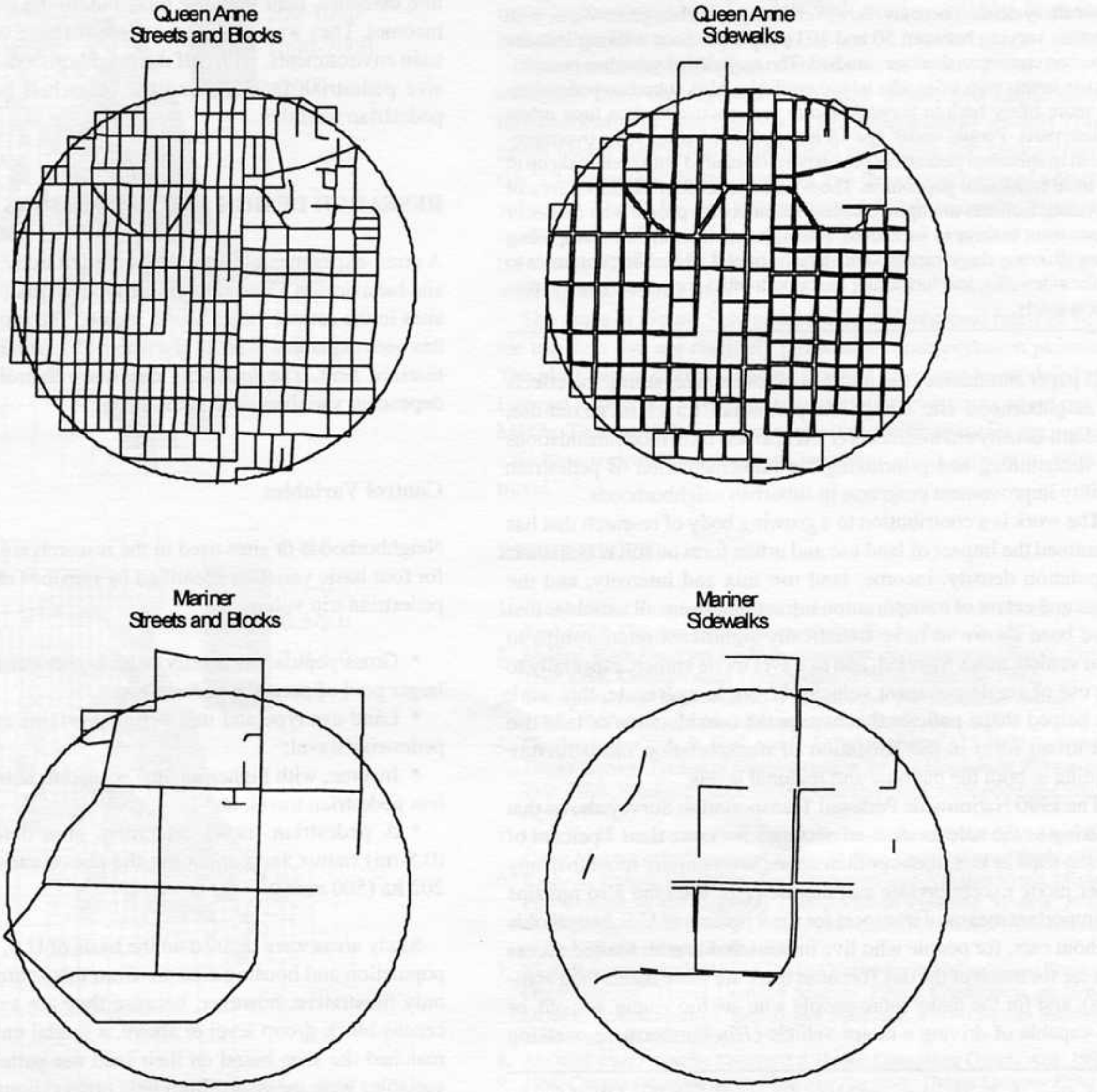

FIGURE 1 Street and sidewalk networks in Queen Anne (urban) and Mariner (suburban), shown with 0.8-km. (0.5-mi.) radius circles.

• An incomplete and discontinuous public sidewalk system, averaging 12.5 km (7.8 mi) in total length per site, and lining less fewer than half of the streets of the site; and

• No on-street parking and large, off-street parking lots.

The sites also exhibit other common differences between urban and suburban site design that were not explicitly measured. These include the distance at which buildings are set back from streets, the differences in the use of landscaping, and the differences in traffic signal phasing, among others. These differences, however, are consistent between urban and suburban sites. For example, in all urban sites, retail facilities line one main street in single-story structures or mixed-use, multistory buildings, while in suburban sites, retail facilities are located in large blocks of private land that contain very large areas of surface parking. Figures 2 and 3 illustrate the two types of sites.

Matching Urban and Suburban Sites

The 12 sites initially were placed into groups to match densities, retail mix and intensity, and average incomes (using block-group data). This matching procedure both reflected and was constrained by the limited number of potential sites in the Puget Sound region and by problems of matching census data to sites. Each group contains both urban and suburban sites. Four groups of sites were created: two groups each with two sites with large commercial centers, one group of five sites with a medium-sized commercial center, and one group of three sites with a small commercial center. Following theories of accessibility, the size of commercial centers was given slightly more weight in the matching process than the other control variables. Commercial-center size was defined using the number of businesses and types of retail facilities provided within the 0.8 km (0.5-mi) pedestrian catchment area.

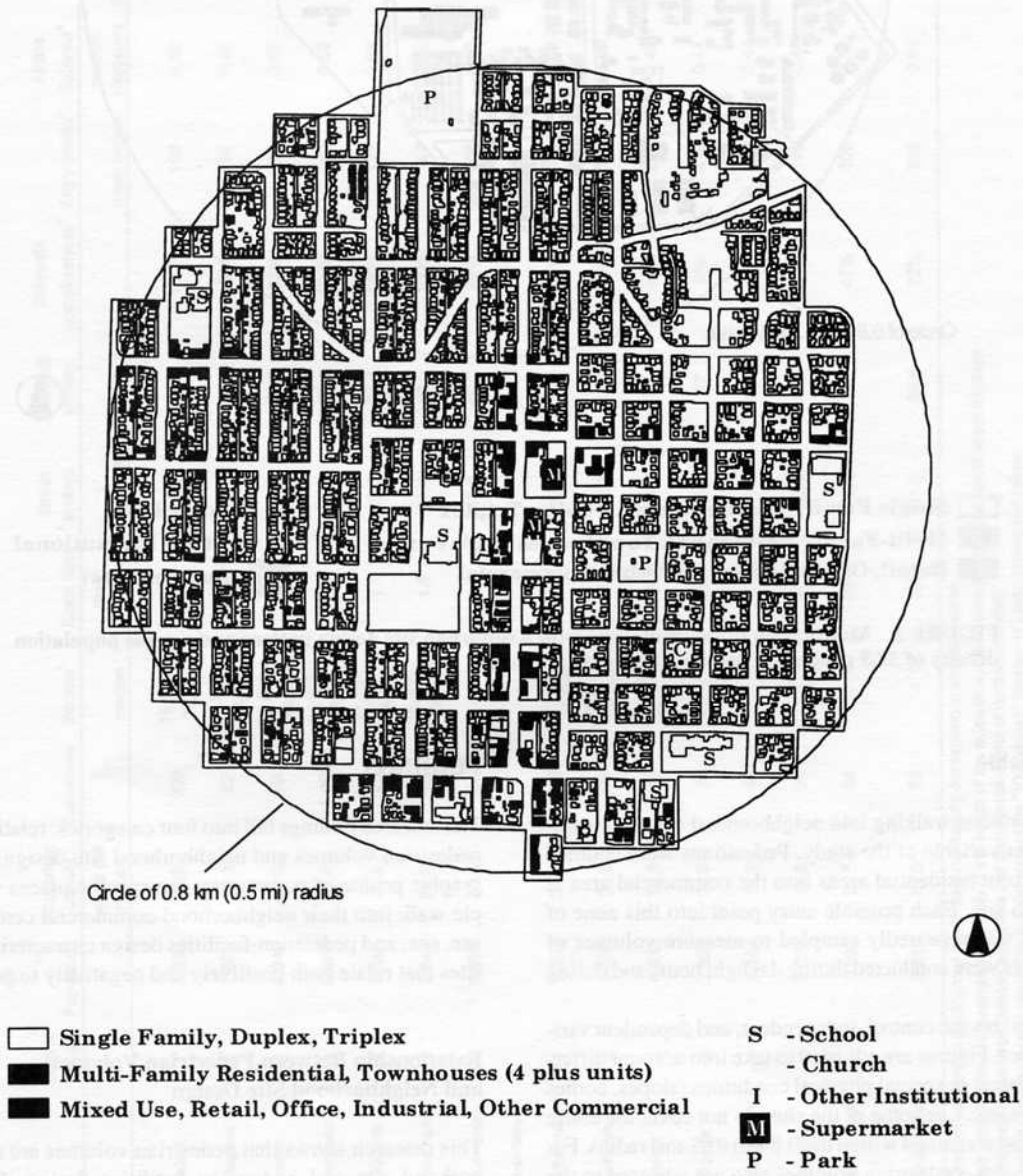

FIGURE 2 Queen Anne: an example of a site with an urban site design pattern and a gross population density of 36.8 people per hectare (14.7 people per acre).

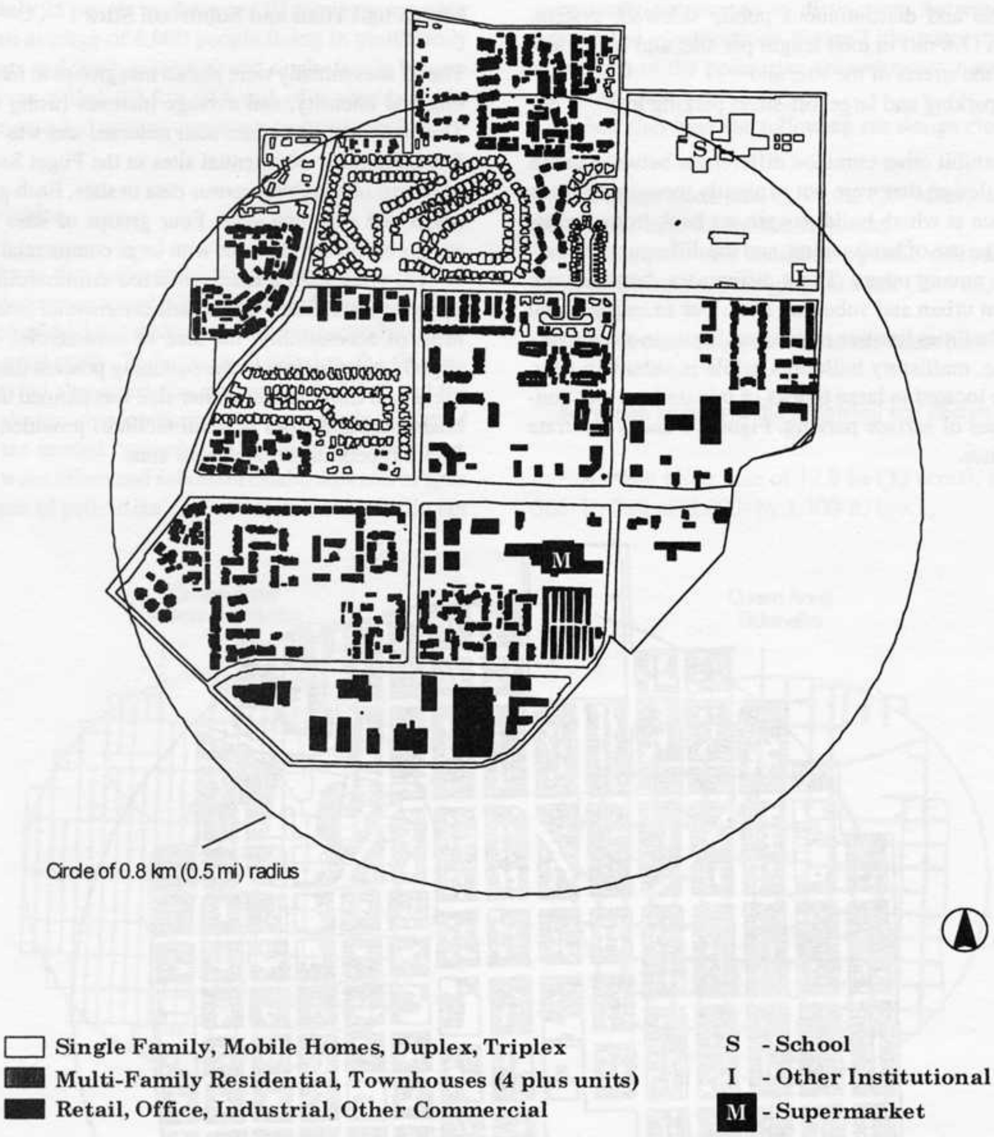

FIGURE 3 Mariner: an example of a site with a suburban site design pattern and a gross population density of 32.5 people per hectare (13 people per acre).

Dependent Variable

Volumes of pedestrians walking into neighborhood centers constitute the dependent variable of the study. Pedestrians were counted as they crossed from residential areas into the commercial area at the center of each site. Each possible entry point into this zone of commercial land was repeatedly sampled to measure volumes of pedestrians. Counts were conducted during daylight hours and during good weather.

Table 1 summarizes the control, independent, and dependent variables for all 12 sites. Figures are adjusted to take into account differences in topographical or special physical conditions (slopes, bodies of water, freeways, etc.), as some of the sites do not cover the entire 202.5 ha (500 acres) contained within the 0.8-km (0.5-mi) radius. For comparative purposes, pedestrian volumes also are adjusted to the site's actual population.

FINDINGS

The research findings fall into four categories: relationships between pedestrian volumes and neighborhood site design; the sociodemographic profile of pedestrians; the specific places where most people walk into their neighborhood commercial center; and the land use, site, and pedestrian-facilities design characteristics of suburban sites that relate both positively and negatively to pedestrian travel.

Relationship Between Pedestrian Volumes and Neighborhood Site Design

This research shows that pedestrian volumes are related to neighborhood site and pedestrian facilities design. Specifically, the three measures traditionally employed to predict pedestrian

TABLE 1 Summary of Site Characteristics and Pedestrian Volumes

Site	Control group	Population	Population density (Control Variables)	Businesses	Income[1]	Block size (Independent Variables)	Street system	Sidewalk system	Sidewalk completeness[2]	Entry points[3]	Airline distance[4]	Route length	Route directness[5]	Observed pedestrians per hour (Dependent Variables)	Pedestrians per hour per 1,000 residents	Pedestrians per hour (complete site)[6]
			people per hectare		median	mean hectares	kilometers	kilometers		mean meters	median kilometers	mean kilometers				
Urban Sites																
Ballard	1	5,936	35.3	205	16,500 - 27,000	1.0	45.1	65.0	100%	193	0.53	0.65	1.24	299	50	355
Wallingford	2	7,577	39.3	82	24,000 - 43,500	0.7	49.7	71.5	100%	194	0.43	0.58	1.32	271	36	280
Proctor	3	4,343	24.0	63	20,500 - 44,000	1.0	56.7	53.0	83%	193	0.57	0.70	1.25	105	24	105
Queen Anne	3	6,983	36.8	68	24,500 - 52,500	0.8	49.8	63.4	100%	160	0.53	0.70	1.29	360	52	379
West Seattle	3	5,388	29.8	63	27,000 - 44,000	1.1	49.5	61.2	100%	121	0.58	0.71	1.28	118	22	130
Madison Park	4	3,647	35.5	46	38,500 - 135,000	1.5	37.4	48.9	100%	147	0.32	0.49	1.23	152	42	296
Urban Average		5,629	33.4	88	-	1.1	47.9	60.5	97%	168	0.50	0.64	1.27	217	38	257
Suburban Sites																
Kent East Hill	1	7,332	34.0	110	33,000 - 71,500	19.6	10.5	9.8	57%	369	0.73	1.06	1.57	85	12	79
Crossroads	2	7,037	30.8	96	23,000 - 38,000	18.4	12.7	12.4	63%	343	0.59	0.86	1.49	112	16	98
Mariner	3	4,932	32.5	55	31,000 - 34,000	12.0	13.4	9.1	44%	280	0.46	0.87	1.80	78	16	103
Oakbrook	3	2,930	31.0	70	33,000 - 71,500	14.5	15.1	1.7	9%	410	0.44	0.80	1.77	40	14	85
Juanita	4	5,294	32.3	44	33,000 - 71,500	6.2	21.4	16.2	45%	250	0.44	0.79	1.76	41	8	50
Kingsgate	4	6,028	28.8	30	34,000 - 55,500	6.1	22.6	25.7	64%	195	0.46	0.76	1.57	54	9	52
Suburban Average		5,592	31.5	68	-	12.8	15.9	12.5	47%	308	0.52	0.86	1.66	68	12	78
Average All Sites		5,611	32.5	78	-	6.9	31.9	36.5	72%	238	0.51	0.75	1.5	143	25	168

1. Measured on the census block group level; does not exactly correspond to site boundaries.
2. Sidewalk completeness is measured as a ratio of the length of the sidewalk system to the length of all public street frontage.
3. Mean distance between pedestrian entrances into commercial center at cordon boundary.
4. Fifty percent of housing units are within this distance of the "100 percent" location of each commercial center.
5. Route directness is measured as the ratio of average route length to average airline distance.
6. Measured for a "complete site," that is, a hypothetical site developed at the same densities and physical characteristics over an area of 202.5 hectares (500 acres).

Sources: U.S. Census of Population and Housing, 1990; field data.

volumes—population density, income, and land use distribution and intensity—are, individually and together, insufficient to explain pedestrian volumes: neighborhood site design, and specifically block size and the extent of pedestrian facilities provided, also must be considered (Figure 4).

All urban sites studied have a higher volume of pedestrians than the suburban sites. On average, urban sites have three times as many pedestrians as suburban sites. Similarly, the urban sites with the highest pedestrian volumes have three times more pedestrians than the suburban sites with the highest pedestrian volumes. The urban sites with the lowest pedestrian volumes have more than twice as many pedestrians as the suburban sites with the lowest pedestrian volumes, and 40 percent more pedestrians than the suburban sites with the highest pedestrian volumes.

At the same time, a substantial number of people do walk in suburban areas. The research shows that for every 1,000 residents of the suburban sites, 8 to 16 people per hour walk into their neighborhood commercial centers, with the total number of people walking varying between 50 and 102 per hour (figures adjusted by site area for comparability purposes). In other words, as many as 400 to 800 people are walking into their suburban commercial centers over the course of normal working hours even given the lack of extensive pedestrian networks and incomplete pedestrian facilities.

The research shows that pedestrian volumes are not related to the size of neighborhood commercial centers. In urban sites, both the lowest and highest pedestrian volumes correspond to sites with medium-sized commercial centers. In suburban sites, the lowest pedestrian volumes are found in the sites with the smallest commercial centers. However, the site with the largest center has fewer pedestrians than any of the medium-sized center sites. This suggests that for pedestrians, the relationships between the size of a commercial center and the volumes of trips to that center are more complex than assumed by most accessibility indexes.

Overall, the distinction between urban and suburban neighborhood site design characteristics carries the most explanatory power in defining pedestrian volumes. Variations within site design and pedestrian facilities measures used do not, in themselves, explain variations in pedestrian volumes within either urban or suburban site categories. Measures such as block size, total length of streets and of sidewalks, the completeness of the sidewalk system relative to the street network, and the directness of the routes traveled by pedestrians, are not linearly related to pedestrian volumes. Other variables come into play such as variations in population density, income, and size of retail centers—none of which are linearly related to pedestrian volumes either. In this study, the simple combination of variables characterizing urban and suburban site and pedestrian facilities design is the best predictor of differences in pedestrian volumes. As a result, further analyses of the 12 sites divide them accordingly.

Profiles of Pedestrians

The research identifies many young pedestrians in suburban areas. In urban sites the percentage of observed pedestrians who were young (under 18) is similar to the percentage of young people living in the site as found in census data. In suburban sites, however, there is a disproportionately large number of young people walking, an average of 180 percent higher than the ratio of young people in the census population. On average, 41 percent of pedestrians in suburban sites were young, compared with 16 percent in urban sites. In three of the suburban sites, young people constituted the

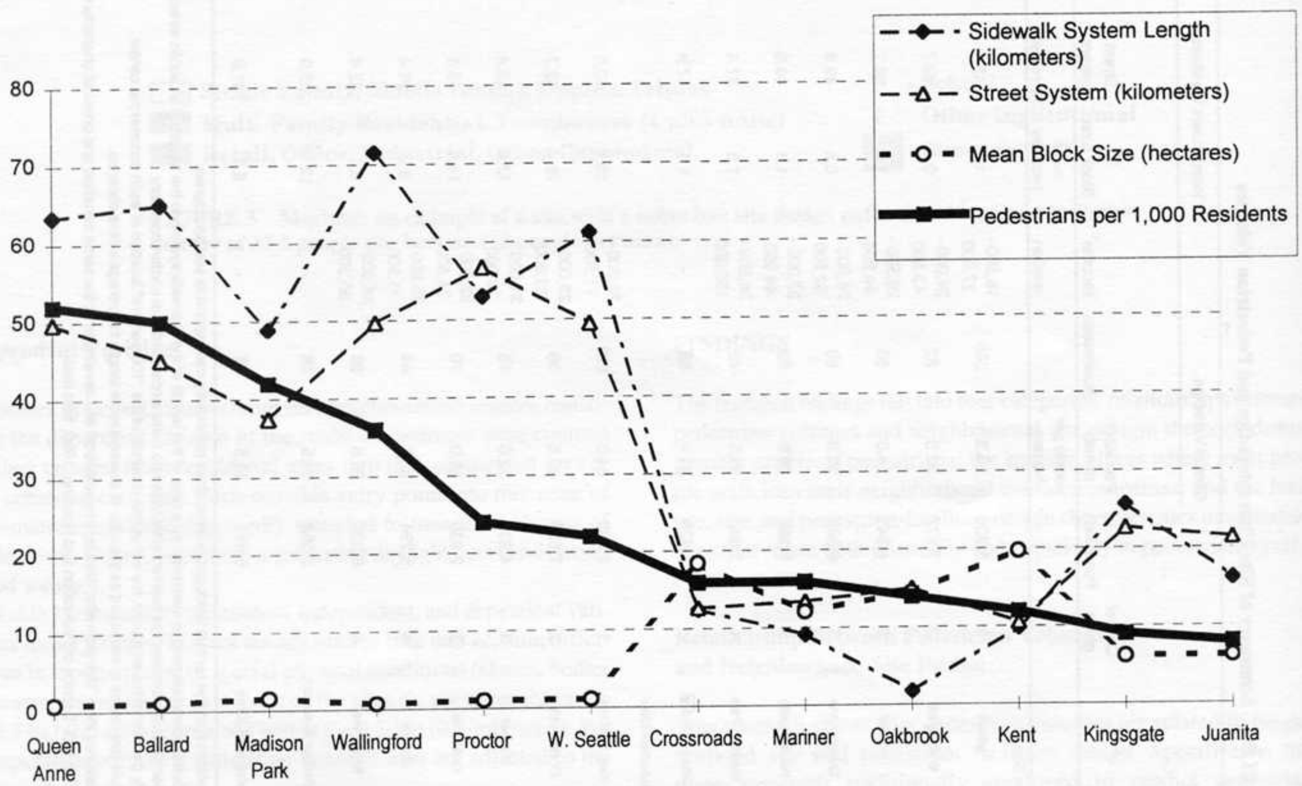

FIGURE 4 Pedestrian volumes by neighborhood site design measures.

majority of pedestrians counted. The substantial share of pedestrians trips by young people in suburban sites indicates that fewer adults choose to walk in suburban than urban sites. This is a reasonable finding, suggesting that mostly those people without access to an automobile are found on suburban streets. However, the high proportion of young pedestrians combined with the lack of appropriates pedestrian facilities in suburban sites raises troubling safety issues because children are particularly vulnerable to being hit and injured by automobiles.

There are also many pedestrians of color in urban and suburban areas. A disproportionately high number of people of color is found walking in both urban and suburban sites, with averages of more than 200 and 240 percent of the corresponding census populations in urban and suburban sites, respectively. On average, urban pedestrians of color constitute 10 percent of the total number of pedestrians, versus 29 percent in suburban sites. These high percentages suggest a population that may be culturally disposed to walking, or that has lower incomes and lower rates of automobile ownership than the white population. However, these relationships cannot be probed here, because income and automobile ownership data are not available in the block-level census data necessary to match the sites. Nevertheless, the uneven distribution of pedestrians of color in suburban sites raises serious questions regarding the safety of people who cannot or do not want to drive, as well as equity questions regarding how transportation facilities are provided and used. These issues deserve study (Figure 5).

Finally, pedestrians with impairments are found in three of the suburban sites despite the lack of complete sidewalks networks. In general, the presence of large numbers of young pedestrians and pedestrians of color, as well as the presence of impaired pedestrians, point to the importance of providing facilities for safe pedestrian travel in suburban areas.

Where People Walk

Most people walk on streets with sidewalks. Seventy-eight percent of all pedestrians enter commercial centers on a street lined with sidewalks. In urban areas where sidewalks are nearly ubiquitous, 98 percent of the pedestrian trips are on streets with sidewalks. In suburban sites, only 43 percent of the possible entry points into suburban commercial centers have sidewalks, yet 60 percent of the suburban pedestrians trips use these entries, indicating that many people choose to use sidewalks.

Most people walk along wide "main" streets. In urban sites, streets wider than 14.6 m (48 feet) represent only 26 percent of the possible entry points into the commercial center, yet 41 percent of the pedestrians enter on these streets. In suburban sites, 71 percent of the pedestrians use streets wider than 11 m (36 ft), representing 55 percent of the possible entry points.

The incidence of jaywalking is high. In this study jaywalking is defined as crossing a vehicular street anywhere except at an intersection or at marked mid-block crossings (a definition that does not exactly correspond to Washington State law). Of those pedestrians crossing a street at the point of entry into the commercial area, 32 percent of suburban pedestrians were jaywalking versus 20 percent in urban sites. While jaywalking is relatively safe in urban sites, where most streets are narrow and automobile traffic is slow, it represents substantial risk-taking for suburban pedestrians crossing wide streets with heavy traffic. The very high incidence of jaywalking in suburban sites suggests that pedestrians take risks because they lack options in their walking routes, and this points to a major safety problem.

Of those pedestrians crossing a street as they enter the commercial center from residential areas, 14 percent use a marked crosswalk in urban sites, versus 60 percent in suburban sites, again reflecting the fact that people prefer to use safe pedestrian facilities whenever they are available. Thus, compared with urban residents, suburban residents are more likely both to jaywalk and to use crosswalks, showing a split between those people who risk dangerous crossings and those who use formal crossings as the perception of traffic risk increases (*14*).

Schools generate pedestrian traffic. As would be expected, the presence of schools corresponds to high volumes of pedestrians in the three suburban sites and two urban sites with a school near to their commercial center.

Multifamily housing and grocery stores generate pedestrian traffic In both urban and suburban sites, the distribution of pedestrians entering the commercial center shows a positive relationship between pedestrian volumes and dense housing and commercial activity. This relationship is especially strong when dense housing connects to a grocery store. This suggests that a significant amount of grocery shopping is done on foot.

Land Use, Site, and Pedestrian Facilities Design Characteristics of Suburban Sites

In the process of identifying the six suburban sites, this research has uncovered dozens of small concentrations of medium-density residential and commercial activity spread throughout the suburban parts of the central Puget Sound region. Hence relatively compact, mixed-use neighborhood centers exist not only in urban but also in suburban areas. The six suburban sites that were part of this study are as compact as their urban counterparts, with 50 percent of their dwelling units falling within an average of 0.5 km ($^1/_3$ mile) air line distance, or less, of the 100 percent corner in the commercial center. This indicates that land use distribution and intensity are potentially as conducive to pedestrian travel in medium-density suburban areas as they are in urban areas. As a relatively common occurrence in suburban areas, the small suburban center could play a significant role in future transportation planning.

The research also indicates that suburban neighborhood site design (as opposed to land use distribution and intensity) falls short of supporting pedestrian travel because suburban pedestrian travel routes are notably less direct than those in urban sites. On average, the length of walking routes is 27 percent longer than the air line distance between residential and commercial areas in urban sites, versus 66 percent longer in suburban sites. This creates pedestrian walking routes that are, on average, 183 m (600 ft) longer in suburban sites than in urban sites. Also, in urban sites, 50 percent of dwelling units are within a 640-m (2,100-ft) walk of the commercial center, versus more than 823 m (2,700 ft) in the suburban sites. Hence suburban neighborhood site design and pedestrian route structure are less efficient for pedestrians. This is an important finding because pedestrians are known to be very sensitive to travel distances, and longer suburban travel routes alone are likely to suppress pedestrian activity.

The reasons behind indirect travel routes in suburban sites include the inordinate size of suburban street blocks, their limited and incomplete sidewalk system, and, generally, the inadequate network of pedestrian routes. First, suburban multifamily and commercial devel-

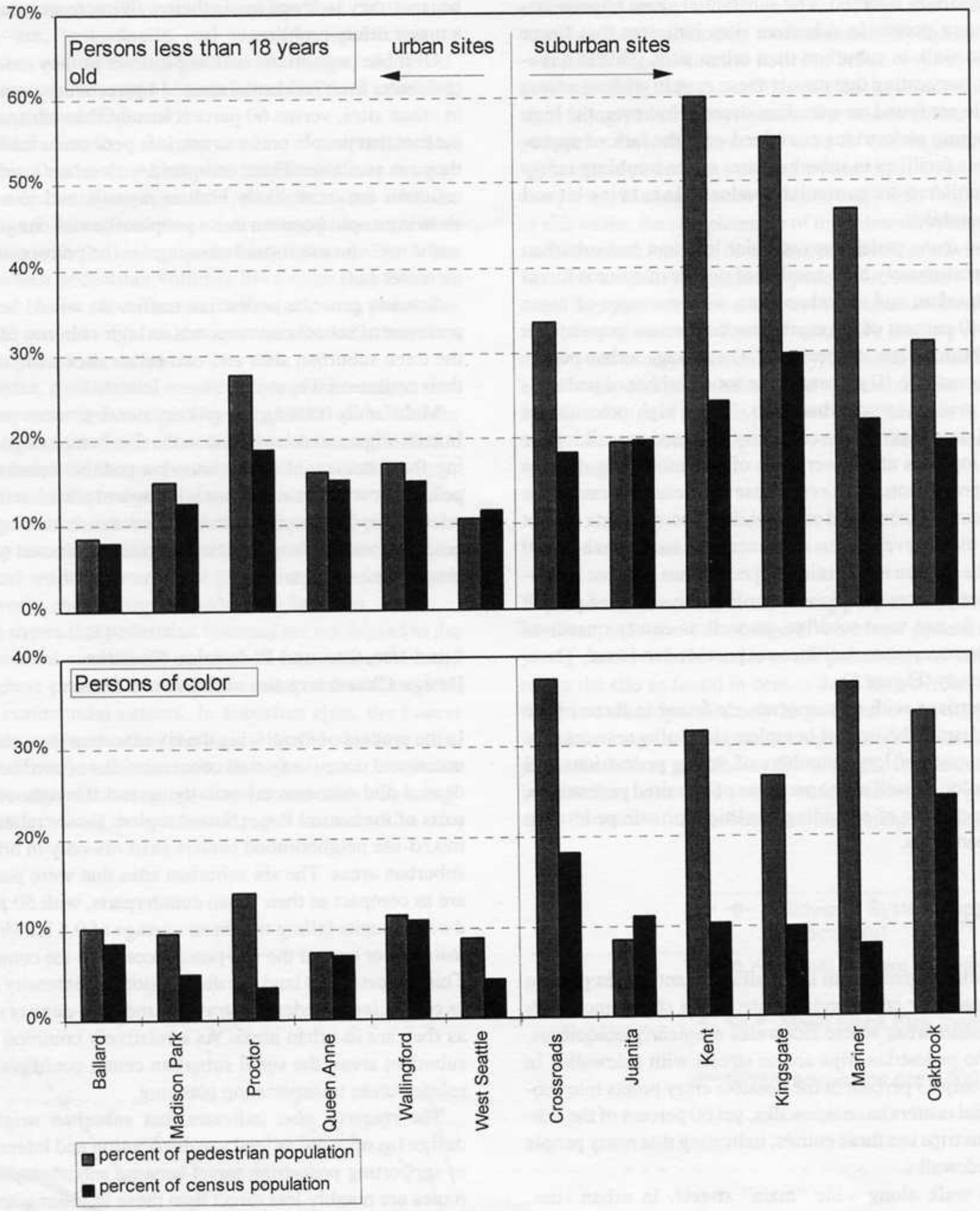

FIGURE 5 Percentage of young people and people of color in pedestrian and census populations (1990 census block-level data).

opment occurs on large parcels, yet does not tend to create new public through-streets. The size of blocks in suburban sites is, in fact, inversely related to the intensity of activities located within them. In other words, higher-density commercial and residential development is associated with very sparse street systems even though such development generates high levels of vehicle and pedestrian traffic (see Figures 2 and 3). Instead of taking into account the number of people who will use the streets, suburban blocks correspond to the size of the properties they serve. To wit, blocks for single-family development are 61 to 91 m (200 to 300 ft) wide and 183 to 305 m (600 to 1,000 ft) long, about 2 to a maximum of 4 ha (5 to 10 acres), while blocks for multifamily and commercial development vary upward from 16 ha (40 acres). Three of the suburban sites have blocks that are more than 36 ha (90 acres) in area, with one block reaching 79 ha (195 acres). These very large blocks range up to a full 0.8 km (0.5 mile) or even more on a side and have few or, more commonly, no legal street crossing opportunities along this distance. Even the smaller commercial and multifamily blocks are 15 times the size of an average urban block, with the largest ones more than 70 times larger than urban blocks. Even with wide, high-capacity streets, suburban block sizes address neither pedestrian nor automobile travel demand as related to land use patterns.

Second, suburban sites only have one-fifth of the sidewalks that are found in urban sites. On average, the total length of sidewalk systems in suburban sites would have to be doubled in order to line both sides of every public street. Further, the sidewalks that do exist in suburban sites do not generally correspond to areas of concentrated residential or commercial activity. The most extensive sidewalks networks are found along streets serving single-family dwellings where sidewalks are required as part of subdivision regulations. Sidewalks also are found along some, but by no means all, wide arterial streets in commercial and multifamily areas. Again, because arterials form very large blocks, the sidewalk network that they provide is too coarsely distributed for pedestrian travel. Completed sidewalk systems would still form a very sparse network in suburban sites.

Third, the mean distance between points where pedestrians can enter the commercial center is twice as long in suburban as in urban sites, indicating a lack of options to navigate between a site's residential and commercial areas. At 168 m (550 ft) in the urban sites, this distance is probably already larger than optimal to support pedestrian travel (*15*). The inefficiencies of pedestrian facilities in suburban sites can be improved as outlined in the recommendations that follow.

RECOMMENDATIONS

This research gives strong evidence that neighborhood site design affects pedestrian activity. It highlights the value of pedestrian infrastructure in helping people choose to walk and identifies pedestrian safety issues that appropriate facilities can mitigate. The findings also point to opportunities for improving pedestrian travel and volumes in suburban areas that already have the requisite population densities and land used mix and intensity to support walking. Specifically, the following findings are significant:

- The comparatively high number of people walking in suburban areas;
- The disproportionately high number of young pedestrians and pedestrians of color;
- The comparatively high number of pedestrians using streets with sidewalks in spite of the low incidence of such streets in suburban areas; and
- The high number of pedestrians jaywalking in spite of the dangerous conditions found in the wide, automobile-oriented streets common in suburban areas.

The results of this study suggest that the significant volumes of pedestrian travel found in urban sites also could be generated in appropriately dense and mixed-use suburban areas. The provision of additional pedestrian facilities in such suburban areas is likely to increase pedestrian volumes as well as help to reduce local automobile traffic congestion by encouraging people to substitute automobile trips with walking trips. Further, because the vast majority of transit riders access public transportation by foot, developing appropriate pedestrian facilities also is relevant to supporting the use of public transportation. Even automobile users walk to and from their vehicles and benefit from adequate pedestrian facilities.

The recommendations below fall into two categories. One is the need to identify specific areas in the suburbs where land uses already exhibit characteristics that are conducive to pedestrian travel. The second is the need to develop neighborhood site design guidelines for the implementation of pedestrian-facility improvements in suburban areas.

Location and Type of Small Concentrations of Activity in Suburban Areas

Analysis of the central Puget Sound region undertaken in the site selection phase of this project pointed to more than 80 areas in the suburbs that have a potentially large "latent" pedestrian market. Overall, more than 30 percent of the region's suburban population lives at a density higher than 25 people per hectare (10 people per acre), and almost 20 percent of that population lives in small clusters similar to the ones used in this research (*16*). While not all of these clusters host the mixes of land uses necessary to make viable neighborhood commercial centers, their relatively high population densities offer sufficient promise to warrant further research on their potential to support pedestrian activity. Region-wide, the sheer number of people living in these neighborhoods (typically in multifamily developments) also calls for further research on the potential of these areas to contribute to a balanced transportation program. These medium-density clusters also need to be integrated into current planning programs as places that should receive priority for pedestrian infrastructure investment.

Although a precise understanding of these suburban locations and their land use conditions and pedestrian circulation systems is lacking, the six sites used in this study offer insight into the strengths and the shortcomings of suburban neighborhood site design in fostering pedestrian travel (*17*). On the positive side, the six sites exhibit an arrangement of land use within a relatively small area that is entirely conducive to pedestrian activity. The sites' compact land use program is centered appropriately on retail centers. Also appropriate are the two bands of residential uses surrounding these retail facilities: first, a band of dense multifamily development, and then, in many cases, a band of single-family subdivisions.

On the other hand, impediments to walking between activities include not only the large size of street blocks (increasing the length of travel routes) and the lack of continuous sidewalks, but also the lack of connections between the ring of multifamily housing and the commercial center. Apartment complexes ranging from 2 to more than 8 ha (5 to 20 acres) often are surrounded by fencing with only a single connection to the public street system. The same conditions also are found in suburban school campuses. In both cases, the options for pedestrians to use the shortest routes to adjacent residential or commercial areas are extremely limited. Again, in the areas studied as part of this research, these impediments add an average of 183 (600 ft) to walking distances, a significant distance for pedestrians. Finally, retail areas are themselves ringed with large off-street parking lots and are usually along wide, difficult-to-cross, and heavily trafficked streets. These conditions create hostile walking environments. Hence, while these sites' compact and mixed land use program is promising for pedestrian travel, their design characteristics discourage walking. Guidelines need to be developed to improve suburban sites' pedestrian facilities and to support the development of both safer and shorter pedestrian travel routes.

Site Design Guidelines to Support Pedestrian Travel

New guidelines or regulations need to address retrofitting existing suburban clusters as well as improving the site design of new development. The focus needs to be on the provision of shorter and safer pedestrian routes among major land uses—residential, commercial, and school facilities. Sites with a concentration of mixed land uses and activities need to offer a continuous, fine-grained network of walkways that allows people to walk safely between land uses and activities. This network should build on existing arterials as well as on the informal paths that pedestrians already have established. Establishing regulations for new areas will be easier than retrofitting existing centers, but in either case the institutional and budgetary constraints to improving pedestrian facilities should not be underestimated. Although some of the following measures will be difficult to implement, they are aimed at being relatively simple and inexpensive:

- To address safety issues, provide sidewalks along all arterials and streets in and around the commercial center and its surrounding ring of multifamily housing. The width of sidewalks must be commensurate with the width of the street or arterial. Buffers between sidewalks and streets need to be created wherever the speed of traffic constitutes a perceived danger to pedestrians.
- To reduce the effect of the large size of suburban blocks, pedestrian crossing opportunities should occur at short, regular intervals along streets and arterials serving concentrations of multifamily housing, commercial development, and schools. A crossing every 152 ms (500 ft) would be commensurate with older, urban, more pedestrian-oriented neighborhoods. These crossings will provide additional route options and reduce the incidence of jaywalking. Given the mixed results concerning their safety, crosswalks must be accompanied by the appropriate signage ("Stop for me, it's the Law") or even traffic signals to make drivers aware of pedestrians (*18,19*).
- Provide gates in fences surrounding multifamily housing complexes and schools. Because they act as de facto "street intersections," these gates should occur at short, regular intervals, such as every 61 m (200 ft), especially when the fence is located along the edge of the commercial center or along the arterials bordering the complex. Where security is perceived to be a problem, gates can be locked and keyed to the building entries in multifamily developments.
- Provide marked pedestrian walkways leading people in and out of gates and through both multifamily complexes and commercial development to act as a de facto pedestrian street network. These marked walkways should form a continuous network that uses the shortest and most practical routes between residential and commercial building entries and that connects all building entries to the public sidewalk system found along streets. A common but unsafe occurrence is for parking lot curb cuts to serve as the only pedestrian entries into retail complexes. Instead, shoppers on foot need to be able to reach the sidewalks along streets at short, regular intervals.

Overall, the pedestrian network should form a simple grid with 61- to 91-m (200- to 300-ft) spacing between walkway intersections. This grid can be adjusted to parking lot design to support people who are first parking and then walking in both multifamily and commercial areas. The network also should take into account the fact that grocery stores tend to be strong attractors of pedestrian traffic. Finally, it should include safe and direct pedestrian routes between school facilities and commercial land uses, especially because older schoolchildren tend to gravitate to retail areas.

CONCLUSION

This research suggests that neighborhood site design plays a determining role in supporting walking as a means of transportation. Controlling for population density, income, and land use mix and intensity, the volume of pedestrian trips is three times higher in urban sites with small street blocks and continuous sidewalks than in suburban sites with large blocks and discontinuous sidewalks. This demonstrates that population density, income, and land use mix are not sufficient to predict pedestrian volumes. A combination of variables capturing site-design characteristics, including street block size, length of sidewalks, and pedestrian route traveled, also has explanatory power for defining pedestrian volumes.

At the same time, the research shows that people do walk in suburban areas with appropriate population density and land use mix. Given the substantial number of people living in such areas, improving suburban neighborhood site design and pedestrian facilities could contribute to limiting the use and impact of the single-occupant vehicle. The disproportionate numbers of young pedestrians and people of color found walking in suburban areas suggest that further research is essential on the need to improve pedestrian safety for people who may not be able or may not want to drive in such areas.

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