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Streetscape Features Related to Pedestrian Activity

Reid Ewing[1], Amir Hajrasouliha[2], Kathryn M. Neckerman[3], Marnie Purciel-Hill[4], and William Greene[5]

Abstract

By measuring twenty streetscape features and numerous other variables for 588 blocks in New York City, we were able to identify variables that explain pedestrian traffic volumes. We found significant positive correlations between three out of twenty streetscape features with pedestrian counts after controlling for density and other built environmental variables. The significant streetscape features are the proportion of windows on the street, the proportion of active street frontage, and the number of pieces of street furniture. This study provides guidance for streetscape projects that aim to create walkable streets and pedestrian-friendly environments.

Keywords

pedestrian activity, streetscape features, urban design measures, walkability

Introduction

Some of today's most vexing problems, including sprawl, congestion, air pollution, oil dependence, and climate change, are prompting states and localities to turn to land planning and urban design to rein in automobile use. As a consequence, the role of the built environment in influencing travel behavior may be the most widely researched topic in urban planning. In more than 200 studies, the built environment has been measured, or operationalized, in terms of D variables. The original three Ds, coined by Cervero and Kockleman (1997) are *density, diversity*, and *design.* The Ds were later expanded to include *destination accessibility* and *distance to transit* (Ewing and Cervero 2001). An additional set of D variables, related to *demographics*, have been controlled in travel studies to determine the independent effect of the built environment on travel behavior.

For four of the D variables, measurement is fairly straightforward. Density, for example, is just a measure of activity divided by a measure of land area. While there are choices to be made, and some D variables overlap (e.g., diversity and destination accessibility), academics who conduct research in this area seem comfortable with these four dimensions of the built environment and the metrics used to operationalize them.

The remaining D, *design,* is more nuanced. Design is widely thought to include street network characteristics of a neighborhood or district. Street networks vary from dense urban grids of highly interconnected, straight streets to sparse suburban networks of curving streets forming loops and lollipops. However, urban design also incorporates micro features of the street environment that affect the pedestrian experience, referred to herein as streetscape features. The experience of walking down a given street may have less to do with gross qualities such as average block size than with the micro environment of the street itself. Urban designers presume that these features are important for active street life but have little empirical evidence to back the claim.

In the new book *Measuring Urban Design,* Ewing and Clemente (2013) seek to validate urban design qualities against pedestrian counts on 588 street segments in New York City. They show that the urban design quality of transparency—measured in terms of *windows overlooking the street, continuous building facades forming a street wall,* and *active street frontage*—has a stronger relationship to pedestrian counts than any of the standard D variables. This paper builds on their research, using the same data set. The difference between the two studies is that we relate streetscape features directly to pedestrian activity instead of relating them to urban design constructs, such as transparency, complexity, or imageability.

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[1]University of Utah, Salt Lake City, UT, USA
[2]Cal Poly State University, San Luis Obispo, CA, USA
[3]Columbia University, New York, NY, USA
[4]Human Impact Partners, Oakland, CA, USA
[5]New York University, New York, NY, USA

Corresponding Author:
Reid Ewing, Department of City and Metropolitan Planning, University of Utah, Salt Lake City, UT 84112, USA.
Email: ewing@arch.utah.edu

Literature

There are at least fourteen surveys of the literature on the built environment and travel, including pedestrian travel (Badoe and Miller 2000; Brownstone 2008; Cao, Mokhtarian, and Handy 2009; Cervero 2003; Crane 2000; Ewing and Cervero 2001; Handy 2005; Heath et al. 2006; McMillan 2005, 2007; Pont et al. 2009; Saelens, Sallis, and Frank 2003; Salon et al. 2012; Stead and Marshall 2001). There are another fourteen surveys of the literature on the built environment and physical activity, including walking and biking (Badland and Schofield 2005; Cunningham and Michael 2004; Frank 2000; Frank and Engelke 2001; Humpel, Owen, and Leslie 2002; Kahn et al. 2002; Davison and Lawson 2006; Lee and Moudon 2004; McCormack et al. 2004; National Research Council et al. 2005; Owen et al. 2004; Saelens and Handy 2008; Trost et al. 2002; Wendel-Vos et al. 2004). The literature is now so vast it has produced three reviews of the many reviews (Bauman and Bull 2007; Gebel, Bauman, and Petticrew 2007; Ding and Gebel 2012).

A recent meta-analysis found more than 200 individual studies of the built environment and travel (Ewing and Cervero 2010). Ewing and Cervero (2010) list thirty travel behavior studies that relate walking to some aspect of design. Only six studies include variables that have some relationship to streetscape design, the rest dealing instead with street network design. The six studies measure such gross qualities as ease of street crossings and sidewalk coverage.

Focusing on recent reviews, Salon et al. (2012) survey thirty-two studies of the built environment and travel. Only three studies deal with the pedestrian environment, and the measures used in these studies are gross qualities: sidewalk length, sidewalk width, and a combination of four variables referred to as a pedestrian environment factor. The four variables are subjective assessments of ease of street crossings, sidewalk continuity, local street characteristics (grid vs. cul-de-sac), and topography.

Saelens and Handy (2008) review not only studies of travel behavior but also studies of recreational walking. All told, they survey twenty-nine studies. A few studies deal with "aesthetics," "pedestrian infrastructure," and "physical activity facilities." But only two studies contain objective measures of what might be referred to as streetscape quality ("streetlights" and "street trees").

Hence both the travel and physical activity literatures largely ignore the streetscape features deemed so important by urban designers. At least six known audit tools for measuring built environment exist that may be linked to travel and physical activity. All six include—at least some—streetscape features in their measurement tool. Urban Design Tool—introduced in the Introduction (Ewing et al. 2005; Ewing et al. 2006; Ewing and Clemente 2013)—is the measurement tool that we used in this study. The other five measurement tools are (1) the Systematic Pedestrian and Cycling Environmental Scan (SPACES) instrument (Pikora et al. 2002) developed in Australia; (2) the Pedestrian Environment Data Scan (Clifton, Livi Smith, and Rodriguez 2007; Schlossberg, Agrawal, and Irvin 2007), developed at the National Center for Smart Growth at the University of Maryland; (3) the Walkable Places Survey (WPS) tool (Shriver, Planner, and Council 2003); (4) the St. Louis University Analytic Audit Tool (Hoehner et al. 2007; Brownson et al. 2009); (5) the Irvine-Minnesota Inventory (IMI) (Day et al. 2006; Boarnet et al. 2006; Boarnet et al. 2011). SPACES, the Pedestrian Environment Data Scan, and the WPS audits contain few subjective evaluations of the attractiveness (e.g., segment is attractive for walking), while the other three tools evaluate many more streetscape features (e.g., counting all pieces of street furniture). However, none of the audit tools covers all potential streetscape features. The reason can be in the preference of researchers to develop a concise tool versus an extensive tool. Also, it is hard to imagine a universal tool for measuring streetscape features, due to the architectural and city design differences of different cities.

Fortunately, predictive validity studies for some of the measurement tools were conducted. Pikora et al. (2006) correlated neighborhood environmental factors with walking using SPACES. One of the factors was a streetscape factor measuring trees, garden maintenance, street maintenance, cleanliness, parks, views, sights, and architecture. In their study, none of these elements showed a significant relationship with walking behavior. However, they reported some evidence that more aesthetically pleasing neighborhoods may influence walking for recreation. In other research, Boarnet et al. (2011) used a version of the IMI in the Twin Cities Walking Study. They found that measures of physical infrastructure, such as sidewalks, street characteristics, pedestrian crossings, and traffic signals, can be linked to physical activity and walking, while nature elements, streetscape features, and architectural and neighborhood characteristics (e.g., historic buildings, the presence of bars on windows) are less important for physical activity and walking. In their conclusion, they suggest that "it will not be necessary to delve into areas of aesthetics—where support for policy intervention might be more tenuous—to improve neighborhood walking and physical activity" (p. 34). However, they also encouraged further research on the subject since many measured aesthetic characteristics varied little in their study area.

Despite the fact that literature may not strongly support the influence of streetscape features on walking, we believe that using one of the most extensive audit tools in one of the most urban environments in the world, New York City, can significantly contribute to this discussion.

Data and Variables

Using ratings of video clips by an expert panel, Ewing et al. (2005), Ewing et al. (2006), and Ewing and Handy (2009)

Table 1. Streetscape Features Contributing to Urban Design Qualities.

Urban Design Quality	Significant Physical Features
Imageability[a]	Proportion of historic buildings
	Courtyards/plazas/parks (number)
	Outdoor dining (yes/no)
	Buildings with nonrectangular silhouettes (number)
	Noise level (rating)
	Major landscape features (number)
	Buildings with identifiers (number)
Enclosure	Proportion street wall—same side
	Proportion street wall—opposite side
	Proportion sky across
	Long sight lines (number)
	Proportion sky ahead
Human scale	Long sight lines (number)
	All street furniture and other street items (number)
	Proportion first floor with windows
	Building height—same side
	Small planters (number)
Transparency	Proportion first floor with windows
	Proportion active uses
	Proportion street wall—same side
Complexity[a]	Buildings (number)
	Dominant building colors (number)
	Accent colors (number)
	Outdoor dining (yes/no)
	Public art (number)

[a]Number of people on the street was also a significant determinant of imageability and complexity ratings. However, as it is our dependent, it has been dropped from the list.

operationalized five urban design qualities in terms of 20 streetscape features. The urban design qualities and the component streetscape features are identified in Table 1. In their study, more than 130 features of streetscapes were measured in a content analysis of video clips. These features were then tested for relationships to urban design quality ratings by the expert panel. Twenty features proved significant in one or more models. Six features were significant in two models: long sight lines, number of buildings with identifiers, proportion first-floor façade with windows, proportion active uses, proportion street wall—same side, and number of pieces of public art. For operational definitions of these and other physical features of commercial streets, see Ewing et al. (2005).

Soon after the original study, another study implemented the observational protocols of Ewing et al. (2005) and Ewing et al. (2006). The researchers, from Columbia University, developed observational data for a sample of block faces in New York City (Purciel et al. 2009). Pedestrian counts and streetscape measurements were completed for 588 of the 600 sampled blocks (for 12 blocks, no block face met study criteria). These data are used in the current study to relate streetscape features directly to pedestrian counts.

Table 2. Cronbach's Alpha Values for Field Counts versus Web Counts by One Rater.

	Field Counts versus Google Counts	Field Counts versus Bing Counts	Field Counts versus EveryScape Counts
Cronbach's alpha	.864	.470	.784
Sample size of block face	588	169	201

Pedestrian Activity

The outcome variable explained in this study is the average number of people encountered on four passes up and down a given block face. All fieldwork was conducted between 10 a.m. and 5 p.m. on weekdays. Field observers walked the length of the segment one time for each count and included every pedestrian they encountered during that exercise, noting the time of day and weather conditions observed for that period.

Because the sample of counts is small for each block face ($n = 4$) and the counts are sequential rather than independent, we needed to establish the reliability of our outcome variable, the average pedestrian count. This was done by counting pedestrians on three websites that provide street-level imagery and comparing these counts to the manual counts. The three are Google Street View, Bing StreetSide, and EveryScape. For these counts, the same street was filmed at different times by the different suppliers of imagery. Thus, with the field counts, we had four independent measures of pedestrian activity.

Equivalence reliability was judged with Cronbach's alpha. Cronbach's alpha is widely used in the social sciences to see if items—questions, raters, indicators—measure the same thing. If independent counts—four based on fieldwork and three based on street imagery—agree, we can assume that the field counts are reliable measures of pedestrian activity. Some professionals require an alpha value of .70 or higher before they will use an instrument. Alpha values were consistent with this guideline for two out of three websites.

Streetscape Features

At the same time as the pedestrian counts, the Columbia University team also measured twenty streetscape features (see measured streetscape features at Table 3, and as an example of the measuring process see Figure 1). To assess interrater reliability, thirteen block faces were scored

Table 3. Measured Physical Features of Streetscapes based on Purciel et al.'s (2009) Protocol.

Variable Long Name	Definitions	Directions
Proportion of historic buildings	**Historic:** clearly determined to be pre–World War II: high detailing, dumbbell shape, iron fire escape, and so forth; post–World War II buildings are usually geometrically and architecturally simple (though they may be impressive), have lots of glass surface area, and little detailing.	- Estimate the proportion of historic buildings visible at street level (out of total block length excluding cross streets). - Record the estimate as a decimal using increment of tenths (.10).
Courtyards/plazas/ parks—both sides	**Courtyard:** a permanent space in which people are intended and able to enter **Plaza:** large, enterable open space (bigger than fifteen square feet), often with art, plants, or associated with building(s) **Park:** place intended for human use/recreation, often with greenery, a playground, and so forth **Garden:** enterable and larger than ten square feet	- As you walk count instances of (not elements or sections of) courtyards, plazas, and parks on both sides. - Record the number of courtyards, plazas, or parks you encountered within the study area.
Outdoor dining	**Outdoor dining:** dining tables and seating located mostly or completely outside. Even if there are no patrons, there is outdoor dining as long as the tables and chairs are present.	- Note the presence (1) or absence (0) of commercial or public outdoor dining on your side. - Record a 1 if outdoor dining is present and a 0 if it is not.
Buildings with nonrectangular silhouettes	**Buildings with nonrectangular shapes:** those that do not have simple rectangular profiles from at least one angle, as seen by the passing pedestrian. Visible pitched roofs, bay windows in the roof or foundation lines, dormers, and so forth qualify buildings as nonrectangular. Signs, awnings, entrances, and porches are not considered in the shape of the building.	- Count buildings with nonrectangular shapes on both sides. - Record the number of buildings with nonrectangular shapes you counted within the study area. If the building is ambiguous, take a picture.
Major landscape features	**Major landscape features:** prominent natural landscape views like bodies of water, mountain ranges, or man-made features that incorporate the natural environment; serve as natural landmarks for orientation or reference. Parks do not count as major landscape features.	- Looking at both sides of the street and in the distance (only visible and prominent features ahead), count instances of individual/distinct natural landscape elements. - Record the number of distinct landscape elements you encountered on either side of the street or in the distance (prominent distant features only).
Buildings with identifiers	**Identifiers:** clear signs or universal symbols that reveal a building's street-level use. A steeple can identify a church, gas pump a gas station, tables and chairs a restaurant, mannequins a clothing store, and so forth. Words can also identify a lot/ building: "high school," "restaurant," "pharmacy," "shoe store," "café," and brand or franchise names. A name such as "Joe's" would not work, while "Joe's Pub" would identify the building.	- Count the buildings on both sides with identifiers that are visible from the sidewalk/path. - Record the number of buildings with identifying features within the study area.
Proportion of street wall—same side	**Street wall:** the effect achieved when structures on a block continuously front the sidewalk/path providing a defined street edge and feeling like a wall. A façade or wall greater than five feet contributes to the street wall if it is set back no more than ten feet from the sidewalk/path edge. Gates/ fences, greenery, or both greater than five feet tall that obstruct more than 60 percent of your view of the space beyond also count.	- Note the proportion of your side of the block that consists of a street wall (of the total block length) (excluding the cross streets from the denominator). - Record the proportion estimates (use decimal increments of .10) for your side.
Proportion of street wall—opposite side	Same as above	Same as above for the opposite side
Long sight lines	**Long sight line:** the ability to see at least 1,000 feet or about three city blocks into the distance at any point during your walk through the block.	- As you walk count the number of directions (front, right, and left) in which you see at least one long sight line at any point along the block. - Record a 1 if you had a long sight line in one direction, a 2 for two directions, and a 3 if you had a long sight line in all three directions at least once during your walk through.
Proportion of sky ahead	**Frame of vision:** your frame of vision is the "box" that is visible when you look ahead with your line of sight parallel to the ground. To better define the area, make a box with your fingers (thumbs and pointer fingers) and hold it up to your face. Slowly move it away until you can see all four sides—this is your "box."	- Look directly ahead. - Without moving your head, assess the percentage of sky visible in your frame of vision. - Record the estimated proportion (use decimal increments of .05).

(continued)

Table 3. (continued)

Variable Long Name	Definitions	Directions
All street furniture and other street items	**Street furniture and other street items:** only the following: tables (without associated chairs), chairs (without associated tables), vendor displays (count one per vendor), ATMs, hanging plants, benches, flower pots, parking meters, umbrellas, trash cans (public only), newspaper boxes, mail boxes, bike racks, bollards (count one per set), hydrants, flags, banners, merchandise stands, street vendors, pedestrian-scale street lights (not for cars), phone booths (one per structure), bus stops (count one per stop), and train stations (count one per entrance).	- Count visible street furniture and other items on your side and within the block. Do not count furniture in enclosed parks, gardens, plazas, and courtyards.
Proportion of first floor with windows	**Windows:** average proportion of first-floor façade made up of windows.	- Note the proportion of street-level façade on your side that is covered by windows of any size. - Record the proportion out of the whole block length (use decimal increments of .10) that is covered by street-level windows.
Building height—same side	**Building height:** 12 ft. per floor times the number of floors, including the roof floor of buildings with slanted roofs and dormers and any visible sunken floors	- Note the height of the buildings on your side, whether they are set back, and the percentage of the block that the buildings of the same height occupy. - Record the heights of the buildings (record buildings of the same height together) considering their width, the total length of the block, and thus the percentage of the block (adding to 100 percent) each building height spans on the reverse side of the form.
Small planters	**Small planters:** any potted arrangement of trees, shrubs, or flowers that are smaller than ten square feet at their base. The planter should be within ten feet of the sidewalk edge and appear to be permanent (not small enough to be able to be brought inside at the end of the day) but not in ground.	- Count all the visible street-level planters on your side of the block and within ten feet of the sidewalk edge. This includes planters on private and public property but not those inside enclosed parks or gardens. - Record the total number of small planters on your side, within the study area.
Proportion of active uses	**Active use building:** one in which there is frequent pedestrian traffic (more than five people enter/exit while you are observing the block) **Always active:** parks, stores, restaurants, attached/apartment-style residential buildings, hospitals, and schools **Always inactive:** construction sites, parking lots, churches, detached/single residence units, and vacant or abandoned lots.	- Note the amount of active-use buildings that are on your side within the study area. If a building is active, assume all sides are active (even blank walls). - Record the proportion of the total block (use decimal increments of .10).
Number of buildings	**Visible building:** buildings that can be distinguished by separate doors/entrances (especially for residential), architecture, colors, and so forth	- Count the visible buildings on both sides of the street within the study area. - Record the number of buildings within the study area.
Dominant building colors	**Basic colors:** the colors used for the majority of the building's facade	- Count the number of basic building/structure/surface colors on both sides of the street within the study area. Do not distinguish between different shades of the same color. - Record number of distinct building colors.
Accent colors	**Accent colors:** the colors used for building trims and roofs, street objects, awnings, signs, and so forth	- Count the number of accent colors used on either side of the street and within the study area. - Record the number of distinct accent colors.
Public art	**Public art:** monuments, sculptures, murals, and any artistic display that has free access. Art must be the size of a small person or have clear identification indicating its status as art (creator, dedication, year, materials, etc.).	- Count individual pieces of public art that are within the study area or intended for viewing from the sidewalk/path. - Record the number of pieces of public art.

independently by all observers and interclass correlation coefficients were calculated for each variable and each rater. Results indicated a high degree of consistency among field observers (Purciel et al. 2009).

"D" Variables

For control variables, we drew on characterizations of D variables from Ewing and Cervero (2010) and Ewing et al. (2011). In an effort to make the process replicable, secondary data were limited to those that are publicly available in other parts of the country. Geographic Information System (GIS) data for the study area were acquired directly from the New York City Department of City Planning, including DCPLION (the street centerline GIS file from City Planning), street segment centerlines, and MapPluto™ parcel layers. Census 2010 SF1 100% and Tiger 2010 Census Block shapefiles were used to calculate roadway network, land use, and demographic variables.

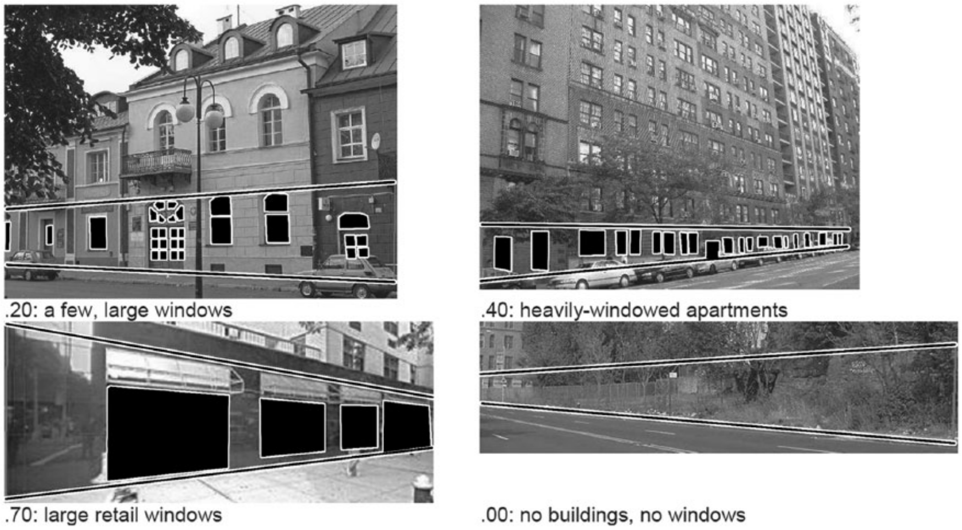

Figure 1. Proportion of First Floor with Windows.
Source: Purciel and Marrone 2006.

Two density measures were computed for the quarter-mile buffer around each street segment. A quarter mile was selected as a standard walking distance beyond which walk frequency drops off rapidly. One density variable is the average floor area ratio (FAR), computed as the total building floor area for all parcels within the buffer, divided by the total area of tax lots (far). The other is the average population density, computed as the population of all census blocks whose centroids fell within the buffer divided by the total area of residential tax lots whose centroids fell within the buffer, measured in 1,000 residents per square mile (population density).

Diversity was related to the number of different land uses within the quarter-mile buffer and the degree to which they were balanced in floor area. An entropy measure of diversity was computed with the following formula:

$$\text{entropy} = -\begin{bmatrix} \text{residential share} * \ln(\text{residential share}) + \\ \text{retail share} * \ln(\text{retail share}) + \\ \text{office share} * \ln(\text{office share}) \end{bmatrix} / \ln(3),$$

where the shares were computed based on floor area of each use for tax lots within the buffer and ln refers to the natural logarithm of the share of floor area.

While much of this article focuses on streetscape design features, gross measures of street network design were computed with GIS. One was intersection density, computed as the number of intersections within the quarter-mile buffer divided by the gross area of the buffer in square miles (intersection density). The other was the proportion of four-way intersections within the buffer (proportion 4-way).

The D variable destination accessibility was represented by Walk Scores (walk score). Walk Score is an Internet-based platform that rates the walkability of a specific address on a numeric scale (from 0 to 100) by compiling the number of nearby stores and amenities within an extended walking distance. The platform specifically measures walkability relative to thirteen amenity categories including grocery stores, coffee shops, restaurants, bars, movie theaters, schools, parks, libraries, book stores, fitness centers, drug stores, hardware stores, and clothing/music stores (Carr, Dunsiger, and Marcus 2010). Amenities within 0.25 miles receive maximum points, and no points are awarded for amenities farther than one and a half miles from the address. For this study, an address at the approximate midpoint of each block face was retrieved using Google Street View and then entered into the Walk Score web site to obtain a score for each segment.

Using ArcInfo Network Analyst (software provider: ESRI 2009) and the New York City road centerline shapefile, a network analysis was performed to find the shortest distance from each study segment center point to the closest rail station (mostly subway but other rail on Staten Island). The result was a mile distance to transit variable related to each study segment (distance to rail).

The only demographic variable computed was average household size for blocks whose centroids fell within the quarter-mile buffer around each block face (household size). We would have estimated median household income or per capita income from the American Community Survey, but complete data were available only at the block group level.

Reasoning that pedestrian counts on a given block face may depend as much on land uses along the block face as on development patterns within easy walking distance, we estimated three additional D variables: average FAR for the block face, computed as the total building floor area for parcels abutting the street, divided by the total area of tax lots (block far); an entropy measure based on floor area for parcels abutting the street, computed with the formula above (block entropy); and proportion of retail frontage along the block face, on the assumption that retail frontage generates more pedestrian activity than other frontage (proportion retail).

One final control variable used in this study is the length of each block face (block length). The simple theory is that after controlling for other influences, the longer the block, the more pedestrians will occupy it at any given time.

Negative Binomial Regression

With a full set of variables in hand, we sought to explain pedestrian counts on the 588 sampled block faces. The method of analysis was dictated by the distribution of the dependent variable, the average pedestrian count for four passes up and down each block face rounded to the nearest integer. Many streets have low pedestrian counts, few streets have high pedestrian counts, and no streets can have negative counts. Counts range from 0 to 176, with a mean value of 5.78 and a standard deviation of 12.97. The assumptions of ordinary least squares regression are violated in this case. Specifically, the dependent variable is not normally distributed, and the error term will not be homoscedastic nor normally distributed.

Two basic methods of analysis are available when the dependent variable is a count, with nonnegative integer values, many small values, and few large ones. The methods are Poisson regression and negative binomial regression, both fairly new to the planning field. The models differ in their assumptions about the distribution of the dependent variable. Poisson regression is the appropriate model form if the mean and the variance of the dependent variable are equal. Negative binomial regression is appropriate if the dependent variable is overdispersed, meaning that the variance of counts is greater than the mean. Because the negative binomial distribution contains an extra parameter, it is a robust alternative to the Poisson model.

Popular indicators of overdispersion are the Pearson and χ^2 statistics divided by the degrees of freedom, so-called dispersion statistics. If these statistics are greater than 1.0, a model is said to be overdispersed (Hilbe 2011, 88). By these measures, we have overdispersion, and the negative binomial model is more appropriate than the Poisson model. We used the software package SPSS to estimate two negative binomial models of pedestrian counts (see Table 4). Model 1 contains the standard D variables without the streetscape variables, while model 2 includes the streetscape variables that entered at significant levels. The three streetscape variables that proved significant, in combination with the standard D variables, are the *proportion of active uses along the block face,* the *number of pieces of street furniture and other street items,* and the *proportion of first floor with windows.* The *proportion of active uses* ranges from 0 to 1, with a mean value of .53 and a standard deviation of .39. The *number of pieces of street furniture* ranges from 0 to 50, with a mean value of 5.55 and standard deviation of 6.96. And finally, the *proportion of first floor with windows* ranges from 0 to 1, with a mean value of .24 and a standard deviation of .24.

Both models have highly significant likelihood ratio chi-squares, indicating a good fit to the data relative to a null model with only intercept terms. The likelihood ratio chi-square of model 2 relative to model 1—58.0 with 3 degrees of freedom—indicates that the fit is significantly better for model 2 at the .001 probability level. In both models, the three density measures—buffer FAR, buffer population density, and block FAR—are directly and significantly related to pedestrian counts. In both models, our measure of buffer diversity, entropy, is not significant. Nor is block entropy significant in the second model. Neither of the two measures of street network design, intersection density or proportion of four-way intersections, is significant. Our measure of destination accessibility, walk score, is not significant in either model. Distance to rail is significant with the expected negative sign, pedestrian counts dropping off with distance. The proportion of retail frontage along the block face is positively related to pedestrian counts in both models. Household size is positively related to pedestrian counts in both models but at a significant level only in model 1. Block length is directly related to pedestrian counts at significant levels in both models.

As for the streetscape variables in model 2, all three are significant after controlling for other D variables. This is a novel finding, to our knowledge the first time anything like this has been reported in the literature.

We tested for multicollinearity and spatial autocorrelation. The lowest tolerance value is 0.263, for buffer FAR, which shows that there is no multicollinearity among predictors. For spatial autocorrelation, we used Moran's I to test whether the residuals of the model are independently distributed. We tested Moran's I for different potential spatial relationships between our samples. We found insignificant spatial autocorrelation in our tests (e.g., inverse distance: Z score = 0.34, p value = .72; fixed-distance band of half a mile: Z score = –1.43, p value = .15). Based on these results, we believe our coefficients are efficient and unbiased.

Discussion

This study has sought to explain pedestrian counts on 588 block faces in New York City in terms of D variables—development density, land use diversity, street network design, destination accessibility, distance to transit, and one demographic variable, household size—plus micro streetscape features. Not all of the tested D variables have the expected relationships to pedestrian counts. While land use entropy, intersection density, and destination accessibility are strongly associated with walking in household-level travel studies (Ewing and Cervero 2010), our data show no

Table 4. Negative Binomial Regression Models of Pedestrian Counts (588 Block Faces).

	Model 1			Model 2		
Variable	Coefficient	Standard Error	*p* Value	Coefficient	Standard Error	*p* Value
Intercept	−1.422	0.583	.015	−1.741	0.591	.003
Far	0.120	0.040	.003	0.095	0.042	.026
Population density	0.012	0.002	<.001	0.008	0.002	.001
Entropy	0.336	0.326	.303	0.390	0.330	.239
Intersection density	–0.001	0.001	.317	–0.001	0.001	.447
Proportion 4-way	0.332	0.277	.233	0.378	0.287	.188
Walk score	0.005	0.004	.244	0.004	0.004	.407
Distance to rail	–0.180	0.066	.007	–0.166	0.067	.015
Block far	0.092	0.019	<.001	0.059	0.020	.004
Block entropy	0.727	0.216	.001	0.304	0.224	.176
Proportion retail	1.313	0.210	<.001	0.646	0.234	.006
Household size	0.166	0.115	.151	0.206	0.116	.076
Block length	5.567	1.294	<.001	4.299	1.329	.001
Proportion windows				0.623	0.258	.016
Street furniture				0.035	0.009	<.001
Proportion active uses				0.630	0.161	<.001
n		588			588	
Likelihood ratio chi-square (*df*)		627.3 (12)			685.3 (15)	

significant relationship between these factors and pedestrian volume. Also, apparently having equal proportions of residential, retail, and office on a block face is less conducive to pedestrian activity than having a disproportionate share of retail frontage. The differences between our findings and the literature may be due to the fact that we are relating built environment characteristics to pedestrian counts rather than explaining individual walking trips. However, the three streetscape design features, the proportion of active uses along the block face, the number of pieces of street furniture and other street items, and the proportion of first floor with windows, add significantly to the explanatory power of our second model. This is a novel finding that suggests that urban design generally, and streetscapes in particular, have a significant influence on pedestrian activity.

What are the implications for planning practice? First, context is important, particularly FAR and population density, within a quarter mile of commercial streets. Zoning can be amended to achieve high values of each of these variables. Accessibility to rail transit can have a positive impact on street life. In addition, streets themselves should have high FARs and predominantly retail frontage.

From the perspective of urban design practice, it is important to know which streetscape features have a significant relationship to pedestrian activity and how to operationalize these features. Out of twenty streetscape features that were proven to have an impact on urban design qualities (Ewing et al. 2005; Ewing et al. 2006), this study could identify three significant streetscape features that can contribute to walkability of streets. The first feature is street furniture, defined as all kinds of signs, benches, parking meters, trash cans, newspaper boxes, bollards, street lights, and so forth, anything at human scale that increases the complexity of the street. Providing urban furniture and specifically urban seating is a common recommendation for activating public spaces. Our study verified the power of this recommendation. However, it is important to note that this recommendation can also cause a not so rare practical error among urban designers. The perception that installing urban furniture guarantees or increases pedestrian activities without taking into account all other important factors, such as land use, public safety, or other design elements, is simply not accurate.

The second feature is the percentage of active uses, defined as shops, restaurants, public parks, and other uses that generate significant pedestrian traffic. Inactive uses include blank walls, driveways, parking lots, vacant lots, abandoned buildings, and offices with no apparent activity. In regard to residential uses, when the density is more than ten units per acre, we assume that the land use is active. A lesson from this finding is to monitor land use changes at the street level before investing in streetscape projects. For example, a corridor that is losing its commercial identity to nonactive uses may not be a priority for becoming a pedestrian-dominated street.

The last feature is "windows as a percentage of ground floor façade," which is a common operational definition of transparency. Street vitality highly depends on its interaction with adjacent buildings, and a high level of transparency at the ground level can facilitate this interaction. It may be argued that the impact of transparency is mainly due to the presence of retail activities. However, we controlled for the proportion of retail activities and did not detect multicollinearity effects in our regressions.

We conclude by acknowledging limitations of this study both in validity and in reliability. Obviously, New York City is unique among cities in the United States, which limits the external validity of our findings. While wide swaths of the city, including much of Staten Island and the North Bronx are suburban in nature, New York City is overwhelmingly urban. Four of five counties that constitute the city rank as the four most compact counties in the nation (Ewing et al. 2014). The metropolitan area has by far the highest walk mode share, 21.4 percent, of any large metropolitan area (Federal Highway Administration 2009). Our first research recommendation would be to repeat this validation study in more typical cities.

The main threat to the reliability of our results is the limited counts done on each block face. The days and times of the counts were variable. Only four counts were done on each block face, as field observers walked up and down the block face. Our second research recommendation would be to conduct longer standardized counts on each street segment in any future study. If replicated we believe that this study and its progeny will provide urban planners and urban designers with some of the clearest and most compelling guidance yet available for creating vibrant street life.

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Author Biographies

Reid Ewing is a professor of city and metropolitan planning at the University of Utah and a columnist for *Planning* magazine. He is a coauthor of *Measuring Urban Design: Metrics for Livable Places.*

Amir Hajrasouliha is a lecturer in urban planning and design at Cal Poly State University, San Luis Obispo. His research interests include urban design, campus planning and design, and spatial analysis.

Kathryn M. Neckerman is the associate director of Columbia University's Health & Society Scholars Program. She has written extensively about disparities in neighborhood conditions and their implications for health and well-being.

Marnie Purciel-Hill is a senior research associate at Human Impact Partners. Her research uses spatial data to examine the implications of the built environment.

William (Bill) Greene is a professor of economics at New York University's Stern School of Business. He is the author of the widely used textbook, *Econometric Analysis.*