
How the Built Environment Affects Physical Activity

Views from Urban Planning

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Abstract: The link between the built environment and human behavior has long been of interest to the field of urban planning, but direct assessments of the links between the built environment and physical activity as it influences personal health are still rare in the field. Yet the concepts, theories, and methods used by urban planners provide a foundation for an emerging body of research on the relationship between the built environment and physical activity. Recent research efforts in urban planning have focused on the idea that land use and design policies can be used to increase transit use as well as walking and bicycling. The development of appropriate measures for the built environment and for travel behavior is an essential element of this research. The link between the built environment and travel behavior is then made using theoretical frameworks borrowed from economics, and in particular, the concept of travel as a derived demand. The available evidence lends itself to the argument that a combination of urban design, land use patterns, and transportation systems that promotes walking and bicycling will help create active, healthier, and more livable communities. To provide more conclusive evidence, however, researchers must address the following issues: An alternative to the derived-demand framework must be developed for walking, measures of the built environment must be refined, and more-complete data on walking must be developed. In addition, detailed data on the built environment must be spatially matched to detailed data on travel behavior.

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Introduction

The link between the built environment and human behavior has long been of interest to the field of urban planning, particularly to the subfields of urban design and transportation planning. The theoretical, empirical, and practical work in these fields has generally aimed at the goals of enhancements to quality of life, improvements in system efficiency, or reductions in environmental impacts—in other words, the physical health of the community rather than the personal health of its residents. Direct assessments of the links between the built environment and physical activity as it influences personal health are still rare in urban planning. Yet the concepts, theories, and meth-

ods used by urban planners provide a foundation for an emerging body of research on the relationship between the built environment and physical activity.

The purpose of this article is to provide an overview of this foundation and outline the potential contributions from the field of urban planning toward the exploration of the relationship between the built environment and physical activity. We begin with a background section that defines key terms and describes how the interest in this topic has evolved within the field of urban planning and its traditional focus on travel behavior. The next section discusses the challenges associated with measuring characteristics of the built environment and travel behavior. We then turn to the theories used to assess the link between the built environment and travel behavior, and conclude with a discussion of the issues that must be addressed in extending this research to the question of the link between the built environment and physical activity.

Background

Urban planners use a variety of terms when referring to the built environment. Although these terms often seem interchangeable, the distinctions among them are

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important. "Urban design" usually refers to the design of the city and the physical elements within it, including both their arrangement and their appearance, and is concerned with the function and appeal of public spaces. "Land use" typically refers to the distribution of activities across space, including the location and density of different activities, where activities are grouped into relatively coarse categories, such as residential, commercial, office, industrial, and other activities. The "transportation system" includes the physical infrastructure of roads, sidewalks, bike paths, railroad tracks, bridges, and so on, as well as the level of service provided as determined by traffic levels, bus frequencies, and the like. The "built environment," as we define it, comprises urban design, land use, and the transportation system, and encompasses patterns of human activity within the physical environment. The built environment is constantly changing in countless ways; some changes are fast (e.g., the drop in pedestrians on a downtown street from noon to midnight) and some are slow (e.g., the deterioration of building exteriors over decades or more).

The urban design literature provides mostly a normative theory of the link between urban design and the use of public spaces—in other words, a prescription for how to create public spaces that people will use and enjoy. The principles for creating great public places that are widely accepted by today's urban planners can be traced to a handful of key thinkers. Jane Jacobs,¹ a commentator rather than a designer, passionately argued that cities need "a most intricate and close-grained diversity of uses that give each other constant mutual support, both economically and socially." Christopher Alexander's 1977 book *A Pattern Language*² and Kevin Lynch's 1981 book *Good City Form*³ provided a language for describing and evaluating the built environment and defined physical characteristics that contribute to good design. William Whyte's⁴ observational studies of public plazas in New York City and Donald Appleyard's⁵ mapping of relationships between neighbors on streets of varying traffic levels in San Francisco stand as seminal studies of the link between urban design and human behavior.

This literature provided the foundation for the new urbanism movement, which emerged in the late 1980s and has received considerable attention in the popular press. As defined by the Congress for the New Urbanism, this movement embraces urban design and planning principles that both create great public places and reduce automobile use. According to the Congress for the New Urbanism,⁶ one of the primary tenets of the new urbanism is the idea that "communities should be designed for the pedestrian and transit as well as the car." Authors identified with the new urbanism⁷⁻⁹ have articulated specific design characteristics to achieve this goal. These authors and other supporters claim that by putting the activities of daily living within walking

distance and providing an interconnected network of streets, sidewalks, and paths, walking will increase and driving will decrease.

Such claims are at least partly responsible for a subtle yet important shift in the focus of research in the planning field related to land use and transportation. The link between land use and travel patterns has long been of interest to transportation planners. Mitchell and Rapkin's 1954 *Urban Traffic: A Function of Land Use*¹⁰ first articulated this connection. The most influential model of travel behavior, developed soon afterward, postulates that commuting travel is shaped in part by the physical arrangement of residences and workplaces in an urban area.^{11,12} The goal of this model, at least traditionally, was to predict future traffic levels in order to plan for roadway expansions needed to meet the predicted demand. The idea that land use and design policies could be used to influence travel behavior was not widely explored until the mid-1980s, when physical, financial, and environmental constraints began to limit additional roadway expansions. The primary goal of these new studies, reviewed below, has been to characterize the link between the built environment and travel behavior and, more specifically, to test the hypothesis that policies that shape the built environment can be used to reduce automobile travel.

Measuring the Built Environment and Travel Behavior

Efforts to characterize the link between the built environment and travel behavior start with the nontrivial task of developing appropriate measures. The measures most commonly used by researchers reflect the availability of data as well as the traditional concerns of transportation planning and are not necessarily well suited to the study of the link between the built environment and physical activity. Recent improvements in the measurement of both the built environment and travel behavior are promising, however.

The Built Environment

The built environment, as defined in the previous section, is a multidimensional concept. When examining interactions between the built environment and travel behavior, various elements of the built environment are more appropriately measured at various scales of geography. Past research has typically focused either on the scale of a neighborhood (an area often conceptualized as several city blocks) or broader regional scales (which could be several square miles within a larger city or metropolitan area or even the entire metropolitan area). We discuss measures of the built environment by dividing those measures into local (or neighborhood) and regional characteristics.

Studies suggest at least five interrelated and often correlated dimensions of the built environment at the neighborhood scale (Table 1).

Table 1. Dimensions of the built environment

Dimension	Definition	Examples of measures
Density and intensity	Amount of activity in a given area	Persons per acre or jobs per square mile Ratio of commercial floor space to land area
Land use mix	Promixity of different land uses	Distance from house to nearest store Share of total land area for different uses Dissimilarity index
Street connectivity	Directness and availability of alternative routes through the network	Intersections per square mile of area Ratio of straight-line distance of network distance Average block length
Street scale	Three-dimensional space along a street as bounded by buildings	Ratio of building heights to street width Average distance from street to buildings
Aesthetic qualities	Attractiveness and appeal of a place	Percent of ground in shade at noon Number of locations with graffiti per square mile
Regional structure	Distribution of activities and transportation facilities across the region	Rate of decline in density with distance from downtown Classification based on concentrations of activity and transportation network

1. Density and intensity of development. Density is a measure of the amount of activity found in an area. It is usually defined as population, employment, or building square footage per unit of area and may be measured as people per acre or jobs per square mile, for example. The floor-area ratio, defined as the ratio between the floor space in a building (counting the area of each story of the building) and the size of the parcel on which that building sits, is another popular measure of density. Density is perhaps the easiest characteristic of the built environment to measure and is thus widely used.
2. Mix of land uses. Land use mix is defined as the relative proximity of different land uses within a given area. A mixed-use neighborhood would include not just homes but also stores, offices, parks, and perhaps other land uses. Measures of land use mix are not standardized. One study used the distance from each house in a neighborhood to the nearest store as a measure of land use mix.¹³ Another study used a “dissimilarity index” that divided an area into grid cells and for each cell counted the number of neighboring cells occupied by different land uses.¹⁴ A simple breakdown of the total land in an area into shares of each type of land use is another way to measure land use mix.
3. Connectivity of the street network. Connectivity is defined as the directness and availability of alternative routes from one point to another within a street network. It can be measured, for example, by the number of intersections per square mile,¹⁵ or by the ratio between the straight-line distance between two points and the distance along the network between these points.¹⁶ Average block length is often used in planning practice as a measure of connectivity.
4. Scale of streets. Scale refers to the three-dimensional space along a street as bounded by buildings or other features (e.g., trees or walls) and is usually

described in terms such as “human-scale” or “automobile-scale.” It can be measured, for example, by the ratio between building heights and street widths, or the average building “setback,” the distance from the street to the building. Scale is often depicted graphically rather than measured numerically.^{17,18}

5. Aesthetic qualities of a place. Aesthetic qualities, the qualities that contribute to the attractiveness or appeal of a place, are the most intangible of the five dimensions and are more often described than measured. Factors that contribute to aesthetic qualities include, for example, the design of buildings, including the size and orientation of windows, the location of the door relative to the street, decoration, and ornamentation; landscaping, particularly trees and the shade they provide; and the availability of public amenities such as benches and lighting. Places with desirable aesthetic qualities are often said to have a strong “sense of place,” a clear identity.³

Planners often label neighborhoods “pedestrian-oriented” if they have relatively high densities of development, a mix of land uses, a street network with high connectivity, human-scale streets, and desirable aesthetic qualities in that they make walking both more viable and more appealing. Areas with the opposite characteristics are labeled “automobile-oriented” in that they make walking, transit, and other alternatives to the car a practical impossibility or at least a significant challenge. However, these labels are based more on intuition than on empirical testing of the connection between these characteristics and pedestrian behavior.

Each of these dimensions of the built environment can also be measured for an entire metropolitan area, usually as an overall average or as the distribution of neighborhoods along a particular dimension. In addi-

tion, the overall structure of the metropolitan area becomes another important dimension of the built environment at the regional scale. Regional structure depends on the distribution of activities and transportation facilities across the region and can be defined by the degree of centralization or decentralization of activity, the continuity or scattering of development, and so on. For example, regions have often been differentiated as “monocentric,” with a single downtown area, and “polycentric,” with multiple identifiable concentrations of office and retail activity. In 1977, Thomson¹⁹ defined five different metropolitan archetypes based on the structure of the transportation system and the patterns of land use in the region: “full motorization” (e.g., Los Angeles); “weak center” (e.g., San Francisco Bay Area); “strong center” (e.g., New York); “low-cost strategy” (e.g., Manila); and “traffic-limitation strategies” (e.g., London). More recently, Cervero²⁰ classified cities by the match between land use patterns and the structure of the transit system and defined the categories of “adaptive transit,” where the transit system is designed to serve low-density patterns of growth; “adaptive cities,” where land use policies are designed to encourage development along a rail system; and “hybrids,” a mix of both approaches.

Data used to measure the different dimensions of the built environment come from a variety of local sources, such as property tax records, building permit records, aerial photos, and street and sidewalk inventories, and are often stored and available via geographic information systems (GISs). For example, a current project in Gainesville, Florida,²¹ mapped density, measured by the average ratio between floor area and parcel area for commercial land uses, for “traffic analysis zones,” geographic units widely used in transportation planning that are about the size of census tracts. The map shown in Figure 1 illustrates the relatively dispersed pattern of development in Gainesville.²¹ It bears repeating that such data sets are specific to particular metropolitan areas, and many metropolitan areas lack such recent and rich data sets for measures of the built environment. A recent study at the University of Texas²¹ assessed the availability of data for a variety of measures of the built environment for metropolitan areas in Texas and found many important gaps, particularly in the dimension of aesthetic qualities.²²

Data on the built environment are also available from national sources, giving urban planners the ability to conduct research across metropolitan areas. While usually more limited than local data sources, the national sources have the advantage of consistency of data collection and variable definition. National data on the built environment are available from the U.S. Census of Population and Housing, American Housing Survey, Census Transportation Planning Package, Natural Resources Inventory, and Census TIGER/line files. Data from these sources can be used to construct measures

of density and intensity, land use mix, and street network structure. A recent study funded by the Environmental Protection Agency on sprawl in different metropolitan areas used data from these sources to measure density (average lot size), street connectivity (average block length), and regional structure (density gradient). Figure 2 plots the proportion of households in the region that are within a half block of a business, a measure of land use mix, for metropolitan areas in the sample. These sources generally provide data for neighborhoods, as defined by traffic analysis zones or census tracts, but can be used to develop overall measures of the built environment for one or more metropolitan areas.

Travel Behavior

In the field of transportation planning, travel is generally defined according to “trips,” defined as the movement from one street address to another, and dissected into several components: the frequency of trips; the destination of trips and the resulting trip length; and the mode of travel, such as automobile, transit, walking, or biking. In addition, trips are differentiated by “purpose,” that is, the type of activity found at the destination, categorized as work, shopping, recreation, and so on. Travel can be analyzed at either the “disaggregate” level of the individual or the household, or the “aggregate” level of the traffic analysis zone or even metropolitan area. Disaggregate data are better suited for purposes of studying the link between the built environment and travel behavior because they enable more sophisticated behavioral modeling, as described in the following section, and because the use of disaggregate data averts the problem of ecologic fallacy, wherein relationships seen at the aggregate level do not hold at the disaggregate level.

Disaggregate data on the travel behavior of individuals and households are available for most major metropolitan areas. These data typically come from regional travel diary surveys conducted for purposes of long-range transportation planning. In most of these surveys, several thousand households in the region are asked to keep detailed diaries of all trips made by household members for ≥ 1 day. The data from the diaries then can be used to estimate trip frequencies, trip lengths and travel times, and mode choices. While these surveys concern themselves only with what are sometimes called “utilitarian” trips, the purpose of which is to reach specific destinations, they provide a starting point for broader activity-based research. In fact, many recent surveys have used activity diaries, which are structured around the activities (e.g., at home, shopping, and work) that household members participate in throughout the day rather than the trips they make (Table 2). Time-use surveys, which are

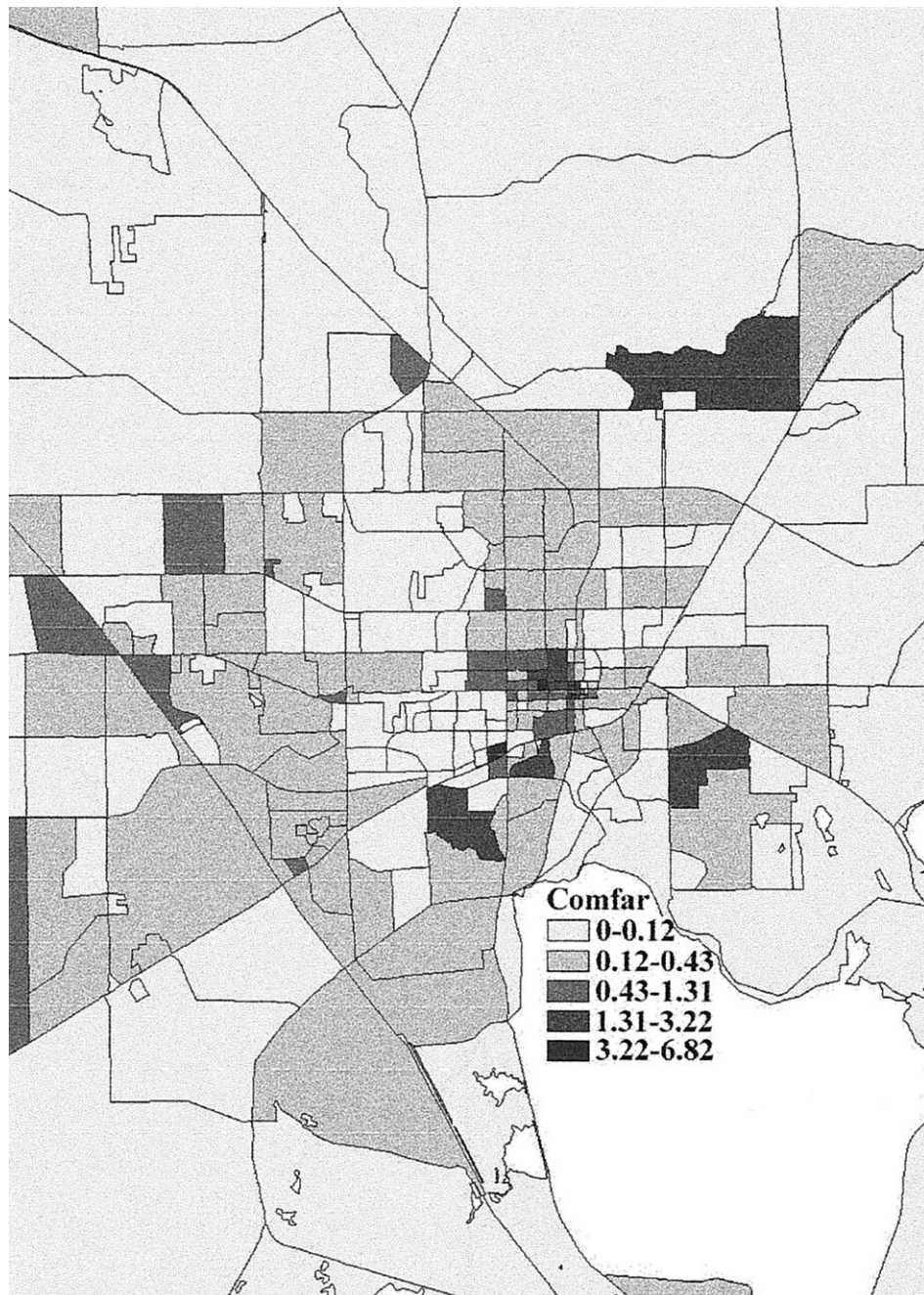


Figure 1. Commercial density in Gainesville, Florida (floor-area ratios for commercial uses).

structured according to regular time intervals throughout the day, are rarely used in transportation planning.

Both the travel-diary and activity-diary approaches are based on the assumption that travel is a “derived demand,” or that the demand for travel is derived from the demand for activities (as discussed further in the following section). In other words, they assume that individuals travel in order to reach a destination or participate in an activity and do not travel simply for the sake of travel. Thus, these sources largely omit travel for the primary purpose of exercise, unless that travel happens to involve a destination, such as when some-

one walks to the post office as an excuse to get out of the house for a little exercise. Activity-diary surveys may do a better job of collecting data about trips made solely for the purpose of exercise, although transportation planners generally agree that the data for walking trips are less complete than the data for automobile trips in both kinds of surveys.

Travel data are also available from national sources. These data are also collected at the individual and household level through travel diaries and other kinds of surveys, but are often presented in aggregate form. The U.S. Census and Census supplementary surveys

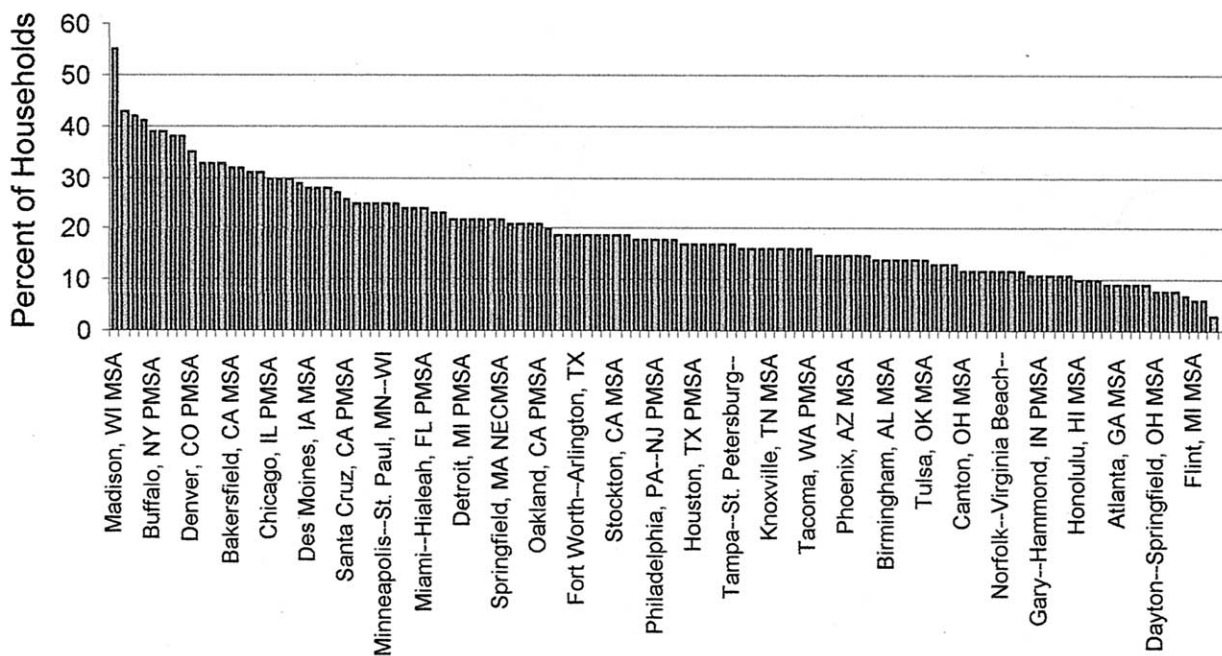


Figure 2. Percentage of households with businesses within a half block for major metropolitan areas in the United States

report data on the length and mode of the work trip. The American Housing Survey also provides data on work trips, as will the American Community Survey, a new effort associated with the national decennial census. The Nationwide Personal Transportation Survey (NPTS) provides the most comprehensive travel data at the national level collected through a travel-diary survey. The NPTS sample included 22,000 households in 1990 and 42,000 households in 1995. Renamed in 2001, the National Household Travel Survey will include 25,000 households in a national sample and another 40,000 households in areas participating as "add-ons." The survey thus provides important data on travel trends, although changes in the survey method have limited the comparability of data across years. Unfortunately, the diary data are available with place of residence identified only for the largest metropolitan areas, thus limiting the usefulness of this data set in studying the link between the built environment and travel behavior. These data on utilitarian travel can be supplemented by data collection instruments supported by the Centers for Disease Control and Prevention. These include the Behavioral Risk Factor Surveil-

lance System, National Health Interview Survey, and the National Health and Nutrition Examination Survey. These surveys report on a variety of leisure-time activities, including walking and bicycling.

Matching the Data

The challenge in using available data to study the link between the built environment and travel behavior is to find sufficiently detailed data on the built environment that are spatially matched to sufficiently detailed data on travel behavior. Travel-diary surveys conducted for transportation planning purposes provide detailed data for a sample of households distributed throughout the metropolitan area. However, the metropolitan-wide data sets on the built environment are generally limited to a few basic characteristics. To build a detailed database of built-environment characteristics requires a substantial investment of resources and necessarily involves extensive fieldwork. As a result, few places have built such databases for an entire metropolitan region. To address this challenge, researchers have thus far taken one of two approaches: (1) using existing travel data and making do with data on the built environment available for the entire metropolitan area,²³ or (2) conducting original travel surveys in selected neighborhoods and building detailed data sets on the built environment for those neighborhoods.^{13,14} However, advances in the use of GISs to derive measures of the built environment from a variety of existing data are making it easier to spatially match detailed travel data with detailed data on the built environment.

Table 2. Types of surveys used in travel behavior studies

Survey type	Structure	Primary question
Travel diary survey	Trips	Where did you go next?
Activity diary survey	Activities	What did you do next?
Time-use survey	Time intervals	What did you do during this time interval?

Table 3. Types of travel behavior studies

Type of study	Key characteristics	Examples
Simulation	Use of travel demand models to estimate impacts of changes in the built environment	Kulash et al. ²⁹ Stone et al. ³¹ McNally and Ryan ³⁰
Aggregate	Cross-sectional correlations between zone averages for travel and the built environment	Cervero and Gorham ³² Friedman et al. ³³ JHK Associates ³⁴
Disaggregate	Cross-sectional models of relationships between individual or household travel and the built environment	Cervero and Kockelman ¹⁴ Boarnet and Crane ²⁷ Handy and Clifton ²⁴

Making the Link Between the Built Environment and Travel Behavior

Since the early 1990s, studies of the link between the built environment and travel behavior have appeared in the literature with increasing frequency. Recent literature reviews document over 70 studies published during the 1990s that have explored and quantified these relationships.^{25–28}

Studies of the built environment and travel behavior have focused almost exclusively on automobile travel. From a transportation perspective, the automobile is by far the dominant mode of travel nationwide. According to the 1990 U.S. Census, 86.5% of all commute trips in the United States were in personal vehicles, 5.3% were on public transportation (bus and rail), 3.9% were walking trips, 0.4% were bicycle trips, 0.9% were by other modes, and 3% of people worked at home. Thus, transportation planning has naturally focused on car travel, and much of what is known about the built environment and travel behavior has been learned in this context. It is important to note that the relationship between the built environment and walking is different from the relationship between the built environment and driving. We review the literature on the built environment and driving here not because the results of that literature can be used to infer the relationship between the built environment and walking, but because the literature on driving provides concepts and methods that can be applied to studies of the built environment and walking.

Studies of the built environment and travel behavior can be divided into three groups: simulation studies, empirical studies with aggregate data, and empirical studies with disaggregate data (Table 3). The simulation studies ask how travel patterns would change if a small number of variables in the built environment changed, holding other characteristics constant.^{29–31} Because some elements of travel (usually driving) behavior are held fixed, these studies provide limited ability to assess a behavioral response to changes in the built environment. Thus, after the initial simulation studies in the early 1990s, attention in the literature shifted to empirical studies of travel behavior in different urban settings. These studies were almost always

cross-sectional, using existing variation in land use and urban design across different cities or neighborhoods to examine how differences in automobile travel are associated with differences in the built environment.

Studies using aggregate data typically examine mode split (the fraction of travelers going by a particular mode, such as transit or private vehicle, for example); vehicle miles of travel; and the number of trips as a function of characteristics such as density, the mix of residential and nonresidential land uses, and street patterns in geographic areas.^{32–34} Some of the studies use multivariate statistics to control for several variables at once. The insights were illuminating, but the behavioral process was sometimes obscured by the aggregate nature of the data. Some authors concluded that analyses of aggregate data established associations but did little to provide evidence of a causal link between the built environment and travel. Attention then turned to studies of disaggregate data that could match individual travel behavior to characteristics of land use and urban design.

The disaggregate studies are also almost exclusively cross-sectional, comparing individual travel behavior across places with different characteristics of the built environment, but nevertheless represent a significant improvement over aggregate studies. As a theoretical framework, most of these studies have followed on earlier work by viewing travel as a derived demand. According to this viewpoint, long held by economists, individuals travel to consume goods or participate in activities at the destination.³⁵ By understanding the demand for activities that require travel, one can understand the demand for travel. The assumption that travel is largely a derived demand has recently been called into question by Mokhtarian and Salomon.³⁶ Their research showed, for example, that the average commuter prefers a commute of about 16 minutes, rather than 0 minutes as the derived-demand assumption would suggest. For walking and bicycling, the derived-demand framework might be even more inappropriate, as discussed below.

Within the derived-demand framework, researchers have used two basic models of travel behavior: simple econometric models of trip making (number of trips or

miles of travel) and models of discrete travel choices (destination, mode, or both). The influence of the built environment has often been incorporated into models of the first type. In these models, trip making is defined as a function of the price of travel, the income of the individual, other sociodemographic characteristics of the individual, and characteristics of the built environment, as follows:

$$N=f(p, Y, SD, LU)$$

where

N = number of trips made or miles traveled by an individual in total or using a particular mode (e.g., by automobile or by walking)

p = price of travel, including out-of-pocket and time cost

Y = individual income

SD = sociodemographic characteristics of the individual

LU = characteristics of the built environment, typically near the person's residence, although characteristics of other locations, such as a workplace, can also be included

A model such this can be used to test hypotheses about how different elements of the built environment influence trip making.^{14,27,37} The model, based on microeconomic demand theory, has been applied almost exclusively to automobile travel. However, Handy and Clifton¹³ developed a model of the frequency of walking to the store using an equivalent framework.²⁴ This model showed that the distance to the store—or the price of travel—explained a significant portion of the variation in walking frequency, along with selected characteristics of the neighborhood and sociodemographic characteristics of the traveler, including the basic propensity to walk. Greenwald and Boarnet³⁸ also applied this framework to the study of walking and the built environment. They found that the median distance of an individual's walking trips (possibly a proxy for the distance to nearby walking destinations) was negatively associated with walking, and that characteristics of the built environment, such as higher density, land use mix, and street network connectivity, were positively associated with walking.

Discrete travel choices, such as the choice of destination or mode, are widely modeled using a utility-maximizing framework, also borrowed from microeconomics. In this framework, each possible choice in the "choice set" confers a certain "utility" or benefit to the traveler. The utility of each choice depends on both positive and negative characteristics of the choice, the characteristics of the decision maker, and the relative importance of all those characteristics. The model estimates the probability of a particular choice based on the utility of that choice relative to the utility of all choices. The application of this framework to the study

of travel behavior has been articulated by Domenich and McFadden,¹¹ Ben Akiva and Lerman,³⁹ and Train,⁴⁰ among others. Travel demand researchers have made significant contributions to the development of the literature on discrete choice models over the past four decades, and the utility-maximizing framework has been a powerful tool in the ongoing effort to model travel behavior. The model is usually formulated as follows:

$$P_{in} = \frac{e^{U_{in}}}{\sum_{j \in J_n} e^{U_{jn}}}, \text{ for all } i \text{ in } J_n$$

and

$$U_{in} = f(z_{in}, s_n, \beta)$$

where

P_{in} = probability that decision maker n will choose alternative i

J_n = set of alternatives for decision maker n

U_{in} = utility of alternative i for decision maker n

z_{in} = characteristics of alternative i as observed by decision maker n, including variables related to the built environment

s_n = observed characteristics of decision maker n, including variables such as income and auto ownership

β = coefficients for characteristics of alternatives and decision maker, reflecting their relative importance

Mode choice models developed using this framework have traditionally focused on the choice between driving and transit, or sometimes on driving alone, carpooling, or transit. Many of the mode choice models developed in recent years for transportation planning purposes in major metropolitan areas have included walking and biking, however. Even so, the variables used to represent these modes are usually limited to travel time and fail to account for other aspects of the built environment that influence the utility of these choices. These models have shown that travel time is the most significant predictor of mode choice and that out-of-vehicle travel time—walking and waiting for a bus—is considered more costly than in-vehicle travel time. These models thus explain the relatively low share of trips that are made by walking.

Extensions to Physical Activity Behavior

Despite the focus on automobile travel, models of both trip making (as in equation 1) and discrete travel choices (as in equation 2) have provided several insights that are potentially helpful in understanding the link between the built environment and physical activity. Two important results that almost certainly pertain

to the study of the built environment and walking are discussed below.

Changes in the urban environment influence the price or utility of travel. Many of the physical design elements advocated for by the new urbanism movement (such as mixed land uses, higher densities, and improvements in street and sidewalk connectivity) change the price or utility of travel, primarily by changing travel distance and time. However, for walking and biking, the quality of the travel experience, including perceptions of safety, comfort, aesthetics, and so forth, may also be important components of price or utility that are influenced by physical design.¹³

Geographic scale matters. To explain travel behavior, the built environment at the scale of the neighborhood as well as the scale of the region must be considered.^{13,41} However, automobile trips are more heavily influenced by the structure of the region than the characteristics of the neighborhood,^{37,42} while walking trips are more heavily influenced by characteristics of the neighborhood than by the structure of the region.³⁸

Both of these results point to a need for more analysis at the disaggregate level, using detailed data on both physical activity and the built environment at the individual or household level. To move beyond a rather general understanding of the link between the built environment and physical activity, researchers must address the issues summarized below.

A derived-demand perspective is too narrow for understanding walking behavior. The idea that travel is a derived demand, likely true in the case of much automobile travel, might be less applicable to walking. Some walking trips are pursued, at least in part, as an end in themselves.¹³ Both the trip-making model and the discrete-choice model can be adapted to study this broader conception of travel. Another approach is to combine the demand framework, which views travel as an adjunct to consumption and suggests that the minimization of travel time is the primary goal in travel choices, with perspectives from other disciplines. For example, psychological and social factors are probably more important for walking than for driving. The influence of friends and peer groups, perceptions about crime rates and personal safety, and the pleasure one gets from the aesthetic appeal of a streetscape are almost certainly more important determinants of walking behavior than of driving behavior.

Measures of the built environment must be refined to understand walking behavior. Measures of land use and urban design have typically been constrained by data availability and are relatively crude. This problem is likely more severe in the context of walking than driving, for several reasons. GISs have been used in the past to measure the connectivity of street systems^{43,44}

and accessibility to local shopping,¹³ but sidewalk information is not as readily available from current GIS databases. Aesthetic features, such as the presence or absence of street trees, graffiti, benches, and blind alleyways might influence walking,⁴⁵ but few studies have measured such characteristics in a consistent manner. More fundamentally, qualitative research methods should be used to identify the characteristics of the built environment that should be measured and to explore appropriate ways of measuring them.

More complete data on walking behavior must be developed. Most sources of travel data used in the transportation planning field provide limited and probably inaccurate data about walking. Most notably, travel-diary surveys focus on travel to a destination rather than travel as an activity in and of itself. Walking and bicycling trips not associated with a destination may be omitted entirely, and researchers have generally concluded that even walking and biking to destinations are under-reported in these surveys. Current experiments with the use of global-positioning-system devices as a way to collect more complete data on physical activity show promise. Whatever approach is used, data on walking behavior must be spatially matched to detailed data on the built environment.

Conclusions

Walking and bicycling have been more successful as modes of exercise than as modes of travel. Compared to other modes of exercise, walking and bicycling are popular because they are relatively easy for the vast majority of the population and offer relatively little risk of injury. But compared to other modes of transportation, walking and bicycling play a minor role. The explanation is simple: Driving is considerably faster than walking or biking for most trips. But it may be possible to increase this share in a couple of ways. First, programs to promote the health benefits of walking and convince the public that walking is time well spent might tip the balance toward walking in more situations, particularly for the 25% of trips that are <1 mile in length. Second, efforts to increase the pedestrian orientation of the built environment through mixed-use development, street connectivity, and good design, among other strategies, can enhance both the feasibility and the attractiveness of walking and bicycling by reducing physical and psychological barriers. Even a small increase in walking would help to substantially improve the health and quality of life of most people.

Understandably, many questions remain about the interconnectedness of the built environment, travel behavior, and public health. The challenge is to understand the interrelationship between the built environment and human behavior and then to develop models that can predict the environmental conditions under

which humans will be more physically active. Such models can assist planners in the design and management of the built environment so as to promote physical activity. The available evidence lends itself to the argument that a combination of urban design, land use patterns, and transportation systems that promotes walking and bicycling will help create active, healthier, and more livable communities. Collaborative research efforts that build on the research paradigms of the fields of both urban planning and public health are essential to making further progress in the effort to build healthier and more livable communities.

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