Evaluating Neighborhood Accessibility: Possibilities and Practicalities

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ABSTRACT

Efforts to improve transportation choices and enhance accessibility at the neighborhood level have been hampered by a lack of practical planning tools. This paper identifies the factors that contribute to accessibility at the neighborhood level and explores different ways that planners can evaluate neighborhood accessibility. A gap between the data needed to describe important accessibility factors and the data readily available to local planning departments points to two complementary strategies: a city-wide approach using available data and geographic information systems to evaluate accessibility for neighborhoods across the city, and a neighborhood-specific approach to building a detailed accessibility database. Examples of both are presented.

INTRODUCTION

Several trends in the 1990s brought new attention to the importance of alternatives to driving. Federal transportation policy, as shaped by the Intermodal Surface Transportation Efficiency Act of 1991 and the Transportation Equity Act for the 21st Century of 1998, emphasizes transit, as well as walking and biking, out of concern for both the environment and equity of service. The New Urbanism move-

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ment has focused attention on how the design of neighborhoods encourages or discourages walking, among other things, and has given weight to the idea that land-use regulations are also an important element of a transportation program. In addition, the relative lack of services in many lower income neighborhoods, where auto ownership is often low as well, has been the target of renewed attention in recent years. In response, planning agencies are taking a new look at both transportation policies and neighborhood planning in an effort to enhance transportation choices. Their efforts are hampered, however, by a dearth of applicable planning tools, particularly measures or indicators that can be used to identify problems and needs, determine the adequacy of current policies, or evaluate the impacts of proposed policies at the neighborhood level.

Planners are beginning to turn to accessibility measures as a way of evaluating the availability and quality of basic services and alternative modes at the neighborhood level. As generally defined, accessibility reflects the ease of reaching needed or desired activities and thus reflects characteristics of both the land-use system (where activities are located) and the transportation system (how the locations of activities are linked). Extensive academic literature on accessibility measures suggests many ways to define and measure accessibility, although examples of the actual use of accessibility measures in planning are relatively scarce. In addition, the literature offers few approaches that adequately assess accessibility to different modes of travel at the neighborhood level. While traditional measures of accessibility focus on the distance to and size of potential destinations, for example, other characteristics of the local environment may have an important impact on modes like walking and biking. Unfortunately, incorporating such qualities into an assessment of accessibility requires data that are not readily available or easy to collect, a real obstacle to developing practical accessibility measures. In addition, traditional measures of accessibility combine a variety of factors to produce a single measure of accessibility. This approach is useful for comparisons but masks important qualities of the neighborhood that contribute to accessibility. As an alternative, planners might build and analyze an accessibility database rather than calculate an accessibility measure.

The goals of this paper are twofold: to identify the factors that contribute to accessibility at the neighborhood level and to explore the options available to planners for measuring this accessibility. A gap between the data needed to describe important accessibility factors and the data readily available to planning departments points to two complementary strategies for measuring accessibility: a city-wide assessment of neighborhood accessibility using existing data sources and the capabilities of geographic information systems (GIS), and a neighborhood-specific approach to building a detailed accessibility database. This paper begins with a brief overview of the literature on accessibility measures and a summary of factors identified in travel behavior research and planning practice that may contribute to neighborhood accessibility. After establishing a framework for evaluating neighborhood accessibility, the paper turns to an assessment of available data sources and a discussion of the two proposed approaches to measuring neighborhood accessibility.

MEASURING ACCESSIBILITY

Accessibility is an important concept for urban planners because it reflects the possibilities for activities, such as working or shopping, available to residents of a neighborhood, a city, or a metropolitan area. Accessibility is determined by attributes of both the activity patterns and the transportation system in the area. The spatial distribution of activities as determined by land development patterns and their qualities and attributes are important components of accessibility, as are the qualities and attributes of the transportation system that links these activities, such as travel time and monetary costs by mode. Although most researchers agree on this general definition of accessibility, they have developed a wide variety of ways to measure it.

The literature on accessibility measures has a long history. Most measures can be classified as one of three basic types (Handy and Niemeier 1997). *Cumulative opportunities measures* are the simplest type. These measures count the number of opportunities reached within a given distance or travel time and give an indication of the range of choices available to residents. *Gravity-based measures* are derived from the denominator of the gravity model used to predict trip distribution; these measures weight the amount of activity at different destinations by the cost, time, or distance to get there. The third type of measure is based on *random utility theory,* in which the probability of an individual making a particular choice depends on the utility of that choice relative to the utility of all choices; the accessibility measure comes from the denominator of the model and reflects the total utility of all choices. In general, the three approaches offer different tradeoffs between the simplicity and thus ease of comprehension of the measure and the sophistication with which the activities and transportation system are characterized. The more sophisticated measures also require more sophisticated data.

In developing a practical technique for assessing neighborhood accessibility, a number of questions must be addressed. First, what factors tend to matter most to residents? Clearly it is impossible to measure, let alone know, every factor that matters to every resident. Fortunately, a number of studies help to identify the factors that seem to be most important to a majority of residents, and a list of these factors is compiled below.

Second, what kind of data are available or can be collected about these factors? The data commonly used by planning departments miss many of the factors important to neighborhood accessibility and may not be available in a useful format if they are available at all. These issues are explored in the section on data availability.

Third, how can planners make sense of the available data on neighborhood accessibility factors? Traditional accessibility measures can, depending on their structure, specification, and calibration, combine a number of important factors into a single, all-encompassing measure of accessibility. This approach, however, may be neither practical nor desirable for planning purposes. The more complex the measure the more data and analysis skill required, limiting the ability of most planning departments to develop such measures. The development of utility-based measures, for example, is probably beyond the capability of most departments. In addition, much important information is lost when the data are collapsed into a single or even a few measures. Traditional measures of accessibility may help planners identify neighborhoods with relatively high or low accessibility, but they do not, on their own, point to the specific factors contributing to accessibility. As an alternative, the possibilities and practicalities of developing a database of neighborhood accessibility factors using either a city-wide or neighborhood-specific approach is explored in this paper and this effort is described in the section on strategies.

Finally, the use of the neighborhood as the spatial unit of analysis presents both opportunities and challenges. Analysis at the neighborhood level allows for a more detailed examination of the qualitative characteristics of the local environment than would an analysis at a larger geographic level. However, if neighborhoods are defined by their natural boundaries, usually major arterials or open space, their areas and populations may vary considerably. Some normalization by area or population may be necessary if the goal is to compare accessibility between neighborhoods. In addition, accessibility may vary considerably within a neighborhood depending on the distribution of retail and services relative to the population within and beyond the neighborhood. Therefore, it is important also to evaluate accessibility from different points or for different areas within the neighborhood. Residents also make use of activities outside of the neighborhood, not just those found within their boundaries. Thus, an assessment of accessibility within the neighborhood would provide only part of the picture. On the other hand, an assessment of accessibility within and beyond the neighborhood must consider what distance beyond the neighborhood is appropriate. These issues arise in many of the examples presented in the strategies section of this paper.

The first step in designing a neighborhood accessibility database is to identify the factors that contribute to accessibility for residents. Although few studies address this need directly, we found a number of studies that provide insights into the factors that matter to residents and a smaller number that provide ways of measuring these factors. These studies can generally be classified in two ways: empirical studies of travel behavior and level-of-service measures designed for use in planning practice. Although both types prove useful in identifying potentially important accessibility factors, both also have notable limitations. In the case of the former, observed behavior, which is constrained by the available options, provides a convenient but imperfect way of assessing true preferences and priorities. In the case of the latter, the relative importance of different factors is often assumed rather than tested. Nevertheless, these studies provide an important starting point.

Activity Factors

The most basic characterization of activity is that a particular type of activity can be found at a particular location. Cumulative opportunities measures, for example, typically reflect a simple tally of locations of a particular type of activity. Another common approach is to account for the relative amount of activity at each location, usually measured by the number of employees or the square footage of buildings. This approach is commonly used in both gravity measures and utility measures of accessibility. But beyond the existence of an activity and the amount of an activity at a particular location, what factors influence the attractiveness of a particular destination to residents?

Our previous research identified several specific characteristics that residents consider in evaluating the activities in and around their neighborhood; these characteristics range from mostly objective to highly subjective (Handy et al. 1998; Handy and Clifton 2001). The more objective factors of an activity such as grocery shopping include size of store, prices, ease of parking, and range of product selection. More subjective factors include quality of products, crowds, and length of check-out lines. Highly subjective factors like atmosphere also matter. The relative importance of such factors is difficult to assess, however. Not only does the importance of these factors vary by individual, but it may vary at different times for each individual: residents may use different criteria in evaluating stores for major food shopping than for a trip to buy a gallon of milk, for example.

Recker and Kostyniuk (1978) studied factors that influence destination choice for grocery shopping trips in urban areas. Their study included a survey of respondents' perceptions of grocery stores they frequented on a variety of different attributes. Using factor analysis, they reduced these attributes to four factors: quality (determined by reasonable prices, variety of items, meat and produce quality, and selection of goods), accessibility (determined by ease of getting from home to stores and back and to stores from work), convenience (determined by parking facilities, proximity to other shops, hours of operation, ease of finding items in stores, and crowding in stores), and service (acceptance of credit cards, check cashing, and ease of returning goods). In the destination choice models estimated, only the service factor proved insignificant.

Research in the field of retailing provides additional insights into factors that influence a customer's choice of a particular establishment. A 1980 study by Nevin and Houston, for example, looked at the role of image in the attractiveness of urban shopping areas. Besides factors such as the quality of stores, the variety of stores, product quality and selection, and general price level, they found that the availability of lunch or refreshments, the adequacy of restrooms, the friendliness of the atmosphere, the helpfulness of store personnel, and whether the center was an easy place to take children also contributed to the attractiveness of a shopping area.

These studies suggest a list of factors that contribute to the attractiveness of a particular activity site. These factors can be grouped as relating to the activity itself or relating to the design of the site (table 1). This list is by no means exhaustive, but it gives a sense of the wide range of factors that contribute to attractiveness. It is also important to remember that the relative importance of these factors will vary depending on the type of activity.

What activities to include in an assessment of neighborhood accessibility is also an important question. Most examples of accessibility measures in the literature use total retail and service employment without further differentiation of activity types. Some studies focus on specific kinds of activities, such as grocery shopping (Handy and Niemeier 1997) or health care services (Wachs and Kumagai 1973). One study (Handy et al. 1998) gives some indication of the local businesses most frequently used by residents of six Austin, Texas,

TABLE 1 Activity Factors

Factors related to activity	Size and scale Quality of products/services Variety of products/services Price of products/services Hours of operation Crowds/lines Interior design Atmosphere Ownership (local vs. chain) Customer recognition
Factors related to site design	Mix of activities at site Density of activities at site Parking facilities Atmosphere Landscape design

neighborhoods. Supermarkets and grocery stores topped the list, followed by drug stores, restaurants, discount stores, convenience stores, video stores, laundromats or dry cleaners, and bakeries. This list can serve as a guide to activities to include in an assessment of neighborhood accessibility. What it leaves out, however, are possible high-priority activities not located in or near those particular neighborhoods.

Transportation Factors

Just as important as the activities found in and around the neighborhood are the options residents have for getting to them. Distance and time are used most often as measures of impedance in accessibility functions and represent the burden required to travel to a particular destination. While distance and time can be important considerations in the decision to drive, walk, bike, or ride transit, additional factors contribute to the varying degrees of accessibility offered by different modes of travel in different neighborhoods. Mode choice models and level-of-service measures as well as exploratory studies suggest a long list of transportation factors that contribute to neighborhood accessibility for different modes (table 2). These factors can be categorized as impedance, level-of-service, terminal, and comfort.

Accessibility factors for drivers are, perhaps, the most straightforward. Mode choice models consistently show that travel time, or sometimes a generalized travel cost including travel time and monetary costs, is the most significant factor to drivers. Factors that influence the travel time or cost, including traffic volume, signalization, directness of route, and continuity of route, may also be important as well as the availability and cost of parking at the destination. Some drivers may consider comfort factors in their perception of accessibility. Poor lighting, bad weather, excessively high or low traffic speeds, high volumes of traffic, unappealing scenery, inadequate signage, or poor pavement condition may contribute to a negative perception of accessibility. The importance of these perceptual factors is mostly undocumented. Work by Ulrich et al. (1991), however, shows that the kind of chaotic visual environments found along many arterials in metropolitan areas significantly increases driver stress.

Mode choice models further show that travel time is the most significant factor in the decision to use transit. However, most models also show that transit users differentiate between in-vehicle and out-of-vehicle time, assigning significantly greater cost to the latter. This finding reflects the exposure of the transit user to the elements as well as to the uncertainty of transit service. As a result, amenities such as benches and shelters are important to transit users as are factors that influence the feeling of safety while waiting, including lighting, the speed and volume of passing traffic, and crime levels in the area. A study of customer satisfaction among riders of the San Francisco, California, Bay Area Rapid Transit (BART) system (Weinstein 2000), for example, used factor analysis to group over 40 attributes of the system into 8 factors influencing satisfaction, listed in order of relative importance: service and information timeliness, station entry and exit, train cleanliness and comfort, station cleanliness, police presence, policy enforcement, and parking.

Although pedestrians also are sensitive to travel time and are limited in how far they can travel by walking, they are also highly sensitive to the character and quality of the environment through which they walk. One study showed that perceptions of safety, shade, and the presence of other people were important determinants of the fre-

TABLE 2 Transportation Factors by Mode

	Automobile	Transit	Walking	Bicycling
Impedance factors				
Distance	X	X	X	X
In-vehicle time	X	X		
Out-of-vehicle time	X	X	X	X
Cost	X	X		
Topography			X	X
Level-of-service factors				
Volume/crowding	X	X	X	X
Signalization	X	X	X	X
Service frequency		X		
Hours of operation		X		
Directness of route	X	X	X	X
Continuity of route	X	X	X	X
Information availability		X		
Signage	X	X	X	X
Facility widths	X		X	X
Vehicle design	X	X		X
Shelter		X	X	X
Benches		X	X	
Terminal factors				
Parking availability	X	X		X
Parking cost	X	X		
Terminal locations		X		
Intermodal connections		X	X	X
Terminal design	X	X	X	X
Comfort factors				
Traffic speed	X	X	X	X
Traffic volume	X	X	X	X
Pavement condition	X	X	X	X
Lighting	X	X	X	X
Weather	X	X	X	X
Shade		X	X	X
Scenery	X	X	X	X
Crime/police presence		X	X	X
Cleanliness		X	X	X
Conflicts with other modes	X	X	X	X
Other users	X	X	X	X

quency with which residents walked in the neighborhood (Handy et al. 1998).

Several recent efforts to evaluate the pedestrian environment also point to important accessibility factors. In the LUTRAQ ("Making the Land-Use, Transportation, Air Quality Connection") studies, a Pedestrian Environmental Factor was calculated from four factors: ease of street crossing, sidewalk continuity, local street connectivity, and topography (1000 Friends of Oregon 1993). In Fort Collins, Colorado, a pedestrian level-of-service measure was used to evaluate the traffic impacts of new development. This measure incorporated the directness of street layout, the continuity of sidewalks, the width of street crossings, visual interest and amenities, and security and safety evaluations (Moe and Reavis 1997). Gainesville, Florida, developed a pedestrian level-of-service measure that included the provision of a pedestrian facility, conflict points with vehicles, amenities, motor vehicle level-of-service, maintenance, and transportation demand management or multimodal policies (Dixon 1995). Pedestrian level-of-service is also influenced by the degree to which sidewalks and curb ramps meet the requirements of the Americans with Disabilities Act of 1990. Sidewalk characteristics such as driveway crossings, cross slopes, level irregularities, clearance widths, and protruding objects determine the accessibility of sidewalks to persons with disabilities (Axelson et al. 1999); parents with strollers; children on skateboards, scooters, or bicycles; and pedestrians in general.

Bicycle riders are influenced by a mostly parallel set of factors. The Federal Highway Administration's (FHWA) National Bicycling and Walking Study included an assessment of the reasons why bicycling is not used more extensively (USDOT 1992). In reviewing a number of surveys on bicycle use, this study found that primary deterrents to cycling included traffic safety concerns, adverse weather, inadequate parking, and road conditions, and that secondary deterrents included fear of crime, lack of bicycle routes, inconsiderate drivers, and inability to bring bicycles on buses. FHWA has, more recently, developed a "bicycle compatibility index" to evaluate the appropriateness of a roadway for bicycle use. This index includes the presence and width of a bicycle lane, curb lane width, traffic volume in the curb lane and other lanes, traffic speed, parking lane presence and occupancy, truck volume, parking turnover, and right-turn volume (USDOT 1999). Gainesville also developed a bicycle level-of-service measure similar to its pedestrian measure but with slightly different definitions of each factor (Dixon 1995).

DATA AVAILABILITY

Unfortunately, data for only a few of the accessibility factors identified earlier are readily available. Data can usually be found for basic characteristics of land use and transportation systems, but data on qualitative and subjective factors are scarce; these factors are hard to assess and the accuracy and stability of the observations are often questionable. The result is a significant gap between the data needed to describe important accessibility factors and the data readily available to planning departments.

Land-Use Data

At a minimum, an accessibility analysis requires information about what kinds of activities exist and where they are located. The availability and level of detail of land-use data often vary by local planning department. Data about employment are more difficult to find than data about residents, which are available through the decennial census. Most metropolitan planning organizations (MPOs) and some cities have developed databases of employment by type and by area, census tract or traffic analysis zone, but the quality of such data is notoriously poor and the categories of employment are usually quite broad. Data on floor space by type of commercial or industrial use can sometimes be extracted from the databases of local tax assessors, and zoning classifications are also sometimes used as an indication of land use. However, it is often difficult to find accurate and specific information about current land use in electronic format, and collecting detailed information through field work can be laborious and time consuming. In most cases, data on the quantity of several general categories of activities at the zone or tract level are available, if nothing more.

Business and residence telephone directory listings provide more specific data on land use and are readily available in electronic format. For a study of accessibility in Austin, Texas, neighborhoods, the Select Deluxe CD-ROM was used for the year 1996[1] (Handy and Clifton 2000). These data include business or residential name, address, phone number, and geographic coordinates in latitude and longitude. Business listings also include approximations of the appropriate Standard Industrial Classification (SIC) codes to the four-digit level.

The use of telephone listings as a source for land-use data offers several advantages. First, the data are readily available and relatively inexpensive. The CD-ROM can be purchased at many computer

[1] Select Deluxe CD-ROM is available from ProCD, Inc., 222 Rosewood Drive, Danvers, MA 01923, http://www.procd.com.

software retail stores, and data for the entire United States cost less than $150 as of this writing. Second, the SIC approximation allows for easy classification of business types and thus permits disaggregate analysis on specific industries or services. Third, the addresses for business and residential listings are already geocoded and can be easily imported into GIS software. Last, the availability of disaggregate data for an entire urban area permits a detailed analysis at both the local and regional levels. However, using these data for accessibility analysis also has its drawbacks. Establishments with multiple telephones are overrepresented in the database, and businesses without a phone at the time of publication are missing from the data set. Also, the SIC codes are only approximations based on the category under which the business is listed in the directory.[2] In addition, frequent business turnover reduces the accuracy of the available data, and those listings that do not include an address in the telephone directory are omitted. Although these data provide detailed information about the location and type of establishment, other land-use characteristics such as size, quality, or site design cannot be obtained from this data set.

Transportation Data

The availability and detail of transportation information also varies widely by planning department. In most areas, zone-to-zone characteristics such as travel time or travel cost are available, but data are not usually available for travel within neighborhoods and for modes other than automobile and transit. The task of compiling the necessary transportation data is complicated by the lack of coordination between the various government agencies responsible for data on different transportation factors.

Transportation network files can be obtained from the U.S. Census Bureau in the TIGER/Line files. Enhanced and updated network files can be obtained from private vendors, MPOs, or other local agencies. These files allow for distance calculations between points on the network, although travel times are usually more important to residents. Estimating the travel times between two points requires estimations of the average travel speeds for each link in the network, which for drivers is dependent on traffic volume. Data on automobile travel times are available from regional transportation planning models usually maintained by MPOs. These data can be problematic, however; they are not always accurate, are not available for most local roads in the network, rarely include temporal variations, and give zone-to-zone rather than point-to-point times. As an alternative, speed limits can be used to estimate travel time, but speed limit data are often not available in GIS format. A few studies have estimated point-to-point travel times and distances using the capabilities of a transportation modeling package (Handy 1996; Handy et al. 1998) or GIS (Crane and Crepeau 1998). These estimates provide a reasonably accurate indication of driving distances at the neighborhood scale and also walking and biking distances.

Data for modes other than driving are often more difficult to locate. For transit, data about the location of transit stops, routes, capacity, and schedules are usually available but not always in electronic format. Accurate information about the spatial distribution of benches, shelters, and lighting, and crime and safety statistics is less often available. For example, as of this writing, Capital Metro, the transit authority in Austin, Texas, has data on the locations of transit stops in electronic format but no additional information about the stops, such as presence of bus shelters, that might be valuable in an accessibility analysis. Ridership information has been available in electronic format by route and stop for some time, but bus routes have been added only recently.

Data on infrastructure for pedestrians and bicycling are not generally available, although this situation seems to be changing. Some cities may have an inventory of sidewalks, but such data seem rarely to be in electronic form. In the mid-1990s, the city of Portland, Oregon, completed a city-wide sidewalk inventory that required considerable time and labor. Data on other factors that influence the quality of the walking and biking experience, such as tree canopy, can sometimes be extracted from aerial photos. Data on more qualitative factors, such as the scenery and the presence of interesting

[2] In an ironic, and we hope inadvertent twist, we found driving schools (of the sort for ticketed drivers) classified as "drinking places."

houses or gardens to look at, can only be evaluated through field work and the development of criteria by which to judge such factors. The LUTRAQ study used such a system to evaluate less qualitative factors, such as topography and the interconnectedness of the street network (1000 Friends of Oregon 1993).

The changing attitudes about alternate modes and the availability of federal funding for transit, bicycling, and pedestrian projects have influenced some planning agencies to focus more attention on the deficits in modal data. In Austin, Texas, an extensive effort was initiated to collect data about the street conditions and physical characteristics along existing and proposed bike routes and their adjacent streets. Data about traffic volume and speed, pavement condition, street and lane width, presence and continuity of bike lanes, number of stop signs and traffic signals along the route, and other objective criteria were compiled. Based on this information, the street segments were then ranked for bicycle friendliness and published on the bicycle route maps for public distribution. Such efforts can contribute to the development of a database of accessibility factors for use in both neighborhood-specific and city-wide analyses.

STRATEGIES

What can a planning department do, given the gap between the data needed to describe important accessibility factors and the readily available data? Two complementary strategies might prove useful: one is a city-wide approach using existing data and GIS to evaluate accessibility for neighborhoods across the city and the other involves a neighborhood-specific approach to building a detailed accessibility database. If the goal is to compare accessibility across neighborhoods to identify neighborhoods with deficiencies in accessibility or to evaluate the equity impacts of proposed policies, then a city-wide approach makes sense, even though the available data are limited to the most basic accessibility factors. If the goal is to develop a neighborhood plan, then the neighborhood-specific strategy might prove useful, even though extensive data collection is involved. Planning departments might employ both strategies at different stages of a planning effort.

City-Wide

Several recent research projects demonstrate some of the ways that existing data can be combined with the capabilities of GIS to evaluate accessibility at a relatively coarse level on a city-wide basis. In all these examples, researchers point to the power of visualization as an important benefit of the use of GIS for accessibility analysis.

Talen (1998) used GIS to evaluate the distribution of public facilities, such as parks, in terms of the match between the facilities provided and the needs of residents and in terms of the equity of the distribution across socioeconomic groups. Four different measures of access from census blocks to parks were calculated: the *gravity model,* with parks weighted by size and separation distance between origin and each park destination; *minimizing travel cost,* determined by the straight-line distance between each origin and each park destination; *covering objectives,* measuring the number of parks located within a critical distance (essentially a cumulative opportunities measure); and *minimum distance* between each origin and the nearest park. This study demonstrates the power of GIS as a tool for evaluating accessibility across an urban area and the impact of public facilities plans on the equity of accessibility patterns. As Talen points out, the analysis can be refined through more precise measurement of accessibility, including an assessment of the quality of the facility or service, the use of origin zones smaller than census blocks, and more sophisticated measures of transportation. However, the increased costs of data collection and analysis may outweigh any benefits from increased precision. “The real benefit of the approach outlined in this paper is that it is a technique that is readily available to local planners” (Talen 1998).

A study by Grengs (2000) underway at Cornell University uses GIS to evaluate accessibility of inner-city neighborhoods to supermarkets. The initial approach was to use a buffer of a given distance around a bus line that serves a supermarket and then analyze the portion of each traffic analysis zone within the buffer area. Assuming that population and households are uniformly distributed throughout the zone, the area within the buffer can then be translated into the share of population within the buffer and, in particular, the share of carless households within the buffer. Grengs points to several limitations of this analysis. First, the analysis would ideally account for the affordability and quality of products offered by each supermarket. Second, the buffers were drawn around bus lines rather than bus stops given limitations of the data. Third, only transit trips possible without transfers were considered. Fourth, the approach estimates equal accessibility for households with and without cars. Nevertheless, an application of the analysis approach to Syracuse, New York, points to the probability of underestimated disparities in accessibility to supermarkets for low-income and African-American households.

The British Government's Planning Policy Guidance 13, which encourages plans that promote development at locations accessible by modes other than automobile and that improve access by non-car modes, has led to the creation of at least two models that evaluate accessibility using GIS. One project evaluated both the accessibility of a particular residential location to public transit, *local accessibility,* and the accessibility of locations to specific destinations using public transit, *network accessibility* (Hillman and Pool 1997). Local accessibility was calculated as a combination of the walk time to a transit stop and the average wait time for service at that stop. For each residential location, access to all possible stops was evaluated and combined into one measure. Network accessibility was calculated by defining a set of destinations (e.g., schools or shopping centers), identifying the transit routes that link the residential zone to the selected destinations, and estimating the total travel time to those destinations. An integrated system consisting of a GIS and public transit planning software was used to compile an extensive database and calculate accessibility measures, but the lack of required data on public transit systems has been an obstacle to the more widespread use of this tool.

A second U.K. project focused on selected destinations and determined the number of residents within various travel times of a destination by each transportation mode (Hardcastle and Cleeve 1995). Although data on land uses and road networks were readily available for this model, estimates of travel times by mode were relatively crude, depending on assumptions about the match between the pedestrian network and the road network, for example, and about average travel speeds by mode.

In an exploration of the potential for using GIS with available data to assess neighborhood accessibility on a city-wide basis, a variety of measures was calculated for seven neighborhoods in Austin, Texas (Handy and Clifton 2001). Simple counts of the numbers of selected types of retail establishments located within buffers of various distance around the neighborhood were used to measure activity *intensity* (total number of establishments); *diversity* (number of types of activities); and *choice* (number of establishments of each type). These measures were also normalized for neighborhood population and for neighborhood area in order to facilitate comparisons. A more direct assessment of the number of retail establishments found in one neighborhood compared with others was made using a location quotient, defined as the share of establishments of a certain type within a neighborhood relative to the share of establishments of this type for the city overall. A value greater than one indicates that the neighborhood has a greater share of establishments of that type than the city as a whole and may thus be overserved; a value less than one indicates that the neighborhood may be underserved. A high location quotient is not always positive, however. The location quotients for seven neighborhoods in Austin showed that the low-income neighborhood had over nine times the share of drinking establishments as the city overall. These analyses demonstrate both the usefulness and the limitations of relying on existing data and the capabilities of GIS to assess neighborhood accessibility.

Neighborhood-Specific

The available data and the capabilities of GIS clearly fall short of providing planners with a full assessment of the factors that influence neighborhood accessibility as listed earlier. Developing a comprehensive neighborhood accessibility database, consisting of detailed data about a wide range of accessibility factors for all neighborhoods in a city, requires a significant commitment of resources on the part of a planning department. An intriguing alternative is to make data collection itself an important part of the planning process and to use neighborhood residents to design and build the neighborhood accessibility database. Not only is this approach cost-effective for the city, it uses data collection as way to facilitate public involvement and build technical capacity within neighborhoods, important benefits in their own right.

In Austin's neighborhood planning program, for example, residents and other local stakeholders are responsible for developing their own plan for the neighborhood, with guidance and some assistance from city staff. An early task is to compile data about existing conditions in the neighborhood, such as inventories of existing land uses and infrastructure and an assessment of the condition of infrastructure. In addition, the planning team is required to conduct surveys of residents' concerns and priorities. This approach has many benefits. Such data-collection efforts are labor-intensive and thus need many volunteers from the neighborhood involved. Those who participate learn the kinds of information useful for planning purposes and the techniques effective in collecting that information. Participants are likely to understand and appreciate the results more than if city staff simply presented the results to them. In addition, participants can decide for themselves which accessibility factors are of greatest importance. The data produced by this effort can also be incorporated into a detailed city-wide database, constructed over time as more neighborhoods participate.

Providing the neighborhood planning team with direct access to GIS software and sufficient training to use it effectively could be even better and may not be as costly or impractical as one might think, as demonstrated by a growing number of examples. In 1993, a group of graduate students at the University of Wisconsin-Milwaukee developed a process for training neighborhood residents to use GIS to analyze a publicly accessible database of property characteristics, including ownership, zoning, land use, assessed value, and other useful information (Myers 1994). One step in the process included a walk through the neighborhood to collect information about the condition of properties. The project succeeded in providing residents with the capability to use GIS to analyze and address a variety of problems in the neighborhood. In Philadelphia, the city has allocated funds to Community Development Corporations (CDCs) for GIS hardware, software, and training so that the CDCs can better illustrate the quality and character of the environment of the neighborhood (Casey and Pederson 2000). Such examples hint at the power of GIS not only as a planning tool but also as a public involvement technique.

CONCLUSIONS

As efforts to promote the use of modes other than driving grow and as neighborhood planning programs proliferate, planners need new and better tools to identify problems, highlight inequities, and evaluate potential solutions at the neighborhood level. The concept of neighborhood accessibility provides a useful framework for the development of such a tool. As defined here, neighborhood accessibility includes a wide range of factors that describe both the quantity and quality of activities in and around the neighborhood and the characteristics of the transportation systems that link one activity to another. The key to identifying the factors that contribute to accessibility is to examine their relative importance to residents. Although no systematic effort has been undertaken to catalog these factors, a review of the literature points to a long list of factors likely to be important.

Unfortunately, data are readily available for only a small subset of these factors. The gap between the data needed to measure these factors and the data that are readily available demands a creative approach to measuring accessibility. Two strategies are proposed here: a city-wide strategy using available data and the capabilities of GIS and a neighborhood-specific strategy that asks residents themselves to build a detailed accessibility database as a part of a neighborhood planning process. Several documented planning efforts provide examples of how these strategies might be implemented and the kinds of benefits they can produce. Other strategies may also prove effective. This paper provides a starting point and, it is hoped, will lead to new efforts and greater creativity on the part of others to define and measure neighborhood accessibility.

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