EVALUATING MEASURES OF GEOGRAPHIC ACCESSIBILITY
TO HEALTH CARE IN URBAN DIABETICS OF CUYAHOGA COUNTY

by

CONSTANCE WEI-FANG LIU

Submitted in partial fulfillment of the requirements
For the degree of Doctor of Philosophy

Dissertation Adviser: Dr. Duncan Neuhauser

Department of Epidemiology & Biostatistics
CASE WESTERN RESERVE UNIVERSITY

May, 2008
We hereby approve the dissertation of CONSTANCE WEI-FANG LIU, candidate for the Doctor of Philosophy degree.*

(signed) David Litaker, MD/PhD

Duncan Neuhauser, PhD

Doug Einstadter, MD/MA

Mei-po Kwan, PhD

(date) January 3, 2008

* We also certify that written approval has been obtained for any proprietary material contained within.
# TABLE OF CONTENTS

Acknowledgements ............................................................................................................ 4  
List of Abbreviations ......................................................................................................... 5  
Glossary .............................................................................................................................. 6  
Abstract ............................................................................................................................... 7  
Chapter 1: Introduction ..................................................................................................... 9  
Chapter 2: Evaluating the Association Between Euclidean Distance and Attendance at Outpatient Primary Care Appointments in an Urban, Diabetic Sample .............................................................................................................................. 39  
Chapter 3: Evaluating Distance and Activity Space-Based Measures in Geographic Accessibility to Health Care in Urban Cleveland .............................................................................................................................. 65  
Chapter 4: Siting of Health Centers in an Urban Setting, A Case Study of MetroHealth System’s Strategy .............................................................................................................................. 103  
Chapter 5: General Discussion ........................................................................................ 128  
Appendix A: Phone Survey of Locations ....................................................................... 136  
Appendix B: Building Activity Density of Clinic Location (ADCL), an activity space-based measure .................................................................................................................................................. 147  
Bibliography of Works Cited ............................................................................................ 153
<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1.1</td>
<td>Distances equivalent to 30-minute travel time in Cuyahoga County</td>
<td>20</td>
</tr>
<tr>
<td>Table 2.1</td>
<td>Characteristics of study sample: Euclidean distance, number of primary care visits, and attendance rates stratified by selected demographic variables</td>
<td>52</td>
</tr>
<tr>
<td>Table 2.2</td>
<td>Bivariate association between distance and attendance, stratified by demographics</td>
<td>54</td>
</tr>
<tr>
<td>Table 2.3</td>
<td>Distance and the dichotomous attendance measure modeled using logistic regression, adjusted for demographic, clinical, and transportation-related variables</td>
<td>55</td>
</tr>
<tr>
<td>Table 3.1</td>
<td>Characteristics of study sample subdivided into high vs. low attendance (total n=143)</td>
<td>84</td>
</tr>
<tr>
<td>Table 3.2</td>
<td>Multivariate analysis: Odds ratio of attending scheduled visit, stratified</td>
<td>88-90</td>
</tr>
<tr>
<td>Table B.1</td>
<td>Frequency and location of common activities over the last six months for example participant</td>
<td>148</td>
</tr>
</tbody>
</table>
**LIST OF FIGURES**

| Figure 1.1 | Andersen model | 12 |
| Figure 1.2 | Aquarium model depicting Hagerstrand’s space-time path | 14 |
| Figure 1.3 | Conceptual model of geographic accessibility as related to activity space, individual-level and structural-level factors, and health care utilization | 15 |
| Figure 2.1 | Selection of participants | 45 |
| Figure 2.2 | Whisker-box plot of attendance rate, by site of care | 51 |
| Figure 3.1 | Conceptual model of geographic accessibility as related to activity space, individual-level and structural-level factors, and health care utilization | 69 |
| Figure 3.2 | Study sample selection procedures, Aim 2 | 73 |
| Figure 3.3 | Example of the Activity Density Location of Clinic (ADCL) measure overlaid on a map of Cleveland | 77 |
| Figure 3.4 | Correlation between ADCL, Euclidean distance, and travel time | 87 |
| Figure 4.1 | The MetroHealth System, Center for Community Health | 109 |
| Figure 5.1 | Conceptual Model of Geographic Access, v. 1.0 | 130 |
| Figure 5.2 | Conceptual Model of Geographic Access, v. 2.0 (Taking into account activity space) | 131 |
| Figure 5.3 | Conceptual Model of Geographic Access, v. 3.0 (Taking into account effect modification) | 132 |
| Figure 5.4 | Conceptual Model of Geographic Access, v. 4.0 (Taking into account system response) | 134 |
| Figure B.1 | Geocoded addresses | 149 |
| Figure B.2 | Distance from home to all locations using network analyst | 150 |
| Figure B.3 | Kernel density plot | 151 |
| Figure B.4 | Contoured representation of kernel density | 152 |
| Figure B.5 | Determining clinic activity density | 153 |
This dissertation is dedicated to my parents especially, Wen-shin and Wan-tzu Liu.
# LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADCL</td>
<td>Activity Density of Clinic Location</td>
</tr>
<tr>
<td>CARDIA</td>
<td>Coronary Artery Risk Development in Young Adults</td>
</tr>
<tr>
<td>CCH</td>
<td>Center for Community Health</td>
</tr>
<tr>
<td>EMR</td>
<td>Electronic Medical Record</td>
</tr>
<tr>
<td>ESRI</td>
<td>Environmental Systems Research Institute</td>
</tr>
<tr>
<td>HCAP</td>
<td>Hospital Care Assurance Program</td>
</tr>
<tr>
<td>HPSA</td>
<td>Health Professional Service Area</td>
</tr>
<tr>
<td>ICD</td>
<td>International Classification of Diseases</td>
</tr>
<tr>
<td>IQR</td>
<td>Interquartile Range</td>
</tr>
<tr>
<td>MAUP</td>
<td>Modifiable Aggregation Unit Problem</td>
</tr>
<tr>
<td>MHS</td>
<td>MetroHealth System</td>
</tr>
<tr>
<td>OR</td>
<td>Odds Ratio</td>
</tr>
<tr>
<td>SES</td>
<td>SocioEconomic Status</td>
</tr>
</tbody>
</table>
GLOSSARY

Access to health care: The fit between the health care consumer and the health care system

Activity space: the subset of locations in which individuals conduct their daily activities

Activity Density of Clinic Location: A measure of geographic accessibility as a function of activity space

Case study approach: An empirical inquiry that focuses on contextual conditions, and that uses multiple sources and types of data

Geographic Accessibility: The fit between individuals and the geographic distribution of health care
Evaluating Measures of Geographic Accessibility to Health Care
In Urban Diabetics Living in Cuyahoga County

Abstract

by

CONSTANCE WEI-FANG LIU

This dissertation evaluated the association between measures of geographic accessibility and attendance at primary care visits in a sample of poor, urban, diabetic patients that received care from a large health care network in Cuyahoga County (MetroHealth System, or MHS). Study Design: The study had three aims. In the first two aims, we assessed associations between Euclidean distance from home to clinic and attendance to primary care clinic in our study sample, then used a subsample of Medicaid patients selected by a stratified random process to evaluate a novel measure of geographic accessibility (“Activity Density of Clinic Location”, or ADCL) based on “activity space”, or the subset of locations where individuals conduct their daily lives. The outcome of interest was attendance at primary health care visits (1=attended/0=missed) scheduled between July and December of 2006. Data was drawn from the electronic medical records (EMR) of the study sample and responses to a cross-sectional phone survey of the subsample. Multivariate logistic regression was used to evaluate associations between geographic accessibility and attendance after adjusting for transportation, demographics, and clinical characteristics. In Aim 3, we conducted contextual analysis of archival information and text from interviews with MHS decision-makers to describe how siting decisions were made by MHS in expanding its primary health care system from 1992 to 2005. Principal Findings: Distance was not associated with attendance at primary care
visits in this sample, even after adjusting for demographic, clinical, and transportation-related factors. After rigorous adjustment for confounders, a 1 unit increase in ADCL was associated with a 7% decrease in probability of attending a visit (OR=0.93; 95% CI 0.87-1.00) in our sample of Medicaid patients, although the association was marginally significant (p=0.05). In our case study, MHS leaders, motivated by an altruistic mission and a strategy of solidifying its patient referral networks, based the siting of community health centers on patient location and the location of neighborhood centers of activity.

**Conclusions:** Our activity-space based measure appeared to measure aspects of geographic accessibility in urban areas distinct from distance, and may have better distinguished individual differences in geography. Future studies should evaluate similar measures, address effect modification, and explore how health systems can use such information to address geographic issues in their patient populations.
Chapter 1: Introduction

A Review of the Geographic Accessibility Literature
“If you can not measure it, you can not improve it.”

– Lord William Thomson Kelvin, (1824-1907)

It is simplest to begin with the primary objective that guides this dissertation, which is to answer the question: “Is geographic accessibility associated with attendance at primary care appointments in an urban, chronically ill population?” It is more accurate, however, to say that I conceived of this dissertation as an exercise in the measurement of complex human behavior. I sought to measure the interface between individuals and the systems of transportation, social support, employment and the manmade surroundings that constitute the built urban environment. Inequalities in health care exist; they are a product of critical social factors that contribute to disease status. This dissertation is one small part in understanding how those inequalities can be addressed. In conducting this work, I hope I did not lose sight of Lord Kelvin’s reminder that our attempts at measurement, however frustrating, or inaccurate, are the first and necessary step towards improvement.

[1.0] CONCEPTUAL MODEL

To adequately address the question at hand (“Is geographic accessibility associated with attendance at primary care visits in an urban, chronically ill population?”), it is important to first understand how geographic accessibility is defined, and to determine the elements of health care access to which it is conceptually linked.

Geographic accessibility to health care is but a smaller, integral piece of the concept of general access to health care. We thus begin with a holistic treatment of the concept of “access” to health care, using existing conceptual models of access, exploring geography’s place in those models, and describing how these inform the model that guides the work of this particular dissertation.

[1.2] Penchansky and Thomas: Of the various definitions and uses of the term access to health care, it is most appropriate to begin with that put forth by Penchansky and Thomas, who define access as simply the “degree of fit” between health care consumer and the health care system.¹ This definition is useful for several reasons: not only does it provide a broad definition of access, but it also describes it as a multifaceted construct that balances features of the system of health care provision, the expectations and perceptions of consumers (both potential and actual), and the resources available to both. These factors are, in brief: affordability, or the cost of health care; availability, or the resources and supplies available and provided by the health system; accommodation, or the health system’s responsiveness to consumer constraints and needs, as in wait times and response to service requests; acceptability, or the extent to which health care delivery meets consumer expectations; and accessibility, or the geographic distribution of health care. Of the five factors identified by Penchansky and Thomas, geography figures most prominently in “accessibility”: the relative geographic availability of health care, with specific reference to the spatial distribution of those resources.
**Andersen Model:** Another important health care access model critical to the development of the conceptual framework is the Andersen Model, which has been used to explain family use of health services since its development in the late 1960s. If the Penchansky and Thomas model provides insight to the domains that contribute to access to health care, Andersen’s model describes those factors as belonging to individual, societal and institutional-level realms. The model has evolved in the last three decades, and in its current iteration, contributes to the thinking behind this dissertation in its description of how these factors contribute to individual health behaviors and outcomes (Figure 1.1).

**Figure 1.1: Andersen Model**

The implication in this model is that explaining health behavior and access to health care are affected by factors at many different levels: systemic, societal, and individual-level factors. The left-most “Environment” factors describe system-level factors, including neighborhood effects, the structure of the health care system, social support systems, and macro-level dynamics that not only influence “Health Outcomes”, but also affect
“Population Characteristics” (that is, predisposing characteristics such as cultural beliefs or propensity to seek care, enabling resources, and ability to utilize resources that facilitate access to care and actual need. “Population Characteristics” also influence “Health Behaviors”; both of these factors also ultimately influence “Health Outcomes”.

We take from this model the need to consider geographic accessibility from a variety of perspectives. Geography, viewed through the Andersen Model, matters at the level of the health care system (vis a vis the placement of clinics), the community (transportation systems and road networks), and the individual (access to a car, money for public transportation).

[1.4] Hägerstrand’s Space-Time Geography: A third conceptual model that underpins this dissertation is the concept of space-time geography developed by geographer Torsten Hägerstrand in 1970. His paper, “What about People in Regional Science?”3 was a departure from previous approaches to geographic accessibility research, which emphasized a population-based approach, and treated distance as the primary consideration in studying “access”. In this old paradigm, time was considered to be related, but external to access.

Hägerstrand’s primary contributions were twofold: first, he defined the individual as the unit of analysis, believing that observing geographic phenomena at a population or community level masks important patterns of behavior that are only observable from the individual level. Secondly, he placed an emphasis on time as an integral component of
geographic access: whether an individual has access to a particular location is not only a function of how far away that place is, but also demands on the person’s time.

Hägerstrand proposed a method to visualize the integration of space and time (Figure 1.2). In this model, space is represented as a flat, horizontal plane; time is represented vertically.

**Figure 1.2: Aquarium Method**

![Aquarium Method Diagram](image)

This “aquarium” perspective of an individual’s movement through space provides an important foundation for current “activity space” methodology. Activity space is defined as the space in which individuals conduct their daily activities, after accounting for fixedness of an individual’s routine in space and time, which is affected by the availability of travel resources, and economic and social expectations placed on the individual.⁴,⁵

[1.5] **Current Conceptual Model**

14
A conceptual model was developed to depict how geographic accessibility is associated

with other features of health care access. The model, introduced in Figure 1.3, is

informed by the Penchansky/Thomas, Andersen, and Hägerstrand models, but differs

from them in key respects. Those previous models of health care access acknowledge the

importance of geography in influencing access to care, but do not tend to expansively

define the concept, except to emphasize the importance of clinic placement, or, from the

individual perspective, to allude to access to transportation resources. The primary

feature of this model is that it defines geographic accessibility as a direct consequence of

activity space, and thus, influenced by important components of space and time. By
doing so, we create an important link between geographic accessibility and important demographic, economic, and social factors.

Several other organizing principles directed the development of the model. First, it emphasizes the perspective of the individual, as many factors impact access at the individual level. Second, it makes a distinction between those factors that are structural and those that are individual, so as to better identify actionable targets for improving geographic accessibility, as interventions that impact individual behavior differ from policies directed at structural change. The model highlights those elements that have a direct bearing on geographic accessibility to health. Within this schema, factors identified in the Penchansky and Thomas and Andersen models are re-aligned. It is important to identify those modifiable factors to guide methodology, and to understand the application of the results of analysis.

**Individual-level Factors:** Transportation, economic, social, and health care status – related factors influence or are associated with overall access to health care. Transportation-related factors include access to a car or public transportation: literature on missed visits identify having a driver’s license and lack of transportation as important barriers to the patient’s ability to interface with the health system.\(^6\textsuperscript{-9}\) Demographic factors include age, race/ethnicity, gender, education, and socioeconomic status, all of which has been shown to have an association with health care access.\(^6\textsuperscript{-10,11}\) Prior research indicates that older individuals tend to have higher attendance rates than younger patients,\(^6\) that minorities have consistently poorer access to care than whites,\(^1\textsuperscript{2}\) and that
low socioeconomic status\textsuperscript{13} and uninsurance or underinsurance\textsuperscript{14} are also associated with poor access to care. Last, illness and disability have an impact on access: individuals who are ill tend to be less satisfied with their care, and those with disabilities such as blindness, deafness, or difficulties in mobility encounter have specific logistical needs that may not be met by all points of service.\textsuperscript{15} These demographic factors also have a particular association with the time-space dimensions of geographic accessibility: prior research demonstrates that cultural factors are associated with demands on time, as they dictate social or cultural considerations that influence an individual’s geography.\textsuperscript{4, 16, 17} For example, individuals who do not speak English find their geographies circumscribed to those places where their language is spoken, or where language is not required to accomplish desired aims.\textsuperscript{18}

**Structural Factors:** Two families of structural factors are included in this category. The first group of factors describes the organization of the external environment. In this model, we pay attention to the external structure (i.e. quality of public transportation, and the location of other existing urban opportunities such as employment and retail) as related to access to health care.\textsuperscript{9, 19} The second group of factors describes how the physical “fit” of the health care system with individual geography has direct bearing on geographic accessibility to health care. The placement of clinics is most obviously related to geographic accessibility to health care; in addition, other health care characteristics such as the types of services offered, and the hours that the clinic is open all contribute to the level of geographic accessibility to health care.\textsuperscript{6}
**Access to health care and utilization:** The model makes a distinction here between access and utilization. In this case, we consider “access” to describe the previously-described “degree of fit” that serves as the broadest definition of the term. With access, we assume that individuals are able to place themselves in a position to receive health care services: we define “utilization” as that primary consequence of access. We list “attendance at health care visit” as one indicator of access to health care.

The model is a tool to which we will return repeatedly during the course of this dissertation. We use it now to understand what aspects of these relationships might be important to the study population in question, and what gaps in the literature exist. It serves, too, as an eventual guide to the refinement of our methodology, including the selection and development of appropriate measures of health care access, and as a tool for helping us to interpret and suggest potential applications of the results.

**[2.0] Geographic Accessibility in Policy:** With a better understanding of the purpose of the multiple dimensions of access and geography, we now describe the use of geographic information in health policy. We first illustrate the association between geographic accessibility measures and outcomes for patients with chronic illness and then provide an example of how geographic information is currently used in health care policy.

**[2.1] Geographic accessibility and chronic illness:** Although the direct link is not well studied, patients with chronic illness seem to be particularly impacted by lack of geographic access, not only in terms of the ability to obtain minimal standards of care,
and the degree of follow-up care, but also in terms of control of disease consequences. Understanding why and how this occurs will be helpful in developing targeted interventions.

The direct link between geographic accessibility and health outcomes is not well-established, but clearly, access to health care is important for individuals with chronic illness. Attendance at visits is especially critical for diabetics; diabetic patients who miss their appointments tend to have poorer outcomes, including poorly controlled glucose. The American Diabetes Association’s guidelines for the care of diabetes are evolving towards stricter regulation of glucose, blood pressure and cholesterol levels. Patients are being prescribed a higher number of medications, and office visits have grown longer. Multiple providers, including the primary care physician and specialists, are now involved in patient care. As regular contact with the health care system becomes more important, adequate geographic accessibility to care becomes even more critical to patient’s health care continuity and health outcomes.

[2.2] Public Policy Impact: We exemplify the use of geographic information in health policy through the definition of Health Professional Shortage Areas (HPSA), a designation that identifies regions with poorer access to dental, mental health, and primary care services. HPSA classification guides eligibility or funding preference for over 34 federal programs, including the National Health Service Corps, which prioritizes physician trainee assignments to HPSA’s, and Medicare, which provides an automatic bonus for physicians who provide services within HPSA-designated zip codes.
A few recent studies suggest that HPSA designation may not reflect actual deficiencies in access to primary care.\textsuperscript{32-34} In the last forty years, there has been little revision of the original distance definition that was a foundation for the HPSA designations. A half-hour travel time is the federal government’s definition of the maximum limit of “accessibility”. This assumption plays two roles in the definition of HPSA: 1) in the definition of the boundaries of a single “rational area” of determination, and 2) in evaluating which providers are considered accessible to the population in the HPSA designation. In the first instance, 30 minutes travel time between population centers defines whether adjacent counties or census tracts should be considered part of the same rational area; in the second, providers within a 30 minute travel of a particular area’s population center are considered to be “accessible” to that population. The quality of road, terrain, the area’s level of urbanicity and types of transport available govern the calculation of distances that constitute a 30-minute travel time according to the following schema (Table 1.1).

\textbf{Table 1.1:} Distances equivalent to 30-minute travel time in Cuyahoga County

<table>
<thead>
<tr>
<th>Condition</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal conditions with primary roads available</td>
<td>20 miles</td>
</tr>
<tr>
<td>Mountainous terrain or areas with only secondary roads available</td>
<td>15 miles</td>
</tr>
<tr>
<td>Flat terrain or areas connected by interstate highways</td>
<td>25 miles</td>
</tr>
<tr>
<td>Inner portions of metropolitan areas where ( \geq 20% ) population lives at 100% poverty or below</td>
<td>Dependent on information on the regional public transportation system</td>
</tr>
</tbody>
</table>

42 CODE OF FEDERAL REGULATIONS (CFR), CHAPTER 1, PART 5, Appendix A (October 1, 1993, pp. 34-48,) & the Ohio Department of Health (Cuyahoga County)
The arbitrary designation of 30-minute travel time is problematic. There is little evidence that 30 minutes reflects an appropriate point for dichotomizing between “accessible” and “not accessible”. Given the variation in each individual’s access to transportation, the equivalent of half hour travel may be very different for populations who utilize varying modes of transport. The presumption of uniformity in mode of transport and proximity to road networks breaks down especially in urban areas, where car ownership and use of public transportation are more widely variable. The Ohio Department of Health attempts to adjust for these variations in HPSA designations by using public transportation distances (as opposed to road network distances) to determine half-hour accessibility in urban areas where more than 20% of the population lives below the poverty line. However, this adjustment is probably not adequately representative of transportation use even in Cleveland’s poor areas: according to the census, only 12% of the population in the Cleveland area relies on public transportation to travel to work, with only two census tracts reporting rates of public transportation use greater than 50% 35.

Funding decisions related to geography are made at a federal level on the assumption that distance is an adequate metric for defining accessibility to providers. This assumption, however, has not been well-validated against outcomes of actual utilization,34 and potentially has less meaning in an urban area where variations in access to transportation vary.

[3.0] Geographic Accessibility in Research
This section describes how measures of distance and activity space have been used in the literature.

[3.1] Challenges to health services research in measuring geographic accessibility

We turn to two recent articles to frame this discussion about the selection of measures.

The first article we cite is by Kwan et al, and was published in the Journal of Geographical Systems. It describes the primary considerations for a measure of geographic measure, which includes a consideration of what it represents, what methodology is used to construct it, and how the measure could be applied. To expand:

- **What does the measure represent?** In other words: Do we wish to represent access to or from a specific geography? Do we want to represent global access to a type of location, or local access to a discrete location? Do we wish to represent access to a specific type of population?

- **What methodology is to be utilized?** Are we using existing information? What kind of data can be collected to build the measure? What level of sensitivity do we require?

- **What is the potential application of results of analysis using the measure?** In other words, how do we measure geographic accessibility in such a way that we can do something about it?
The second article we cite is a review of geographic accessibility measures used specifically in health services research, undertaken by Guagliardo.37 From his view, measures of geographic accessibility in health care are subject to two problems. One is a lack of validation of these measures: we do not know which measures of access are most appropriate for given levels of urbanicity, racial/ethnic composition, or economic status of the area under study. The second is that geographic accessibility is potentially highly interrelated with other aspects of access. The spatial accessibility of a clinic means little if a consumer cannot afford the services there, or if the clinic’s hours do not agree with her work schedule. In fact, as an editorial in a 2002 issue of Health Services Research articulates, the conceptual chain of access is “no stronger than its weakest link”.38 For example, lack of insurance may pre-empt issues of geographic access.

Guagliardo also pointed out gaps in our use and knowledge of measures of geographic access. They are not well-validated in different contexts: this is especially true in urban centers, where a distinct environment, travel constraints, population density, and demographic composition render its geography unfavorable to commonly used measures. In fact, the nature of travel is so different between these environments that current definitions of urban versus rural areas are based in part on the different set of travel constraints faced by these populations.39 With a few exceptions, geographic accessibility in US city centers has not been studied in the past three decades.37 Practically, too, researchers who use measures of geographic accessibility face particular challenges in data and interpretation. Data used to build measures of access are subject to issues of incompleteness or inaccuracy. Interpretation also requires caution: awareness of issues
such as confounding or errors in measurement due to aggregation by zones (the modifyable aggregation unit problem, or MAUP)$^{40}$ may be critical.

[4.0] Measures of geographic accessibility used in this dissertation

We return to the three questions of representation, methodology, and application in evaluating measures. In terms of representation: we are specifically interested in measures that represent access to health care from an individual point of view, and to a discrete location. In terms of methodology: our primary sources of data are the electronic medical record of a major public hospital system and the results of a telephone survey used to gather information about the location and frequency of daily activities. At minimum, we have information about place of residence, as well as location of access to health care, although we also have the ability to interview patients. In terms of potential application: we hope to identify patterns of utilization to better understand how policy interventions might be targeted in urban areas to mitigate any inequalities that are the result of disparities in access.

With these objectives in mind, we focus on two types of measures of individual access in this dissertation: distance, and activity-space based measures. The following sections detail the current use, advantages, and disadvantages of each class of measures.

[4.1] Distance measures: Distance from place of residence to point of health care service is the most frequently used measure of geographic accessibility in research and policy.$^{37}$
The US federal government uses the physical distance equivalent of half-hour travel time by road as a foundational component of the definition of “accessibility”, while researchers use physical distance in population-level studies as a measure of geographic distance.

Physical distance measures, measured either by Euclidean (or straight-line) or road distance, are primarily advantageous for the minimal data and computing power required to build the measure. Overall, the literature supports the notion that physical distance appears to be inversely related to utilization of care. Results of recent studies use the Electronic Medical Record (EMR) to demonstrate this relationship: distance measures built from patient place of residence information in the Veterans’ Administration EMR have been associated with the utilization of a number of services, including: follow-up to inpatient substance abuse treatment, outpatient treatment post-myocardial infarction, and outpatient service utilization in veterans with spinal cord injuries.

These measures, however, have several disadvantages, particularly in urban areas. One study suggests that the measure’s predictive value disappears when distance is less than 15 miles in urban areas, while other studies suggest a contradictory relationship between appointment keeping and distance, perhaps due to the nature of urban structure.

The varying utility of distance might be because it does not capture the unquestionable complexity of geographic access, nor is it sensitive to the effect of demographic,
socioeconomic, and environmental factors that influence it. Some of these factors undoubtedly play a role in shaping an individual’s geography, and mediate or perhaps confound geography’s role in the phenomenon of health care access. A literal measurement of geography as a representation of physical space between point A and point B does not take into account an individual’s ability to navigate the distance from home to clinic, which may be due to issues of transportation, or to other stresses on the individual’s time and subsequent ability to go to certain locations or to travel certain distances.4,48,49

A related disadvantage of this measure is that it does not capture the probable differences in modes of transport that are variable in urban areas. A distance measure based on Euclidean distance does not change, even if the mode of transport does, which is problematic when comparing an individual who makes frequent use of their car and the highway to another individual who relies on public bus and train to get to the same destination. We do not expect these to be prominent issues in rural areas, but this will certainly be a consideration for populations in urban areas, who by definition experience a more diverse set of travel constraints.39

[4.2] Activity-space measures: We evaluate a second class of individual-level access measures that are based on activity space. Activity-space research may yield alternative ways of measuring geographic accessibility to health care. Whether they are a representation for a person’s potential space (that is, the area to which a person could travel, based on their resources and location), or a representation of their actual space
(that is, a representation of the area a person has traveled), these measures are multidimensional, and are a richer representation of a person’s daily geography than measures based on distance.

Measures based on activity space have not been used extensively in health care access research, primarily due to past limitations in software and data. In the 1970’s Shannon and Spurlock carried out a laborious process of grouping the activity spaces of 243 families, so as to identify common patterns of health care access. Since then, advances in software and technology have created new opportunities for analysis: these measures have been used to identify points of intervention within “socio-spatial knowledge networks” for diabetes education, while among rural elderly, having a primary care physician within activity space is found to be more predictive of utilization than distance to care. Initial efforts have been made, too, to compare measures of activity space and their representations of access to health care.

These studies, however, are the exception, not the rule, although it is clear that activity space-based measures have a distinct advantage over simpler measures such as distance in that they represent geographic accessibility holistically, and thus, provide a more accurate perspective of geographic access’s complexity. These measures take into account not only the individual’s place of residence, but also the space they occupy during the course of their day, and the organization of their time, that all-important aspect of Hagerstraand’s notion of geography as a space-time continuum.
On the other hand, activity space-based measures compare less favorably to distance measures because of the intensity of data required for their calculation. Without exception, prior studies using activity space-based measures require additional survey data that is otherwise not available using electronic medical record, large health care database, chart abstraction, or other existing health care-related data. In our evaluation of these measures, this is an important point: if distance measures perform as well as activity space-based measures in representing access to health care, or at least well enough to be a meaningful representation of health care access, then we would reasonably wish to use distance, as it is much less data intense than activity space measures. Because activity space measures require additional data, and because they are not used extensively in health services research, we looked to the travel sciences to provide guidance on how to collect the data used to construct such measures. Typical methods of data collection for activity space information are patterned on the “travel diary”, a detailed record of where individuals travel in their daily lives over a specified period of time.\textsuperscript{4,5,17,48,49,54} In this dissertation, we used a study of activity space-based measures that utilized a survey of the locations and frequency of places that individuals went on a daily basis.\textsuperscript{53}

[5.0] Aims of the study

Having reviewed the literature, generated a conceptual approach and identified the measures that might be relevant to geographic accessibility to health care, we returned to the initial question that we asked: “How is geography related to access to health care in
an urban, diabetic population living in Cuyahoga County?” To answer that question, we formulated the following objectives: 1) Describe the relationship between geography and access in an urban, diabetic sample, 2) Determine whether geographic accessibility to health care can be measured in an urban sample, and 3) Describe how geographic information can be used to generate institutional health care policy. The aims that we describe in this section carried out these three objectives. Aims 1 and 2 were oriented to validate activity-space based measures compared to distance measures, and to determine their relationship to attendance to health care visits in an urban setting. Aim 3 described the role of geographic information in policy decision-making for the urban health system in which this study takes place. This aim provided a context for understanding how geographic accessibility data can be made useful, and in what ways a system directly or indirectly responds to the changing geography of an urban patient population.

[5.1] **Aim 1: To evaluate the ability of typical measures of geographic accessibility to predict attendance to health care visits in an urban setting.**

   ➢ **Subaim 1: Evaluate the ability of distance measures to predict attendance at health care visits in an urban setting.**

To carry out this aim, we evaluated distance from place of residence to point of care as an indicator of geographic accessibility in a sample of diabetic patients living in an urban area of Cleveland who received continuity care within the MetroHealth system. “Distance” is defined in two ways: 1) as Euclidean (straight-line) distance, and 2) as road network. Provided that the measures of Euclidean distance and road network are highly
correlated, Euclidean distance was used preferentially in analysis because it requires less data to compute than road network distance.

The study sample was adult diabetic continuity patients seen at one of 10 outpatient practices of the MetroHealth System (MHS). The dissertation evaluated the association between Euclidean distance and attendance at primary care visits in this setting, using place of residence and appointment status information available through an electronic medical record database. Supplementary data downloaded from the US census was integrated to geocode residential addresses and to calculate distances.

[5.2] *Aim 2: To evaluate the ability of measures of geographic accessibility based on “activity space” to predict attendance at health care visits in an urban setting.*

- **Subaim 2a:** Evaluate the ability of activity-space based measures to predict attendance at health care visits in an urban setting.
- **Subaim 2b:** Compare novel activity-space measures against traditional distance measures.
- **Subaim 2c:** Evaluate the role of confounding and effect modification in the association between activity space-based measures and attendance at primary care visits.

In aim 2, we sought to validate novel measures of geographic accessibility to health care that are based on activity space, or the area that the individual occupies on a daily basis, against traditional measures that are based on distance from home to clinic. In this aim,
we defined distance from home to clinic in two ways: 1) Euclidean distance, and 2) self-reported travel time. Individuals were asked questions about the fixedness of the location and times of those activities, travel habits, perceptions of space, and their ability to navigate from one activity to the next according to the physical and social constraints unique to the urban environment. Activity space provides a more meaningful representation of those constraints than distance, and is thus perhaps a more appropriate context for geographic accessibility for the urban context, where difficulties in movement are more related to congestion, accessibility of public transport, and social rules such as economic segregation than they are to distance.

A sample of diabetic continuity patients from MHS who receive Medicaid as their insurance and who live in Cleveland were called to complete a phone survey that gathered two primary types of information about daily activities: 1) the location of activities over a six-month period of time, and 2) frequency of those activities. This information was used to develop measures of geographic accessibility based on an activity space-based measure, utilizing a kernel density plot method of estimation. The text of the survey is available in Appendix A, while the development of the measure is shown in Appendix B.

Multivariate regression models were used to evaluate how well activity space-based measures predict attendance to health care visits. Comparative analysis between these measures and the distance measures was used to describe whether activity space measures better or differently predict rates of attendance to health care visits in
comparison to distance. We also controlled for confounding by available structural and individual-level factors that are depicted in the conceptual model (Figure 1.3).

**[5.3]** Aim 3: Evaluate the policy-making process by which MHS uses geographic information in its institutional decision-making.

- **Subaim 3a:** Understand the motivations and external environment that influence decisions regarding new clinic siting for a public hospital that serves an underserved population.
- **Subaim 3b:** Develop an understanding of the kinds of geographic information that are used in policy decisions.
- **Subaim 3c:** Develop a set of recommendations that can help replicate the policies to enable public systems to successfully address local geographic issues in uninsured or Medicaid populations.

In Aim 3, we used case study methods to evaluate decisions regarding the siting of primary care clinics within MHS, the health system under study. Over the last 15 years, MHS underwent an expansion of its facilities, based on a strategic planning initiative that took into account not only demographic information about its market (traditionally defined as a low-income, uninsured or Medicaid-insured population), but also proximity to retail areas and other centers of activity.
This case study utilized in-depth interviews with former administrators and archival information from Board Meeting minutes that pertained to MHS’s decision to site two new clinics in 2002-2003. Through this analysis, we sought to gain a better understanding of the results of Aim 1 and Aim 2. Because this was an exploratory analysis, and because we did not have a clear understanding of how well distance and activity space behave in urban settings, it was necessary and important to understand if there are context-specific explanations for why our measures behaved the way they did. We also hoped that by reconstructing the recent policy history of this system’s conscious decision to change its geographic “fit” with its population, we could document lessons that might be applicable to hospital systems in other urban areas that wish to do the same.
INTRODUCTION: ENDNOTE REFERENCES


49. Kwan MP. Gender, the home-work link, and space-time patterns of nonemployment activities. *Economic Geography* 1999;75:370-394.


Chapter 2: Evaluating the Association between Euclidean Distance and Attendance at Outpatient Primary Care Appointments in an Urban, Diabetic Sample
ABSTRACT: This investigation explored whether distance from home to clinic was associated with attendance at scheduled primary care appointments in an urban, chronically ill population. Study Design: The study was carried out using data drawn from the electronic medical records (EMR) of a cross-sectional sample of urban, diabetic patients who had at least two visits thirty days apart to the MetroHealth System, a public healthcare provider in Cuyahoga County, Ohio. The outcome was attendance at scheduled primary health care. This was measured as attendance rate in descriptive analyses of sample patients; in multivariate analysis, we used a dichotomous attendance measure of whether the individual appointment was attended (1=attended, 0=missed). The independent measure was distance from home to primary care clinic, measured in terms of Euclidean distance. The association between distance and the dichotomous attendance measure was modeled using logistic regression, adjusted for clustering by patient, and for confounders, including patient age, sex, race/ethnicity, insurance, number of co-morbid conditions, proximity to public transportation, and median income of patient census tract. Results were reported as odds ratios (OR) and associated 95% confidence intervals. Results: The sample included 9,950 primary care appointments scheduled for 3,426 patients who lived an average of 5.9 km (95% CI: 5.8 to 6.1 km) from their clinic. The median attendance rate in this sample was 100% (IQR: 66.7% to 100%); 40.3% of the study sample failed to attend at least one of their scheduled appointments. After adjusting for age, sex, race/ethnicity, and number of co-morbid conditions, distance was not found to be associated with attendance at scheduled appointments. In subgroup analysis, the association between distance and attendance at scheduled appointments was only significant in the white sample, where living further
away was associated with better attendance. **Conclusions:** Distance was not associated with attendance at primary care appointments in this sample. This negative result has one of several explanations: 1) Distance is not a sensitive measure of geographic accessibility in urban settings, 2) Geographic barriers have been mitigated in this sample, or 3) There is no relationship between geographic accessibility and attendance at primary health care appointments. Evaluating other measures for health care access and an understanding of the health system’s responsiveness to a population’s geography will assist in understanding the association between geographic accessibility and attendance at primary health care appointments.
In this study, we test a frequent assumption that distance is a reasonable proxy for geographic accessibility to health care. We see this assumption in both policy and research: the US federal government, for example, uses the physical distance equivalent of half-hour travel time as a foundational component in its definition of “accessibility” in defining Health Professional Shortage Areas, while researchers use distance as a measure of geographic accessibility in population-level studies. The measure is attractive, given the minimal data and computing power it requires, but no compelling evidence exists to support its use as a representation of geographic accessibility in an urban setting.

Distance as an indication of geographic accessibility is not an unreasonable assumption, but the relationship appears to be inconsistent in the few studies that attempt to demonstrate its utility as a measure. The literature thus far appears to demonstrate an association between distance and utilization of health services in specific circumstances, particularly in rural context, or for the utilization of specific services (as in follow-up to inpatient substance abuse treatment, outpatient treatment post-myocardial infarction, and outpatient service utilization in veterans with spinal cord injuries). However, the association is uncertain, weak, or even contradictory in urban environments, where a distinct environment, travel constraints, population density, and demographic composition potentially render its geography unfavorable to distance measures. Determining the circumstances where it is a reasonable measure may prove useful for the design and interpretation of future studies on geographic accessibility in urban areas.
This study is focused particularly on how geography is associated with the utilization of health care by diabetic patients. The question is important for these patients, as individuals with chronic illness are negatively impacted by lack of access and subsequent underutilization of care.\textsuperscript{1} For example, diabetic patients who miss their appointments tend to have poorer health outcomes, including higher glucose levels.\textsuperscript{12, 13} The issue of underutilized primary health care becomes more important as medical regimen grow more complex. The American Diabetes Association’s guidelines for the care of diabetes have evolved towards stricter regulation of glucose, blood pressure and cholesterol levels, which means longer, more frequent office visits.\textsuperscript{14} Literature on the reasons for missed appointments make reference to various aspects of geographic accessibility (distance, lack of transportation) as identifiable or probable barriers to the patient’s ability to interface with the health system, but the nature of that relationship is not well-explored.\textsuperscript{15-17} Therefore, in this study, we test for an association between distance and attendance at outpatient primary care appointments in a chronically ill, diabetic population in the Cuyahoga County area.

\textbf{[2.0] Methods:} Our study sample included 9,950 outpatient primary care appointments that were scheduled for 3,426 diabetic patients living in Cuyahoga County at any of ten primary care practices of MetroHealth System (MHS), the area’s largest public healthcare provider. These patients were selected to reflect a sample of adult, urban, chronically ill patients who require routine visits to their primary care physician.
**Study Period:** A six-month study period (July–December, 2006) was chosen to conform to the American Diabetes Association guidelines that recommended that diabetic patients attend at least one primary care visit every six months to check levels of hemoglobin a1c. Every eligible patient in our sample, in keeping with the guidelines, should have attended at least one scheduled outpatient primary care appointment during this period of time.

**Data Sources:** Data used in this study were drawn from MHS’s electronic medical record (EMR). We extracted clinical data, some demographic information (sex, race/ethnicity, insurance), home address, which was mapped, or “geocoded”, to determine the location of each participant’s residence, and information regarding utilization of care.

**Selection of Participants:** Strict inclusion and exclusion criteria were applied to select our sample from the EMR, as shown in the flowchart in Figure 2.1. The sample included patients who had been diagnosed with diabetes mellitus (identified using the International Statistical Classification of Diseases and Related Health Problems, or ICD-9 code: 250.xx) prior to the study period who lived in Cuyahoga County and had attended at least two scheduled appointments to outpatient primary care at least 30 days apart in the year prior to the beginning of the study period. We additionally excluded individuals who were diagnosed with end-stage renal disease, as these individuals differ in their health care needs from other patients and have primary contact with the health care system through dialysis; as well as individuals with nongeocodable addresses (e.g. PO boxes). The inclusion and exclusion criteria are listed in Figure 2.1.
**Independent Measure:** The primary independent variable of interest was a measure of distance from home to clinic that was calculated in terms of Euclidean (or straight-line) distance from home to clinic. Values were in kilometers. Distance was originally calculated in terms of Euclidean and path (or network) distance. However, the two types of distance are highly correlated ($r=0.99$), so only Euclidean distance was used, as it requires less information to construct than path distance.

**Outcome Measure:** The outcome of interest was attendance at outpatient primary care appointments. This outcome has been validated in repeated studies in health care literature as an indicator of access,¹⁰,¹⁵,¹⁶,¹⁹-⁲¹ and has been shown to be associated with health-related outcomes in diabetic populations.²²
Attendance at outpatient primary care appointments was measured in one of two ways in our analysis. For the purposes of descriptive univariate and bivariate analysis, the unit of analysis was the individual patient. For these analyses, attendance was measured as attendance rate, or the percentage of scheduled appointments attended by the individual patient. In subsequent bivariate and multivariate analyses using a logistic regression model, the unit of analysis was the scheduled outpatient primary care appointment. Here, the outcome was a dichotomous attendance measure of whether or not a scheduled appointment was attended (1=attended the scheduled appointment, 0=failed to attend the scheduled appointment). We considered the electronic medical record data used in this approach to provide an accurate reflection of clinic attendance, as patient attendance was necessary to record to avoid inappropriate billing for services not rendered. Appointments that were cancelled ahead of time were excluded.

**Covariates:** Several demographic, clinical and geographic variables had the potential to confound the relationship between distance and attendance at scheduled appointments. These were abstracted from encounter and problem list diagnosis in the electronic medical record, and from census files.

Potential confounding demographic variables used in analysis include: race/ethnicity, age, gender, insurance status, and socioeconomic status. We defined race/ethnicity using the following categories: “Black”, “White,” “Hispanic/Latino”, and “Other”. The “Other” category included those individuals described as “Asian/Pacific Islander”, “Multi-racial”, “Other”, or “Unknown” in the electronic medical record, or for
whom race/ethnicity was not recorded. *Age* was defined as a continuous variable
describing the patient’s age at the beginning of the study period (7/1/2006), according to
birth date. *Gender* was a categorical variable: male or female. *Insurance status* was
determined by the patient’s recorded insurance at the end of the study period
(12/31/2006), and was categorized as “Commercial”, “Medicaid”, “Medicare”, or
“Uninsured”. We approximated the *socioeconomic status* of the patient’s neighborhood,
using median income of the census block where each patient resided. We lacked
information about overall access to transportation, but were able to approximate *access to
public transportation* using a dichotomous variable that described whether or not the
individual lived within 200 meters of a bus or regional transit train. We deviated from the
standard distance of 400 meters that normally defines “access” to public transportation,\(^23\)
as diabetics have a higher risk of limited ambulation due to illness.\(^24\)

The model was also adjusted for confounding by severity of illness, represented by *count
of prevalent chronic comorbidities*.\(^25\) The previously validated list of included
comorbidities\(^25\) was originally designed to reflect prevalent diseases that are commonly
reported on community surveys. Prior research in older community-dwelling adults has
demonstrated that this simple count performs nearly as well as more complex measures in
its ability to predict health care utilization.\(^25\) The comorbidities included in the count
were defined by ICD-9 codes present in the problem and encounter diagnosis lists, which
included: arthritis (ICD-9 codes 711, 712, 714 - 716, 720, 726), coronary artery disease
(414), cancer (140 - 239), congestive heart failure (428), chronic obstructive pulmonary
disease (490 - 496), hypertension (401 - 405), liver disease (751), stroke (430 - 438), and
psychiatric disease (295 - 301, 308, 309, 311).\textsuperscript{15, 25, 26} Diabetes and end-stage renal disease were not included in the comorbidity count, because each condition comprised either an inclusion or exclusion criteria that was applied uniformly to all participants.

\textbf{Analysis:} We first characterized our sample in terms of the univariate distribution of demographic and clinical variables in the sample, with the individual patient as the unit of analysis. We then performed a bivariate analysis to evaluate the distribution of Euclidean distance, total number of scheduled appointments to outpatient primary care (both attended and missed), and attendance rate (the percentage of scheduled primary care appointments attended by the individual patient) across groups defined by demographic characteristic, or site of care. We also evaluated the potential that site of care might be a determinant of attendance using a box-plot of attendance rates across sites of care.\textsuperscript{16}

For the subsequent analyses, the unit of analysis was the scheduled appointment to primary care, clustered by patient, using robust standard errors to account for within-subject correlation.\textsuperscript{27} A logistic regression was used to model the association between geographic accessibility (as measured by Euclidean distance) and the dichotomous outcome of attended the appointment/did not attend the appointment. The unadjusted model was presented in the whole sample, as well as within subgroups, defined by demographic and clinical variables. Because we were concerned that insurance\textsuperscript{19, 28-30} and site of care\textsuperscript{16} might be two major confounders of geography and attendance at primary care appointments, we repeated the logistic regression on the sample of patients.
who received their primary care at the main hospital, and then repeated the regression in
the sample limited to patients with Medicaid insurance.

A final multivariate logistic regression, adjusted for clustering by patient, was carried out
on the entire sample to evaluate the potential association between distance and attendance
at scheduled primary care appointments, adjusted for demographic variables (sex, age,
race/ethnicity, neighborhood SES), access to public transportation, and count of
comorbidities.

In all statistical tests, probability levels of less than 0.05 were considered significant. We
used Intercooled STATA 7.0 for Windows 98/95/NT.

An institutional review board reviewed and approved the protocol.

[3.0] Results: Following inclusion and exclusion criteria, 3,426 patients were identified
in the electronic medical record. In the sample, 62.9% of participants were female, 50%
Black, 27.5% Medicaid and 24.4% uninsured (Table 2.1). The mean age was 53.2 years.
Nearly half (45.9%) of the sample scheduled their primary care appointments at this
hospital system’s main campus. The remaining patients scheduled their appointments at
any of nine satellite clinics, which were distributed around Cuyahoga County. Patients
had an average of 1.48 comorbidities (95% CI: 1.44 to 1.57).
During the six-month study period, patients had a median of 2 (IQR: 2 to 4) scheduled appointments to primary care, and a median attendance rate of 66.7% (IQR:60.0% to 75.0%). In this sample, 40.3% of the study sample missed at least one visit. An examination of the median and IQR of Euclidean distance, scheduled visits, and attendance rates, stratified by sex, race/ethnicity, and insurance elicited some useful patterns (Table 2.1). We observed that in terms of distance, Hispanics as a group appeared to live closer to their clinics with a median of 2.4 km (IQR: 1.5 to 4.5) than other racial/ethnic groups in the sample. When we examined the sample stratified by insurance, we found that individuals with commercial insurance lived the furthest median distance (5.1 km, IQR: 2.6 to 9.7) from the clinic where their appointments were scheduled; patients with Medicaid lived the closest median distance (4.2 km, IQR: 2.2 to 7.0) from their clinic. We did not apply tests of statistical significance to our evaluation of these patterns, but to the extent that they reflect actual differences in Euclidean distance from the clinic, they can be explained by the larger number of Medicaid patients that lived within the city of Cleveland, where a higher density of the clinics for this health system were located, and the higher number of commercially insured who lived outside the city of Cleveland, where public transportation was not as extensive, and where individuals relied more heavily on cars for transportation.31

We also noted that when we examined the patient sample according to the clinic where their appointments were scheduled, the primary care clinic at the main hospital (clinic #5) drew patients from the widest range of distances (5.6 km, IQR: 2.9 to 9.4).
In terms of scheduled visits, White patients had a smaller median number (1 visit, IQR: 1 to 4) of visits than other patient groups identified by race or ethnicity.

We found a broad range of median scheduled appointments per patient and attendance rates when we evaluated these variables according to clinic. The median number of scheduled visits ranged from 2 to 3. Median attendance rates ranged from 66.7% to 100.0%. The variation was expected, given clinic-specific differences in payor and demographic profiles. The IQR of attendance rates was also demonstrably broad within clinic, as shown in the box-and-whisker diagram in Figure 2.2; we were reassured that site of care was not a sole, primary determinant of attendance.

---

**Figure 2.2: Whisker-box plot of attendance rate by site of care**

The box-and-whisker diagram illustrates the distribution of data.

- The box is bounded by the first and third quartile.
- A vertical line in the box indicates the median value.
- The “whiskers” (the horizontal lines extending from the box) indicate either the minimum and maximum data values that lie within 1.5*IQR. If outliers are present, the line extends to 1.5*IQR.
- Suspected outliers are indicated by points outside the ends of the whiskers.
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Euclidean Distance (km)</th>
<th>Scheduled Appointments to Outpatient Primary Care per Patient (n)</th>
<th>Attendance Rate (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>median (IQR)</td>
<td>median (IQR)</td>
<td>median (IQR)</td>
</tr>
<tr>
<td>Total</td>
<td>3,426</td>
<td>4.6 (2.3 to 8.1)</td>
<td>2 (2 to 4)</td>
</tr>
<tr>
<td>Age, years, mean</td>
<td>53.22 (52.90 to 53.59)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex, n(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1272 (37.1%)</td>
<td>4.8 (2.4 to 8.7)</td>
<td>2 (2 to 4)</td>
</tr>
<tr>
<td>Female</td>
<td>2154 (62.9%)</td>
<td>4.4 (2.3 to 7.8)</td>
<td>2 (2 to 4)</td>
</tr>
<tr>
<td>Race/Ethnicity, n(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>1251 (36.5%)</td>
<td>4.7 (2.3 to 8.4)</td>
<td>2 (1 to 4)</td>
</tr>
<tr>
<td>Black</td>
<td>1697 (49.5%)</td>
<td>5.0 (2.7 to 8.5)</td>
<td>3 (2 to 4)</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>384 (11.2%)</td>
<td>2.4 (1.5 to 4.5)</td>
<td>3 (2 to 4)</td>
</tr>
<tr>
<td>Other/Unknown</td>
<td>94 (2.7%)</td>
<td>5.8 (2.9 to 11.1)</td>
<td>2.5 (2 to 4)</td>
</tr>
<tr>
<td>Insurance, n(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>997 (29.1%)</td>
<td>5.1 (2.6 to 9.7)</td>
<td>2 (1 to 3)</td>
</tr>
<tr>
<td>Medicaid</td>
<td>942 (27.5%)</td>
<td>4.2 (2.2 to 7.0)</td>
<td>3 (2 to 4)</td>
</tr>
<tr>
<td>Medicare</td>
<td>652 (19.0%)</td>
<td>4.8 (2.4 to 8.4)</td>
<td>3 (2 to 4)</td>
</tr>
<tr>
<td>Uninsured</td>
<td>835 (24.4%)</td>
<td>4.4 (2.2 to 7.9)</td>
<td>2 (1 to 4)</td>
</tr>
<tr>
<td>Site of Care, n(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Hospital</td>
<td>1,573 (45.9%)</td>
<td>5.6 (2.9 to 9.4)</td>
<td>2 (1 to 3)</td>
</tr>
<tr>
<td>Health Center #1</td>
<td>16 (0.47%)</td>
<td>3.0 (1.5 to 6.2)</td>
<td>3 (2 to 4)</td>
</tr>
<tr>
<td>Health Center #2</td>
<td>328 (9.6%)</td>
<td>4.1 (2.4 to 6.4)</td>
<td>2 (2 to 4)</td>
</tr>
<tr>
<td>Health Center #3</td>
<td>178 (5.2%)</td>
<td>3.0 (1.5 to 6.2)</td>
<td>3 (2 to 4)</td>
</tr>
<tr>
<td>Health Center #4</td>
<td>463 (13.5%)</td>
<td>4.1 (2.2 to 5.9)</td>
<td>3 (2 to 4)</td>
</tr>
<tr>
<td>Health Center #5</td>
<td>53 (1.6%)</td>
<td>3.8 (1.5 to 6.0)</td>
<td>3 (2 to 5)</td>
</tr>
<tr>
<td>Health Center #6</td>
<td>222 (6.5%)</td>
<td>3.6 (2.0 to 7.1)</td>
<td>2 (1 to 4)</td>
</tr>
<tr>
<td>Health Center #7</td>
<td>250 (7.3%)</td>
<td>2.7 (1.7 to 5.3)</td>
<td>3 (2 to 5)</td>
</tr>
<tr>
<td>Health Center #8</td>
<td>123 (3.6%)</td>
<td>4.7 (2.5 to 8.6)</td>
<td>2 (2 to 4)</td>
</tr>
<tr>
<td>Health Center #9</td>
<td>220 (6.4%)</td>
<td>4.7 (2.5 to 8.6)</td>
<td>2 (1 to 4)</td>
</tr>
</tbody>
</table>
Table 2.2 shows the results of a bivariate logistic regression, adjusted for clustering by patient. Overall, there was no significant association between distance and our dichotomous measure of attendance (OR=1.01, p=0.11). When we repeated the regression in sample subgroups defined by sex, race/ethnicity, or insurance, we found that the association between distance and the dichotomous attendance measure was only significant in the white subsample (OR=1.05, p<0.01), and indicated that living a kilometer further improved the odds of attending a scheduled visit by 5%. We restricted our analysis to the 4,101 visits made by the 1,573 patients who attended their primary care clinic at the main hospital, and then to the 2,884 visits made by 942 patients with Medicaid. When we evaluated the regression within the subgroup of patients who receive the primary care site located at MHS’s main hospital, the association between distance and the dichotomous attendance measure in Whites remained significant (OR=1.06, p<0.01), but was not significant in other strata or in the sample as a whole. The association was not significant overall or in any subgroup when we ran the model on Medicaid patients only.

**Multivariate Analysis:** The results of the final multivariate model showing the association between the dichotomous attendance measure and Euclidean distance, adjusted for clustering by patient and for confounders were presented in Table 2.3 Distance was not significantly associated with the dichotomous attendance measure, although other confounders, such as age, being black, having Medicaid, being uninsured,
<table>
<thead>
<tr>
<th></th>
<th>Whole Sample</th>
<th></th>
<th>Metrohealth only</th>
<th></th>
<th>Medicaid only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (patients)</td>
<td>OR (95% CI)</td>
<td>p-value</td>
<td>n (patients)</td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3,426 patients (9,950 visits)</td>
<td>1.01 (0.99 to 1.02)</td>
<td>0.11</td>
<td>1,573 patients (4,101 visits)</td>
<td>1.02 (1.00 to 1.03)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1272 (37.1%)</td>
<td>1.02 (1.00 to 1.03)</td>
<td>0.06</td>
<td>596 (37.9%)</td>
<td>1.02 (0.99 to 1.04)</td>
</tr>
<tr>
<td>Female</td>
<td>2154 (62.9%)</td>
<td>1.00 (0.98 to 1.02)</td>
<td>0.91</td>
<td>977 (62.1%)</td>
<td>1.01 (0.99 to 1.04)</td>
</tr>
<tr>
<td><strong>Race/Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>1251 (36.5%)</td>
<td>1.05 (1.03 to 1.08)</td>
<td>0.00</td>
<td>719 (45.7%)</td>
<td>1.06 (1.03 to 1.10)</td>
</tr>
<tr>
<td>Black</td>
<td>1697 (49.5%)</td>
<td>1.00 (0.98 to 1.01)</td>
<td>0.69</td>
<td>610 (38.8%)</td>
<td>0.99 (0.97 to 1.02)</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>384 (11.2%)</td>
<td>1.00 (0.96 to 1.04)</td>
<td>0.98</td>
<td>197 (12.5%)</td>
<td>1.06 (0.96 to 1.16)</td>
</tr>
<tr>
<td>Other/Unknown</td>
<td>94 (2.7%)</td>
<td>1.01 (0.96 to 1.06)</td>
<td>0.75</td>
<td>47 (3.0%)</td>
<td>1.03 (0.95 to 1.11)</td>
</tr>
<tr>
<td><strong>Insurance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>997 (29.1%)</td>
<td>1.00 (0.98 to 1.02)</td>
<td>0.92</td>
<td>404 (25.7%)</td>
<td>1.00 (0.98 to 1.04)</td>
</tr>
<tr>
<td>Medicaid</td>
<td>942 (27.5%)</td>
<td>1.00 (0.98 to 1.03)</td>
<td>0.94</td>
<td>495 (31.5%)</td>
<td>1.02 (0.98 to 1.05)</td>
</tr>
<tr>
<td>Medicare</td>
<td>652 (19.0%)</td>
<td>1.01 (0.98 to 1.05)</td>
<td>0.45</td>
<td>356 (22.6%)</td>
<td>1.00 (0.96 to 1.04)</td>
</tr>
<tr>
<td>Uninsured</td>
<td>835 (24.4%)</td>
<td>1.02 (0.99 to 1.04)</td>
<td>0.21</td>
<td>318 (20.2%)</td>
<td>1.02 (0.98 to 1.06)</td>
</tr>
</tbody>
</table>
and census tract median income were associated at a p-value of less than 0.05 (see Table 2.3).

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distance</strong></td>
<td>1.00 (0.99 to 1.02)</td>
<td>0.84</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>1.03 (1.02 to 1.03)</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.03 (0.92 to 1.16)</td>
<td>0.60</td>
</tr>
<tr>
<td>Male</td>
<td>ref</td>
<td>ref</td>
</tr>
<tr>
<td><strong>Race/Ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>ref</td>
<td>ref</td>
</tr>
<tr>
<td>Black*</td>
<td>0.57 (0.50 to 0.66)</td>
<td>0.00</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>0.85 (0.70 to 1.03)</td>
<td>0.10</td>
</tr>
<tr>
<td>Other/Unknown</td>
<td>1.16 (0.79 to 1.71)</td>
<td>0.44</td>
</tr>
<tr>
<td><strong>Insurance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>ref</td>
<td>ref</td>
</tr>
<tr>
<td>Medicaid*</td>
<td>0.69 (0.59 to 0.81)</td>
<td>0.00</td>
</tr>
<tr>
<td>Medicare</td>
<td>0.90 (0.75 to 1.06)</td>
<td>0.21</td>
</tr>
<tr>
<td>Uninsured*</td>
<td>0.82 (0.70 to 0.96)</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Comorbidities</strong></td>
<td>1.06 (0.99 to 1.12)</td>
<td>0.08</td>
</tr>
<tr>
<td>Live within 200 ft of public transportation</td>
<td>0.94 (0.83 to 1.06)</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Median Income, Census Tract</strong></td>
<td>1.01 (1.01 to 1.01)</td>
<td>0.00</td>
</tr>
</tbody>
</table>

* OR is significant at a level of p ≤ 0.05

[4.0] Discussion

Euclidean distance from home to clinic was not significantly related to a patient’s attendance at clinic, defined by a dichotomous attendance measure, in either bivariate or multivariate analysis (adjusted for clinical and demographic confounders, and for clustering by patient). This was true in the sample as a whole, and in most subgroups identified by demographics or site of care. The bivariate association between the dichotomous attendance measure and Euclidean distance was significant only in the White sample, although the relationship indicated that a 1 km increase in Euclidean distance was associated with a 5% increase in the probability of attendance, counter to
the decrease that we would expect with a greater distance to care to overcome. The negative finding is consistent with prior literature that suggests that distance is at best an inconsistent measure of geographic accessibility, whether due to confounding by factors such as socioeconomic status, or access to transportation. Our results, however, may not completely negate the possibility that geographic accessibility is associated with attendance at scheduled primary care appointments. In studies of health care utilization, problems with travel are frequently reported as a reason for missed health care appointments. With these considerations in mind, we explore several possible explanations for the negative result that can be broadly categorized as follows: 1) In this sample, geographic accessibility was not associated with attendance to primary care appointments because other factors were more important, 2) Our negative finding was the result of an imperfect measure: distance from home to clinic is not an adequate indicator of existing geographic accessibility in this sample, or 3) In this sample, geographic accessibility was not an important factor associated with attendance at outpatient primary care appointments because the health systems’ sites of care are well-placed relative to the individuals who use these services.

We consider first the possibility that distance was not associated with geographic accessibility in urban areas because other factors affecting access were more important. Prior studies indicate that geography is related to demographic characteristics, urban economic and social patterns that ultimately impact access to health care. No recent portrait of geographic accessibility in the Cuyahoga area exists, but a 1971 study of the area by Bashshur et al demonstrated that utilization of health care “[was] patterned by the
social and ecological systems within which they occur[red], rather than geography. For example: Bashshur et al suggested segments of both the Black and Jewish populations of Cleveland traveled long distances for their care, but for different reasons. Discrimination and income limited available medical services for Blacks, while the Jewish population held a strong preference for one the region’s traditionally Jewish hospital for cultural reasons. Demographic patterns have shifted in the three decades since this study was conducted, but there is no doubt that patterns of segregation by class and race/ethnicity persist, with attendant inequality of access to resources and services, including those that facilitate access to health care.

A second explanation for the negative association is that distance is not an adequate measure of geographic accessibility in urban areas. In an urban environment, getting from Point A to Point B might require negotiating circuitous roadways, congestion, or public transit. Previous research in the transportation sciences further suggests that individual geography is complex, socially constructed, and dependent on limitations on time and access to resources, especially transportation. For example, a diabetic patient’s ability to navigate her way around a city depends on factors like the quality of the city’s public transportation network, or the individual’s access to a car, which might enable her to travel further and more quickly than public transportation. Furthermore, an individual’s daily activities, including work and other responsibilities, also shape the flexibility of a person’s time and space, and ultimately, geographic access: even if our theoretical patient lives close to the clinic, her ability to negotiate her clinic appointments might be complicated if she works on the other side of town, is caring for
young children, is a caretaker for a family member, or if her geography is constrained in ways that are not captured by the measure of distance from home to clinic. Simply put: distance may not adequately represent these complex dimensions of geography.

A third category of explanations explore the possibility that geography may not have been an explanatory factor for attendance to health care appointments in this sample because the degree of fit is good between health system sites of care relative to consumers. Nationally, federal health centers that provide comprehensive preventive and primary care services in designated underserved areas have improved access to health care. MHS’s health centers fulfill a similar function, serving the low-income population of Cleveland as a part of its mission. This patient population encounters a number of serious barriers to health care. Over the past ten years, MHS developed a strategy to improve referral patterns, and to make care more accessible to their traditional patient population living further away from the main hospital. For example, MHS built satellite health centers in areas where the system’s traditional population resides. In keeping with its mission and strategy, these were located in response to the stated preferences of its patient population, with the goal of being accessible by car or public transportation to the hospitals’ traditional low-income patient population. It is possible that for the study sample, geographic barriers were less important, perhaps in part due to the success of this approach. Our negative finding may have been an artifact of that success.
Limitations: The study had several limitations. There exists the possibility of a selection bias in the study sample. By selecting only continuity patients who have a documented history of visits within this system, it is possible that we selected a sample of patients who had already demonstrated their success in overcoming the geographic barrier to health care. A second limitation is that we did not have detailed information about visits: research on appointment-keeping suggests that factors such as weather, time of appointment, and how far in advance the appointment was scheduled may impact the probability that a patient shows up for the visit.\textsuperscript{10, 15, 44} However, because our sample was drawn from one health care system in a defined area, we know that scheduling processes were consistent, and that events, such as inclement weather, were relatively random across patients, such that these factors did not bias our sample. A third limitation is that the outcome measure used in our logistic regression, the dichotomous measure of attendance at scheduled primary care appointments, may not be a true measure of access. However, we found that the dichotomous attendance measure was associated with age, race/ethnicity, insurance, level of illness, and median income of the patient’s census tract. These associations were expected, given that prior literature consistently indicates that race/ethnicity, insurance, and socioeconomic status are also often cited as also significantly associated with likelihood of missed visits,\textsuperscript{10, 16, 45-47} and that younger patients are more likely to miss visits.\textsuperscript{10, 15, 19-21, 44-47} Given the strength of these associations, we are confident that our outcome measure does represent an important dimension of access to primary health care.
**Conclusion:** Attendance at primary care appointments was associated with several demographic and clinical variables, but was not associated with Euclidean distance from home to primary care in this study. We are not certain why distance failed to yield this association, but are certain that future work will help to confirm which of our alternate explanations are most plausible. To that end, future work should focus on more complex measures that take into account the complexity of individual urban geography, and more closely examine potential confounders or modifiers of geographic access. Developing a better understanding, too, of how health care systems might overcome existing geographic accessibility issues, either by strategic siting of health centers or by improvements in processes, might enable us to understand whether or not a negative finding might also be conceivably due to the geography and other characteristics of the health care system itself.
CHAPTER 2: ENDNOTE REFERENCES


31. NorthEast Ohio: Community and Neighborhood Data for Organizing: Center on Urban Poverty and Community Development, Case Western Reserve University Mandel School of Applied Social Sciences; 2007.


34. Coulton CJ, Chow J, Pandey S. An analysis of poverty and related conditions in Cleveland area neighborhoods: Case Western Reserve University; 1990.


Chapter 3:
Evaluating Distance and Activity Space-Based Measures in Geographic Accessibility
to Health Care in Urban Cleveland
**ABSTRACT:** The objective of this investigation is to evaluate the utility of a measure based on the concept of “activity space”, or the subset of locations in which individuals conduct their daily activities, as compared to Euclidean distance and travel time to clinic.

**Study Setting/Data Sources.** A stratified random sample of 143 urban diabetic Medicaid patients living in Cuyahoga County who had at least two primary care visits thirty days apart at one of nine outpatient clinics that were part of MetroHealth System, a public healthcare provider in Cuyahoga County. Data was drawn from electronic medical records (EMR), and patient responses to a 20-minute phone survey about the frequency and location of daily activities. **Study Design:** We compared a measure of geographic accessibility based on activity space (Activity Density of Clinic Location, or ADCL), to traditional measures of Euclidean distance, and travel time from place of residence to clinic. The outcome was attendance at appointments (1=attended, 0=missed) scheduled between July and December of 2006. A logistic regression model was used to evaluate the association between these measures of geographic accessibility and attendance after adjusting for clustering by patient, and confounding by patient demographic characteristics, number of co-morbid conditions, and access to private vehicular and public transportation.

**Principal Findings:** Patients had a median ADCL of 7 (IQR: 2 to 9), lived 4.4 (IQR: 2.4 to 6.8) km from, and traveled 20 (IQR: 10 to 45) minutes to their clinic. The correlation between ADCL and Euclidean distance was moderate ($r=0.5$), and with travel time was weak ($r=0.3$). A 1 decile increase in ADCL was associated with a 7% decrease in probability of attending a visit ($OR=0.93; 95\% CI 0.87-1.00$), after adjusting for age, sex, race/ethnicity, socioeconomic status, education, number of co-morbid conditions, car
ownership, and proximity to public transportation, but the association was marginally significant (p=0.05). Neither Euclidean distance nor travel time was associated with attendance.

Conclusions: Our activity-space based measure, ADCL, appeared to measure aspects of geographic accessibility distinct from Euclidean distance and travel time, and may have better distinguished individual differences in geographic accessibility as compared to Euclidean distance and travel time. Future studies should further evaluate measures of geographic accessibility, and the impact of effect modification and confounding.
[1.] **Background:** In policy and research, measures based on distance from residence to clinic are currently used as a proxy for an individual patient’s geographic accessibility to health care.\(^1\) These measures are rooted in the assumption that the further a patient lives from a health care provider, the less likely that patient is to utilize that provider’s services. Prior studies have suggested the validity of this association, but only in certain contexts (usually rural),\(^2-7\) or for specific services\(^8-10\). The results of the few published studies of geographic accessibility in urban populations indicate a limited, confounded, or even contradictory association between distance (measured both as Euclidean and path distance) and access. One study of the use of surgical services at an urban Veterans Administration hospital finds that distance by road matters only for patients living at least 15 miles away;\(^11\) another study suggests that living *further* from an urban hospital is related to higher utilization of primary care services.\(^12\) A third study of 1970’s Cleveland describes subpopulation variations in Euclidean distance to care related to a variety of factors, such as patient preference, or the constraints of discrimination or poverty.\(^13\)

Chief among the potential reasons for this inconsistency is the problem of measurement. Euclidean distance is a convenient and frequently-used measure because it requires only two data points (location of home and location of clinic) to be calculated. However, it is also a potentially problematic measure because it only represents one physical dimension of individual geography, even though the geographic literature supports the notion of an individual’s geography as a multidimensional,\(^14\) socially constructed concept\(^15,16\) that is dependent on limitations on time\(^17,18\) and access to resources, especially transportation.\(^19\) We call on the concept of “activity space” to unify these complexities. Activity space,
defined as the subset of locations in which individuals conduct their daily activities, has been used to guide work in the geographic sciences, especially as it pertains to patterns of transportation use. In this study, we conceptualized geographic accessibility to health care as a function of activity space, as depicted in our conceptual model (Figure 3.1).

Figure 3.1: Conceptual Model of Geographic Accessibility as related to Activity Space, Individual-Level and Structural-Level factors, and Health Care Utilization

Aside from measurement issues, we must also consider that the relationship between geographic accessibility and health service utilization is subject to confounding. The confounded nature of these dimensions is depicted over widely-cited and validated conceptual models, including the Andersen model, and the Penchansky and Thomas model. The Andersen model describes factors related to individual need, access to
resources, and predisposing characteristics associated with individual health-seeking behavior. The Penchansky and Thomas model characterizes health care access as the “fit” between a patient and the health care system with regards to five interrelated dimensions, one of which is geographic “accessibility”, or the fit between service and patient location. For example, patient location in urban areas is frequently a function of socioeconomic status and race/ethnicity, attributes that might influence access to health care vis a vis the dimensions of affordability (cost and ability to pay for health care) and acceptability (provider attitudes towards patients, and vice versa). These components of access and their interaction with geographic accessibility, health care access, and with each other are illustrated in Figure 3.1.

Additionally, there exists the possibility of effect modification, that is, the association between geographic accessibility and utilization differs in different subpopulations. This occurs as a plausible consequence of differences in access to resources. Access to a car, for example, attenuates the impact that distance might have on someone who relies on public transportation.

In this investigation, we confronted the challenges of measurement, confounding, and effect modification in evaluating geographic accessibility to health care. We focused our efforts on studying a measure based on activity space, called the Activity Density of Clinic Location (ADCL). A few studies have used measures based on activity space to study geographic accessibility to health care in rural settings, but their utility has not been fully explored in urban areas. We compare this activity-space based measure to
traditional measures of distance (represented as Euclidean distance, or travel time), with a focus on potential effect modification and confounding by sex, race/ethnicity, and socioeconomic status.

**Methods:** Our study sample included 143 diabetic Medicaid patients living in Cuyahoga County, selected to reflect a sample of urban, chronically ill individuals who require routine visits to their primary care physician.31

**Study Period:** A six-month study period (July–December, 2006) was chosen to conform to the American Diabetes Association guidelines that recommend that diabetic patients receive at least one primary care visit every six months to check levels of hemoglobin a1c. 32 Every eligible patient in our sample would theoretically have had at least one appointment scheduled during this period of time.

**Data Sources:** Two sources of data were used in this study. The first was 2006 data from the electronic medical record (EMR) of MetroHealth System, Cuyahoga County’s largest public healthcare provider. We extracted clinical data, some demographic information (sex, race/ethnicity, insurance), home address, which was mapped, or “geocoded”, to determine the location of each participant’s residence, and information regarding utilization of care. The second source of data was a phone survey that was used to collect additional demographic information, access to and use of transportation, and location and frequency of places commonly visited over a six month period. Questions about demographics were drawn or modified from the Coronary Artery Risk
Development in Young Adults (CARDIA) survey, which was validated and used for data collection in a prospective, multi-city cohort study of heart disease in young adults over several years. Location/frequency items from a survey of activity space conducted in a rural North Carolina setting were modified to include activities relevant to the poor, urban population of Cuyahoga County. For example, we added items regarding banking, and did not ask questions from the original survey about sports and exercise. A draft of the survey was piloted among ten participants and modified for clarity and brevity. Snap® and Microsoft Access® software were used as the primary means of data entry and storage. The final draft of the survey is available in Appendix A (to be included in the dissertation submission).

Selection of participants: Potential participants were selected using a stratified, random process from an initial pool of patients identified from the EMR. A flowchart describing participant selection procedures can be seen in Figure 3.2. Strict inclusion and exclusion criteria were first applied to select patients for the sample, so as to minimize confounding. Initial inclusion criteria were patients with diabetes mellitus (identified using the International Statistical Classification of Diseases and Related Health Problems, or ICD-9 code: 250.xx), who were continuity patients (that is, had at least two prior visits at least 30 days apart over the year prior to the study period), and had at least one scheduled visit to the primary care physician between June 1 and December 31, 2006. We additionally limited our sample to individuals whose home addresses could be mapped, or “geocoded”, a procedure that was necessary for determining the location of each participant’s residence. Of these, only individuals who lived in Cuyahoga County, which
is MetroHealth System’s primary service area, were included. We also focused only on individuals insured by Medicaid, as we wished to minimize the influence of confounding by insurance status, a well-documented determinant of access to care.\textsuperscript{31, 34, 35} Several other exclusion criteria were applied. These resulted in the exclusion of individuals who did not speak English, as access to health care for individuals who do not speak English is often more limited and subject to different barriers from the target study population.\textsuperscript{36, 37} Individuals who had moved in the six months prior to the interview, who utilized the hospital’s van service, or who relied on a wheelchair for mobility were excluded, as these are characteristics that may affect access and/or activity space.\textsuperscript{38, 39} We had additionally

\textbf{Figure 3.2:} Study Sample Selection Procedures

<table>
<thead>
<tr>
<th>Eligible Sample</th>
<th>n=942</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attempted contact</td>
<td>n=394</td>
</tr>
<tr>
<td>Recruitment/Consent</td>
<td>n=301</td>
</tr>
<tr>
<td>Additional Screen</td>
<td>n=213</td>
</tr>
<tr>
<td>Complete survey</td>
<td>n=143</td>
</tr>
</tbody>
</table>

- Phone Disconnected (n=60)
- No contact made: 8 attempts, 2 messages (n=33)
- Declined (n=37)
- Excluded (n=61): not English-speaking, deceased, other reasons
- Ineligible (n=70): Used a van service, moved, used wheelchair
planned on excluding individuals with end-stage renal disease, as these individuals differ in their health care needs and have primary contact with the health care system through dialysis,\(^3^2\) but after applying our other exclusion criteria no such individuals remained in the sample.

To ensure a distribution of outcomes, sampling strata were defined by a Bayesian-adjusted rate of attendance to scheduled primary care appointments identified by EMR between July and December, 2006.

The Bayesian adjustment, shown in the formula below, was applied to the attendance rate to avoid the problem of small denominators.

\[
p = \frac{x + 1}{n + 2}
\]

Where: \(p = \) Adjusted attendance rate,

\(x = \) Number of visits made, and

\(n = \) Number of appointments scheduled

The adjusted attendance rate was scaled from 0 to 100.

Potentially eligible subjects were divided into four nearly equally-sized quartiles of adjusted attendance (0 to 50, 50 to 60, 60 to 67, 67 to 100). Three research assistants and the Primary Investigator (CL, CS, MR, SY) randomly selected and attempted to contact
subjects from each quartile either until the April-May data collection period ended, or until an \( n \) of 40 completed surveys (for a total sample size of 160, represented about 480 visits) was achieved in each strata.

We attempted to contact each subject up to eight times. When contact was made, the study was explained. The patient subsequently agreed and provided verbal consent, or else declined to participate. The survey was discontinued at this point if the patient did not speak English, per the study’s exclusion criteria.

Participants who agreed to participate were further screened. Those who reported changing place of residence during the six-month study period, utilized a van service to get to any of their primary care appointments, or who self-reported use of a wheelchair for ambulation were not invited to complete the survey, as they did not meet the study’s inclusion criteria.

**Independent measure:** The primary independent variable of interest was a measure of geographic accessibility based on activity space that we term “activity density of clinic location” (ADCL). Locations obtained from survey data were geocoded and weighted according to the frequency with which individuals reported visiting them. A kernel density estimation method was used to estimate the “densities” of activity that comprise a person’s space. The software used to carry out this estimation was ArcGIS\textsuperscript{®}, made by the Environmental Systems Research Institute (ESRI). The kernel density function was a tool in the suite of programs within ArcGIS, titled *Hawth's Analysis Tools*. 
Conceptually, the kernel density estimation method has been described using the following analogy: imagine that a heap of sand is placed on each location point visited by the subject. The volume of sand at each heap corresponds to how we weight the point itself – in this case, by how frequently the individual visits that specific location. The sand is deepest at the point, and slopes downward as we move away. If location points are close together, the sand in overlapping areas will be additive. The depth of sand at any point is analogous to the estimated density of activity at that specific location; the shape of each pile depends on the kernel density equation that we used (a quartic function in ArcGIS®). How far the sand spreads away from the point depends on a radius that we enter as the equivalent of the mean of Euclidean distance from residence to all locations. Density values are divided into deciles. The decile of greatest density is labeled 0; each subsequent decile is labeled from 1, 2, and 3, etc. All areas that fall outside of the individual’s activity space are labeled 10. An example of the ADCL is provided in Figure 3.3. We have identified the ADCL of hypothetical clinics A and B in relation to the ADCL at the point of highest density, and in the area outside the activity space.
We compared two traditional measures of geographic accessibility with ADCL. The first was Euclidean (or straight-line) distance from residence to clinic, as calculated by ArcGIS®. The second was the time required to travel from residence to clinic, as reported by patients in the survey. We use Euclidean distance in favor of distance by road (referred to as “path” or “network” distance) as the two are highly correlated in this population ($r=0.99$), and because the former requires less information and computing power to calculate.

**Outcome Measure:** The outcome of interest was attendance at scheduled outpatient primary care appointments. This outcome has been validated in repeated studies in health
care literature as an indicator of access, and has been shown to be associated with health-related outcomes in diabetic populations. In this study, attendance at scheduled outpatient primary care appointments was measured in one of two ways. For the purposes of describing the distribution of demographic, clinical, geographic, and transportation-related variables in the sample, we stratified individuals according to attendance, using the Bayesian-adjusted attendance rate that was used in the random stratified selection method described earlier. In subsequent bivariate and multivariate analysis utilizing a logistic regression model, attendance at scheduled outpatient primary care appointments was the primary outcome of interest. In these analyses, we used a dichotomous attendance measure of whether or not the patient attended a scheduled appointment (1=attended the scheduled appointment, 0=failed to attend the scheduled appointment).

We considered the electronic medical record data used in this approach to provide an accurate reflection of clinic attendance, as it was necessary to record patient attendance to avoid inappropriate billing for services not rendered. Appointments that were cancelled ahead of time were excluded.

**Covariates:** Several demographic, clinical and geographic variables that had the potential to confound the relationship between geographic accessibility and attendance rate were abstracted from the EMR and survey.
Potential confounding demographic variables included: race/ethnicity, age, gender, educational attainment, and socioeconomic status.\textsuperscript{12, 42, 43} We defined race/ethnicity using the following categories: “Black”, “White”, and “Hispanic/Latino”. Age was defined as a continuous variable describing the patient’s age at the beginning of the study period (7/1/2006), according to birth date. Gender was a categorical variable: male or female. Self-reported educational attainment was defined as whether or not a person has a high school degree. Socioeconomic status was defined by individual self-report of how hard he or she finds it to pay for basics (we collapsed a four-point Likert scale into two categories: very hard/hard, and somewhat hard/not very hard).\textsuperscript{33} Two additional variables that account for access to transportation\textsuperscript{48, 49} were also added: whether the individual owns a car (yes, no), and whether they live within 200 meters of a public transportation stop (yes, no). We deviated from the standard distance of 400 meters that normally defines “access” to public transportation,\textsuperscript{50} as diabetics have a higher risk of limited ambulation due to illness.\textsuperscript{51}

Count of prevalent comorbidities was used as a covariate to account for clinical variation in the population. This previously validated measure includes comorbidities that are commonly reported on community surveys. Prior research in older community-dwelling adults has demonstrated that the simple count performs nearly as well as more complex measures in its ability to predict health care utilization.\textsuperscript{52} The comorbidities included in the count were defined by ICD-9 codes present in the problem and encounter diagnosis lists, which included: arthritis (ICD-9 codes 711, 712, 714 - 716, 720, 726), coronary artery disease (414), cancer (140 - 239), congestive heart failure (428), chronic
obstructive pulmonary disease (490 - 496), hypertension (401 - 405), liver disease (751),
stroke (430 - 438), and psychiatric disease (295 - 301, 308, 309, 311).\textsuperscript{43, 52, 53} Diabetes
and end-stage renal disease were not included in the comorbidity count, because each
condition comprised either an inclusion or exclusion criteria that was applied uniformly
to all participants.

Our analysis also included a consideration of variables that are considered to be
potentially related to the size of an individual’s activity space. These included \textit{having a
driver’s license},\textsuperscript{48, 54} and \textit{household composition},\textsuperscript{55, 56} including whether or not the
individual was living with a partner, and the number of individuals in the individual’s
household.

We also considered a variable that indicated whether individuals live outside of or within
the limits of the city of Cleveland, which is the largest metropolitan area in Cuyahoga
County. Prior studies suggest that individuals who live further from urban health centers
may demonstrate greater utilization of health care, counter to the expectation that living
further away would result in poorer utilization. We expect that these differences might
result from unmeasured differences in environment, access to transportation and
demographic composition of suburban areas versus urban areas.\textsuperscript{11, 13}

To ensure human subjects protection, an institutional review board reviewed and
approved the protocol and the survey that was used.
Analysis: We first evaluated the demographic differences between the final study sample and the individuals we attempted to contact, but did not include, and then characterized our final sample according to the univariate distribution of demographic and clinical variables. We then performed a bivariate analysis to evaluate the distribution of demographic, clinical, and transportation-related variables between high attenders (patients in the sample who had a Bayesian-adjusted attendance rate \( \geq 67 \)) and low attenders (patients in the sample who had a Bayesian-adjusted attendance rate < 67). We selected 67 as the cutoff point for high attendance, as this describes the Bayesian-adjusted attendance rate for individuals who had only one scheduled appointment, and kept it. In these descriptive analyses, the patient was the unit of analysis.

For the subsequent analyses, the unit of analysis was the scheduled appointment to primary care, clustered by patient using robust standard errors to account for within-subject correlation. A logistic regression was used to model the association between geographic accessibility (as measured by ADCL, Euclidean distance, or travel time) and our dichotomous attendance measure (1=attended the appointment/0=failed to attend the appointment). The unadjusted model was presented, as well as the model adjusted for only demographic variables (sex, age, race/ethnicity, education, SES), only transportation-related variables (car ownership, living within 200 meters of public transportation), and only clinical factors (count of comorbidities). A final adjusted model included all these covariates.
We recognized that the study’s sample size would dictate our ability to detect an association in the multivariate analysis. Given the absence of data with which to base an estimate of the potential strength of association, we used STATA® to calculate the sample sizes required to detect a variety of odds ratios. We assumed an alpha of 0.05, a power of 0.80, and a design effect of 1.22. The study design effect was based on the EMR-recorded mean of 3.1 (95% CI 2.9 to 3.2) visits per patient in the initial pool from which we draw our sample, and an intraclass correlation of 0.11, with “class” being defined as the individual patient. With these parameters, our ability to detect associations diminishes rapidly as the magnitude of the odds ratios decreases. For example, we require a sample size of 526 visits (or 175 patients) to detect an OR of 0.79; if the magnitude of the OR increases to 0.75, we require a sample size of 354 visits (or 118 patients). This calculation guided our determination of sample size, but more importantly, assisted us in determining the limitations of our ability to detect associations with our sample.

An exploratory stratified analysis was conducted to test for effect modification in the subpopulations of this sample. The logistic regression was repeated within subpopulations identified by demographic variables (sex, race/ethnicity, education, socioeconomic status), transportation-related variables (living within 200 meters of a public transit station, car ownership), and geographic variables (whether or not the individual lives within the city limits of Cleveland, where the demographic composition differs from the rest of Cuyahoga County, and where public transportation is more readily accessible). These were sensibly selected as factors that have been shown, empirically
or conceptually, to be associated with access to health care and geographic access, as per our conceptual model (see Figure 3.1).

**3.0 Results:** During the two-month data collection period, interviewers attempted contact with 394 of the 942 potentially eligible participants identified through medical record. Of the 394, 143 (36.3%) were successfully contacted and interviewed. The remaining 248 were excluded because they could not be contacted, were ineligible, or declined to participate (Figure 3.2). There were no statistically significant differences between the participant and non-participant groups, except for race/ethnicity. A significantly greater proportion of the individuals we excluded were Hispanic/Latino (23.0% vs. 4.9%, p<0.01), a difference largely that resulted from the exclusion of 36 Spanish-speaking individuals who did not speak English.

Of the whole sample, 72% were women, 58% African American, and 37% White (Table 3.1). The median age was 49.8 years (IQR: 44.1 to 56.5). Nearly half (43%) of the sample had less than a high school education; 35% reported being of low SES (i.e. they found it “Very Hard” or “Hard” to pay for basics). Clinically, participants had a median of 1 (IQR: 1 to 2) comorbid illness in addition to diabetes, with hypertension as the most frequent comorbid illness (not shown). In terms of transportation, only 44% of participants reported owning a car, although 64% of participants reported that a car was their primary means of transport. The median number of visits per patient was 3 (IQR: 2 to 4) during the study period.
Table 3.1 also shows the distribution of demographic, clinical, and transportation-related variables in the 143 individuals in our sample, stratified by whether the patient had a high or low Bayesian-adjusted attendance rate. Chi-square tests were used to compare the distribution of key demographic, clinical and transportation-related variables. The group

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total Sample</th>
<th>Low Bayesian-Adjusted Attendance Rate (&lt;67)</th>
<th>High Bayesian-Adjusted Attendance Rate (≥67)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>143</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, years, median (IQR)</td>
<td>50.9 (44.1 to 56.5)</td>
<td>49.9 (42.2 to 55.0)</td>
<td>51.7 (44.3 to 57.0)</td>
</tr>
<tr>
<td>Sex, n(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>40 (28.0%)</td>
<td>11 (23.9%)</td>
<td>29 (29.9%)</td>
</tr>
<tr>
<td>Female</td>
<td>103 (72.0%)</td>
<td>35 (76.1%)</td>
<td>68 (70.1%)</td>
</tr>
<tr>
<td>Race/Ethnicity, n(%)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>53 (37.1%)</td>
<td>12 (26.1%)</td>
<td>42 (43.3%)</td>
</tr>
<tr>
<td>Black</td>
<td>83 (58.0%)</td>
<td>33 (71.7%)</td>
<td>49 (50.5%)</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>7 (4.9%)</td>
<td>1 (2.2%)</td>
<td>6 (6.2%)</td>
</tr>
<tr>
<td>Level of education, n(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than high school</td>
<td>54 (37.8%)</td>
<td>19 (41.3%)</td>
<td>35 (36.1%)</td>
</tr>
<tr>
<td>High school graduate</td>
<td>89 (62.2%)</td>
<td>27 (58.7%)</td>
<td>62 (63.9%)</td>
</tr>
<tr>
<td>Socioeconomic Status¹</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low SES</td>
<td>51 (35.7%)</td>
<td>16 (34.8%)</td>
<td>35 (36.1%)</td>
</tr>
<tr>
<td>High SES</td>
<td>92 (64.3%)</td>
<td>30 (65.2%)</td>
<td>61 (62.9%)</td>
</tr>
<tr>
<td>Total Comorbidities, #, median (IQR)</td>
<td>1 (1 to 2)</td>
<td>1 (1 to 2)</td>
<td>1 (1 to 2)</td>
</tr>
<tr>
<td>Residence of Cleveland City, n(%)</td>
<td>81 (56.6%)</td>
<td>22 (47.8%)</td>
<td>59 (60.8%)</td>
</tr>
<tr>
<td>Primary Mode of Transportation, n(%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>91 (63.6%)</td>
<td>31 (67.4%)</td>
<td>60 (61.9%)</td>
</tr>
<tr>
<td>Public Transport/Walking</td>
<td>52 (36.4%)</td>
<td>15 (32.6%)</td>
<td>37 (38.1%)</td>
</tr>
<tr>
<td>Own a car, n(%)</td>
<td>64 (44.8%)</td>
<td>16 (34.8%)</td>
<td>48 (49.5%)</td>
</tr>
<tr>
<td>Has a Driver’s License, n(%)*</td>
<td>78 (54.5%)</td>
<td>20 (43.5%)</td>
<td>58 (59.8%)</td>
</tr>
<tr>
<td>Living with Significant Other, n(%)</td>
<td>47 (32.9%)</td>
<td>15 (32.6%)</td>
<td>32 (33.0%)</td>
</tr>
<tr>
<td>People in household, #, median (IQR)*</td>
<td>1 (1 to 2)</td>
<td>1.5 (1 to 2)</td>
<td>1 (1 to 2)</td>
</tr>
<tr>
<td>Measures of Geographic Accessibility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity Density (ADCL), median (IQR)</td>
<td>7 (2 to 9)</td>
<td>8 (5 to 9)</td>
<td>5 (2 to 9)</td>
</tr>
<tr>
<td>Euclidean Distance, km, median (IQR)</td>
<td>4.4 (2.4 to 6.8)</td>
<td>5.0 (3.4 to 7.4)</td>
<td>3.9 (2.2 to 6.7)</td>
</tr>
<tr>
<td>Time to Clinic, minutes, median (IQR)</td>
<td>20 (10 to 45)</td>
<td>20 (10 to 45)</td>
<td>20 (10 to 30)</td>
</tr>
<tr>
<td>Scheduled Appointments, #, median (IQR)</td>
<td>3 (2 to 4)</td>
<td>3 (2 to 4)</td>
<td>3 (2 to 4)</td>
</tr>
</tbody>
</table>

¹As determined by response to the question: “How hard was it for you to pay for the very basics over the last six months?” . Low SES = “Very Hard” or ”Hard”, High SES = “Somewhat Hard” or ”Not Hard at All”.  
* Statistically-significant difference between high and low attenders, indicated by chi-square tests.
with low Bayesian-adjusted attendance rates had a greater proportion of Black patients (72% vs. 51%, p=0.06), and a lower proportion of White patients (26% vs. 43%, p=0.06) than the high attendance group. The group with low Bayesian-adjusted attendance rates also had a lower proportion of individuals who have a driver’s license (44% vs. 60%, p=0.07). The IQR of the number of individuals in the household was the same in both strata (IQR: 1 to 2), but when we compared the means, low attenders had a higher mean of individuals in their household (2.2 vs. 1.5, p<0.05), a factor associated with more constrained activity space in geographic literature.\(^{56}\)

We compared the association between ADCL, Euclidean distance, and travel time from home to clinic in terms of scatter plots in Figure 3.4, and through the calculation of a correlation coefficient. ADCL was moderately correlated to Euclidean distance (Pearson’s \(r=0.5\)), and weakly correlated to travel distance (\(r=0.3\)). Travel time was weakly correlated with Euclidean distance (\(r=0.3\)).\(^{59}\) Three sets of analysis shown in Table 3.2 show the odds ratio for change in attendance due to a one decile increase in ADCL, a 1 km increase Euclidean distance, or a 10-minute increase in travel time respectively, adjusted for clustering by individual. The first column presents the unadjusted model (Model 1). The next three columns are the results of the model adjusted for clinical factor, i.e. number of comorbidities (Model 2); for transportation-related variables, i.e. “living within 200 meters of public transportation” and car ownership (Model 3); and for demographic variables, i.e. sex, age, race/ethnicity, SES, and education (Model 4). The last column (Model 5) is the “fully-adjusted” model, and
includes all the clinical, travel-related and demographic confounders examined separately in Models 2-4.

We focused our attention first on the fit of these models in the entire sample, clustered by individual patient. None of the three measures of geographic accessibility were associated with attendance to visits in the unadjusted Model 1 or in Models 2-4. In Model 5, ADCL was only marginally associated with the dichotomous measure of attendance at a primary care appointment. In terms of model significance, adding demographic variables increased the explanatory power of Models 4 and 5, as shown by a log-likelihood ratio test. Adding transportation-related variables also increased explanatory value, but the increase was only marginally statistically significant.
**Figure 3.4:** Correlation between ADCL, Euclidean distance, and travel time

ADCL vs. Euclidean distance (correlation: $r=0.5$), $n=143$

ADCL vs. Time to clinic (correlation: $r=0.3$), $n=143$
Table 3.2: Multivariate Analysis: Odds Ratio of Attendance at a Scheduled Outpatient Primary Care Visit, Stratified

<table>
<thead>
<tr>
<th>Characteristic, Visits, n Patients, n(%)</th>
<th>Measures</th>
<th>Model 1 Unadjusted OR (95% CI)</th>
<th>Model 2 OR Adjusted for Transportation* (95% CI)</th>
<th>Model 3 OR Adjusted for Comorbidities* (95% CI)</th>
<th>Model 4 OR Adjusted for Demographics* (95% CI)</th>
<th>Model 5 Adjusted OR* (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL SAMPLE n=449 143 total patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADCL</td>
<td></td>
<td>0.94 (0.88 to 1.01)</td>
<td>0.94 (0.88 to 1.01)</td>
<td>0.94 (0.88 to 1.01)</td>
<td>0.93 (0.87 to 1.00)</td>
<td>0.93 (0.87 to 1.00)</td>
</tr>
<tr>
<td>Euclidean Distance</td>
<td></td>
<td>0.95 (0.90 to 1.01)</td>
<td>0.95 (0.90 to 1.01)</td>
<td>0.96 (0.90 to 1.01)</td>
<td>0.95 (0.91 to 1.03)</td>
<td>0.97 (0.91 to 1.03)</td>
</tr>
<tr>
<td>Travel Time</td>
<td></td>
<td>LLR=-230.89</td>
<td>LLR=-230.83</td>
<td>LLR=-229.95</td>
<td>LLR=-224.26*</td>
<td>LLR=-221.34*</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>0.91 (0.84 to 0.97)</td>
<td>0.91 (0.84 to 0.97)</td>
<td>0.91 (0.85 to 0.98)</td>
<td>0.90 (0.84 to 0.98)</td>
<td>0.89 (0.82 to 0.97)</td>
</tr>
<tr>
<td></td>
<td>n=112</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>1.01 (0.98 to 1.04)</td>
<td>1.00 (0.97 to 1.02)</td>
<td>1.01 (0.98 to 1.04)</td>
<td>1.02 (0.99 to 1.05)</td>
<td>1.01 (0.98 to 1.05)</td>
</tr>
<tr>
<td></td>
<td>n=337</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>0.96 (0.90 to 1.03)</td>
<td>0.96 (0.90 to 1.03)</td>
<td>0.97 (0.90 to 1.04)</td>
<td>1.00 (0.92 to 1.08)</td>
<td>0.99 (0.92 to 1.07)</td>
</tr>
<tr>
<td></td>
<td>n=172</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Black</td>
<td>1.00 (0.91 to 1.09)</td>
<td>1.01 (0.92 to 1.11)</td>
<td>0.99 (0.90 to 1.08)</td>
<td>1.01 (0.94 to 1.08)</td>
<td>1.00 (0.93 to 1.08)</td>
</tr>
<tr>
<td></td>
<td>n=251</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
|                                        | *Transportation variables included: Car ownership, Living within 200 meters of public transportation*
|                                        |         |                                 |                                               |                                               |                                               |                                 |
|                                        | *Comorbidities included: Number of comorbid illnesses*
|                                        |         |                                 |                                               |                                               |                                               |                                 |
|                                        | *Demographic variables included: Sex, age, race/ethnicity, socioeconomic status, education*
<p>| | | | | | | |
|                                        |         |                                 |                                               |                                               |                                               |                                 |
|                                        | Adjusted model included all of the Transportation, Comorbidities, and Demographic variables |</p>
<table>
<thead>
<tr>
<th>Characteristic, Visits, n Patients, n(%)</th>
<th>Measures</th>
<th>Model 1 Unadjusted OR (95% CI)</th>
<th>Model 2 OR Adjusted for Transportation* (95% CI)</th>
<th>Model 3 OR Adjusted for Comorbidities* (95% CI)</th>
<th>Model 4 OR Adjusted for Demographics* (95% CI)</th>
<th>Model 5 Adjusted OR* (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; high school</td>
<td>ADCL</td>
<td>0.87 (0.78 to 0.97)</td>
<td>0.87 (0.77 to 0.97)</td>
<td>0.87 (0.78 to 0.97)</td>
<td>0.88 (0.79 to 0.99)</td>
<td>0.88 (0.77 to 1.00)</td>
</tr>
<tr>
<td>n=209</td>
<td>Euc Distance</td>
<td>0.91 (0.84 to 0.99)</td>
<td>0.91 (0.83 to 0.99)</td>
<td>0.91 (0.84 to 0.99)</td>
<td>0.94 (0.85 to 1.04)</td>
<td>0.94 (0.85 to 1.04)</td>
</tr>
<tr>
<td>62(43.4%)</td>
<td>Travel Time</td>
<td>0.99 (0.97 to 1.00)</td>
<td>0.99 (0.97 to 1.00)</td>
<td>0.99 (0.97 to 1.00)</td>
<td>1.00 (0.98 to 1.02)</td>
<td>1.00 (0.98 to 1.02)</td>
</tr>
<tr>
<td>high school</td>
<td>ADCL</td>
<td>1.00 (0.91 to 1.10)</td>
<td>1.03 (0.93 to 1.13)</td>
<td>0.99 (0.91 to 1.09)</td>
<td>0.96 (0.88 to 1.06)</td>
<td>0.97 (0.88 to 1.07)</td>
</tr>
<tr>
<td>n=240</td>
<td>Euc Distance</td>
<td>1.01 (0.91 to 1.11)</td>
<td>1.02 (0.93 to 1.12)</td>
<td>1.02 (0.92 to 1.12)</td>
<td>0.99 (0.89 to 1.10)</td>
<td>0.99 (0.91 to 1.07)</td>
</tr>
<tr>
<td>81 (56.6%)</td>
<td>Travel Time</td>
<td>1.00 (0.98 to 1.01)</td>
<td>1.00 (0.98 to 1.02)</td>
<td>1.00 (0.99 to 1.01)</td>
<td>1.00 (0.98 to 1.02)</td>
<td>1.00 (0.98 to 1.02)</td>
</tr>
<tr>
<td>Socioeconomic Status**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low SES</td>
<td>ADCL</td>
<td>0.96 (0.87 to 1.06)</td>
<td>0.98 (0.88 to 1.08)</td>
<td>0.96 (0.87 to 1.05)</td>
<td>0.95 (0.86 to 1.06)</td>
<td>0.98 (0.89 to 1.09)</td>
</tr>
<tr>
<td>n=168</td>
<td>Euc Distance</td>
<td>0.91 (0.83 to 0.99)</td>
<td>0.91 (0.84 to 1.00)</td>
<td>0.91 (0.84 to 0.99)</td>
<td>0.98 (0.90 to 1.07)</td>
<td>0.99 (0.90 to 1.09)</td>
</tr>
<tr>
<td>41 (28.7%)</td>
<td>Travel Time</td>
<td>0.99 (0.97 to 1.02)</td>
<td>0.99 (0.96 to 1.02)</td>
<td>0.99 (0.97 to 1.02)</td>
<td>1.01 (0.98 to 1.04)</td>
<td>1.01 (0.98 to 1.04)</td>
</tr>
<tr>
<td>high SES</td>
<td>ADCL</td>
<td>0.93 (0.85 to 1.02)</td>
<td>0.93 (0.84 to 1.02)</td>
<td>0.93 (0.85 to 1.02)</td>
<td>0.92 (0.84 to 1.01)</td>
<td>0.93 (0.85 to 1.02)</td>
</tr>
<tr>
<td>n=281</td>
<td>Euc Distance</td>
<td>0.97 (0.90 to 1.05)</td>
<td>0.97 (0.90 to 1.05)</td>
<td>0.99 (0.91 to 1.07)</td>
<td>0.98 (0.90 to 1.07)</td>
<td>1.00 (0.91 to 1.10)</td>
</tr>
<tr>
<td>102 (71.3%)</td>
<td>Travel Time</td>
<td>0.99 (0.98 to 1.01)</td>
<td>0.99 (0.98 to 1.01)</td>
<td>1.00 (0.98 to 1.01)</td>
<td>1.00 (0.98 to 1.01)</td>
<td>1.00 (0.99 to 1.02)</td>
</tr>
<tr>
<td>Live near public transport</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes,</td>
<td>ADCL</td>
<td>0.94 (0.87 to 1.02)</td>
<td>0.95 (0.87 to 1.03)</td>
<td>0.94 (0.87 to 1.02)</td>
<td>0.95 (0.87 to 1.03)</td>
<td>0.95 (0.87 to 1.03)</td>
</tr>
<tr>
<td>n=121</td>
<td>Euc Distance</td>
<td>0.96 (0.89 to 1.03)</td>
<td>0.96 (0.89 to 1.04)</td>
<td>0.96 (0.89 to 1.04)</td>
<td>0.99 (0.91 to 1.08)</td>
<td>0.99 (0.91 to 1.08)</td>
</tr>
<tr>
<td>40 (28.0%)</td>
<td>Travel Time</td>
<td>0.99 (0.98 to 1.00)</td>
<td>0.99 (0.98 to 1.00)</td>
<td>0.99 (0.98 to 1.00)</td>
<td>0.99 (0.98 to 1.01)</td>
<td>0.99 (0.98 to 1.01)</td>
</tr>
<tr>
<td>No,</td>
<td>ADCL</td>
<td>0.96 (0.84 to 1.09)</td>
<td>0.90 (0.77 to 1.04)</td>
<td>0.89 (0.77 to 1.03)</td>
<td>0.90 (0.77 to 1.05)</td>
<td>0.90 (0.77 to 1.04)</td>
</tr>
<tr>
<td>n=328</td>
<td>Euc Distance</td>
<td>0.94 (0.86 to 1.02)</td>
<td>0.94 (0.86 to 1.03)</td>
<td>0.95 (0.86 to 1.05)</td>
<td>0.97 (0.87 to 1.07)</td>
<td>0.97 (0.88 to 1.07)</td>
</tr>
<tr>
<td>103 (72.0%)</td>
<td>Travel Time</td>
<td>1.02 (0.98 to 1.05)</td>
<td>1.02 (0.98 to 1.06)</td>
<td>1.02 (0.98 to 1.06)</td>
<td>1.02 (0.97 to 1.06)</td>
<td>1.02 (0.97 to 1.07)</td>
</tr>
</tbody>
</table>

* Transportation variables included: Car ownership, Living within 200 meters of public transportation
Comorbidities variables included: Number of comorbid illnesses
Demographic variables included: Sex, age, race/ethnicity, socioeconomic status, education
Adjusted model included all of the Transportation, Comorbidities, and Demographic variables
Table 3.2: Multivariate Analysis: Odds Ratio of Attending Scheduled Visit, Stratified (cont’d)

<table>
<thead>
<tr>
<th>Characteristic, Visits, n Patients, n(%)</th>
<th>Measures</th>
<th>Model 1 Unadjusted OR (95% CI)</th>
<th>Model 2 OR Adjusted for Transportation* (95% CI)</th>
<th>Model 3 OR Adjusted for Comorbidities* (95% CI)</th>
<th>Model 4 OR Adjusted for Demographics* (95% CI)</th>
<th>Model 5 Adjusted OR* (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car Ownership</td>
<td>ADCL</td>
<td>0.94 (0.85 to 1.04)</td>
<td>0.94 (0.85 to 1.04)</td>
<td>0.95 (0.86 to 1.06)</td>
<td>0.97 (0.86 to 1.09)</td>
<td>0.95 (0.83 to 1.08)</td>
</tr>
<tr>
<td>n=197</td>
<td>Euc Distance</td>
<td>0.96 (0.89 to 1.03)</td>
<td>0.94 (0.85 to 1.05)</td>
<td>0.96 (0.86 to 1.08)</td>
<td>1.04 (0.93 to 1.16)</td>
<td>1.03 (0.93 to 1.14)</td>
</tr>
<tr>
<td>64 (44.8%)</td>
<td>Travel Time</td>
<td>0.99 (0.96 to 1.02)</td>
<td>0.98 (0.96 to 1.01)</td>
<td>0.99 (0.96 to 1.02)</td>
<td>1.01 (0.97 to 1.05)</td>
<td>1.00 (0.96 to 1.04)</td>
</tr>
<tr>
<td>No,</td>
<td>ADCL</td>
<td>0.94 (0.86 to 1.04)</td>
<td>0.94 (0.86 to 1.04)</td>
<td>0.93 (0.85 to 1.02)</td>
<td>0.94 (0.85 to 1.03)</td>
<td>0.93 (0.85 to 1.02)</td>
</tr>
<tr>
<td>n=249</td>
<td>Euc Distance</td>
<td>0.95 (0.84 to 1.06)</td>
<td>0.96 (0.89 to 1.03)</td>
<td>0.96 (0.89 to 1.03)</td>
<td>0.97 (0.89 to 1.06)</td>
<td>0.96 (0.89 to 1.05)</td>
</tr>
<tr>
<td>79 (55.2%)</td>
<td>Travel Time</td>
<td>1.00 (0.98 to 1.01)</td>
<td>1.00 (0.98 to 1.01)</td>
<td>1.00 (0.98 to 1.01)</td>
<td>1.00 (0.99 to 1.01)</td>
<td>1.00 (0.99 to 1.01)</td>
</tr>
<tr>
<td>Live in Cleveland</td>
<td>ADCL</td>
<td>0.97 (0.89 to 1.06)</td>
<td>0.97 (0.89 to 1.06)</td>
<td>0.97 (0.89 to 1.05)</td>
<td>0.99 (0.91 to 1.08)</td>
<td>1.00 (0.92 to 1.09)</td>
</tr>
<tr>
<td>Yes,</td>
<td>Euc Distance</td>
<td>0.96 (0.89 to 1.03)</td>
<td>0.94 (0.85 to 1.05)</td>
<td>0.96 (0.86 to 1.08)</td>
<td>1.04 (0.93 to 1.16)</td>
<td>1.03 (0.93 to 1.14)</td>
</tr>
<tr>
<td>n=268</td>
<td>Travel Time</td>
<td>0.99 (0.98 to 1.00)</td>
<td>1.00 (0.98 to 1.02)</td>
<td>1.01 (0.99 to 1.03)</td>
<td>1.02 (0.99 to 1.04)</td>
<td>1.02 (0.99 to 1.05)</td>
</tr>
<tr>
<td>62 (43.4%)</td>
<td>ADCL</td>
<td><strong>0.90 (0.79 to 1.03)</strong></td>
<td><strong>0.89 (0.78 to 1.02)</strong></td>
<td><strong>0.90 (0.79 to 1.02)</strong></td>
<td><strong>0.89 (0.78 to 1.02)</strong></td>
<td><strong>0.87 (0.76 to 1.00)</strong></td>
</tr>
<tr>
<td>No,</td>
<td>Euc Distance</td>
<td>0.95 (0.84 to 1.06)</td>
<td>0.96 (0.89 to 1.03)</td>
<td>0.96 (0.89 to 1.03)</td>
<td>0.97 (0.89 to 1.06)</td>
<td>0.96 (0.89 to 1.05)</td>
</tr>
<tr>
<td>n=181</td>
<td>Travel Time</td>
<td>1.00 (0.98 to 1.02)</td>
<td>0.99 (0.98 to 1.01)</td>
<td>0.99 (0.98 to 1.00)</td>
<td>0.99 (0.98 to 1.01)</td>
<td>0.99 (0.98 to 1.01)</td>
</tr>
<tr>
<td>81 (56.6%)</td>
<td>ADCL</td>
<td>0.90 (0.79 to 1.03)</td>
<td>0.89 (0.78 to 1.02)</td>
<td>0.90 (0.79 to 1.02)</td>
<td>0.89 (0.78 to 1.02)</td>
<td>0.87 (0.76 to 1.00)</td>
</tr>
<tr>
<td>Euc Distance</td>
<td>0.95 (0.84 to 1.06)</td>
<td>0.96 (0.89 to 1.03)</td>
<td>0.96 (0.89 to 1.03)</td>
<td>0.97 (0.89 to 1.06)</td>
<td>0.96 (0.89 to 1.05)</td>
<td>0.97 (0.89 to 1.06)</td>
</tr>
<tr>
<td>Travel Time</td>
<td>1.00 (0.98 to 1.02)</td>
<td>0.99 (0.98 to 1.01)</td>
<td>0.99 (0.98 to 1.00)</td>
<td>0.99 (0.98 to 1.01)</td>
<td>0.99 (0.98 to 1.01)</td>
<td>0.99 (0.98 to 1.01)</td>
</tr>
</tbody>
</table>

* Transportation variables included: Car ownership, Living within 200 meters of public transportation
Comorbidities variables included: Number of comorbid illnesses
Demographic variables included: Sex, age, race/ethnicity, socioeconomic status, education
Adjusted model included all of the Transportation, Comorbidities, and Demographic variables

**Socioeconomic Status** was defined by response to the question: "How hard was it for you to pay for the very basics over the last six months?" with a Likert-like responses: "Very Hard", "Hard", "Somewhat Hard", and "Not Very Hard". Individuals of low SES were defined as those who responded "Very Hard" or "Hard"; individuals of "high SES" were defined as those responding "Somewhat Hard" or "Not Very Hard"
Additional clinical variables did not improve statistical significance when we modeled each of the three measures of geographic accessibility.

A subsequent exploratory stratified analysis was used to identify potential effect modification or confounding within sample subgroups identified by demographic profile (race/ethnicity, sex, education, socioeconomic status), access to transportation (car/no car, living within 200 meters of public transportation), or location within or outside the city of Cleveland. We focused our attention first on the fully adjusted model, excluding the variable by which the model was being stratified (Model 5): in terms of ADCL, the strongest (and only statistically significant) associations were in men (OR=0.88, 95% CI: 0.78 to 0.99), Whites (OR=0.87, 95% CI: 0.78 to 0.98), people with less education (OR=0.88, 95% CI: 0.77 to 1.00), and individuals living outside of Cleveland city (OR=0.87, 95% CI: 0.76 to 1.00). When the stratified analysis was repeated to test the association between Euclidean distance and attendance, the odds ratio of an associated change in attendance with a one kilometer change in Euclidean distance was statistically significant only in men (OR=0.89, 95% CI: 0.82 to 0.97); the same analysis testing the association between travel time and utilization showed a significant association only in Whites (OR=0.96, 95% CI: 0.93 to 0.99). We performed a test for heterogeneity by including an interaction term between these variables and geographic accessibility, but the term was not statistically significant in any model or subgroup.
In the whole sample, Model 1 was compared to Models 2 through 5 to evaluate confounding. Adjustment in Models 2 through 5 excluded the variable by which the model was stratified. In terms of ADCL, adding variables overall strengthened the association from insignificant in Model 1 to significant in Model 5 in the categories of men, and people living outside Cleveland. Euclidean distance appeared to be confounded in individuals with a low education and low SES associations. The association attenuated upon adjustment: a significant unadjusted association between Euclidean distance and utilization (Model 1) was no longer statistically significant after adjustment with demographic variables (Models 4 and 5). We also took note of changes in the odds ratio of 10% or more upon adjustment. The odds ratio between ADCL and attendance was 9% stronger from Model 1 to Model 5 in men, and in terms of Euclidean distance, attenuated by 9% from Model 1 to Model 5 in individuals of low SES.

[4.0] Discussion: The results from our study of a small sample \( n=143 \) of diabetic continuity Medicaid patients support our hypothesis that our activity-space based measure of geographic accessibility (ADCL) is different, and potentially more discriminating, than traditional measures of Euclidean distance and travel time. Weak to moderate correlations between ADCL and the other two measures suggest that each of the three measures approximate different aspects of geographic accessibility. Consistent with prior studies, Euclidean distance was not associated with utilization of care, even after adjustment for a number of demographic, clinical and transportation-related variables. ADCL was weakly associated with attendance at visits. Patients have a 7% lower odds of attending a visit to their primary care physician, but the association was
only marginally significant (p=0.05). We draw our conclusions cautiously, as our study does have several limitations (discussed below).

Our results suggest that effect modification and confounding might play some role in our statistically marginal findings. In our stratified, exploratory analysis, we found differences in the strength of association across sample subgroups, which supports, or at the very least does not contradict, the possibility that the relationship between geographic accessibility and utilization was only present in certain groups. If this had been the case, then any existing subgroup association would have been diluted in the sample as a whole. The analysis also indicated that confounding was present: adjustment for demographic variables in particular affected the magnitude of the odds ratio, especially in certain sample subgroups. We included a comprehensive list of potential confounders, and used our inclusion criteria and screening process to eliminate important sources of confounding, especially uninsurance. Nonetheless, it is still possible that we have not adjusted for residual confounding due to other factors, such as quality of transportation, differences in community-level resources borne of historic patterns of segregation and migration, distrust of the medical system, burden of illness, and other, competing stresses. These tentative findings should be noted with caution, as the subgroup analysis was performed post-hoc, but we did carefully limit our sample subgroups to a few demographic, transportation and geographic variables that are conceptually or empirically associated with health care access and geography (as in Figure 3.1).
The General Accounting Office in 1995 concluded that federal and state policies directed at correcting the geographic maldistribution of medical services have largely failed to improve overall access to health care. The underlying premise of these policies is that increasing the number of providers in areas with low ratios of providers to population will improve geographic accessibility to, and overall utilization of, health care. Prior research, however, indicates that in urban areas, these measures of supply are not related to overall health care access. It is reasonable to instead approach the issue of geographic maldistribution in urban areas from the perspective of geographic accessibility, or the ease with which patients travel to obtain services. The studies that use this approach typically use traditional measures of geographic accessibility based on distance, but this measure is inconsistently associated with utilization, partly due to the fact that distance is not a valid or reliable measure in an urban setting, and because the association is also highly confounded. Our findings suggest that measures of geographic accessibility based on activity space might be more strongly associated with health care access and utilization. Future studies are crucial to exploring the potential strength of this measure.

Our findings elicit some concerns in the use of measures of geographic accessibility that should be explored in future studies. We encourage further exploration of activity space-based measures, but recognize that considerable data and calculations are required to build them, rendering them impractical for regular use in policy and research. Future studies might explore other, less arduous ways to enrich our measures so as to capture the complexity of geographic accessibility, possibly by taking advantage of existing data
(such as the National Household Travel Survey), or by supplementing existing data collection efforts. Our findings also suggest that potential effect modification may be an important issue, both for future research and policy. Knowing when, as well as for which subpopulations measures of geographic accessibility are associated with utilization may improve future study design, inform the interpretation of data, and help future researchers to recognize when strata-specific results should be reported. Understanding the extent of effect modification may also inform policy, as the effectiveness of interventions to correct lack of geographic accessibility might be enhanced when directed and actionable towards specific subpopulations.

We should consider other reasons for the weak association. It is plausible that the associations we found here are due to random chance, and that geographic accessibility as we have measured it is not associated with utilization of health care, in urban populations, or in this particular sample. However, we believe that the strength of the association was underestimated due to the limitations of the study. We selected continuity patients, thus biasing our sample to include individuals who have a prior history of attendance to visits. Geographic accessibility may not be as significant an issue as it is for those without a history of clinic attendance. Furthermore, our patients attend their primary care visits at one of the facilities affiliated with MetroHealth System, which has strategically expanded beyond its main campus to include health care centers throughout its service area in the last ten years. These are deliberately located near shopping centers and bus lines to promote ease of access. The weak association may simply be an indication that MetroHealth System has successfully addressed geographic barriers in its patient
population. Lastly, we encounter the most obvious limitation is the small size of our sample: our power to detect an odds ratio of 0.90 in 449 visits in 143 patients (adjusted for a variance inflation factor of 0.22) is 0.80, but if the odds ratio is 0.95, power diminishes to less than 0.60. If the odds ratio were 0.95, the odds of attending a visit decreases by 40% from the highest (ADCL=0) to lowest (ADCL=10) decile. This represents an important difference that has financial consequences for health systems, and medical consequences for diabetics. Our ability to detect smaller, but still clinically relevant associations in the sample in the whole, and in the subsamples in our stratified analysis, is limited.

We should also consider other limitations due to the study design that affect our interpretation of results. First, the results may have limited external validity. The population from which we drew our sample was limited to diabetic individuals who have Medicaid, have obtained their care at MHS, and were not limited in mobility by disability. Individuals who are uninsured, or who lack a regular source of care are shown to have poorer overall access to care, while individuals suffering from other chronic disease have different patterns of care. Furthermore, we only interviewed about a third of the individuals we attempted to contact. The individuals who responded to our survey were different in terms of race/ethnicity from those we could not reach, or who declined to participate. Further unmeasured differences in factors such as quality of life, severity of illness or transportation use might further differentiate the two samples. Secondly, the survey asked about travel behaviors in the six months before the survey was conducted, in April or May of 2007. Recall bias may be an issue: respondents to such surveys tend
to underestimate travel.\textsuperscript{66} It is possible, too, that respondents recalled more recent behavior rather than an average of behaviors over the six month period (a phenomenon called “telescoping”).\textsuperscript{67} Third, we were unable to account for changes in employment or other important changes to daily routine that might have changed activity space. If the relationship between the ADCL and health care utilization is a true one, then the association will likely be attenuated in these individuals.

**Conclusion:** Activity space-based measures require substantial data that is not currently used in access research, but these measures have potentially stronger associations with health care utilization than other measures of geographic accessibility, such as distance. Future research should considering the use and performance of these measures, especially after adjusting for confounding and potential effect modification. Resolving these questions may help to redirect health care policy.
CHAPTER 3: ENDNOTE REFERENCES


4. Noor AM, Zurovac D, Hay SI, Ochola SA, Snow RW. Defining equity in physical access to clinical services using geographical information systems as part of malaria planning and monitoring in Kenya. *Tropical Medicine & International Health* 2003;8:917-926.


33. Friedman GD, Cutter GR, Donahue RP et al. CARDIA: study design, recruitment, and some characteristics of the examined subjects. *J Clin Epidemiol* 1988;41:1105-16.


53. Katz JN. Can Comorbidity Be Measured by Questionnaire Rather than Medical Record Review? Medical Care 1996;34:73-84.


Chapter 4:

Siting of Health Centers in an Urban Setting, A Case Study of MetroHealth System’s Strategy
ABSTRACT:

This chapter is an exploratory case study that evaluates the institutional motives and information that drove the geographic siting decisions made by MetroHealth System (MHS), a public hospital system located in urban Cleveland, from 1992 to 2005. During this period, MHS expanded its Center for Community Health (CCH) to include several new sites of primary care. We specifically focused on the siting of the Broadway and Buckeye Health Centers, built in 2003 and 2004, which represented the fullest realization of MHS’s business strategy at the time. **Data Sources:** Sources of information included interviews with individuals who were involved with or had insight to the development or implementation of the CCH’s expansion, Board of Trustees meeting minutes, strategy documents, newspaper articles, and biannual tracking reports of the Cleveland health care market from the Center for Studying Health System Change. **Methods:** All documents and transcribed interviews underwent content analysis, guided by existing explanatory models of organizational responsiveness to financial incentives. Notes regarding repeatedly observed patterns of motive and use of information were written and revised throughout the data analysis to develop a complete interpretation of data. **Results:** MHS sited its health centers based on proximity to its patient population and in keeping with a “retail model” of care, whereby services were located close to other retail opportunities, public transportation, and convenient parking lots. CCH’s expansion was motivated most directly by the need to solidify its referral networks, but leaders rationalized the process from the perspective of providing better quality care to Cleveland’s indigent population. **Discussion:** MHS as an institution was clearly driven by its altruistic motive and the need to stay financially viable. Not only did altruism help MHS to distinguish itself in the
Cleveland market, it was also a core reason for the expansion of the Center for Community Health. Our study suggests that policies directed at health systems might be key in addressing issues of geographic accessibility in urban areas.
Introduction

The recent consensus of researchers and policymakers is that existing methods for correcting geographic misdistribution are inadequate. Increasing the supply of physicians, or providing economic incentives to individual providers for offering care in shortage areas have not proven to be effective solutions: the barriers that impact access are closely related to the availability of social services and the structure of the health care system.\(^1\) Expanding the availability of health care by locating community health centers in low-income neighborhoods, however, has proven effective in correcting inner-city disparities.\(^2\)

The Council of Graduate Medical Education suggested in a 1998 report that geographic barriers can best be addressed in inner city locations by either expanding or strengthening existing networks of care.\(^1\) Public urban hospitals provide the greatest share of indigent care in these areas, and are therefore an already critical part of the health care system. Because urban hospitals have the capacity to achieve efficiencies of scale, they can be viewed as a potentially important point for expansion. Future policies that provide financial incentives might enable and encourage such systems to proactively address issues of geographic access. We sought to suggest how future policies can be designed to maximally correspond to the needs and existing motivations of public institutions.

Prior research indicates that for-profit health systems prefer to locate their services in better-insured markets, leaving non-profit institutions to provide care in areas where the population is disproportionately uninsured.\(^3,4\) We have found no studies that describe how economic, geographic and organizational factors together influence siting decisions.
However, several studies examine the impact of financial incentives on non-profit
institutions’ decisions with regards to care for poor or indigent populations in general.
These studies adhere to one of three theories: 1) public institutions behaviors and
performance are not responsive to financial incentives either because decision-makers are
inured from the distribution of profits,5 2) public institutions are not responsive to
financial incentives because the institution’s funding derives from alternate sources
independent of the institution’s performance,6 or 3) public hospitals are highly responsive
to such financial incentives because of the intrinsic altruism of individuals who work at
public institutions.6-8

A case study was used to evaluate these existing theories by illustrating the motives that
guided a public institution’s decisions to site primary care clinics. We focused on
MetroHealth System (MHS), the only major public hospital system in Cuyahoga County,
and the area’s largest provider of indigent care. We conducted earlier investigations that
indicated that in a sample of diabetic patients who had established continuity at an MHS
clinic (determined by prior attendance at two primary care appointments at least thirty
days apart), there is no association between distance and attendance at primary care
visits. An activity space-based measure is associated with attendance, but only
marginally so. It is possible that the weakness or lack of these associations might be due
to the fact that throughout the 1990’s, MHS expanded its outpatient services to a network
of outpatient health centers located throughout urban Cleveland. To assist in the
interpretation of these earlier investigations, and to evaluate how MHS chose to address
the geographic barriers faced by its patient population, we centered on the decision-
making processes that informed the planning of these systems. Data gathered from semi-
structured interviews and archival information was used to highlight the institutional motivations and external environment that influenced the system’s recent strategic decisions to expand vis a vis community health centers in low-income neighborhoods.

[2.0] Methods

An explanatory case study research strategy was applied, consistent with Yin’s technical definition of the case study approach as “an empirical inquiry” that focuses on contextual conditions, and that uses multiple sources and types of data.9

Setting: The unit of analysis is defined as MHS’s decision to site Buckeye and Broadway clinics. This analysis covers the period of time roughly from 1994 through 2004, and focuses on the institutional decision processes that led to the siting and opening of the Broadway Health Center and the Buckeye Health Center. We selected the processes surrounding the siting of these two centers, as these represent the fullest realization of MetroHealth’s business strategy of expanding its health care clinics in the context of the Center for Community Health.

The MetroHealth System (MHS) is the third-largest hospital system and the only major public hospital system in Cuyahoga County, serving a volume of 700,000 outpatient visits in Cuyahoga County annually. According to past MHS administrators and MHS’s online information,10 MHS in the 1970’s and 1980’s was comprised of one primary hospital campus located on the west side of Cleveland, and additionally operated and managed several city-owned clinics and community health programs. In 1992, these off-campus efforts were formally consolidated into the Center for Community Health (CCH), which was subsequently expanded into a network of outpatient health centers located
primarily throughout urban Cleveland. The centers brought primary care services into closer proximity to patient populations in the far west side and east sides of Cleveland. The Broadway Health Center and the Buckeye Health Center were a part of that expansion.

**Figure 4.1**: Location of MetroHealth System’s Centers for Community Health in Cuyahoga County

The Broadway and Buckeye Health Centers were located in the eastern half of Cleveland in poor, urban neighborhoods with a high proportion of Medicaid patients. A map of their locations is shown in Figure 4.1. Their placement and character were in keeping with what MHS leaders described as a “retail model” of care, which meant that they were
strategically sited at shopping centers with abundant parking, on public transportation routes, and near grocery stores and other shopping opportunities.

Our intention is not to evaluate the success of these clinics, but it is worth noting that from MHS’s perspective, the health centers were a success. According to leaders, they quickly reached their targets for patient volume, while media reports indicated that they met with an overall positive reception from the community.11, 12

**Data Collection:** Data consisted of interviews and archival material in keeping with Yin’s case study methodology.9 Interviews were conducted over a three-month period with individuals who were involved in or had insight to the development or implementation of the Center for Community Health during some period of 1992 to 2005. Interviews were conducted until the investigator determined that theme saturation had been achieved – in other words, no additional points of discussion were heard in additional interviews. Individuals who held the following positions were interviewed:

- CEOs, MetroHealth Hospital
- Vice President of Strategic Planning
- Vice President of Business Development
- Director of Medical Planning, Center for Community Health
- Administrator, Center for Community Health
- Vice President of Planning and Institutional Research
- Director of Cost Reimbursement

Interviews were semi-structured and open-ended, and focused on the decision-making processes pertinent to the strategic planning and implementation that led to the opening of the Buckeye and Broadway health centers. Because this case study is focused in part on potentially sensitive issues of the institutional motivation behind institutional decision-
making, open-ended inquiry was the most appropriate method, as it provided an
environment that allowed for natural opportunities to ask questions about institutional
motivation.9 Interviews were 45 minutes to two hours long. These were tape recorded,
transcribed, and their content analyzed for recurring themes.

Archival material that could be obtained from MHS included 1) MHS annual reports to
the community from 1993 through 2003, 2) minutes from MHS Board Meetings dating
from 1993 to the present, and 3) focus group reports and market analysis that were
carried out in 2002-2003 as part of a formal research and planning initiative that
evaluated options for MHS expansion (the Satellite Strategic Planning Initiative). Other
information included biannual tracking reports provided insight to the local Cleveland
health care market that were obtained from the Center for Studying Health System
Change.13

**Data Analysis:** Transcripts of interviews and notes on the data described above
underwent content analysis using N-VIVO software, guided by three theories of nonprofit
organizational responsiveness to financial incentives summarized by Duggan in his
evaluation of the behavior of not-for-profits.6 These three models are useful, not only
because they represent the most prominent theories that ground organizational research
and policy in the health sector, but also because they provide a justification for studying
non-profits in health care as distinct from for-profit health institutions, and because they
present testable hypotheses that can be evaluated in our case study. Sample codes
included explanatory statements pertaining to the process by which the siting of Buckeye
and Broadway occurred, explication of MHS’s business strategy during the study period
and expressions of motive. Following this coding, links between items were built to
elucidate chronology and causality. Notes regarding repeatedly observed patterns of motive were written and revised throughout the data analysis to identify theme saturation and develop a complete interpretation of the data.

[3.0] Results: The Buckeye and Broadway health centers were located in two neighborhoods in the eastern part of Cleveland. The geographic placement and related attributes of the clinics were determined by the following information:

- **Proximity to patients:** Demographic analysis regarding the composition of existing and potential MHS patients was carried out to determine where the greatest number of current and potential MHS patients lived. The analysis focused primarily on patients with Medicaid insurance, and also included a more detailed analysis of the location of specific patient populations, such as children, pregnant women, and geriatric patients.

- **Assessment of Sites:** An assessment of locations was carried out to determine the best placement for clinics within the neighborhoods. Ideal sites were identified as being within shopping centers, close to other retail opportunities, parking lots, and along public transportation routes.

The use of these data was determined by long-term business strategy and the condition of the Cleveland health care market. These factors had the following impact on the location of Buckeye and Broadway.

The first section describes the long-term business strategy and concurrent environmental factors that influenced decisions regarding the building and siting of the Broadway and
Buckeye clinics. The second and third sections describe two primary themes underpinning the decision-making process that emerged regarding MHS’s siting decisions: the role of altruism, and the importance of economic pressures.

Section 1: The Influence of Environment and Business Strategy

The long-term business strategy that drove the decisions regarding the location and character of the Broadway and Buckeye Health Centers was influenced by changes in Cleveland’s market in the 1990’s. The immediate need to replace aging facilities and to respond to the closing of several facilities that had served poor, urban populations were important in the siting of these two Health Centers. The development of MHS’s business strategy and the nature of the external circumstances during the study period are described below.

The 1990’s Cleveland Market: Interviewees made multiple references to “strategy” to explain the underlying rationale for several decisions regarding the development of the MHS system during the study period from 1994 to 2005. This “strategy” referred to a set of broad organizational goals was articulated through documents, in particular, a “Vision Plan 2000” document cited in Board Meeting minutes. The components of that strategy, as articulated by interviewees, are described in this section.

The MHS strategy from 1994 onward could be described in part as a response to a changing health care market. In the late 1980’s and early 1990’s, several factors, cited by interviewees and discussed in a 1997 Community Report from the Center for Health System Change, converged to increase competition and to change the behavior of health care systems in the Cuyahoga County area. These included the growing prominence of
managed care programs in Medicaid and Medicare, the advent of Diagnostic-Related Group systems\(^1\), the entrance of two national private for-profit health systems into the Cuyahoga County market, and the retirement of Ohio’s Certificate of Need regulations that had previously limited who could render, and thus earn revenue from, certain health care services. The major hospital systems in the Cuyahoga County area responded to changes in the market by aggressively expanding their referral networks, either through partnerships, acquisition of smaller practices, or negotiation with managed care contracts.\(^{14}\)

MHS experienced additional financial pressures specific to its status as a public institution. Several interviewees underscored tenuous financial support from the Cuyahoga County government in the early 1990’s. Since it took ownership from the city in 1957, Cuyahoga County has provided an annual subsidy to MHS, which shrank from $26.8 million to $13.4 million in 1994,\(^{15}\) a cut the County government argued was offset by money from the state’s Care Assurance Program, and that could not feasibly be restored the next year due to a County financial crisis.\(^{16}\) Board meeting minutes additionally made multiple references to the volatility of funding from the State and federal programs, specifically the uncertainty of funding from the federal Disproportionate Share Hospital Care Assurance Program (HCAP) that provided reimbursement for uncompensated inpatient care,\(^{17,\ 18}\) and ongoing concern regarding proposed US Congressional cuts to Medicaid and Medicare.\(^{18-20}\) These sources of

\(^1\) Diagnostic-Related Group payment systems were meant to allocate payments based on predictions of patient length of stay, based on ICD-9 code, procedures, and relevant comorbidities, complications, and demographic characteristics. Hospitals were only paid for a specified length of hospital stay, but found ways around these regulations by admitting them to rehabilitation centers where payment was not dependent on a DRG, in effect, “starting the clock” again with regards to payment. Other hospital systems in Cleveland began to build up rehabilitation programs that competed with MetroHealth’s own already existing rehabilitation program.
funding were particularly important to MHS, which received the largest share of HCAP money and was the largest provider of Medicaid patients in the state.

In interviews, individuals who served as MHS leaders overall during this time stated that MHS’s response at this time was to solidify MHS’s financial standing during this volatile time. To accomplish this, MHS pursued two objectives. The first objective was to solidify existing patients into a referral network. The second was to diversify payor mix so as to potentially capture a larger share of the commercially-insured market. It is perhaps interesting to note that later leaders emphasized the development of referral networks, but placed less emphasis on diversified payor mix.

**Implementation of Strategy:** According to interviewees, MHS strategy impacted the development of the MHS’s satellite clinics in two ways. First, expanding the Center for Community Health to provide accessible points of access to care in the community became a key areas of focus (other foci included rehabilitation, trauma, and geriatric services) that were viewed as areas in which MHS could be, or was already, competitive. MHS leaders indicated that developing the primary care network *vis a vis* the CCH was thought to be a way of achieving the two objectives of MHS’s strategy (solidifying patient relationships with MHS, and establishing referral patterns to MHS’s more lucrative specialty, inpatient and tertiary care). Geographically, this meant locating primary health services that were meant to be primary points of contact in neighborhoods where patients lived.

Secondly, there was an emphasis on elevating the appearance and operation of MHS to that of a private doctor’s office in the implementation of strategy, so as to attract
commercially-insured patients, and to additionally elevate the quality of care for all patients. The former “clinic” model (or “welfare clinic” model, as one interviewee described it) was a term stigmatized in the minds of MHS leaders by its association to a “large, industrial scale model”, “long waits”, “orange plastic chairs and bad lighting”, and the connotation of being a “place of last resort [care]”. The “private doctor’s office” model, on the other hand, emphasized patient continuity with individual physicians, attractive facilities, and “certain amenities”. Leaders also emphasized that this polished appearance and approach applied to all aspects of MHS care; one interviewee jokingly described a vision of these uniformly built and operated health centers placed throughout MHS’s service areas as “McMetros”. Three other interviewees specifically stated that MHS “is not a two-tier system,” providing one level of care for indigent patients, and another level of care for paying patients. As one interviewee stated: “you didn’t have a choice of roommates, you could be rooming with an uninsured patient who never worked a day in their lives, and the insured professional patient would be in the same room.”

During the first few years that MHS focused on CCH through the lens of “private doctor office” care, several satellite health centers were built. Through the process of building these centers, leaders noted that the success of these health centers was predicated on their prominent location in areas with safe parking lots, and greater accessibility to bus lines; leaders eventually conceptually unified these characteristics as the “retail model”.

**Immediate Circumstances:**

In addition to long-term strategy, several immediate concerns converged during the satellite strategic planning initiative that shaped the decision-making process of building
and siting of the Buckeye and Broadway health centers. These included the deterioration of MHS’s facilities, movement of MHS’s patient population, and changes in the health care market.

In the last half of the 1990’s, MHS assessed ways to address the aging of several of its satellite facilities, primarily the Clement and the Miles-Broadway Health Centers, which were both located on the east side of Cleveland. According to interviewees and to reports by MHS’s Satellite Strategic Planning Initiative, renovation was immediately considered an unappealing option, not only because of the cost of updating aging facilities, but also because migration out of and within the city of Cleveland left the Cleveland neighborhoods served by the Clement and Miles-Broadway Health Centers relatively empty.

Also of importance were concurrent changes in the availability of health care for indigent populations. As MHS was evaluating its satellite facilities, several hospitals that served indigent populations in Cleveland closed, or were struggling in the face of increasing regional competition and consolidation of area health systems. The closing of two of these institutions: Mt. Sinai, and St. Luke’s Hospitals, and the then-imminent closing of St. Michael’s left a significant portion of the east side of Cleveland without a nearby source of primary care.

In interviews, MHS leaders articulated the view that addressing the weakened safety net and the changing needs of the urban community was not only MHS’s obligation as a public institution, but was also consistent with its strategic objectives. In light of the need for identifying gaps in the safety network, a local foundation, The Cleveland
Foundation, provided MHS an $800,000 grant to fund research towards identifying appropriate sites, evaluating demographic trends and performing community focus groups.

**Section 2: Altruistic motive as a factor in geographic decision-making**

At least one major theory of organizational behavior proposes that nonprofit health care institutions are driven to be responsive to financial incentives related to caring for indigent populations due to the altruistic motives of decision-makers. Our data support that theory of behavior at MHS.

Interviewees interpreted the siting of Broadway and Buckeye clinics in poor, urban neighborhoods, as well as the retail model in the context of MHS’s “altruistic side.”

Without exception, every interviewee expressed the philosophic importance of altruism in terms of personal belief, and as part of MHS’s mission statement, which reads as follows:

> “The MetroHealth System commits to leadership in providing outstanding health care for individuals and in promoting the health of the community. We offer an integrated program of services, provided through a system directed by a partnership of physicians and management, which encompasses excellence in patient care, education and research. We are committed to responding to community needs, improving the health status of our region and controlling health care costs. We hold as a core value the provision of service to any resident of Cuyahoga County regardless of ability to pay.”

Data were remarkably consistent regarding the fixedness of the mission (“[The mission is] our starting point.”). All aspects of this mission statement were referenced in
interviews and archival materials, but MHS’s stated altruistic commitment to treating poor, indigent patients “regardless of ability to pay” emerged as the core of its institutional identity. Board meeting minutes, too, confirmed the strength and pervasiveness of that view among the governing Board of MHS with statements like “we are a hospital serving the community.”

All strategies were justified by referring back to the need to serve MHS’s altruistic purpose. This impacted who MHS viewed as “their” market: when carrying out the demographic research that resulted in the Buckeye and Broadway clinics, for example, specific analytic focus was placed on the Medicaid populations. Other strategic decisions were made with reference to mission: an institution-wide effort to improve care was viewed by interviewees not only as economically sensible, but also mission-oriented. One interviewee stated the consensus view that “the other benefit of this strategy [other than attracting paying patients] was that we felt it raised all boats”, while the Board Chairman the MHS Board meeting minutes noted that while it was important to provide “quality care while increasing services to the community”, “it [was] essential for MetroHealth to remain firm, without compromise, in making health care accessible to those who cannot pay”. For example, one MHS leader described the decision-making process regarding the building of a large outpatient center for ambulatory care:

“There was some controversy about that – should you build it across the street or out in the suburbs? Well, out in the suburbs would have been better for attracting paying patients, but across the street was – again, this was the overriding philosophy – that there was one level of care, and we weren’t going to do anything like have a new shiny facility out in the suburbs and then second-rate facilities at Metro, so basically the strategy was put it here, and have the paying patients come to Metro. Again, this was clearly geared to the changing market, it needed more and better outpatient facilities, and you couldn’t just get paying
patients by wishing them, you needed to provide some of those services at this facility, so we did.”

Most interviewees identified and valued the “uniqueness” of MHS’s altruistic mission among Cuyahoga County’s health systems, but acknowledged the positive and negative consequences of its status as Cuyahoga County’s primary provider of last resort. Several interviewees indicated that MHS faced challenges in expanding aggressively, not only because MHS lacked the “money and clout” of the other larger area health systems (University Hospitals and the Cleveland Clinic), but also because of the negative perception of MHS as a public “clinic” (or “poorhouse”). Other health systems sought to locate in suburban areas, where a greater proportion of commercially insured patients resided. MHS’s ability to compete in these areas was not as great as in urban locations, where indigent patients tended to reside. As one interviewee explained, “While other clinics were building palatial things near the freeway interchanges and the suburbs, it basically left a population for Metro [in the city].”

Section 3: Financial incentives as a factor in geographic decision-making

Two other theories of organizational behavior posit that public, nonprofit health care systems are less responsive to financial incentives than for-profit institutions. The first theory hypothesizes that the difference in response occurs because unlike for-profit firms, nonprofit health care systems do not distribute residual income to owners or other individuals who control the system; individual incentives for maximizing profit do not exist. The second theory hypothesizes that because publicly-owned institutions derive at least part of their income from the government, independent of performance, the
institution’s incentive to maximize income is weakened. Our evidence suggests that MHS leaders were in fact responsive to financial incentives, sought to attain economic stability as a strategic goal, and did not perceive government funding, whether by county subsidy or any other mechanisms as certain, or reliable.

Maintaining financial viability was a goal articulated by MHS leaders and in other materials, consistent with the Chairman of the Board’s exhortation in the minutes that “[MHS’s] work must extend to those in the community unable to pay for medical care and at the same time maintain our own financial strength and viability.” MHS leaders justified the economics of siting the Buckeye and Broadway Health Centers as part of a greater strategy to secure a market share of Cleveland’s urban patient population. However, MHS’s financial stability was in reality dependent on several other sources of funding. MHS was therefore not only responsive to the health care market, but was also responsive to indirect reimbursement policies pertaining to its status as a public and academic institution.

Due to its status as a county health system, an academic center, and the provider of last resort in Cuyahoga County, several sources of primarily public funding were available to MHS. As described by interviewees and in the minutes, government funding, whether federal, state, or county-sponsored, was dynamic, and uncertain. Interviewees made reference to the complexity of the laws and formulas related to reimbursement through public mechanisms for graduate medical education and the Hospital Care Assurance Program, which was meant to compensate hospitals that provide a disproportionate share of care to indigent patients. From interviews, it became apparent that MHS not only applied for available public funds, but also directed lobbying efforts towards the state
entities responsible for setting reimbursement levels. This was accomplished by lobbying either through national organizations, with other area nonprofit institutions, or through MHS leaderships’ lobby visits with state legislators in Columbus.

As an example of MHS’s interaction with state government, several interviewees referred to MHS’s efforts to obtain funding through the Upper Payment Limit, which was a mechanism legislated by amendment to the Social Security Act that provided states with federal matching funds to increase Medicaid payments to hospital systems beyond normal rates. As interviewees stated, MHS was responsible for directly educating and negotiating these regulations with state legislators. These relationships with the county, state and federal government were cultivated and maintained; the function was eventually formalized into an Office of Government Relations within the MHS hierarchy.

[4.0] Conclusion:

MHS’s expansion of the Center for Community Health was part of a larger effort to solidify sources of MHS’s income consistent with, and in the service of MHS’s altruistic mission. As the Cuyahoga health care market changed, MHS adapted responsively to financial incentives, actively seeking opportunities for subsidizing the cost of its charity care, seeking ways to solidify existing referral networks, and attempting to expand its current patient base to include a more diverse payor mix. With regard to prior theories of organizational behavior summarized by Duggan, MHS was in fact responsive to financial incentives insofar as such incentives strengthened the institution’s economic standing, and reinforced MHS’s ability to carry out its altruistic mission, but leaders
indicated that MHS was also limited in its ability to aggressively expand, primarily due to the lack of “money and clout” of other health systems in the area.

**Recommendations**

The following are observations from the case study of MHS that have potential applicability to other systems:

First, MHS’s response to external policies or circumstances was dependent on the condition of that market, and that institution. MHS’s siting decisions were the result of strategy, which was rooted in the principles of 1) altruistic mission and 2) economic stability. The implementation in the case of Buckeye and Broadway health clinics, however, was also contingent on local circumstances and the actions of the other major players in the market.

Second, a sense of mission in caring for the underserved was a powerful motivator in this public institution, and was important for helping MHS to distinguish itself as a unique institution in the Cleveland market in terms of mission, the patient population served, and ultimately, location. MHS leaders expressed awareness of this identity as a core guiding principle in development, as well as a justification in the pursuit of government funding for uncompensated care.

Third, the money made available to address the needs of underserved patients was fragmented, and the mechanisms used to administer those funds were complex. Under the system of funding in which MHS operated, hospital systems that were proactive, aware, and who have an open line of communication with policymakers were more likely
to succeed in attaining those funds, and maximizing their utility. In the case of MHS, such funding was viewed as critical to the institution’s ability to operate, but was not viewed as the only source of funding: MHS’s institutional motivation for the geographic expansion of the Center for Community Health was driven by the need to cultivate referral networks, draw a diverse payor mix, and to capture a share of the market, so as to ensure income.

**Limitations:** It is important to note that there are some limitations to the analysis and interpretation of results. Although we used external sources of information as possible as a validation, our interviews were limited in that they were retrospective, and included only the perspectives of the leadership responsible for the strategic planning behind the MHS network expansion. This may have resulted in biases, including recall bias, where interviewees might not recall all pertinent events relevant to the geographic expansion. We furthermore cannot discount the possibility of response bias, whereby interviewees may have only reported motivations and events that depicted MHS and its strategy in a positive, less critical light. We sought to overcome these biases by conducting multiple interviews that continued until we achieved theme saturation, but the possibility of their existence cannot be discounted.

Furthermore, it is difficult to establish to what extent MHS’s altruistic and financial motivations are true of public hospitals elsewhere. This is important in terms of our ability to make more specific policy recommendations that promote geographic expansion of health care systems; we have established that market conditions and mission are important considerations in formulating policy, but incentives that are consistent with
MHS’s mission and culture may not work in another nonprofit that for example experiences a strong soft-budget constraint.

**Conclusion:** Working with existing networks of care is one solution to addressing geographic accessibility issues. Provided appropriate information about patient location, local structures, and the health care environment, proactive health care systems can be appropriately incentivized to structure their networks to meet local need.
CHAPTER 4: ENDNOTE REFERENCES


3. McClellan MB, Staiger DO. Comparing Hospital Quality at For-Profit and Not-for-Profit Hospitals: NBER; 1999.


17. Payment to Hospitals for Inpatient Hospital Services. §§ Ohio Title 42 (2002)


Chapter 5: General Discussion
General Discussion

This dissertation, considered as a whole, evaluated the current model of geographic accessibility in the context of a single, urban health care system in Cuyahoga County. Our current conception of geographic accessibility is not well-developed, either in research or policy; our results are an attempt to evaluate the quantitative measures used to represent access to health care services, and to suggest how policies might better address issues of geographic accessibility in urban settings.

Our investigation of the issues of geographic accessibility within a single system is consistent with the conceptualization of access to health care as a “fit” between a patient population and health services. By focusing on a single health care system, we had the unique opportunity to evaluate multiple parts of one model, focusing not only on the association between geographic accessibility and attendance at primary care visits, but also taking into considering the health system’s response to issues of geographic access.

We first developed a conceptual model (shown in Figure 5.1) based on existing theories of geographic accessibility and its relationship to other dimensions of access. The three study aims of the dissertation evaluated this model using a mixed methods approach. The first two aims utilized a quantitative focus to evaluate measures of geographic accessibility in relation to attendance at primary care visits in a sample of diabetic, continuity patients who received their care at one of nine family medicine or internal medicine sites that were part of a single health care system. The first aim (Chapter 2)
evaluated Euclidean distance and its association with attendance at primary care visits in a sample of chronically ill patients in Cuyahoga County. Our findings indicated that:

- In the sample under investigation, distance from home to clinic, the usual measure of geographic accessibility used in literature and policy, was not associated with attendance at health care visits after adjustment for sex, age, race/ethnicity, and number of comorbid conditions.

- Upon stratification, we found that distance was only associated to a statistically significant degree in the subgroup of Whites; further distance appeared to be associated with better attendance, contrary to the expected interpretation of greater distance as a barrier to access.

Figure 5.1

Conceptual Model of Geographic Access: v. 1.0
In the second aim (Chapter 3), we sought to quantify the complexity of geographic accessibility using a more nuanced measure based on the concept of “activity space”, as per Figure 5.2.

**Figure 5.2**

The measure used, “activity density of clinic location” (ADCL), explicitly defined geographic accessibility as a function of time, space and all the places a person visits during their day. The analysis focused on indigent diabetic patients with Medicaid insurance.

- In this sample, ADCL overall appeared to be associated with attendance to primary care office visits to a marginally statistically significant degree: a 1 unit increase in the ADCL measure was associated with a 7% decrease in probability of attending a visit (OR=0.93; 95% CI 0.87-1.00).
• A subsequent exploratory stratified analysis indicated that the association was significant in some strata, but not others, suggesting effect modification within certain demographics. This finding is reflected in the dashed line shown in Figure 5.3.

**Figure 5.3**

Our final investigation, Aim 3 (Chapter 4), used qualitative case study methods in an exploratory investigation of MHS’s decision-making process with regards to the expansion of its community health centers. MHS, as a county hospital, serves the greatest proportion of uninsured and Medicaid-insured patients in Cuyahoga County. The current system grew from one main hospital and five satellite clinics to one main hospital and nine satellite health centers distributed throughout MHS’s service area. We posited that geographic accessibility is not only dependent on individual patient geography, but is
also dependent on the accessibility of the health care system in question. Our findings indicated that:

- MHS used two types of geographic information to make its expansion decisions. The first type of information was analysis regarding the location of existing and potential patients. The second type of information was an assessment of potential retail locations for their proximity to other retail opportunities, parking lots, and public transportation.

- MHS’s motivation for addressing geographic accessibility issues was rooted in the principles of 1) altruistic mission and 2) economic stability, although the implementation of those principles in the case of Buckeye and Broadway health clinics was contingent on local circumstances, and the actions of the other major players in the market.

This investigation prompted one last revision to the conceptual model (Figure 5.4), which differs from previous versions of the conceptual model in that the relationship between health care system factors, activity space, and individual geographic accessibility to health care is redrawn to be bidirectional, to indicate that at least in the case of MHS, health care systems do make use of geographic information consistent with the measures that we compared in this study.
Next Steps

Geographic accessibility to care is a difficult concept to measure, as it is a highly complex and confounded construct, because it depends on locale, and because the “fit” between patient population and the health system is dynamic. Future studies that evaluate holistic measure of geographic accessibility that can account for some of these complexities are needed, as well as studies that carefully evaluate confounders and their impact on a variety of settings.

We also suggest that because the dynamics of geographic accessibility are depending on locale, future studies should include questions of geographic accessibility that provide a holistic view of the whole system. Such studies may help to validate some of the
findings in this study, provide a better perspective on the relationship between population access and health system structure, and suggest ways in which access might be improved in all urban areas.

From a population perspective, the association between geographic accessibility on attendance may vary; understanding how these associations differ for different demographics, and developing a number of tailored interventions to address the potentially broad range of issues in each may be helpful.
Appendix A: Phone Survey of Locations
Script: Can I start with the questions now? First, I am going to ask you a few questions to make sure you are eligible to participate in the study.

screen1 Have you moved in the last six months, after July 4th?
   Yes → Go to screen1a
   No
screen1a Did you move after the New Year?
   Yes
   No → Exclude

screen2 In the last six months, did you primarily need to use a wheelchair to get around?
   Yes → Exclude
   No

screen3 In the last six months, did you use a van service to get to your primary care appointments?
   Yes → Exclude
   No

Great, it looks like you are eligible for the study. Now, I am going to ask you some questions about your background: your education, the work you do, and your marital status.
qedu1  What is the highest grade (or year) of regular school you have completed? (check one box from 1-20)

Elementary: 1
Elementary: 2
Elementary: 3
Elementary: 4
Elementary: 5
Elementary: 6
Jr High: 7
Jr High: 8
High School: 9
High School: 10
High School: 11
High School: 12
College: 13
College: 14
College: 15
College: 16
Graduate school: 17
Graduate school: 18
Graduate school: 19
Graduate school: 20

qedu2  What is the highest degree education you have earned? (check one only)

High school diploma or equivalent
Associate degree (junior college)
Bachelor's degree

138
Master's degree

Doctorate

Professional (MD, JD, DDS, etc)

Other (specify) __

None of the above

Qedu3 Have you ever attended any school like a technical, vocational, or trade school?

Yes

No

Qmar1 In the last six months, were you married?

Married

Not married

Qmar2 In the last six months, were you living with someone in a marriage-like relationship?

Yes

No

Qhshld2 Who are the people that lived with you over the last six months?

___ Spouse

___ Significant other

___ Brothers/sisters

___ Parents

___ Children (clarify below: how many adult, how many children)

___ Step-children (clarify below: how many adult, how many children)

___ In-laws

139
Script: I’m going to ask some questions about your employment and other main daily responsibilities over the last six months.

qemp1 In the last six months, were you employed?

    Yes
    No

qemp1_hours How many hours a week did you work in the last six months, before you moved?

qemp2 In the last six months, did you go to school?

    Yes
    No

qemp2_hours How many hours a week did you go to school in the last six months?

qemp3 In the last six months, were you responsible for keeping house?

    Yes
No

qemp3_hours  How many hours a week did you spend keeping house in the last six months, ?  __________

qemp4  In the last six months, , were you responsible for caring for someone else, like a child or parent?

Yes

No

qemp4_hours  How many hours a week did you spend caring for him/her/them in the last six months, ?  __________

qemp5  In the last six months, , did you have any other major responsibility that took up more than ten hours of your time per week?

Yes

No

qemp5_text  What was that?  __________________________

qemp5_hours  How many hours a week did you spend on {qemp5_text} in the last six months, ?  __________

qdem1  Over the last six months, , how hard has it been for you to meet the demands on you from these responsibilities?  Would you say it’s

Very hard

Hard

Somewhat hard

Not very hard
qses1  *Over the last six months, how hard was it for you (and your family) to pay for the very basics, like housing, medical care, and food? Would you say it's:*

- Very hard
- Hard
- Somewhat hard
- Not very hard

qses2  *Over the last six months, how frequently did you have trouble making ends meet? (If not clear, explain: "this means living within your income, and avoiding debt")*

- Very frequently
- Frequently
- Somewhat frequently
- Not very frequently

qtrnspt_1  *Over the last six months, what was your primary mode of transportation?*

- Public transportation
- Car
- Bike
- Walking

qtrnspt_2  *Over the last six months, did you have a driver's license?*

- Yes
- No

qtrnspt_3  *Over the last six months, how hard has it been for you to access a car or to get a ride when you needed it? Would you say that it's:*

- Very hard
- Hard
Somewhat hard
Not very hard

qtranspt_4  Over the last six months, did you own a car?

Yes
No

qaccess_1  In minutes, how long does it take for you to get to your primary care doctor's office? ___________

qaccess_2  Over the last six month, how hard was it for you to get the health care you needed?

Very hard
Hard
Somewhat hard
Not very hard

qaccess_3  Over the last six month, how hard was it for you to travel to your primary health care doctor's clinic?

Very hard
Hard
Somewhat hard
Not very hard

Script: Great. Now, we're interested in how close clinics are to the places you go every day. The next part of the survey will give us an idea of where you went during your day in the last six months. Do you have any questions?

1) Where do you go to work (up to 5)?
   a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
b. How often do you go to that location, in times per week, month, or total times over the last six months?

2) Where do you go to school (up to 5)?
   a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
   b. How often do you go to that location, in times per week, month, or total times over the last six months?

3) Where do you go related to keeping house (up to 5)?
   a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
   b. How often do you go to that location, in times per week, month, or total times over the last six months?

4) Where do you go related to caretaking for a child or parent (up to 5)?
   a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
   b. How often do you go to that location, in times per week, month, or total times over the last six months?

5) Where do you go related to other main activities that take up 10+ hours of your time (up to 5)?
   a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
   b. How often do you go to that location, in times per week, month, or total times over the last six months?

6) Where do you go grocery shopping (up to 2 responses)?
   a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
   b. How often do you go to that location, in times per week, month, or total times over the last six months?

7) Convenience store
   a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
   b. How often do you go to that location, in times per week, month, or total times over the last six months?

8) Other kinds of shopping
a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
b. How often do you go to that location, in times per week, month, or total times over the last six months?

9) Bank?
a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
b. How often do you go to that location, in times per week, month, or total times over the last six months?

10) Buy stamps/send packages?
a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
b. How often do you go to that location, in times per week, month, or total times over the last six months?

11) Run other errands
a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
b. How often do you go to that location, in times per week, month, or total times over the last six months?

12) Go to religious services or religion-related activities
a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
b. How often do you go to that location, in times per week, month, or total times over the last six months?

13) To visit friends or family
a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
b. How often do you go to that location, in times per week, month, or total times over the last six months?

14) To relax
a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
b. How often do you go to that location, in times per week, month, or total times over the last six months?
15) To eat out
   a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
   b. How often do you go to that location, in times per week, month, or total times over the last six months?

16) To get gas for your car?
   a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
   b. How often do you go to that location, in times per week, month, or total times over the last six months?

17) To get your car serviced?
   a. Where is that located? (You can give me a nearby intersection, or closeby landmark).
   b. How often do you go to that location, in times per week, month, or total times over the last six months?

18) Anything else (up to 5)?
Appendix B: Building Activity Density of Clinic Location (ADCL), an activity space-based measure
The following is a mock example of how the clinic activity density measure is built. Locations and frequency of visit of common activities over the last six months are gathered through survey (Table B.1). Frequency of visit is converted to determine how many days over the last six months a particular location was visited. Locations related to the individual’s health care were excluded, although visits to the health care system that were a part of someone else’s care, like a child or a parent, were included.

**Table B.1:** Frequency and location of common activities over the last six months for example participant

<table>
<thead>
<tr>
<th>Location Name</th>
<th>Address</th>
<th>Zip Code</th>
<th>Frequency of visit over the last six months</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>XXXX Overlook Rd</td>
<td>44106</td>
<td>7 Per week</td>
<td>168</td>
</tr>
<tr>
<td>School</td>
<td>10900 Euclid Ave</td>
<td>44106</td>
<td>2 Per month</td>
<td>48</td>
</tr>
<tr>
<td>Hospital (work)</td>
<td>2500 Metrohealth Dr</td>
<td>44109</td>
<td>2 Per month</td>
<td>48</td>
</tr>
<tr>
<td>Zagara</td>
<td>1940 Lee Rd</td>
<td>44118</td>
<td>2 Per month</td>
<td>12</td>
</tr>
<tr>
<td>Food Co-op</td>
<td>11702 Euclid Ave</td>
<td>44106</td>
<td>1 Per month</td>
<td>6</td>
</tr>
<tr>
<td>CVS</td>
<td>2160 Lee Rd</td>
<td>44118</td>
<td>1 Per month</td>
<td>6</td>
</tr>
<tr>
<td>Friend's house</td>
<td>2179 W 11th St</td>
<td>44113</td>
<td>3 Per month</td>
<td>72</td>
</tr>
<tr>
<td>Dewey's</td>
<td>13201 Shaker Sq</td>
<td>44120</td>
<td>1 Per month</td>
<td>6</td>
</tr>
</tbody>
</table>
These locations were geocoded using ArcGIS (Figure B.1). Streetmap coordinates were used for this stage of data processing.

**Figure B.1:** Geocoded addresses
Distance from home to all locations on the list was determined, using the network analyst tool in ArcGIS. Mean distance from home to all locations in the person’s activity space was determined from the results.

**Figure B.2:** Distance from home to all locations using network analyst
The kernel density tool was used to draw an activity density map, based on the geocoded points. The radius of the density was specified as mean distance from home to all recorded locations.

**Figure B.3: Kernel density plot**
The contour tool was used to identify deciles of activity. All activity outside the kernel density was labeled as 0%; the area of highest density was labeled 100%.

**Figure B.4:** Contoured representation of kernel density

The decile of density in which the patient’s clinic is located is recorded. For this particular mock patient, the clinic activity density is 20%.

**Figure B.5:** Determining clinic activity density
BIBLIOGRAPHY OF WORKS CITED


Buor D. Analysing the primacy of distance in the utilization of health services in the Ahafo-Ano South district, Ghana. *Int J Health Plann Manage* 2003;18:293-311.


"Center for Community Health: About the Department." <http://www.metrohealth.org/body.cfm?id=739&oTopID=739>.


Coulton CJ, Chow J, Pandey S. An analysis of poverty and related conditions in Cleveland area neighborhoods: Case Western Reserve University; 1990.


154


Duggan MG. Hospital Ownership and Public Medical Spending. Technology 2000;1343.


Freeman HE, Corey CR. Insurance status and access to health services among poor persons. Health Serv Res 1993;28:531-41.

Friedman GD, Cutter GR, Donahue RP et al. CARDIA: study design, recruitment, and some characteristics of the examined subjects. J Clin Epidemiol 1988;41:1105-16.


Glaeser EL, Shleifer A. Not-For-Profit Entrepreneurs: NBER; 1998.


Katz JN. Can Comorbidity Be Measured by Questionnaire Rather than Medical Record Review? *Medical Care* 1996;34:73-84.


Kwan MP. Gender, the home-work link, and space-time patterns of nonemployment activities. *Economic Geography* 1999;75:370-394.


McClellan MB, Staiger DO. Comparing Hospital Quality at For-Profit and Not-for-Profit Hospitals: NBER; 1999.


National Household Travel Survey: U.S. Department of Transportation.


Noor AM, Zurovac D, Hay SI, Ochola SA, Snow RW. Defining equity in physical access to clinical services using geographical information systems as part of malaria planning and monitoring in Kenya. *Tropical Medicine & International Health* 2003;8:917-926.

NorthEast Ohio: Community and Neighborhood Data for Organizing: Center on Urban Poverty and Community Development, Case Western Reserve University Mandel School of Applied Social Sciences; 2007.


Payment to Hospitals for Inpatient Hospital Services. §§ Ohio Title 42 (2002).


Piette JD, Moos RH. The influence of distance on ambulatory care use, death, and readmission following a myocardial infarction. *Health Serv Res* 1996;31:573-91.


Provision of basic, medically necessary hospital-level services. Ohio Administrative Code. §§ 5101: 3-2-0717 (1992)


