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THE IMPACT OF TRANSPORTATION DISADVANTAGE
ON HEALTHCARE ACCESS

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy
Planning, Design and the Built Environment

by
Ying Zhou
December 2019

Accepted by
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ABSTRACT OF THE DISSERTATION

Millions of Americans have difficulties in transporting themselves to desired locations and thus are considered to be transportation disadvantaged (Wallace, Hughes-Cromwick, Mull, & Khasnabis, 2005). This population group is found to participate in fewer out-of-home activities, which may eventually result in social exclusion and impaired well-being (Kenyon, Rafferty, & Lyons, 2003; Marottoli et al., 2000). This research examines one critical aspect that is important for people's well-being—healthcare access. Despite the effort and resources the government has put into improving healthcare access, impaired access remains a problem in the United States (Department of Health and Human Services, 2010). Transportation disadvantage has been reported as one key barrier to healthcare access (Arcury, Preisser, Gesler, & Powers, 2005).

Building on social exclusion theory, this dissertation examines the impact of transportation disadvantage, including limited mobility due to a lack of access to transportation resources and long travel times to usual source of care, on healthcare access among non-institutionalized adults in the United States with the use of secondary data from the National Health Interview Survey (NHIS) and the Medical Expenditure Panel Survey (MEPS), two national surveys that report on healthcare access, health status, healthcare expenditure, and other health-related information.

To be more specific, I use data from the NHIS 1993-1996 to examine the impact of vehicle ownership on healthcare access, which is measured by whether or not one has a usual place that is not a hospital emergency department (ED) for medical care, and

whether or not one has forgone needed medical care in the last 12 months. Those who have no vehicle in the family are considered to be transportation disadvantaged. By using logistic regression models to perform cross-sectional analysis, this study finds that owning a vehicle in the family is associated with higher odds of having a non-ED place for usual source of care and with lower odds of having forgone needed medical care, when demographic, socio-economic and health characteristics are controlled for. I also use data from Panel 5 of the MEPS 2000-2001 to examine the impact of transportation mode (including driving or being offered a ride, using public transit, and walking) on the likelihood of any family member having difficulties in obtaining needed care. Random-effects logistic regression is used to perform longitudinal data analysis. The results show that having access to a car and having access to public transit are associated with decreased odds of any family member having experienced difficulty in getting care. But no significant difference is found between car users and public transit users.

The above three analyses also include the “metropolitan residence” (i.e., whether a person lives in a Metropolitan Statistical Area, in the central city or not, or does not live in an MSA). Given the assumption that healthcare resources are widely dispersed in areas outside an MSA and that the spatial distances between healthcare users and healthcare providers are likely to be greater in non-Metro areas than in the urban areas, the results of metropolitan residence are suggestive of the impact of spatial distance on healthcare access. In this sense, the results suggest no clear evidence that spatial distance plays an important role in preventing people from accessing healthcare: people who live outside an MSA are found to be more likely to have a non-ED place for usual source of care and

to be less likely to have forgone needed care in the past 12 months than people who live in the central city in an MSA; also, no significant difference is found in the likelihood of any family member experiencing difficulty in getting care between those living in an MSA and the ones living outside an MSA. However, it should be noted that the assumption does not always hold true. It is possible that living in areas outside an MSA does not necessarily mean residing farther away from healthcare resources. Also, the results of “metropolitan residence” illustrate the disparity in healthcare access between MSAs and areas outside MSAs, which may result from the combined effect of spatial distance and other factors that also differ significantly between these areas. Therefore, using only the spatial distance to interpret the healthcare access disparity may cause bias.

Next, I focus on the NHIS respondents who reported that they have delayed getting needed care because of a lack of transportation (referred to as transportation deficiency) in the past 12 months. By pooling data from the NHIS 2007-2018, I use logistic regression to examine the disparities in experiencing transportation deficiency among different population groups. The results show that being female, being non-Hispanic African American, being American Indian/Alaska Native, being multiple race, being Hispanic (any race), being unemployed or not in the labor force, having some activity limitations, having never been married, being divorced/separated, and being widowed are associated with increased odds of having experienced transportation deficiency. I also examine the impact of transportation deficiency on the type of usual source of care among adults with a usual source of care. The type of usual source of care includes a doctor’s office or health maintenance organization, clinics or health centers,

hospital outpatient department, hospital emergency department (ED), and other places; those who reported using an ED as usual source of care are considered to have poor healthcare access. Multinomial logistic regression is used for cross-sectional data analysis. The results show that adults who experienced transportation deficiency in the last 12 months are more likely to use an ED than to use other medical resources as their usual source of care, compared with adults who did not experience transportation deficiency.

Lastly, I use data from the MEPS 2002-2016 to analyze the impact of travel time to the usual source of care on the experience of having delayed or forgone needed care in the last 12 months. Random-effects ordered logistic regression is used to perform longitudinal analysis. The results show that when people need to travel more than 30 minutes to their usual source of medical care, the odds of having experienced delayed care or having experienced forgone necessary medical care are expected to increase.

In sum, the results of this dissertation reveal a significant impact of mobility (access to transportation resources) and travel time on healthcare access. Although it cannot be proven, the results are suggestive that there is no clear evidence that spatial distance plays an important role in preventing healthcare access. Based on the findings, policies that help improve people's access to transportation resources are discussed. In particular, facilitating automobile ownership by supporting nonprofit organizations that promote affordable car ownership programs and relaxing welfare asset test limits for the low-income, using ridehailing services, developing public transit services in urban areas,

developing more transportation programs such as nonemergency medical transportation (NEMT), and using telecommunication technologies to deliver healthcare are discussed.

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CHAPTER ONE

INTROUCTION

1.1 Millions of Americans are Transportation Disadvantaged

Transportation is of vital importance in people's daily lives. Being able to access transportation resources, and/or being located close to various activities, is important for fostering people's participation in out-of-home opportunities, ranging from work to education to socializing. It has been shown that greater participation in these out-of-home activities contributes to higher life satisfaction (Morris, 2015; Ettema, Gärling, Olsson, & Friman, 2010; Ravulaparthi, Yoon, & Goulias, 2013). However, millions of Americans are transportation disadvantaged (Wallace et al., 2005). This population group has difficulties in transporting themselves to reach desired locations, due to low incomes, unemployment, disabilities, geographic isolation, inability to drive, lack of access to quality transit service, or other reasons. The transportation-disadvantaged participate less in out-out-home activities, including work, education, shopping, leisure, healthcare, and more (Kenyon, Rafferty, & Lyons, 2003; Marottoli et al., 2000; Syed, Gerber, & Sharp, 2013). Accordingly, they are likely to have their life quality impaired. This research examines one critical aspect that is influential for people's wellbeing—healthcare access.

1.2 Healthcare Access Remains a Problem in the United States

According to the HealthyPeople.gov (2019), having reliable healthcare access can contribute to the prevention, detection and treatment of disease and disability, the improvement of life quality, the decrease in premature death, and the increase in life expectancy. Despite the effort and resources the government has put into improving healthcare access, healthcare access remains a problem in the United States (Department of Health and Human Services, 2010). Disparities exist in healthcare access among people of different ages, genders, races and ethnicities, socioeconomic statuses, residential locations, and insurance coverage statuses (HealthyPeople.gov, 2018). Not having regular and reliable healthcare access is problematic. It is found that the lack of healthcare access may lead to insufficient medical treatment and other unmet healthcare needs, which can worsen health outcomes, for example by exacerbating chronic diseases (Okoro, Strine, Young, Balluz, & Mokdad, 2005). Moreover, a lack of regular healthcare access leads to the overuse of emergency departments (EDs) for non-emergent care and treatments, resulting in excessive medical care expenditure (Uscher-Pines, Pines, Kellermann, Gillen, & Mehrotra, 2013; Wilson & Klein, 2000).

1.3 Transportation Disadvantage as a Barrier to Healthcare Access

Prior research has found that transportation disadvantage is one key barrier to healthcare access in the United States. Access to transportation resources such as automobiles or public transit services, plus high geographic proximity to healthcare

providers, is indispensable in guaranteeing the timely delivery of healthcare services. Transportation deficiency and geographic isolation have been reported as key limitations on people's access to healthcare and their participation in health-promoting programs, especially in rural America (Arcury et al., 2005). There are programs which address this issue; for example, Medicaid subsidizes nonemergency medical transportation (NEMT) for beneficiaries who do not have reliable or affordable transportation because of income, age, chronic conditions or disabilities in order to overcome transportation barriers to non-emergent medical care. NEMT reimburses Medicaid beneficiaries who use public transit to reach healthcare providers; it also contracts with transportation providers to offer transportation services through wheelchair vans, stretcher cars, taxis, automobiles and even air transportation (Musumeci & Rudowitz, 2016). However, the NEMT is not functioning well and is by no means a sufficient solution to solve the transportation problem (Kim, Norton, & Stearns, 2009). In all, it is estimated that about 3.6 million Americans do not obtain health care because of transportation disadvantage (Wallace et al., 2005), which is very concerning.

1.4 Research Purpose and Significance

The purpose of this research is to examine the impact of transportation disadvantage on healthcare access among non-institutionalized adults in the United States. It is noteworthy that both transportation disadvantage and healthcare access are multidimensional constructs. Therefore, different measurements of the two constructs

have been chosen in this research. Further, this research intends to deepen our understanding of which demographic or socioeconomic groups are more likely to suffer from transportation disadvantage that inhibits them from accessing healthcare.

The results of this study can be used for generating policy recommendations aiming at reducing the transportation-related barriers that prevent people from accessing healthcare.

CHAPTER TWO

THEORETICAL FOUNDATION AND KEY CONSTRUCTS

This chapter illustrates the theoretical foundation of this dissertation—social exclusion theory, and the conceptualizations of two key constructs: transportation disadvantage and healthcare access.

2.1 Social Exclusion Theory

This study is built on social exclusion theory. The term “social exclusion” is generally considered to have originated in France in 1970s (Silver, 1994; Atkinson, 2000; Burchardt, Grand, & Piachaud, 1999). French social scientists, such as Lenoir (1974), used the term “socially excluded” to describe those who are administratively excluded from the social insurance system (Burchardt et al., 1999). In 1990s, the UK government established the Social Exclusion Unit, with the purpose of addressing social exclusion issue. Ever since then, the concept of social exclusion has been widely studied by researchers and efforts to combat social exclusion have been undertaken by policy makers (Preston, 2009).

Social exclusion can be understood from different perspectives. The following table summarizes the major definitions that are widely cited in existing literature.

Table 2.1 Definitions of Social Exclusion

Perspective	Author(s)	Definition
View social exclusion as <i>unfulfillment</i> of a basic right of citizens.	Room, 1995	“The denial or non-realization of civil, political, and social rights of citizenship.”
View social exclusion as an <i>end-state</i> .	Burchardt, Grand, & Piachaud, 1999	“An individual is socially excluded if (a) he or she is geographically resident in a society and (b) he or she does not participate in the normal activities of citizens in that society, including consumption, savings, production, political activities, and social activities.”
	Duffy, 1995	Social exclusion includes “not only low material means but the inability to participate effectively in economic, social, and cultural life, and, in some characteristics, alienation and distance from mainstream society”.
View social exclusion as a <i>process</i> of the interaction among various factors.	Walker & Walker, 1997	“The dynamic process of being shut out from any of the social, economic, political and cultural systems which determine the social integration of a person in society.”
	Estivill, 2003	“An accumulation of confluent processes with successive ruptures arising from the heart of the economy, politics and society, which gradually distances and places persons, groups, communities and territories in a position of inferiority in relation

		to centers of power, resources and prevailing values.”
	Kenyon, Lyons, & Rafferty, 2002	“The unique interplay of a number of factors, whose consequence is the denial of access, to an individual or group, to the opportunity to participate in the social and political life of the community, resulting not only in diminished material and non-material quality of life, but also in tempered life chances, choices and reduced citizenship.”
	Levitas et al., 2007	“Social exclusion is a complex and multi-dimensional process. It involves the lack or denial of resources, rights, goods and services, and the inability to participate in the normal relationships and activities, available to the majority of people in a society, whether in economic, social, cultural or political arenas. It affects both the quality of life of individuals and the equity and cohesion of society as a whole.”
	Preston & Rajé, 2007	“Social exclusion is a constraints-based process which causes individuals or groups not to participate in the normal activities of the society in which they are residents and has important spatial manifestations.”

As can be seen from the table above, social exclusion is defined either as a static end-state to describe the situation that a group of people are facing, or as a process which involves the continuous interplay of multiple factors that eventually results in their exclusion from society. Although the above definitions of social exclusion are given from

different perspectives, it is noticeable that the common feature shared by all definitions for deciding whether social exclusion happens is the fact that individuals or groups cannot participate in various aspects of society, with the lack of participation negatively affecting not only the deprived individuals but society as a whole. Socially excluded people suffer from deficiencies in opportunities to access work, education, leisure, shopping, healthcare, housing, welfare, political activities, etc. (Preston & Rajé, 2007). These deficiencies are a violation of a basic right which should be enjoyed by all citizens and will impact individuals' quality of life, recognition, self-esteem, and well-being (Barnes, Blom, Cox, Lessof, & Walker, 2006; Levitas et al., 2007; Klasen, 2001). For society, social exclusion is undesirable as well. As activities such as employment, education, and healthcare generate positive effects on society, those who are excluded from these activities would contribute less to the development of society and may even become a burden to the economy and the whole society. Social exclusion is also considered to be related to other social problems such as societal divisions, social pathologies, racism, xenophobia, etc. (Klasen, 2001).

It can be seen from the definitions that the lack of participation in society can be caused by either the structural constraints that detach individuals and groups from society (see definitions given by Estivill, 2003; and Preston & Rajé, 2007) or the socially excluded population's incapability to participate in society (Duffy, 1995). Structural constraints emphasize the characteristics of society as a whole that contribute to social exclusion, such as politics, social norms, racial discrimination, an unavailability or shortage of resources, and so on (Lucas, 2012; Levitas et al., 2007; Burchardt et al.,

1999). Individual characteristics which may lead to exclusion include factors such as low income, unemployment, low education attainment, disability, and more; all of these may limit individuals' abilities to participate in society (Turok, Kearns, & Goodlad, 1999). Sometimes individuals' incapability of participating in society results from the structural constraints.

2.2 Transportation Disadvantage and Social Exclusion

As social exclusion theory has been developed, more and more researchers have noted that transportation disadvantage is also a contributory factor to social exclusion (Church, Frost, & Sullivan, 2000). It is postulated that social exclusion is partially contributed to by having difficulties in traveling to various out-of-home activities: people cannot reach desired locations within a reasonable time and cost and thus are excluded from these activities (Social Exclusion Unit, 2003). Therefore, the issue of transportation disadvantage should also be examined in order to combat social exclusion.

What is transportation disadvantage? How is transportation disadvantage perceived by researchers? The sections below provides a discussion about the conceptualization of transportation disadvantage.

2.2.1 Definition of Transportation Disadvantage

Transportation Disadvantage is defined as “the disadvantage of a specific group of individuals that results from a difficulty accessing transportation (lack of mobility),

opportunities (lack of accessibility), or both” (Pyrialakou, Gkritza, & Fricker, 2016).

Individuals that encounter difficulties in accessing transportation resources or reaching opportunities are considered as transportation disadvantaged.

2.2.2 Mobility-Related Transportation Disadvantage

The majority of researchers who conduct studies on transportation disadvantage view this construct from the perspective of mobility. Researchers have developed the concept “mobility-related exclusion” to describe the consequences of mobility problems affecting people’s participation in society. Kenyon et al. (2002) define mobility-related exclusion as: “The process by which people are prevented from participating in the economic, political and social life of the community because of reduced accessibility to opportunities, services and social networks, due in whole or in part to insufficient mobility in a society and environment built around the assumption of high mobility.” This definition implies that inadequate mobility results in decreased accessibility to various aspects of society, which contributes to social exclusion. Following this line, the lack of mobility is the primary reason causing social exclusion, or at least a significant contributory factor that worsens existing situation of social exclusion (Kenyon et al., 2003).

Measurements of transportation disadvantage related to mobility aspect consider the ease for people to access transportation resources and transport themselves (Delbosc & Currie, 2011a). Vehicle ownership is one measurement commonly used for defining a transportation disadvantaged group. In places where private vehicles are the predominant

mode of transportation and the built environment is overwhelmingly based on access by private vehicles, such as rural America, those who have no access to a vehicle are likely to be transportation disadvantaged (Rose, Witten, & McCreanor, 2009). Other transportation modes, such as walking, bicycling, or public transit, are often not sufficient for meeting people's mobility needs, making it difficult for them to travel to participate in work, education, sport, leisure, and other out-of-home activities, as well as to access basic goods and services (Dodson, Buchanan, Gleeson, & Sipe, 2006).

In terms of the factors contributing to the lack of vehicle ownership, low income is the major one (Currie & Delbosc, 2011), as people with low incomes may not be able to afford purchasing and operating a car. Unsurprisingly, research has found that the vehicle ownership among low-income Americans is lower than those with higher incomes (Renne & Bennett, 2014). According to the 2009 National Household Travel Survey, 78.6% of the households with a family income less than \$20,000 owned at least one private vehicle, 93.9% of the households with a family income between \$20,000 to \$40,000 owned at least one vehicle, and the vehicle ownership among those with a family income higher than \$40,000 exceeded 98% (Renne & Bennett, 2014). Other factors that may limit the ability to own and operate a private vehicle include age (for those too young to have a driver's license) and health conditions or disabilities (for those with physical or mental conditions, such as macular degeneration, peripheral neuropathy, or dementia) (Murray & Davis, 2001; Hine & Grieco, 2003; Yale, Hansotia, Knapp, & Ehrfurth, 2003; Wood, Black, Mallon, Kwan, & Owsley, 2018).

Some researchers consider the lack of access to public transit services as another source of transportation disadvantage (Murray & Davis, 2001; Battellino, 2009), especially for those who also lack auto access and/or live in an environment that is not walking-friendly (Pyrialakou et al., 2016). This may result from transit simply not being provided at all (Murray & Davis, 2001), or, when transit does exist, it may be caused by poor frequency, reliability, routing, comfort level, information, etc. (Kenyon et al., 2002). Even when there is good transit, individual characteristics, such as age, health, and disability, might inhibit transit use. A major reason is that using public transit normally requires people to walk from their origins to the transit stops or stations, and to then walk from transit vehicle to their final destinations. Thus those who are too young, too old, or have limitations due to physical, mental, or emotional problems may face difficulties doing this walking. Also, these groups may need help from others in using transit when they need to stand on the transit vehicle or use mobility assistive devices, or when they are not cognitively able to use the transit system. People with limited English proficiency are likely to face inhibition in using public transit independently, too. Low income may also negatively impact people's use of public transit if people with low incomes cannot afford transit fares. Psychological factors such as concerns about safety or fear of crime while traveling also limit people's use of public transit, especially among women (Church, Frost, & Sullivan, 2000; Hine & Mitchell, 2001; Cass, Shove, & Urry, 2005; Loukaitou-Sideris & Fink, 2009).

In addition, the unemployed, single parents, shift workers, immigrants, and ethnic minority groups are also found to face greater risk of having mobility problems, though

the situation is often confounded with their socioeconomic status (Murray & Davis, 2001; Bostock, 2001). It is the worst-off that suffer from the restrained mobility the most (Lucas & Jones, 2012).

2.2.3 Accessibility-Related Transportation Disadvantage

In addition to issues of mobility, some researchers focus on accessibility and the context of the built environment. Accessibility refers to the ease of overcoming spatial distance and reaching desired destinations based on the current transportation infrastructure (Levinson & Krizek, 2008). The researchers argue that focusing on mobility alone will not necessarily adequately address transportation disadvantage and social exclusion, and even that it may be counterproductive; Preston and Rajé (2007) think increasing individual mobility will probably exacerbate problems such as environmental degradation and urban sprawl, and thus alleviating social exclusion should focus on improving accessibility to key activities that are necessary for maintaining life quality, including work, healthcare, leisure, education, shopping, etc. (Church, Frost, & Sullivan, 2000).

The built environment is hypothesized to contribute to accessibility-related transportation disadvantage. In areas where land use is low-density and development is widely scattered, such as rural areas, it may be difficult for some people to reach certain activities and resources, regardless of what level of mobility they have (Preston & Rajé, 2007; Currie & Delbosc, 2011). For example, even for people living in rural areas where the traffic congestion level is low and the speed limit may be high, having a private

automobile may not be enough to fully participate in society, due to time or cost constraints resulting from the excessively long distances they have to travel to reach the desired locations (Church, Frost, & Sullivan, 2000). Conversely, individuals living in a compact, dense, mixed-use and pedestrian-friendly built environment where various activities are geographically close to each other may be able to easily get to the desired locations by active transportation, reducing the need for automobiles or public transit. Moreover, the characteristics of the built environment are usually compounded by the characteristics of mobility; these may affect accessibility simultaneously. For example, the effect of long travel distances to social activities in rural areas is exacerbated by the mobility-related transportation disadvantage caused by limited provision of public transit services (Shay et al., 2016). Therefore, accessibility can be used to define transportation disadvantage (Shay et al., 2016).

Some Australian researchers use the term “locational disadvantage” to describe the phenomenon that individuals live in areas that are short of resources essential for maintaining life quality, meaning that they have to travel a long way to reach these resources (Dodson et al., 2006). In the United States, extensive research has been done on the accessibility to some particular resources, such as “spatial mismatch hypothesis”, which claims that the spatial separation between residences and jobs results in the inaccessibility to job opportunities among low-income people and ethnic minorities (Kain, 1992; Raphael, 1998; Gobillon, Selod, & Zenou, 2007) ; and the “food desert” theory, which focuses on areas where accessibility to affordable healthy food sold in

grocery stores, farmers' markets, supermarkets or other healthy food providers is extremely low or absent (Walker, Keane, & Burke, 2010; Rose & Richards, 2004).

In the studies that focus on accessibility-related transportation disadvantage, various measurements have been used to operationalize accessibility, all of which consider the spatial separation between activity locations (Handy & Niemeier, 1997; Miller, 2005). The most straightforward measurement is the geographic proximity to activities. Individuals or areas are considered to be transportation disadvantaged if they are located beyond a threshold distance to key activities such as workplaces, shops, hospitals, schools, etc. (Preston & Rajé, 2007; Næss, 2006). The threshold distance as well as the key activities vary across studies. Euclidean distance or the shortest distance based on road networks are commonly used (Miller, 2005). Another group of geographic proximity measurements include "cumulative opportunities measures" (Handy & Niemeier, 1997), which refers to the total number of activities located within a threshold distance from an origin (such as a residence or the census block centroid) (Wang & Chen, 2015). While straightforward, these measurements view accessibility as exclusively the result of geographic proximity, omitting the possible effect of mobility on traveling through the distance.

Some measurements intend to model the complexity of reaching desired locations by incorporating travel impedance, which is a function of geographic proximity and mobility. Travel time and travel cost are commonly-used measurements (Handy & Niemeier, 1997; Pyrialakou et al., 2016). Considering different travel scenarios, the level

of traffic congestion and transportation mode should also be taken into account when using travel time and travel cost to examine accessibility (Handy & Niemeier, 1997).

Gravity models take a step further by assuming that even if the travel impedance is the same between an origin and several destinations, the attractiveness of each destination is not the same for individuals coming from the origin (Miller, 2005). Thus accessibility is the combined effect of both the attractiveness of a destination (often measured by the number of activities, such as jobs, in that location) and a function of travel impedance between the origin and the destination (such as the inverse power function or the negative exponential function) (Hansen, 1959; Handy & Niemeier, 1997; Miller, 2005; Krizek, 2005).

Another group of accessibility measurements are benefit measures or utility measures, which imply that accessibility to a destination depends on the benefit or utility an individual can get by choosing the destination relative to the utility of all possible choices, as individuals tend to choose the option with the maximum utility (Handy & Niemeier, 1997; Miller, 2005).

2.2.4 Combining Mobility, Accessibility and Individual Characteristics

Some researchers view transportation disadvantage as a multi-faceted construct and use a combination of mobility-related measurements, accessibility-related measurements, and/or the socio-demographic characteristics of individuals to perceive transportation disadvantage. It should be noted that the distinction between mobility measurements and accessibility measurements is not always clear (Pyrialakou et al.,

2016) as some accessibility measurements also take mobility factors into account, such as travel time and travel cost.

For example, Engels and Liu (2011) examine the transportation disadvantage experienced by those who are age 65 years or older, do not drive a car, and live in areas that are beyond a threshold distance from bus stops and key services, including grocery stores, hospitals and doctor's offices, pharmacies, banks, post offices, libraries, churches, and so on. Duvarci and Yigitcanlar (2007) think the transportation disadvantaged are the ones experiencing poor proximity to basic urban amenities, have limited access to an automobile, and at the same time have inadequate or poor-quality public transit services. Other factors such as income, disability are also considered. Blair et al. (2013) focus their study about transportation disadvantage on low-income households in urban areas that are likely to be affected by a poor public transit network. Bascom and Christensen (2017) focus on individuals with disabilities and their access to transportation resources.

2.2.5 Other Measurements of Transportation Disadvantage

In addition to the measurements mentioned above, researchers have used various measurements to identify transportation disadvantage.

Some qualitative studies use self-reported measurements to define transportation disadvantaged groups (Currie, 2009; Currie & Delbosc, 2010; Delbosc & Currie, 2011a; Lucas, 2011; Combs, Shay, Salvesen, Kolosna, & Madeley, 2016; Ma, Kent, & Mulley, 2018). In these studies, interviews and focus groups are often used, in which subjective measurements of experiencing transportation difficulties are reported by research

participants. Participants are asked about “how often do you have difficulties accessing activities because of a lack of transportation” or “how difficult is it to cover the costs of transportation/to get to places quickly/to be able to travel when you want to” or “how often are buses/trains/trams available at night” etc. in addition to open-ended questions regarding their opinions about and experiences of transportation disadvantage (Currie & Delbosc, 2010; Delbosc & Currie, 2011a; Lucas, 2011).

Some researchers use realized trips (e.g. the number of trips made per day or average trip distance) or activity participation to measure transportation disadvantage, with the assumption that the transportation disadvantaged group exhibit different travel patterns and out-of-home activity participation. For example, Kamruzzaman and Hine (2011) construct a “participation index” to identify transportation disadvantage, which is composed of the number of locations a person visited, travel distance to these locations, the area of people’s activity spaces (refers to the spatial coverage of all locations where individual’s daily activities take place), the type of activities a person participated in, how often the person participated in some activities, and the duration of participation.

Although it is reasonable to claim that the transportation disadvantaged travel less, travel shorter distances, and participate less in out-of-home activities, this way of measuring transportation disadvantage assumes that everyone has the same need for traveling and participating in out-of-home activities, which may not be true. Therefore, mobility and spatial accessibility may measure transportation disadvantage better as they can rule out the factors such as different travel needs and self-selection.

Transportation disadvantage affects people's participation in employment, healthcare, volunteer work, religious services, shopping, leisure, and social and community activities, etc. (Delbosc & Currie, 2011b; Dobbs, 2005; Raphael & Rice, 2002; Gurley & Bruce, 2005; Cervero et al., 2002; Ong & Miller, 2005; Grengs, 2010; Bascom & Christensen, 2017; Walker and Hiller, 2007; Kenyon et al., 2003; Marottoli et al., 2000; Syed, Gerber, & Sharp, 2013). These activities are essential in people's daily lives and should be available to everyone; deprivation of these activities will impair people's well-being and contribute to social exclusion. As a very important factor influencing people's well-being and life quality, healthcare access is examined in this dissertation.

2.3 Conceptualization of Healthcare Access

Healthcare Access is defined as “the timely use of personal health services to achieve the best health outcomes” (Institute of Medicine, 1993).

2.3.1 Conceptual Framework

Healthcare access is a multi-dimensional construct. This research takes on the conceptual framework proposed by Aday and Andersen (1974), which views healthcare access as “proceeding from health policy objectives through the characteristics of the healthcare system and of the populations at risk (inputs) to the outcomes or outputs: actual utilization of health care services and consumer satisfaction with these services.”

Following this line, Andersen et al. (1983) illustrate that healthcare access includes “those dimensions which describe the potential and actual entry of a given population group to the health care delivery system.” That is to say, healthcare access is composed of two components: potential healthcare access and realized/revealed healthcare access. Potential access emphasizes the possible occurrence of getting healthcare when the consumers match the providers in space and time. Realized or revealed access focuses on the actual obtaining (or not) of health care services (Khan & Bhardwaj, 1994; Guagliardo, 2004). In particular, Andersen et al. (1983) specify that the potential access is influenced by the characteristics of the health delivery system, such as the availability of healthcare services or the ratio of healthcare providers-to-population, and the characteristics of potential healthcare users, including insurance coverage, age, gender, race, income, and so on; the realization access is reflected in a population's actual obtaining of and satisfaction with the health care.

This conceptualization highlights the interaction between the characteristics of the healthcare delivery system and the characteristics of the potential users in conceptualizing healthcare access, which coincides with the theory proposed by Penchansky and Thomas (1981). Penchansky and Thomas propose that healthcare access includes five dimensions: affordability, acceptability, availability, accessibility, and accommodation. Affordability refers to the ability of a patient to pay for the cost of entering the healthcare delivery system; acceptability refers to patients’ satisfaction with healthcare services; availability refers to the presence and capacity of the provision of healthcare services; accessibility refers to the ease with which certain medical facilities

and services can be reached from a given location or by an individual; accommodation refers to the fit between the provided healthcare and patients' needs.

In this dissertation, realized healthcare access is examined, as I believe that although potential access determines the possible entry into the health delivery system, it does not guarantee the automatic obtaining of the healthcare services. Alternatively, realized healthcare access might be better in revealing the extent to which those who need medical care and actually get it (or need it but could not get it). In this sense, potential access can be viewed as the enabling factor of realized access.

Khan and Bhardwaj (1994) propose that the actual obtaining of the health care is also influenced by the barriers or facilitators that reflect characteristics of both the health delivery system and potential users themselves. Realized healthcare access can only happen when all barriers to healthcare services are overcome. A more detailed discussion about barriers to healthcare access will be presented in Chapter 3.

2.3.2 Operationalization of Healthcare Access in Empirical Studies

The aforementioned work on the conceptual framework of healthcare access contributes to clarifying the substance of healthcare access. However, by far no consensus has been achieved on an exhaustive set of measurements to operationalize the construct of healthcare access. This is perhaps because both the healthcare delivery system and people's health-seeking behavior are complicated. While it is possible to conceptualize the construct in a comprehensive way, it is very difficult to obtain adequate information at the same time when doing empirical studies. Due to the limitations of

available resources that researchers can obtain, the choices of measurements often vary across studies.

Table 2.2 lists some examples of the measurements used for studying realized healthcare access in previous empirical studies. Note that the measurements of potential healthcare access are not included in the table as the focus of this dissertation is realized healthcare access.

Table 2.2 Examples of Measurements of Realized Healthcare Access in Empirical Studies

Dimension	Authors	Measurements of Healthcare Access	Research Findings
Realized healthcare access	Zuvekas & Taliaferro, 2003	Whether a person has a usual source of care; Whether any family member has had difficulties in getting care, or has delayed or forgone care; Whether the family is satisfied with the ability to get needed care; Whether a person had non-emergency room ambulatory treatment; The number of treatment visits	Disparities existed in healthcare access between African Americans, Hispanics, and whites based on the data from the Medical Expenditure Panel Survey from 1996 to 1999.

	Ortega et al., 2007	The odds of having a usual source of healthcare; The odds of having problems in obtaining needed care in the past 12 months.	Undocumented Mexicans and other undocumented Latinos are less likely to have a usual source of care, compared with US-born Mexicans and other US-born Latinos, whilst both undocumented groups are less likely to report having problems in obtaining needed care than their US-born counterparts.
	Bustamante et al., 2012	Whether an individual has a usual place to go when sick; Whether an individual experienced a delay in obtaining healthcare; Whether an individual experienced a delay in receiving a prescription drug	Undocumented immigrants have worse healthcare access than documented immigrants.
	Okoro et al., 2005	Whether an individual has a regular care provider; Whether an individual has a regular place of care;	Those who have positive answers for these three measurements are more

		Whether an individual was able to obtain needed health care in the past 12 months	likely to have obtained preventive care.
	Sudore et al., 2006	Whether a person has a usual source of care; Whether the person has obtained an influenza vaccination in the past 12 months; Whether the person has insurance to cover medications	Health literacy is positively associated with better healthcare access among 2,512 well-functioning Medicare beneficiaries age 70 to 79.
	Washington, Bean-Mayberry, Riopelle, & Yano, 2011	Whether an individual has experienced delays in obtaining care in the last 12 months; Whether an individual has experienced unmet medical needs in the last 12 months	No insurance, limited knowledge about veteran health administration care, healthcare providers not sensitive to women's concerns, and military sexual assault history are associated with increased odds of having delayed or forgone needed care among women veterans.

	Weaver, Rowland, Bellizzi, & Aziz, 2010	Whether an individual has forgone care because of cost; Whether an individual has delayed care because of cost; Whether an individual has forgone prescription medicine, mental healthcare, and dental care due to cost	More than two million cancer survivors in the U.S. had to forego one or more needed medical service due to the medical cost during 2003-2006.
	Chen, Vargas-Bustamante, Mortensen, & Ortega, 2016	Whether an individual has delayed needed care in the last 12 months; Whether an individual has forgone needed care in the last 12 months	Healthcare access of Hispanics is worse than of white non-Hispanics.
	Do et al., 2010	Whether an individual sees the same doctor on each visit; Whether an individual had unmet medical needs in the previous year	African Americans experience worse healthcare access than the white.
	Ponce, Hays, & Cunningham, 2006	Whether an individual has a usual source of care; Whether an individual has delayed or forgone needed medical care in the past 12 months	Limited English proficiency negatively impacts the healthcare access among older adults.

2.4 Conclusions

This chapter illustrates the theoretical foundation—social exclusion theory—and key constructs—transportation disadvantage and healthcare access—used in this dissertation.

Social exclusion theory builds the theoretical foundation for this study. Social exclusion theory describes that individuals or groups cannot participate in various aspects of society, with the lack of participation negatively affecting not only the deprived individuals but society as a whole (Barnes, Blom, Cox, Lessof, & Walker, 2006; Levitas et al., 2007; Klasen, 2001; Preston & Rajé, 2007). Transportation disadvantage is considered to be a contributory factor to social exclusion (Church et al., 2000): people cannot reach desired locations within a reasonable time and cost and thus are excluded from the activities at these locations (Social Exclusion Unit, 2003).

Transportation disadvantage happens when people's mobility is restricted or when people live in areas with low accessibility to other locations. Mobility-related measurements consider people's access to transportation resources, such as vehicle ownership and access to public transit services (Delbosc & Currie, 2011a; Pyrialakou et al., 2016). Accessibility-related measurements consider the spatial separation between activity locations and the ease of overcoming the spatial separation, including spatial distance, travel time, travel cost, and indexes calculated with gravity models and utility models (Handy & Niemeier, 1997; Miller, 2005). Other measurements include self-

perceived transportation disadvantage, realized trips, and activity participation (Currie, 2009; Currie & Delbosc, 2010; Lucas, 2011; Kamruzzaman & Hine, 2011).

The factors contributing to limited mobility and low accessibility are multiple. Generally speaking, the built environment, transportation system, and demographic and socio-economic characteristics are all likely to be significant in contributing to transportation disadvantage. The contributory factors include low income; age; health conditions or disabilities; the availability of public transit; the frequency, reliability, routing, comfort level, and information of public transit; limited English proficiency; fear of crime and concerns about safety; land use pattern, etc. (Murray & Davis, 2001; Hine & Grieco, 2003; Yale, Hansotia, Knapp, & Ehrfurth, 2003; Wood, Black, Mallon, Kwan, & Owsley, 2018; Cass, Shove, & Urry, 2005; Loukaitou-Sideris & Fink, 2009). Other transportation disadvantaged groups include the unemployed, ethnic minority groups, shift workers, and immigrants, though the situation is often compounded by their socio-economic status (Murray & Davis, 2001; Bostock, 2001).

Social exclusion theory implies that transportation disadvantage, either due to limited mobility or low accessibility, negatively impacts people's participation in various out-of-home activities, including employment, healthcare, volunteer work, religious services, shopping, leisure, social and community activities, and so on. (Delbosc & Currie, 2011b; Dobbs, 2005; Raphael & Rice, 2002; Gurley & Bruce, 2005; Cervero et al., 2002; Ong & Miller, 2005; Bascom & Christensen, 2017; Walker and Hiller, 2007; Kenyon et al., 2003; Marottoli et al., 2000; Syed, Gerber, & Sharp, 2013). As an

important factor influencing people's well-being and life quality, healthcare access is examined in this dissertation.

This dissertation takes on the framework of conceptualizing healthcare access as including dimensions of potential access and realized access (Aday & Andersen, 1974; Andersen et al., 1983). This dissertation focuses on realized healthcare access as I believe it can better reveal the extent to which those who need healthcare and actually get it or who need care but could not get any. In empirical studies, researchers use various measurements to operationalize realized healthcare access. However, it can be concluded from reviewing relevant literature that an inclusive, comprehensive set of healthcare access measurements is very difficult, if not impossible, to construct. Therefore, the measurements are chosen based on the available resources and thus vary across different studies. The measurements used by researchers include, but are not restricted to, whether one has a regular/usual source of care; whether one has delayed getting care or prescription medication; whether one had unmet medical needs; whether one has obtained an influenza vaccination in the past 12 months; whether one is satisfied with the ability to get needed care; whether one experienced difficulties in obtaining needed care; to name a few.

Healthcare access is considered to be a basic right of human beings. All members of society have the right to access healthcare without being discriminated because of race, ethnicity, age, gender, or any other factors (WHO, 2017). Having reliable access to healthcare services can contribute to the prevention, detection and treatment of disease and disability, the improvement of life quality, the decrease in premature death, and the

increase in life expectancy (HealthyPeople.gov, 2019). However, social exclusion theory implies that people who have transportation disadvantage, due to either limited personal mobility or low accessibility to healthcare resources, or both, are likely to have difficulties in accessing healthcare or participating in health-promoting programs. Based on social exclusion theory, this dissertation hypothesizes that people who suffer from transportation disadvantage would have worse healthcare access than their counterparts who do not suffer from this disadvantage.

CHAPTER THREE

LITERATURE REVIEW

This chapter reviews the literature on barriers to healthcare access, and transportation issue in healthcare access in the United States, followed by a summary of gaps in the literature.

3.1 Barriers to Healthcare Access

Studies show that not having access to healthcare may result in a lack of timely and proper medical treatment or other unmet healthcare needs, which can worsen health outcomes, for example by exacerbating chronic diseases (Okoro et al., 2005). Given the importance of having healthcare access, researchers have conducted studies to identify barriers that prevent people from accessing healthcare.

Many results are obtained through exploratory studies. Study results are often collected by asking research participants to indicate the barriers they have experienced to accessing healthcare. For example, Goins et al. (2005) explored rural elderly adults' perceived barriers to healthcare access by conducting research with 13 focus groups. The 101 research participants reported barriers to healthcare including transportation difficulties, insufficient healthcare services provision, low-quality healthcare, social isolation, and budget constraints. Ahmed et al. (2001) conducted a discussion about barriers to healthcare access among nonelderly low-income people with a focus group of 20 representatives of healthcare providers, social service agencies, different racial and

ethnic groups, and healthcare advocates. The barriers illustrated include the lack of knowledge about healthcare with low or no costs, inability to pay, problems in getting child care, problems in getting time off-work, difficulty in traveling to healthcare providers, and bad experiences interacting with the health system. Ramondetta et al. (2015) conducted a survey with 138 women diagnosed with cervical cancer. When asked to elaborate on medium or large problems for them in getting care, the respondents reported financial concerns about cancer treatment, excessive clinic waiting time, difficulty in getting a ride to treatment, exams being too uncomfortable, not knowing where to go, and the fear about their diagnosis.

Some results are in the form of descriptive statistics. For example, Okoro et al. (2005) use data from the 2002 Behavioral Risk Factor Surveillance System (BRFSS) to examine healthcare access of people 65 years old and above in the United States. They find that among 1,181 survey respondents who experienced forgoing care in the previous year, 27% reported cost as the reason for forgoing care, 20% reported excessive waiting time, 9% reported no transportation or excessive travel distance, 8% reported time conflicts with the schedule of healthcare providers, and 32% mentioned other reasons. Weathers et al. (2004) conducted a survey of 300 families to study the healthcare access of migrant children in eastern North Carolina. Survey results show that among the 159 respondents who have forgone needed care in the previous year, 80% of them cited the lack of transportation as the primary reason for their unmet medical needs, and 20% of them reported they did not know where to go. Washington et al. (2010) conducted a telephone survey with 3,611 women veterans to study their healthcare access. Among all

respondents, 19% have delayed or forgone needed medical care. The reasons include inability to afford care (40.9%), inability to take time off work (27.9%), difficulty in getting child care (15.5%), transportation difficulties (13.4%), and other.

Through the review of related studies, five major types of barriers to healthcare access can be identified. First are structural barriers. Structural barriers are defined by the availability, capacity, type, location, and organizational configuration of healthcare providers. Examples of structural barriers include insufficient healthcare supply, excessive waiting times, limited operating hours of healthcare providers, and so on (Carrillo et al., 2011; Okoro et al., 2005; Pesata, Pallija, & Webb, 1999; Goin et al. 2005).

Second are financial barriers. These refer to individuals' or families' difficulties in paying for the cost of health care. This type of barriers include low incomes, unemployment, and having no health insurance or being underinsured (Ramondetta et al., 2015; Diamant et al., 2004; Yang, Zarr, Kass-Hout, Kourosh, & Kelly, 2006; Mirza et al., 2014; Okoro et al., 2005;).

Third are cognitive barriers. Cognitive barriers are rooted in the patients' beliefs and health literacy, as well as in communication difficulties. Linguistic problems, lack of knowledge about healthcare services, traditional and cultural health beliefs, the fear of authorities, and negative experience of interacting with the health system are some examples (Heyman, Núñez, & Talavera, 2009; Jenkins, Le, McPhee, Stewart, & Ha, 1996; Ponce, Hays, & Cunningham, 2006; Kruzich, Jivanjee, Robinson, & Friesen, 2003; Whitley, Samuels, Wright, & Everhart, 2005; Mirza et al. 2014; Weathers et al., 2004).

Fourth are coordination barriers. Coordination barriers refer to the difficulties in accessing healthcare due to time conflicts. These barriers include, but are not restricted to, the difficulty in getting time off work, difficulty in getting childcare, and difficulty in coordinating time schedule with healthcare providers (Washington et al. 2010; Okoro et al. ,2005; Ahmed, Lemkau, Nealeigh, & Mann, 2001).

Fifth are transportation barriers. Transportation barriers refer to the difficulties in accessing healthcare due to transportation problems. These barriers include a lack of access to a private automobile or public transit, poor quality of public transit services, long travel distances/times to healthcare providers, the cost of transportation, too much traffic, too little parking, poor road conditions, limited medical transportation programs, and so on (Pesata, 1999; Flores, Abreu, Olivar, & Kastner, 1998; Yang et al., 2006; Goins et al., 2005; Okoro et al., 2005; Washington et al. 2010; Kruzich et al., 2003; Welty et al. 2010; Buzza et al., 2011; Silver, Blustein, & Weitzman, 2012). A more detailed discussion about transportation barriers to healthcare access is presented in Section 3.2.

Other barriers reported occasionally by research participants include immigration status and racism (Heyman, Núñez, & Talavera, 2009; Whitley et al. 2005).

In sum, five major types of barriers to healthcare access have been identified, including financial, structural, cognitive, coordination and transportation barriers. As they are the focus of this dissertation, studies on how transportation influences healthcare access are further reviewed.

3.2 Transportation and Healthcare Access

The previous section outlines the issue of transportation as a barrier to healthcare access in exploratory studies. This section reviews existing literature on the impact of mobility and accessibility on people's healthcare access in the United States.

3.2.1 Limited Mobility as a Barrier to Healthcare Access

Researchers find that having access to transportation resources is an important enabling factor of healthcare access; and that having mobility problems negatively impacts people's healthcare access, prescription medication refills and adherence to treatment regimens. Thomas and Wedel (2014) examine the impact of nonemergency medical transportation (NEMT), a service provided by Medicaid, on 10,824 adults' visits to healthcare providers for managing hypertension, asthma, and heart disease in Oklahoma. Results show that among the Medicaid beneficiaries, those who use NEMT services are significantly more likely to visit healthcare professionals for managing the three types of chronic diseases as recommended, compared with those who do not use NEMT. (Although this difference might be explained by personal characteristics, for example, some patients are more conscientious about their health conditions and thus might be more likely to use NEMT and visit providers for managing the chronic diseases as suggested.) Ramondetta et al. (2015) conducted a survey on 138 cervical cancer patients. They find that the lack of transportation is associated with the cancer being diagnosed at more advanced stages. Tierney et al. (2000) examine the relationship between transportation policy and health care access in a cohort study of 46,722

Medicaid beneficiaries, finding that restricting the payment for transportation by Medicaid results in decreased medication refills.

Within the transportation system, some researchers examine the impact of access to a private vehicle on healthcare access. Results show that having access to a vehicle—including having a driver's license, owning a car, and/or having family or friends to offer a ride—is positively associated with better healthcare access, and that having no access to a vehicle can contribute to delayed/rescheduled/missed medical appointments or less utilization of healthcare services. Arcury et al. (2005) use survey data with a sample size of 1,059 to examine the relationship between transportation access and the number of visits for regular checkups as well as for chronic condition care in rural North Carolina. They find that the number of healthcare visits for chronic care (including arthritis, diabetes, heart disease, cancer, and asthma) among respondents who have a driver's license is 2.29 times more than that among those who do not. Similarly, for respondents with a driver's license the number of healthcare visits for regular checkup is 1.92 times more than for those without one. Arcury and colleagues also find that survey respondents whose relatives, friends, or neighbors offer them a ride to healthcare have 1.58 times more chronic care visits than their counterparts. Salloum et al. (2012) analyze data of 406 insured lung cancer patients with stages II to IV cancer, identified through a tumor registry, finding that having no access to a vehicle negatively impacts their use of chemotherapy. Yang et al. (2006) compare the difference in car use between an interviewee group that kept its medical appointments within the study period and a group that missed its appointments. They find that among interviewees who showed up on time

for their medical appointments, the proportion of having access to an automobile is 82%, while the proportion is 58% among those who missed their medical appointments.

Having constrained access to quality public transit services is also identified as one of the transportation problems that hinder people from accessing healthcare. Pheley (1999) observed a three-week mass transit strike in Minneapolis, Minnesota. Using data on medical appointments from the registration system of a hospital, they find that the bus strike is associated with an increase in missed appointments with nurses, but it had no impact on the total number of kept medical appointments.

3.2.2 The Impact of Accessibility on Healthcare Access

Long travel distance or travel time is reported by many researchers as another component of transportation barriers to healthcare access (Kruzich et al. 2003; Okoro et al. 2005; Goins et al., 2005). However, the research results examining the impact of accessibility on healthcare access are inconclusive.

Some researchers find that the longer the travel time or distance is, the poorer the healthcare access is. Ambroggi et al. (2015) conduct a comprehensive review of 27 existing studies on the impact of travel burden, measured by travel distance or travel time, on cancer diagnosis and cancer treatment. They synthesize the results and conclude that longer travel distance or travel time is associated with a more advanced stage at which the cancer is first diagnosed. Also, travel burden negatively affects patients in terms of getting proper cancer treatment. Littenberg et al. (2006) conducted a survey with 781 patients with type II diabetes, finding that a greater driving distance from a patient's

residence to his/her source of primary care, calculated through the geographic software ArcView 3.3, is negatively associated with the use of insulin. Strauss et al. (Strauss, MacLean, Troy, & Littenberg, 2006) use data from 973 adults with diabetes from the Vermont Diabetes Information System and find that longer driving distance from residence to primary care, also calculated using ArcView 3.3, is associated with poorer glycemic control among an elderly population living in rural Vermont. Nemet and Bailey (2000) conducted a survey with 390 rural elderly and find that people who reported having to travel more than 10 miles to physicians tend to visit their physicians less frequently than do those who travel shorter distances.

However, some other researchers find insignificant relationships between travel distance and healthcare access. Salloum et al. (2012) analyzed data from 406 insured lung cancer patients with stages II to IV cancer, finding no significant association between travel distance from each patient's residence to the nearest chemotherapy facility and the use of chemotherapy. Featherstone et al. (2016) examine the impact of travel time to the delivery hospital from the maternal residence on neonatal mortality among 2,030 singleton very-low birthweight infants in South Carolina from 2010 to 2012. Travel time is calculated through ArcGIS based on the address on the birth certificate. They find no significant correlation between travel time and infant mortality among singleton very-low birthweight infants during the study period. Wang et al. (2008) examine the relationship between spatial proximity to mammography services and the stage of breast cancer diagnosis among breast cancer patients in Illinois. They use ArcGIS to calculate both Euclidean distance and road network-based travel time from each zip code centroid to its

nearest mammography facilities in Illinois. The results show that neither Euclidean distance nor travel time is significantly associated with the late-stage diagnosis of breast cancer.

3.2.3 Transportation Disadvantaged Group in Accessing Healthcare

Studies do reveal that transportation is, in particular, problematic for certain population groups, especially ethnic minorities.

Probst et al. (2007) conducted a cross-sectional study of the 2001 National Household Travel Survey to examine the disparities in transportation difficulties in accessing healthcare among different racial groups and residential locations. They find that being an African American increases the odds of traveling 30 minutes or longer for a single trip to healthcare by a factor of 3.04 compared with whites. Johnson et al. (2010) use data from the National Health Interview Survey from 1997 to 2006 to examine the disparities in healthcare access between American Indian/Alaska Native (AIAN) veterans age 18 to 64 and their non-Hispanic white veteran counterparts. They find that AIAN veterans are more likely to delay care because of no transportation than white veterans, after controlling for insurance coverage and demographic and socioeconomic characteristics. Call et al. (2006) conducted a survey on a sample randomly selected from enrollees of Minnesota Health Care Programs to examine barriers to healthcare. Among the 1,281 Native Americans and non-Hispanic whites, Call et al. find that 39% of Native Americans report transportation difficulties as a barrier to care while the percentage of non-Hispanic whites is 18.2%. Yang and Wapnir (2018) use data from 1,938 breast

cancer patients who underwent treatment at a cancer center designated by the National Cancer Institute to examine the difference in travel distance for surgical care between Hispanic patients and non-Hispanic patients. The result shows Hispanic patients have to travel longer distances to obtain surgical care than non-Hispanic patients.

On the other hand, although it seems intuitive that people living in rural areas would have more difficulties in accessing healthcare due to accessibility issues, considering the sparsely-distributed residences and medical resources, the scarce provision of public transit services, and the long travel distances to healthcare providers, research results are mixed. Using data from 2001 National Household Travel Survey, Probst et al. (2007) find people living in rural areas report more problems with transportation and have to travel further to access healthcare than do their urban counterparts. However, Blazer et al. (1995) conducted a survey on 4,162 urban and rural elderly residents and find no difference in the frequency of using healthcare services or in the identification of transportation barriers between these two groups.

In sum, empirical studies have been conducted to understand the impact of transportation on healthcare access. Some researchers find limited access to transportation resources, including a lack of access to a private vehicle and a lack of access to public transit services, contributes to delayed, rescheduled, or missed medical care, less utilization of healthcare services, and failure to get medication fills or adhere to treatment regimens. However, research on the impact of spatial accessibility (usually measured by travel time or travel distance) on healthcare access is inconclusive, with some studies concluding travel time/distance to be negatively associated with healthcare

access, and other studies finding no significant relationship between them. This is probably due to the different sample sizes and different measurements researchers use in their studies. Researchers also find that different population groups may face different levels of transportation barriers to healthcare access.

3.3 Gaps in the Literature and the Unique Contribution of This Study

In reviewing the literature on transportation disadvantage and healthcare access, several gaps can be identified.

First, although the limited access to transportation resources, including a lack of access to a private vehicle and a lack of access to public transit services, is considered to be transportation disadvantage and contribute to less participation in various out-of-home activities, few studies have been done on examining the impact of limited mobility on healthcare access. Particularly, in a highly automobile-oriented society, having access to a private vehicle is of particular importance in fulfilling people's mobility needs in most of the areas. However, there has been a debate over whether or not the use of private vehicles should be encouraged. Therefore, more research should be conducted to examine the relationship between access to transportation resources, especially a private vehicle, and healthcare access.

Second, the impact of accessibility, often measured by travel distance or travel time, on healthcare access is inconclusive, with some studies indicating a positive association and others showing an insignificant relationship. More research is needed to

understand the impact. Also, different researchers use different methods to measure travel distance or travel time. Some researchers use the information reported by research participants; more researchers use geographic software, such as ArcGIS or ArcView, to estimate the travel time. While the latter approach does provide valuable insights, the actual travel time to access healthcare may differ significantly from the estimated time. Therefore, this study will use the actual travel time to healthcare provider reported by the survey respondents in order to better measure this variable.

Third, most of the reviewed studies are exploratory in nature. In these studies, interviews, surveys, or focus groups are usually used. Insights about transportation difficulties in accessing healthcare are generated through organizing the information reported by research participants. More explanatory research is needed to examine the relationship between transportation disadvantage and healthcare access.

Last, most studies use data collected from a restricted geographic area. This is not denying the value of these studies, but it is possible to argue that a study using data at national level which is representative of the whole country may illuminate new insights on the topic, such as this one. This research uses the National Health Interview Survey and the Medical Expenditure Panel Survey as data sources. The research results thus can be geographically representative of the general situation in the United States.

This dissertation intends to fill in these gaps.

CHAPTER FOUR

GENERAL RESEARCH DESIGN

This chapter explains the general research methodology of the dissertation.

4.1 Methodology Overview

In Chapter 5, 6, and 7, I will report the analysis of the impact of transportation disadvantage on healthcare access in the United States. Data is extracted from the National Health Interview Survey (NHIS) and the Medical Expenditure Panel Survey (MEPS). The unit of analysis is non-institutionalized adults in the United States. The general data analysis method is statistical analysis. Stata[®] 15.1 (StataCorp LP, College Station, TX) is used to perform cross-sectional and longitudinal data analysis.

In Chapter 5, I examine the impact of mobility on healthcare access. To be more specific, I examine how vehicle ownership in the family and the transportation mode a person usually uses for traveling to the usual source of care would affect healthcare access. Data from the NHIS 1993-1996 and the MEPS 2000-2001 is used.

In Chapter 6, I also examine the impact of mobility on healthcare access. I focus on those who have experienced delayed getting needed care due to transportation deficiency in the previous 12 months and consider them as the transportation disadvantaged. Data from the NHIS 2007-2018 is used.

In Chapter 7, I examine the impact of accessibility, measured by travel time, on healthcare access. Data is from the MEPS 2002-2016.

4.2 Data Sources

This dissertation uses the National Health Interview Survey (Blewett, Drew, King, & Williams, 2019) and the Medical Expenditure Panel Survey (Blewett, Drew, Griffin, & Williams, 2019) as the two sources of data.

The National Health Interview Survey (NHIS) is one of the major survey programs of the National Center for Health Statistics. The U.S. Census Bureau has been conducted the survey annually since 1957. The NHIS is a cross-sectional household interview survey. It collects data on demographics, socioeconomics, and various health-related fields. Each year the NHIS selects a new sample to conduct survey with. The sampling design follows a multistage probability design which guarantees a final sample representative of the non-institutionalized population of the United States. The sampled households participate in the survey voluntarily, and the annual response rate is approximately 80%. The sample size is about 35,000 households with a total of 87,500 individuals each year (CDC, 2018).

The Medical Expenditure Panel Survey (MEPS) is the most complete source of data on healthcare use and expenses, sources of payment for healthcare, as well as health insurance coverage among the non-institutionalized population of the United States. MEPS has been conducted annually since 1996 and is administered by the Agency for Healthcare Research and Quality, as well as the Centers for Disease Control and Prevention. It includes a set of three large-scale surveys: the Household Component

(MEPS-HC), which collects data on individuals' demographic, socioeconomic, and healthcare information; the Medical Provider Component (MEPS-MPC), collecting data on MEPS-HC respondents' medical expenditures, sources of payment, etc.; and the Insurance Component (MEPS-IC), which collects data on the health plans and insurance provided by public and private employers. Only data of MEPS-HC is available for download, and this is used for this dissertation. Information is collected on surveyed households in each panel through five rounds of interviews within two years. Surveyed households are a subsample of the households that have participated in the National Health Interview Survey approximately six months to a year earlier. In 2016, the sample size was 13,587 households with 33,259 respondents (AHRQ, 2013; AHRQ, 2018).

The data of the NHIS and the MEPS are available for public access on IPUMS — the Integrated Public Use Microdata Series, which is the largest population database at individual level around the world. The data are organized and converted into a consistent format and are available to researchers upon request via an online data system (IPUMS, 2019c).

4.3 Measurements of Key Constructs

Measurements of healthcare access: As is illustrated in Chapter 2, a comprehensive set of measurements to operationalize healthcare access is very hard to construct. This is due to the complexity of healthcare access as well as the constraints of available resources in conducting empirical studies. Operationalization is usually the

result of balancing the comprehensiveness of a construct and the information that is practically feasible. Consequently, researchers often choose different measurements based on available resources as well as their research needs. In this dissertation, healthcare access is measured by: having a regular source of medical care; the type of usual source of medical care; having forgone needed medical care in the past 12 months; having delayed needed care in the past 12 months, and anyone in the family having experienced difficulty in obtaining any type of health care, delayed obtaining care, or not received health care they thought they needed in the past 12 months. These measurements can be categorized into two categories: usual source of care and delayed/unmet medical needs. The measurements are chosen because they all measure realized healthcare access well and have been used in previous studies.

Measurements of transportation disadvantage: As noted in the review of existing literature, transportation disadvantage is defined as having limited mobility or poor accessibility or both (Pyrialakou et al., 2016). Social exclusion theory also implies that people's lack of participation in society is contributed to by limited mobility and excessive spatial separation. Therefore, research intending to study the impact of transportation disadvantage on healthcare access should examine mobility as well as accessibility. In this dissertation, transportation disadvantage is measured by: not owning a private vehicle in the family, relying on walking (instead of using a car or using public transit services) to the usual source of care, having experienced delayed getting care due to transportation deficiency in past 12 months, and having a long travel time to the usual source of care as reported by the survey respondents.

Chapters 5, 6, and 7 use different measurements to operationalize transportation disadvantage and healthcare access. More details on each chapter follow.

CHAPTER FIVE

THE IMPACT OF MOBILITY ON HEALTHCARE ACCESS

5.1 Background, Research Questions and Hypotheses

The purpose of this chapter is to examine the impact of mobility-related transportation disadvantage on healthcare access. In a built environment that is designed and developed on the assumption of high mobility, those who have restricted mobility are transportation disadvantaged and may face risk of being socially excluded (Kenyon et al. 2002). In particular, having access to a private vehicle is of particular importance in fulfilling people's mobility needs for traveling to out-of-home activities in most of the areas in the United States. Also, public transit is a very important transportation mode for those who do not have automobile access to fulfill their mobility needs (Pyrialakou et al., 2016), especially if they live in a built environment that is not friendly for active transportation. Therefore, this chapter considers those who do not own a vehicle in the family, or rely on walking (instead of using a car or using public transit) to their usual source of medical care as transportation disadvantaged.

This chapter uses two sets of data to examine this topic.

First, by using data from the National Health Interview Survey (NHIS) 1993-1996, I intend to understand the impact of vehicle ownership on healthcare access. Healthcare access is measured by two variables: whether or not one has a place that is not a hospital emergency department (ED) as usual source of medical care, and whether or

not one has forgone needed medical care in the past 12 months. In this section, I try to answer the following research questions: 1) Which population groups are more likely to own a vehicle in the family? I hypothesize that those who do not live in the central city in a metropolitan area, are employed, and have higher income are more likely to own a vehicle in the family; 2) Does having a vehicle in the family affect the likelihood of having a usual place that is not an ED for medical care? I hypothesize that people who have a private vehicle in the family are more likely to have a non-ED place as usual source of medical care than those who do not have a vehicle; 3) Does having a vehicle in the family affect the likelihood of having forgone needed care in the last 12 months? I hypothesize that having a vehicle in the family is associated with decreased likelihood of having forgone needed care in the past 12 months.

Second, I use data from the Medical Expenditure Panel Survey (MEPS) 2000-2001 to examine the impact of transportation mode used for traveling to the usual source of care (including drive/offered a ride, public transit, and walk) on healthcare access (Note in this analysis, transportation mode is considered as representing a family's access to transportation resources). Healthcare access is measured by whether or not any family member has experienced difficulty in obtaining needed healthcare in the past 12 months. The research question is: Does transportation mode have an impact on the likelihood of experiencing difficulty in getting care? I hypothesize that compared with those who have access to a car or public transit, those who walk to the usual source of care are more likely to have experienced difficulty in obtaining needed care (although it should also be

noted that transportation mode does not always reflect someone's access to transportation resources; rather, it can be an illustration of travel needs).

5.2 The Impact of Vehicle Ownership on Usual Source of Care and Forgoing Needed Medical Care

5.2.1 Study Setting

This section aims to examine the impact of vehicle ownership on healthcare access. Healthcare access is measured by whether or not one has a usual source of care, and whether or not one has forgone needed medical care in the last 12 months. The data of the key variable "vehicle ownership" is available in the NHIS from 1993 to 1996. Therefore, survey data from this time period is used for analysis. During 1993 to 1996, the NHIS collected data on 391,691 respondents from age 0 to 98. I believe that children might be dependent on their parents when making healthcare-seeking decisions; therefore, 110,811 respondents younger than 18 years old are excluded from the sample. Of those who were 18 years old or older, 58,251 respondents did not state the vehicle ownership in their families and thus are excluded. This yields a sample size of 222,629 people (18 years old or older) who have indicated whether or not they have a private automobile/truck/other vehicle in the family.

Variables used for analyzing the impact of vehicle ownership on usual source of care and forgoing needed medical care are summarized in Table 5.1. Details about the variables are presented below.

Table 5.1 Variables for Analyzing Vehicle Ownership, Usual Source of Care, and Forgo Needed Care, NHIS 1993-1996

Variables of Interest	Covariates	Year
<p>a. Vehicle ownership</p> <p>0: Has no car/truck/other vehicle in family 1: Has a car/truck/other vehicle in family</p> <p>b. Usual source of care</p> <p>0: Has no usual place for medical care or use a hospital emergency department (ED) as usual source of care 1: Has one or more than one place (non-ED) as usual source of care</p> <p>c. Forgo needed medical care</p> <p>0: Did not forgo needed medical care in last 12 months 1: Had to forgo needed medical care</p>	<p>Age (18 to 98) Age-squared Gender Race and ethnicity Education attainment Marital status Employment status Family income Metropolitan residence Census region Health status Activity limitation Insurance status</p>	<p>1993-1996</p> <p>NHIS</p>

Variables of Interest. The data for “vehicle ownership” is extracted from the answers to the question in the NHIS asking each respondent if anyone in the respondent’s family owns an automobile, or a truck, or a private vehicle of any type. The answers are coded in a binary format with 0 indicating no vehicle in the family, and 1 indicating one (or more) vehicle in the family. It should be noted that the NHIS imputed the missing values of vehicle ownership and flagged the imputed observations. Since vehicle ownership is the key variable of interest, I believe the un-imputed data would be more

appropriate for analysis. Therefore, all the imputed observations are treated as missing and are thus excluded from the sample.

The data for “usual source of care” is extracted from the answers to two questions in the NHIS. The respondents were first asked to state whether or not they have a place (or more than one place) that they usually go when they have medical needs or when they seek advice from health professionals about their own health. If the respondents answered “yes”, they would be further asked to specify the type of their usual source of care. The answers reported by respondents include health center, clinic, doctor’s office, Health Maintenance Organization (HMO), hospital outpatient department, military or veteran health care facility, hospital emergency department (ED), and other places. Those who reported using a hospital emergency department (ED) as usual source of care cannot be considered as having quality healthcare access (Uscher-Pines et al., 2013). Therefore, I combine the answers to the two questions and recode the data of “usual source of care” into dichotomous format, with 0 indicating no usual place for medical care or using an ED as usual source of care, and 1 indicating having one (or more than one) non-ED place as usual source of medical care.

The data for “forgo needed medical care” is obtained from the survey question asking a respondent if there was any time in the last 12 months that he or she was in need of healthcare or surgery but did not get it. The answers are coded as dichotomous with 0 indicating the respondent did not forgo needed medical care or surgery and 1 indicating he or she has forgone needed medical care or surgery in the last 12 months.

Covariates. Age, age-squared, gender, race and ethnicity, marital status, educational attainment, employment status, family income, metropolitan residence, census region, health status, activity limitation, and insurance status are the covariates.

Among the covariates, “age” reports each survey participant’s age, ranging from 18 to 98 “Race and ethnicity” records the main racial and ethnic background self-reported by the respondents. The categories include white; African American; Aleut, Alaska Native, or American Indian; Asian or Pacific Islander; other race; multiple race, no primary race selected; and Hispanic. The category “Hispanic” includes people of Hispanic heritage of any race; other racial groups refer to non-Hispanic individuals.

“Education attainment” reports each respondent’s education level indicated by the highest grade of school or year of college the person completed. Five categories are included in the variable, including less than high school, high school diploma, one to three years of college, bachelor’s degree, five years of college and more. “Marital status” reports on the marital status of survey respondents, including married, never married, divorced or separated, and widowed. “Employment Status” indicates if a respondent was employed, unemployed, or not in the labor force. “Family income” reports on each respondent’s family income in grouped intervals. The missing values of this variable was imputed by the NHIS. The original data structure was categorical with 27 groups top-coded at \$50,000. I recode the data into 6 groups: less than \$10,000; \$10,000 to \$19,999; \$20,000 to \$29,999; \$30,000 to \$39,999; \$40,000 to \$49,999; and \$50,000 and over.

“Metropolitan residence” indicates whether a respondent was living in the central city of a metropolitan statistical area (MSA), or living in an MSA but not in the central city, or

not living in an MSA. According to the U.S. Office of Management and Budget (OMB), an MSA is defined as a geographic area “consists of the county or counties (or equivalent entities) associated with at least one urbanized area of at least 50,000 population, plus adjacent counties having a high degree of social and economic integration with the core as measured through commuting ties”(US Census Bureau, 2019). “Census region” reports the region of the U.S. where each survey participant’s residence was located. Four categories are included in the variable that correspond to the classification recognized by the Census Bureau: West, Northeast, North Central/Midwest, and South. “Health status” represents the self-reported health status perceived by the respondents as poor, fair, good, very good, or excellent. “Activity limitation” is a binary variable indicating whether or not the respondent had any activity limitation due to physical or mental conditions. “Insurance status” is a binary variable that indicates whether or not the respondent was covered by health insurance. According to the NHIS, “uninsured persons include those without any private insurance, or without public health insurance coverage through Medicaid, Medicare, military health care, Children's Health Insurance Program (CHIP), or a state-sponsored or other government program. Persons covered only by a private plan that paid for one type of service, such as accidents or dental care, and persons only covered by the Indian Health Service are also considered uninsured” (IPUMS, 2019b).

5.2.2 Data Analysis

The NHIS selects a new sample every year, therefore, data from different survey years can be combined together to obtain a larger sample size. For this section,

observations from the NHIS 1993 to 1996 are pooled to perform cross-sectional analysis. Stata 15.1 (StataCorp LP, College Station, TX) is used for data analysis. The survey modules in Stata (*svy:* prefix) are used to account for the stratification, clustering and sampling weights of the complex sampling design of the NHIS to avoid biased estimates of model parameters and variances.

First, the characteristics of the variables of interest in this section are described, including vehicle ownership, usual source of care, and forgo needed medical care. I also use cross-tabulations to describe characteristics of the sampled adults by vehicle ownership while accounting for the sampling design. Next, I use a logistic regression model of vehicle ownership on all covariates to analyze which population groups are more likely to be transportation disadvantaged, i.e., those who do not own a vehicle in the family. I am particularly interested in examining the impact of vehicle ownership on healthcare access, which is measured by people's usual source of care as well as the experience of forgoing needed care in the last 12 months. In order to do so, I examine unadjusted associations between vehicle ownership and the two healthcare access measures. I also perform logistic regression analysis to examine the associations with all covariates being controlled.

Note that except for family income, the missing values of which were imputed by the NHIS, none of the variables used in the models is imputed. All the data used for analysis is directly extracted from the original dataset. Due to the missing values of some variables, the final sample sizes of the statistic models below are slightly different from

one another, as Stata omits observations with any missing values when performing analysis.

5.2.3 Results

5.2.3.1 Characteristics of the Sample

The variables of interest in this section include vehicle ownership, usual source of care, and forgo needed care. The descriptive statistics of these variables of interest are shown in Table 5.2.

Table 5.2 Descriptive Statistics of Variables of Interest, NHIS 1993-1996

Variables	Unweighted Sample Size	Weighted Percentage % [†] (95% Confidence Interval)
Vehicle ownership (n= 222,629 *)		
Has no vehicle	24,089	10.1 (9.6 — 10.6)
Has a vehicle	198,540	89.9 (89.4 — 90.4)
Usual source of care (n= 219,621*)		
No usual source of care or use an ED as usual source of care	34,918	15.6 (15.3 — 16)
Has at least one place (non-ED) as usual source of care	184,703	84.4 (84 — 84.8)
Forgo needed medical care (n= 221,712*)		
Did not forgo needed care	214,873	97 (96.9 — 97.1)
Had to forgo needed care	6,839	3 (2.9 — 3.1)

*Sample is restricted to 222,629 adults with a valid observation of vehicle ownership.

Sample sizes are different due to missing values.

†All percentages are weighted to reflect the effects of the sampling design of the National Health Interview Survey and may not add to 100 because of rounding.

As can be seen from the above table, during 1993 to 1996, a total of 222,629 adults have indicated vehicle ownership. After accounting for sampling weights, 10.1% of these adults have no vehicle and 89.9% have a vehicle in their families. 219,621 adults have indicated their situation about usual source of care. 15.6% of them reported having no usual source of care or using a hospital emergency department (ED) as usual source of care; 84.4% reported having one (or more than one) place that is not an ED as usual source of care. 221,712 adults have reported their experience in regard to if they needed medical care or surgery but did not get any in the last 12 months. 3% of the surveyed adults indicated that they have experienced unmet medical needs in the past 12 months. Note that all percentages are weighted.

Table 5.3 summarizes the demographic and socioeconomic characteristics of the sample stratified by vehicle ownership.

Table 5.3 Characteristics of Adults With or Without A Vehicle, NHIS 1993-1996

Characteristics	Owns a vehicle		Has no vehicle		Total
	Unweighted	Weighted %	Unweighted	Weighted %	%
	No. *	(Column) [†]	No. *	(Column) [†]	(Col) [†]
Sample size	198,540	100	24,089	100	100
Gender					
Male	95,025	49	8,457	37.4	47.8
Female	103,515	51	15,632	62.6	52.2
Race and ethnicity					
White	147,622	78.8	10,377	50.8	76
African American	19,226	8.8	7,210	27.1	10.6

Aleut, Alaska Native, or American Indian	1,280	0.7	201	1	0.7
Asian or Pacific Islander	5,703	3.1	761	3.9	3.2
Other race	684	0.4	175	0.8	0.4
Multiple race, no primary race selected	208	0.1	39	0.2	0.1
Hispanic	22,858	8.1	5,195	16.3	8.9
Education attainment					
Less than high school	36,037	16.7	10,169	39.1	19
High school diploma	74,312	37.6	7,651	32.9	37.2
One to three years of college	43,772	22.7	3,547	16.4	22.1
Bachelor's degree	24,912	13.3	1,492	7.2	12.7
Five or more years of college	18,267	9.7	913	4.5	9.1
Marital status					
Married	136,670	68.6	6,524	26.4	64.4
Never married	32,219	16.9	8,515	37.2	19
Divorced /separated	17,906	8.9	4,308	17	9.7
Widowed	11,473	5.6	4,674	19.4	7
Employment status					
Employed	133,454	68	9,077	38.6	65.1

Unemployed	5,327	2.7	1,217	5	2.9
Not in labor force	59,759	29.3	13,795	56.4	32
Family income					
Less than \$10,000	13,627	6.5	11,001	44.5	10.3
\$10,000~\$19,999	35,559	17	7,649	31.5	18.5
\$20,000~\$29,999	36,438	18.1	2,485	10.5	17.3
\$30,000~\$39,999	31,138	15.7	1,103	4.8	14.6
\$40,000~\$49,999	25,886	13.2	627	2.7	12.2
\$50,000 and over	55,892	29.6	1,224	6	27.2
Metropolitan residence					
Live in the central city in a Metropolitan Statistical Area	55,825	27	14,090	55.9	29.9
Live in an MSA, not in central city	98,013	50.7	6,642	29.5	48.6
Not in an MSA	44,702	22.3	3,357	14.6	21.6
Census region					
West	45,523	21.7	4,522	18.8	21.4
Northeast	37,467	19.1	8,368	34	20.6
North Central/Midwest	48,330	24.8	4,591	19.7	24.3
South	67,220	34.4	6,608	27.6	33.7
Health status					
Poor	6,480	3.1	1,959	7.7	3.6
Fair	17,249	8.3	4,145	16.7	9.2
Good	50,667	25.1	7,006	28.8	25.4
Very good	58,338	30	5,913	25.4	29.5

Excellent	64,727	33.5	4,873	21.5	32.3
Activity limitation					
No activity limitation	164,860	83.4	16,535	68.7	81.9
Some activity limitations	33,680	16.6	7,554	31.3	18.1
Insurance status					
Uninsured	30,768	14.8	5,786	23.2	15.7
Insured	167,279	85.2	18,188	76.8	84.3
Age	Mean=44		Mean= 47		Overall mean=44

*Numbers may not add to the total sample size due to missing values.

†All percentages are weighted to reflect the effects of the sampling design of the National Health Interview Survey and may not add to 100 because of rounding.

Table 5.3 shows that the average age of all sampled respondents is 44 years old. 52.2% of the sampled respondents are female. Non-Hispanic white is the largest population group (76%), followed by non-Hispanic African American (10.6%), Hispanic (8.9%), and Asian/Pacific Islander (3.2%). 19% of the respondents have less than high school level of education, 37.2% have a high school diploma, 43.9% of them have education level higher than high school. The majority of the respondents are married (64.4%) and employed (65.1%). In terms of the residential area, 48.6% of the respondents live in an MSA (not in the central city), 29.9% of them live in the central city in an MSA, and 21.6% live outside an MSA. Most of them have no activity limitation (81.9%) and are covered by insurance (84.3%).

5.2.3.2 Disparities in Vehicle Ownership

I hypothesize that people who do not live in the central city in an MSA are more likely to have a vehicle in the family, because of the dependence on automobiles in the suburban and rural areas caused by limited public transit provision, the more scattered land use pattern, and the less pedestrian-friendly built environments in these areas. Also, people who are employed or have a higher income would be more likely to have a vehicle in the family. Table 5.4 shows the results of logistic regression of whether or not one has a private vehicle in the family on all covariates.

Table 5.4 Logistic Regression of Vehicle Ownership on Covariates, NHIS 1993-1996

Has a vehicle in the family	Odds Ratio	t	P> t
Age	1.05***	12.38	<0.001
Age²	0.99***	-13.81	<0.001
Gender			
Male	Omitted		
Female	0.85***	-7.41	<0.001
Race and ethnicity			
White	Omitted		
African American	0.35***	-23.52	<0.001
Aleut, Alaska Native, or American Indian	0.59**	-2.66	0.008
Asian or Pacific Islander	0.53***	-7.88	<0.001
Other race	0.37***	-4.12	<0.001
Multiple race, no primary race selected	0.55*	-2.08	0.038

Hispanic	0.48***	-14.19	<0.001
Education attainment			
Less than high school	Omitted		
High school diploma	1.34***	9.77	<0.001
One to three years of college	1.48***	10.30	<0.001
Bachelor's degree	1.04	0.83	0.408
Five or more years of college	1.05	0.81	0.419
Marital status			
Married	Omitted		
Never married	0.33***	-26.96	<0.001
Divorced/separated	0.39***	-25.10	<0.001
Widowed	0.37***	-25.76	<0.001
Employment status			
Employed	Omitted		
Unemployed	0.7***	-7.58	<0.001
Not in labor force	0.72***	-10.89	<0.001
Family income			
less than \$10,000	Omitted		
\$10,000~\$19,999	2.9***	31.62	<0.001
\$20,000~\$29,999	7.73***	40.29	<0.001
\$30,000~\$39,999	12.08***	44.09	<0.001
\$40,000~\$49,999	16.23***	33.06	<0.001
\$50,000 and over	15.22***	43.37	<0.001
Metropolitan residence			
Live in the central city in a Metropolitan Statistical Area	Omitted		
Live in an MSA, not in central city	2.19***	14.57	<0.001
Not in an MSA	2.66***	18.37	<0.001

Census region			
West	Omitted		
Northeast	0.34***	-12.19	<0.001
North Central/Midwest	0.98	-0.39	0.7
South	1.33***	4.69	<0.001
Health status			
Poor	Omitted		
Fair	1.03	0.56	0.577
Good	1.13*	2.37	0.018
Very good	1.11	1.73	0.084
Excellent	1.22**	3.34	0.001
Activity limitation			
No activity limitation	Omitted		
Some activity limitations	0.8***	-7.10	<0.001
Insurance status			
Uninsured	Omitted		
Insured	1.13***	3.95	<0.001

Number of observations = 218,079

*p<0.05, **p<0.01, ***p<0.001

As can be seen from the table above, income is the most significant factor predicting vehicle ownership (P<0.001). Also, living in an MSA but not in the central city (Odds Ratio=2.19, P<0.001) or not living in an MSA (OR=2.66, P<0.001) is associated with increased odds of having a vehicle in the family, supporting the hypothesis that people living in suburban and rural areas have more dependence on automobiles due to the lack of public transit provision and the more scattered built environment. In addition, being older (OR=1.05, P<0.001), having a high school diploma

(OR=1.34, P<0.001) or some years of college education (OR=1.48, P<0.001), living in the South of the U.S. (OR=1.33, P<0.001), being in good (OR=1.13, P=0.018) or excellent (OR=1.22, P=0.001) health, and being insured (OR=1.13, P<0.001) are associated with increased odds of having a vehicle in the family.

Meanwhile, being unemployed (OR=0.7, P<0.001) or not in the labor force (OR=0.72, P<0.001) is associated with decreased odds of having a vehicle, the reason of which may be that employed people are more in need of a car for commuting to work. Also, being female (OR=0.85, P<0.001), not being married, and having some activity limitations (OR=0.8, P<0.001) are associated with decreased odds of having a vehicle in the family. Compared with whites, racial or ethnic minorities have decreased odds of owning a vehicle, which might be explained by the situation that some immigrants of racial or ethnic minorities have limited English proficiency, which negatively impacts the probability of having a driver's license and purchasing a car. People living in the Northeast (OR=0.34, P<0.001) Census region have decreased odds of owning a vehicle in the family. This is probably because the public transit systems are better developed in that region, plus some cities in the Northeast are very walkable, reducing the need for owning a car. Cities like New York City, Boston and Philadelphia are some cases, although more specific geographic information of the sample is omitted.

5.2.3.3 Vehicle Ownership and Usual Source of Care

Table 5.5 describes the characteristics of usual source of care among those with or without a private vehicle in the family using cross-tabulations while accounting for the

survey design of the NHIS. The bivariate association between vehicle ownership and usual source of care is also examined using a design-based F test, which is converted from the Pearson chi-squared test after correcting for the survey design.

Table 5.5 Characteristics of Usual Source of Care by Vehicle Ownership, NHIS 1993-1996

	No usual source of care or use an ED as usual source of care	Has at least one place (non-ED) as usual source of care	P*
	Unweighted No. (Weighted %)	Unweighted No. (Weighted%)	
Vehicle ownership	34,918 (100%)	184,703 (100%)	<0.001
Has no vehicle	5,323 (14.4%)	18,331 (9.3%)	
Has a vehicle	29,595 (85.6%)	166,372 (90.8%)	

A total of 219,621 respondents with complete data on these two variables.

All percentages are weighted to reflect the effects of the sampling design of the National Health Interview Survey and may not add to 100 because of rounding.

*Design-based $F(1, 480) = 445.9788$

The table above shows that the vehicle ownership among the respondents who reported having one or more than one non-ED place as usual source of care is 90.8%, which is higher than the vehicle ownership among their counterparts who reported having no usual source of care or using an ED as usual source of care (85.6%). The design-based F test shows that the bivariate association between these two variables is significant.

Table 5.6 presents the results of logistic regression of whether or not one has a non-ED usual place for care on vehicle ownership, with covariates being controlled.

Table 5.6 Logistic Regression of Usual Source of Care on Vehicle Ownership and Covariates, NHIS 1993-1996

Has at least one place (non-ED) for usual source of care	Odds Ratio	t	P> t
Vehicle ownership			
Has no vehicle	Omitted		
Has a vehicle	1.34***	10.16	<0.001
Metropolitan residence			
Live in the central city in a Metropolitan Statistical Area	Omitted		
Live in an MSA, not in the central city	1.15***	5.23	<0.001
Not in an MSA	1.35***	6.78	<0.001
Age	0.99***	-4.35	<0.001
Age²	1 ***	10.82	<0.001
Gender			
Male	Omitted		
Female	1.9***	46.90	<0.001
Race and ethnicity			
White	Omitted		
African American	1.23***	6.12	<0.001
Aleut, Alaska Native, or American Indian	1.24	1.83	0.067
Asian or Pacific Islander	0.8***	-3.79	<0.001
Other race	0.89	-0.94	0.346
Multiple race, no primary race selected	0.8	-1.02	0.308
Hispanic	0.89***	-3.88	<0.001
Education attainment			

Less than high school	Omitted		
High school diploma	1.21***	8.62	<0.001
One to three years of college	1.32***	10.73	<0.001
Bachelor's degree	1.1**	3.15	0.002
Five or more years of college	1.18***	4.52	<0.001
Marital status			
Married	Omitted		
Never married	0.94*	-2.52	0.012
Divorced/separated	0.79***	-10.19	<0.001
Widowed	0.8***	-5.61	<0.001
Employment status			
Employed	Omitted		
Unemployed	0.88***	-3.61	<0.001
Not in labor force	1.09***	3.91	<0.001
Family income			
less than \$10,000	Omitted		
\$10,000~\$19,999	1.09*	2.52	0.012
\$20,000~\$29,999	1.31***	7.66	<0.001
\$30,000~\$39,999	1.62***	12.05	<0.001
\$40,000~\$49,999	1.85***	14.39	<0.001
\$50,000 and over	2.27***	19.73	<0.001
Census region			
West	Omitted		
Northeast	1.4***	7.24	<0.001
North Central/Midwest	1.17***	3.63	<0.001
South	0.98	-0.44	0.660
Health status			

Poor	Omitted		
Fair	0.8***	-4.18	<0.001
Good	0.67***	-7.51	<0.001
Very good	0.6***	-9.30	<0.001
Excellent	0.49***	-12.58	<0.001
Activity limitation			
No activity limitation	Omitted		
Some activity limitations	1.53***	15.40	<0.001
Insurance status			
Uninsured	Omitted		
Insured	3.88***	54.32	<0.001

Number of observations = 215,390

*p<0.05, **p<0.01, ***p<0.001

The results above show that when covariates are controlled, compared with surveyed adults who do not have a vehicle in the family, the odds of having at least one non-ED place for medical care are expected to increase by 34% among those who have a vehicle in the family (Odds Ratio=1.34, P<0.001).

Although not controlling directly for geographic proximity because I do not observe distance to healthcare facilities, this analysis includes the variable of metropolitan residence. It is reasonable to assume that healthcare resources are widely distributed in areas outside an MSA and that the spatial separation between healthcare users and healthcare providers is greater in areas outside an MSA than in the central city in an MSA. In this sense, the result of this variable is suggestive of the impact of spatial distance on healthcare access. The result shows that compared with people living in the central city in an MSA, the odds of having at least one non-ED place as usual source of

care are increased by 35% among those not living in an MSA (OR=1.35, $P<0.001$). The result suggests that there is no clear evidence that spatial distance to healthcare providers plays an important role in preventing people from accessing healthcare.

Two things should be noted. First, the information about the actual spatial distance to healthcare providers is lacking. It is possible that some survey respondents residing outside an MSA live close to healthcare resources or that they are able to reach reliable healthcare through some health programs such as mobile clinics. Thus living outside an MSA does not necessarily mean residing far away from healthcare resources.

Second, essentially the result captures the disparity in healthcare access between the central city in an MSA and areas outside an MSA. However, these two areas differ in aspects more than land use patterns, such as traffic congestion levels and speed limits. The level of social support and social capital may also be different between these areas which would also contribute to the healthcare access disparity. Therefore, the access disparity revealed in the analysis may result from the combined effect of spatial distance and other factors that are not controlled in the model. It is possible that spatial distance to healthcare providers does act as a barrier to healthcare access in areas outside an MSA, but this disadvantage is overcome by the positive effects of other factors, for example, by less traffic congestion, higher speed limits, and/or better social support. In this case, using only spatial distance to interpret the result would cause bias.

As expected, being insured (OR=3.88, $P<0.001$) and having a higher income are associated with increased odds of having at least one (non-ED) place as usual source of care. These two factors are related to the affordability of healthcare, which is very

important in affecting people's healthcare access. In addition, being female (OR=1.9, P<0.001), being better educated, being not in the labor force (OR=1.09, P<0.001), living in the Northeast (OR=1.4, P<0.001) and North Central/Midwest (OR=1.17, P<0.001) Census regions are associated with increased odds of having at least one (non-ED) place as usual source of care. Surprisingly, compared with whites, being African American (OR=1.23, P<0.001) is associated with increased odds of having at least one (non-ED) place as usual source of care, contradicting studies that show racial minorities have worse healthcare access. Having some activity limitations is also positively associated with having a usual source of care (OR=1.53, P<0.001).

On the other hand, being older (OR=0.99, P<0.001), having never been married (OR=0.94, P=0.012), being divorced or separated (OR=0.79, P<0.001), being widowed (OR=0.8, P<0.001), being unemployed (OR=0.88, P<0.001) are associated with decreased odds of having at least one usual source of care. Being Asian/Pacific Islander (OR=0.8, P<0.001) and being Hispanic (OR=0.89, P<0.001) are associated with lower odds of having a usual source of care compared with whites, confirming previous research findings about healthcare access disparities among racial and ethnic groups. Being healthier is also negatively associated with having a usual source of care; this may be because people who perceive themselves as in better health do not have medical needs or do not proactively maintain a usual source of care (they do not think they need one).

This analysis also predicts the probability of having a usual place for medical care among survey respondents who do or do not have a vehicle, with all covariates held at the means. The results are listed in Table 5.7.

**Table 5.7 Predicted Probability of Having A Usual Source of Care for Adults
With or Without A Vehicle, NHIS 1993-1996**

Having at least one usual source of care (non-ED)	Predicted Probability
Adults who have no vehicle in the family	83.6%
Adults who have a vehicle in the family	87.2%
Difference between the above two groups	3.6 percentage point ***

Number of observations = 215,390

*p<0.05, **p<0.01, ***p<0.001

Predicted probabilities are calculated using marginal effects with covariates held at the means.

The results show that when all the covariates are held at the means, the probability of having at least one usual source of care for the adults who have no vehicle in the family is expected to be 83.6%; and the probability of having at least one usual source of care for the adults who have a vehicle in the family is expected to be 87.2%. The results also show that the difference in the predicted probabilities is significant.

5.2.3.4 Vehicle Ownership and Forgoing Needed Medical Care

Table 5.8 describes the characteristics of forgoing needed medical care among those with or without a private vehicle in the family using cross-tabulations while accounting for the survey design of the NHIS. The unadjusted association between vehicle ownership and forgoing needed care is also examined using design-based F statistic, which is converted from the Pearson chi-squared statistic after correcting for the survey design.

Table 5.8 Characteristics of Forgoing Needed Care by Vehicle Ownership, NHIS 1993-1996

	Did not forgo care	Had to forgo care	P*
	Unweighted No. (Weighted %)	Unweighted No. (Weighted%)	
Vehicle ownership	214,873 (100%)	6,839 (100%)	<0.001
Has no vehicle	22,625 (9.8%)	1,322 (18.4%)	
Has a vehicle	192,248 (90.2%)	5,517 (81.6%)	

A total of 221,712 respondents with complete data on these two variables.

All percentages are weighted to reflect the effects of the sampling design of the National Health Interview Survey and may not add to 100 because of rounding.

*Design-based $F(1, 480) = 326.7373$

As can be seen from the table above, among those who did not forgo needed care in the last 12 months, 9.8% reported not having a vehicle in the family; while among the respondents who had to forgo needed care, 18.4% reported not having a vehicle in their families. The design-based F test shows that the unadjusted bivariate association between these two variables is significant.

Table 5.9 shows the results of logistic regression of whether one has forgone needed medical care on vehicle ownership, with covariates being controlled.

Table 5.9 Logistic Regression of Having Forgone Needed Medical Care on Vehicle Ownership and Covariates, NHIS 1993-1996

Has forgone needed care	Odds Ratio	t	P> t
Vehicle Ownership			
Has no vehicle	Omitted		
Has a vehicle	0.83***	-3.80	<0.001
Metropolitan residence			

Live in the central city in a Metropolitan Statistical Area	Omitted		
Live in an MSA, not in central city	1.02	0.42	0.672
Not in an MSA	0.78***	-4.45	<0.001
Age	1.04***	7.07	<0.001
Age²	0.99***	-10.44	<0.001
Gender			
Male	Omitted		
Female	1.34***	10.10	<0.001
Race and ethnicity			
White	Omitted		
African American	0.68***	-7.21	<0.001
Aleut, Alaska Native, or American Indian	1.22	1.41	0.159
Asian or Pacific Islander	0.65***	-3.86	<0.001
Other race	0.61	-1.89	0.059
Multiple race, no primary race selected	0.86	-0.33	0.743
Hispanic	0.78***	-5.01	<0.001
Education attainment			
Less than high school	Omitted		
High school diploma	0.95	-1.33	0.185
One to three years of college	1.2**	3.42	0.001
Bachelor's degree	1.23**	2.77	0.006
Five or more years of college	1.37***	4.06	<0.001

Marital status			
Married	Omitted		
Never married	0.9*	-2.55	0.011
Divorced/separated	1.35***	7.17	<0.001
Widowed	1.26**	2.90	0.004
Employment status			
Employed	Omitted		
Unemployed	1.19**	2.76	0.006
Not in labor force	0.81***	-5.87	<0.001
Family income			
less than \$10,000	Omitted		
\$10,000~\$19,999	0.79***	-5.34	<0.001
\$20,000~\$29,999	0.61***	-8.42	<0.001
\$30,000~\$39,999	0.46***	-11.00	<0.001
\$40,000~\$49,999	0.38***	-11.78	<0.001
\$50,000 and over	0.32***	-15.59	<0.001
Census region			
West	Omitted		
Northeast	0.71***	-5.58	<0.001
North Central/Midwest	0.86*	-2.57	0.01
South	0.82**	-3.41	0.001
Health status			
Poor	Omitted		
Fair	0.65***	-7.82	<0.001
Good	0.37***	-16.75	<0.001
Very good	0.26***	-19.82	<0.001
Excellent	0.18***	-24.54	<0.001
Activity limitation			
No activity limitation	Omitted		

Some activity limitations	2.22***	19.77	<0.001
Insurance status			
Uninsured	Omitted		
Insured	0.24***	-37.80	<0.001

Number of observations = 217,263

*p<0.05, **p<0.01, ***p<0.001

The results in Table 5.9 indicate that when covariates are controlled, compared with surveyed adults who do not have a vehicle in the family, the odds of having forgone needed medical care in the last 12 months are expected to decrease by 17% among those who have a vehicle in the family (Odds Ratio=0.83, P<0.001).

Not living in an MSA (OR=0.78, P<0.001) is also associated with decreased odds of having forgone needed medical care in the last 12 months, compared with living in the central city in an MSA. Similar to the previous section, the implication is complicated. Assuming people outside an MSA live farther from healthcare facilities than do people in the central city, the result suggests there is no clear evidence that the long spatial distances between healthcare users and providers play an important role in contributing to people's unmet medical needs. Again, this implication should be taken with caution. Bias can result from the lack of data on actual spatial distance and the effects of some other factors, such as traffic congestion and speed limits, contributing to the healthcare access disparity between the central city and areas outside an MSA.

In addition, having never been married (OR=0.9, P=0.011), living in the Northeast (OR=0.71, P<0.001), living in the North Central/Midwest (OR=0.86, P=0.01), and living in the South (OR=0.82, P=0.001) are associated with decreased odds of having

forgone needed medical care in the last 12 months. Higher-income and insured (OR=0.24, P<0.001) people are less likely to have forgone care, this is because they are less likely to encounter affordability issue when seeking care. People that are not in the labor force are less likely to have forgone needed care than people who are employed (OR=0.81, P<0.001). This may be because of the difficulty in getting time off work or coordinating the time schedule with healthcare providers among employed people. Healthier people are less likely to have forgone needed care. This might be because healthy people did not have any medical needs in the past 12 months, or because they are more conscientious about their health and proactively got all needed care to stay healthy. Also, being African American (OR=0.68, P<0.001), Asian/Pacific Islander (OR=0.65, P<0.001) or Hispanic (OR=0.78, P<0.001) is associated with decreased odds of having forgone care, compared with being white. This may be explained by the difference in health literacy and perceived medical needs among racial and ethnic groups. That is to say, when facing some health conditions, some racial and ethnic minorities may not consider themselves as in need of medical care and thus are less likely to have forgone “needed” care.

On the other hand, being older (OR=1.04, P<0.001), being female (OR=1.34, P<0.001), having more than a high school level of education, being divorced/separated (OR=1.35, P<0.001) or being widowed (OR=1.26, P=0.004), and being unemployed (OR=1.19, P=0.006) are associated with increased odds of having forgone needed medical care in the last 12 months. Those having some activity limitations are also more

likely to have forgone needed care (OR=2.22, P<0.001), the reason for which may be that mobility problems cause barriers for them to getting medical care.

This section also predicts the probability of having forgone needed care among survey respondents who do or do not have a vehicle, with all covariates held at the means. The results are listed in Table 5.10.

Table 5.10 Predicted Probabilities of Forgoing Needed Medical Care for Adults With or Without A Vehicle, NHIS 1993-1996

Had to forgo needed medical care	Predicted Probability
Adults who have no vehicle in the family	2.3%
Adults who have a vehicle in the family	1.9%
Difference between the above two groups	-0.4 percentage point ***

Number of observations = 217,263

*p<0.05, **p<0.01, ***p<0.001

Predicted probabilities are calculated using marginal effects with covariates held at the means.

The results show that when all the covariates are held at the means, the probability of having forgone needed care for the adults who have no vehicle in the family is expected to be 2.3%; and the probability of having forgone needed care for the adults who have a vehicle in the family is expected to be 1.9%. The results also show that the difference in the predicted probabilities is significant.

5.2.3.5 *The Effect of Metropolitan Residence*

The results presented above reveal the impact of vehicle ownership on healthcare access. However, this impact may vary upon the areas people reside in, considering the

different levels of importance of vehicles in fulfilling people’s mobility needs within different built environments. Some researchers also suggest that the issue of mobility limitation is better viewed within the context of the built environment. I postulate that the impact of vehicle ownership on healthcare access is different among people living in the central city in a Metropolitan Statistical Area, people living in an MSA but not in the central city, and people living outside an MSA. The reasoning is that for people who live in the central city in an MSA, the impact of the lack of vehicle access may be attenuated by the factor that the public transit services are normally better developed in the city, so that people would have more mode options besides private vehicles. Also, the built environment in the central city is likely to be more walkable and the distance between residence and healthcare providers smaller.

This section then examines the effect of metropolitan residence on the relationship between vehicle ownership and healthcare access by incorporating an interaction term of vehicle ownership * metropolitan residence, and the results are briefly presented in Table 5.11.

Table 5.11 Logistic Regression of Usual Source of Care and Forgoing Needed Care on Vehicle Ownership, Metropolitan Residence, Interaction, and Covariates, NHIS 1993-1996

	(1) Having a USC	(2) Having a USC	(3) Forgo care	(4) Forgo care
	Odds ratio (t statistics)	Odds ratio (t statistics)	Odds ratio (t statistics)	Odds ratio (t statistics)
Vehicle ownership				

Has no vehicle	Omitted	Omitted	Omitted	Omitted
Has a vehicle	1.34 (10.16)***	1.31 (6.2)***	0.83(-3.8)***	0.82 (0.003)**

**Metropolitan
residence**

Live in the central city in an MSA	Omitted	Omitted	Omitted	Omitted
Live in an MSA, not in the central city	1.15 (5.23)***	1.12 (1.51)	1.02 (0.42)	0.99 (0.907)
Not in an MSA	1.35 (6.78)***	1.28 (2.74)**	0.78(- 4.45)***	0.83 (0.109)

**Vehicle ownership #
Metropolitan
residence**

Has a vehicle and live in the central city in an MSA		Omitted		Omitted
Has a vehicle and live in an MSA (not in the central city)		1.03 (0.42)		1.03 (0.743)
Has a vehicle and live outside an MSA		1.06 (0.63)		0.94 (0.606)

Number of observations for Model (1) and Model (2)= 215,390

Number of observations for Model (3) and Model (4)= 217,263

*p<0.05, **p<0.01, ***p<0.001

Covariates include survey respondent’s age, age-squared, gender, race and ethnicity, education attainment, marital status, employment status, family income, census region, health status, activity limitation, and insurance status. The results of covariates are omitted for brevity. Detailed results of Model (1) are reported in Table 5.6. Detailed results of Model (3) are reported in Table 5.9.

The results show that the interaction of vehicle ownership * metropolitan residence is insignificant in both Model (2) and Model (4), suggesting that the impact of vehicle ownership on healthcare access does not depend on which geographic area people reside in.

In order to make the results more intuitive, I calculate the predicted probabilities of having a usual source of care and having forgone needed care within each combination group of vehicle ownership and metropolitan residence using marginal effects at the means. Results are summarized in Table 5.12. Figures are also generated based on the predicted probabilities to provide a clear illustration.

Table 5.12 Predicted Probabilities of Having A Usual Source of Care and Having Forgone Needed Care, NHIS 1993-1996

Having at least one usual source of care (non-ED) *	Predicted Probability
No vehicle & Live in the central city in an MSA	80%
No vehicle & Live in an MSA but not in central city	84.9%
No vehicle & Live outside an MSA	85%
Have a vehicle & Live in the central city in an MSA	84.2%
Have a vehicle & Live in an MSA but not in central city	88.2%
Have a vehicle & Live outside an MSA	88.4%
Had to forgo needed medical care †	Predicted Probability

No vehicle & Live in the central city in an MSA	2.8%
No vehicle & Live in an MSA but not in central city	2.2%
No vehicle & Live outside an MSA	2.3%
Have a vehicle & Live in the central city in an MSA	2.3%
Have a vehicle & Live in an MSA but not in central city	1.8%
Have a vehicle & Live outside an MSA	1.9%

* Number of observations = 215,390

† Number of observations = 217,263

Predicted probabilities are calculated using marginal effects with covariates held at the means.

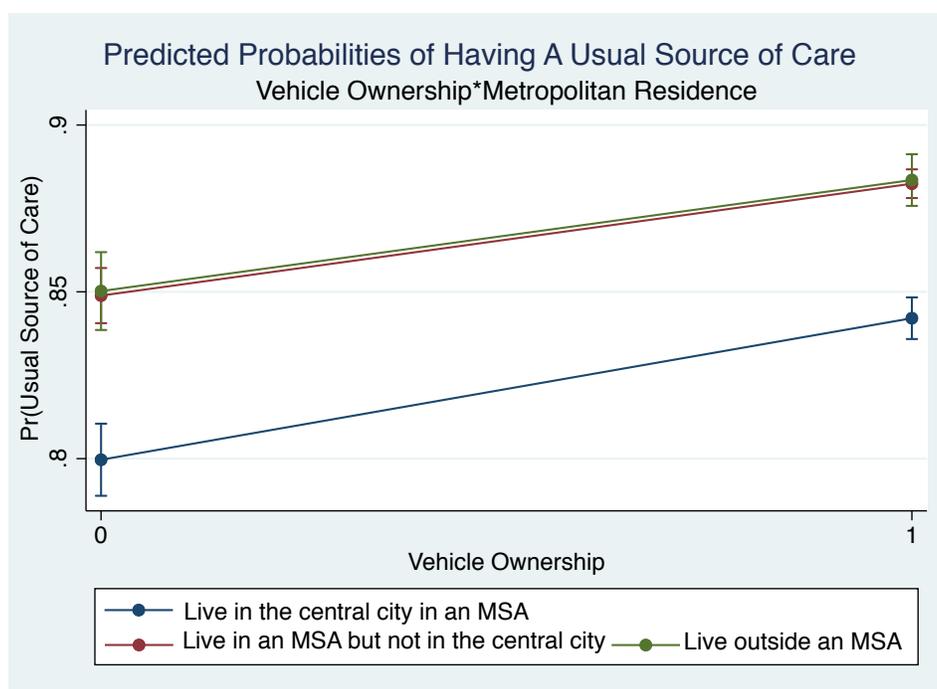


Figure 5.1 Predicted Probabilities of Having A Usual Source of Care, Vehicle Ownership*Metropolitan Residence, NHIS 1993-1996

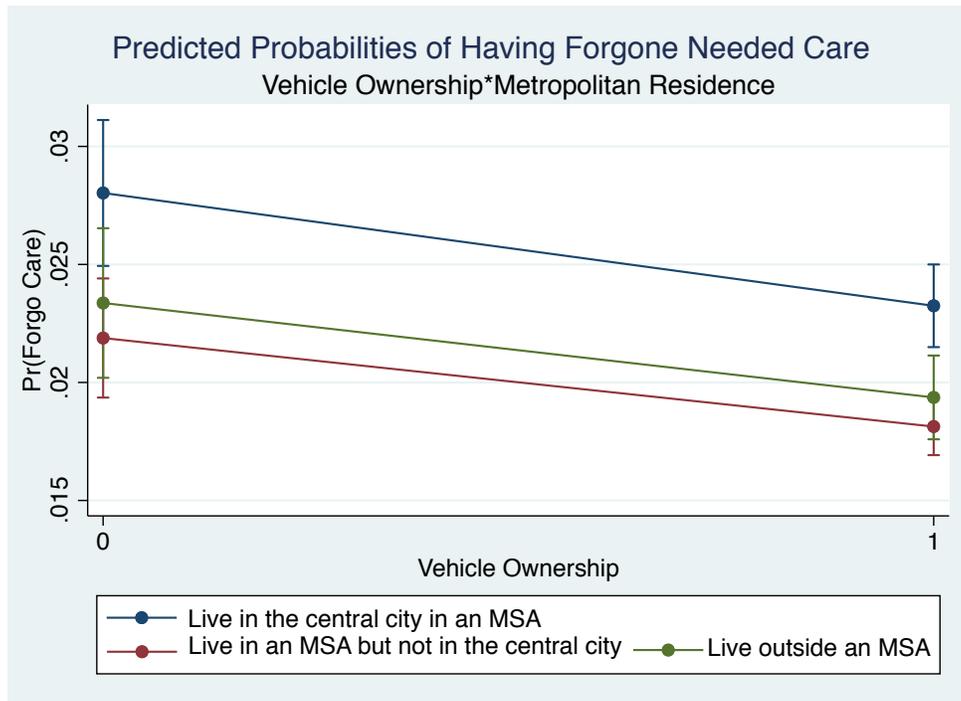


Figure 5.2 Predicted Probabilities of Having Forgone Needed Care, Vehicle Ownership*Metropolitan Residence, NHIS 1993-1996

5.2.3.6 The Effect of Family Income

I also postulate that the impact of vehicle ownership on healthcare access may be different among people with different incomes. To be more specific, I hypothesize that vehicle ownership will affect healthcare access more for people with lower incomes than for people with higher incomes. Similarly, I calculate the predicted probabilities of having a usual source of care and having forgone needed care among each combination group of vehicle ownership and family income to see if interaction effect exists between these two variables; and then I graph the results to make the results more intuitive.

Figures are shown below.

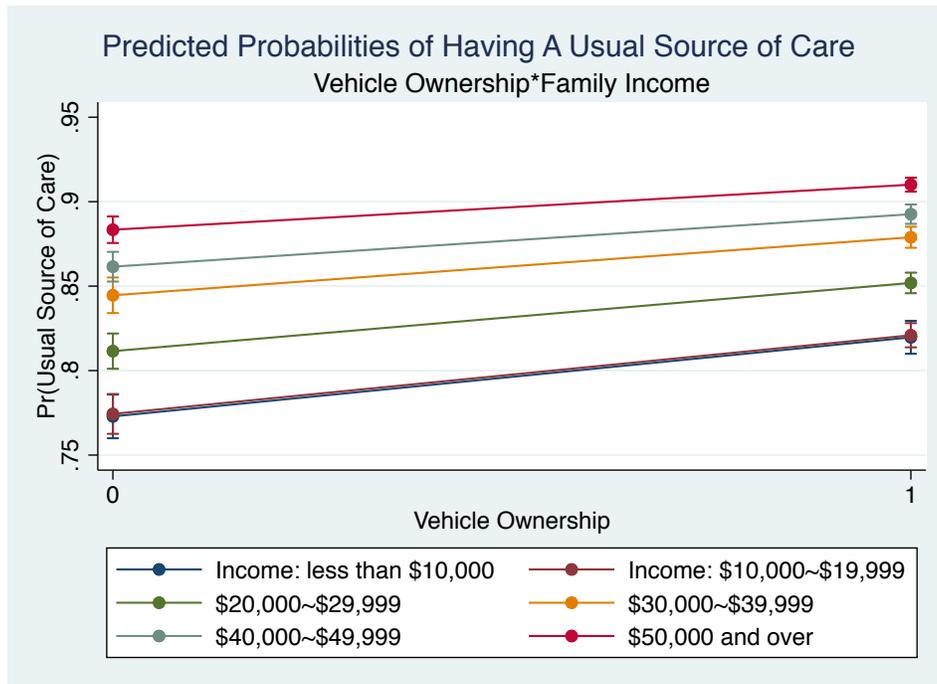


Figure 5.3 Predicted Probabilities of Having A Usual Source of Care, Vehicle Ownership*Family Income, NHIS 1993-1996

As can be seen from Figure 5.3, within all income groups, vehicle ownership is significant in affecting the predicted probability of having a usual source of care. However, as the family income gets lower, the slope that corresponds to each income group gets slightly more steep. This means there might be interaction effect between vehicle ownership and family income, and that the impact of vehicle ownership on the predicted probability of having a usual source of care is more significant among people with lower incomes.

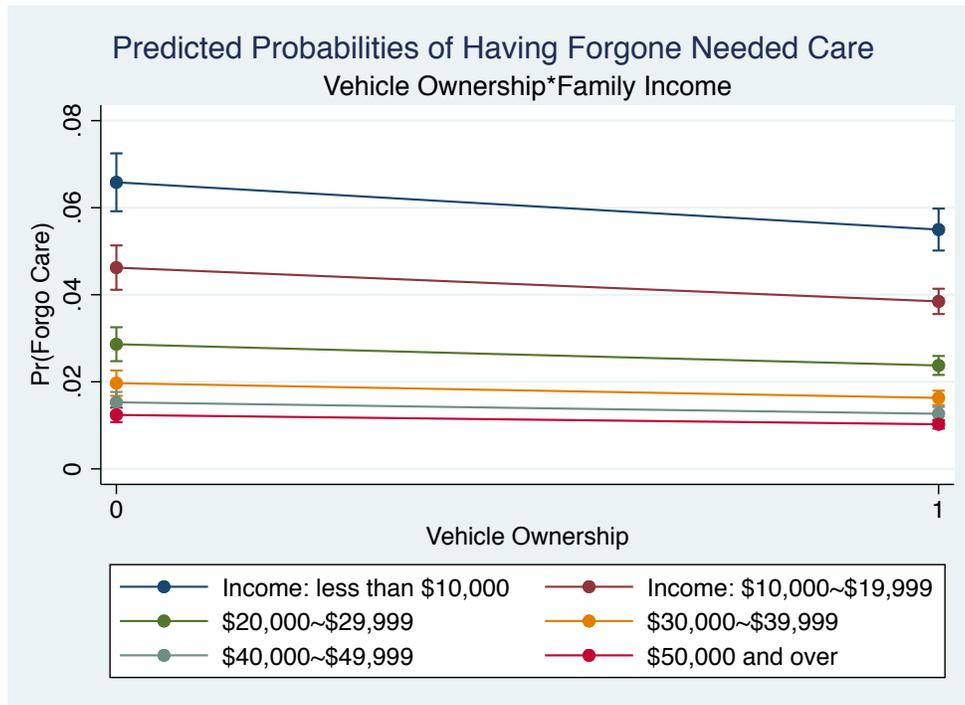


Figure 5.4 Predicted Probabilities of Having Forgone Needed Care, Vehicle Ownership*Family Income, NHIS 1993-1996

Figure 5.4 shows that as family income gets higher, the impact of vehicle ownership on the probability of having forgone needed care becomes less significant, indicating an interaction effect between vehicle ownership and family income.

5.3 The Impact of Transportation Mode on Difficulty in Getting Needed Care

5.3.1 Study Setting

This section aims to examine the impact of transportation mode on healthcare access among the adults who reported having one or more than one usual place for

medical care. Healthcare access is measured by having experienced difficulty in getting needed care in the last 12 months. Data is extracted from the Medical Expenditure Panel Survey 2000 to 2001, which includes complete longitudinal data of Panel 5. Of the 11,416 survey respondents age 0 to 90 in this panel, 3,241 are younger than 18 years old across the survey years and are excluded from the sample. Among the surveyed adults, 1,375 reported not having a usual place to go when they have medical needs or seek advice from health professionals and are excluded. Of the 6,800 adults with a usual source of care, 6 people did not state the transportation mode they usually use to get to usual source of care and are thus further excluded. This yields a sample size of 6,794 adults with a usual source of care who have indicated the mode of transportation they usually use to travel to their usual source of care.

Variables used for analyzing the impact of transportation mode on the difficulty of getting needed care are summarized in Table 5.13. Details about the variables are presented below.

Table 5.13 Variables for Analyzing Transportation Mode and Difficulty in Getting Needed Care, MEPS 2000-2001 Panel 5

Variables of Interest	Covariates	Year
a. Transportation Mode 0: Walk 1: Drive or offered a ride 2: Bus/train/taxi/other public transit b. Any family member experienced difficulty in obtaining any type of healthcare, delayed	Age (18 to 90) Age-squared Gender Race and ethnicity Education attainment Marital status Employment status Family income Metropolitan residence	2000-2001 MEPS

obtaining care, or did not receive needed healthcare in the past 12 months 0: Did not experience difficulty 1: Has experienced difficulty	Census region Health status Activity limitation Insurance status	
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Variables of interest. “Transportation mode” is the key independent variable. Data of transportation mode is from the answers to the question in the MEPS asking the respondents to specify the transportation mode they normally use for traveling to their usual source of care. Respondents who reported having no usual source of care would not be asked this question. It means all respondents included in the sample reported having one or more than one usual source of care. The data of this variable is grouped into three categories: walk, drive or offered a ride, bus/train/taxi/other public transit.

The outcome variable is “difficulty in getting needed care”. The data of this variable is from the answers to the question asking the respondents if anyone in the family experienced difficulty in getting any type of healthcare, delayed getting needed care, or did not get needed care in the last 12 months. The data is dichotomized into “did not experience difficulty in getting care” and “has experienced difficulty in getting needed care”.

Note that there is a mismatch in the data in that the key independent variable “transportation mode” and covariates (except for metropolitan residence, family income, and census region) report the information of each respondent, while the outcome variable indicates the experience of all family members, including the respondent himself/herself.

This is a limitation of this analysis. However, in this section I view transportation mode as a family's access to transportation resources.

Covariates. Age, age-squared, gender, race and ethnicity, education attainment, marital status, employment status, family income, metropolitan residence, census region, health status, activity limitation, and health insurance status are included as covariates.

“Age” reports each respondent's age, ranging from 18 to 90. “Race and ethnicity” reports each respondent's racial and ethnic background. This variable is grouped into non-Hispanic white, non-Hispanic African American, non-Hispanic American Indian or Alaska Native, non-Hispanic Asian or Pacific Islander, and Hispanic (any race).

“Education attainment” reports each respondent's highest level of education. It is categorized into less than high school, high school diploma, one to three years of college, bachelor's degree, and advanced degree. “Marital status” indicates if a respondent was married, never married, divorced/separated, or widowed during the survey period.

“Employment status” is dichotomized into employed and unemployed. “Family income” is a numerical variable reporting each respondent's family income, top-coded at \$352,114. The natural log of income is taken for analysis. “Metropolitan residence” is a binary variable indicating whether a respondent lived in a metropolitan statistical area (MSA) or not. “Census region” records the region of the U.S. where each survey participant's residence was located. Four categories are included in the variable: West, Northeast, Midwest, and South. “Health status” represents the self-reported health status perceived by each respondent as poor, fair, good, very good, or excellent. “Activity limitation” is a dichotomous variable indicating whether or not the respondent had any

activity limitation due to physical, mental, or emotional conditions. “Insurance status” is a dichotomous variable that indicates whether or not the respondent was covered by health insurance. (IPUMS, 2019a).

5.3.2 Data Analysis

The MEPS conducted five rounds of survey interviews with each respondent in Panel 5 from 2000 to 2001. Round records are used for analysis in this section, which means each respondent would have 5 observations, were there no missing values. That being said, the total number of observations of the 6,794 sampled adults is 29,302 (some respondents are missing at some interview round(s)). The data structure allows me to do a longitudinal analysis to examine the impact of transportation mode on healthcare access. Stata 15.1 (StataCorp LP, College Station, TX) is used for data analysis. Given that the survey modules in Stata do not support longitudinal analysis, the sampling design of the MEPS is not controlled for the analysis in this section. I first summarize the descriptive statistics of the variables of interest in this section. I also explore the demographic and socioeconomic characteristics of the sample, examining the distribution of each covariate. Then I construct a random-effects logistic regression model to analyze the impact of transportation mode on the difficulty in getting needed care.

5.3.3 Results

5.3.3.1 Characteristics of the Sample

The descriptive statistics of the variables of interest in this section are illustrated in Table 5.14.

Table 5.14 Descriptive Statistics of Variables of Interest, MEPS 2000-2001 Panel 5

Variables of Interest	Overall No. (%)	Between No. (%)	Within %
Transportation mode			
Walk	570 (2)	180 (2.7)	74.7
Drive or offered a ride	27,685 (94.5)	6,496 (95.6)	98.7
Bus/train/taxi/other public transit	1,047 (3.6)	318 (4.7)	78.1
Total	29,302 (100)	6,994 (102.9)	97.1
Difficulty in getting needed care			
Did not experience difficulty	26,320 (89.9)	6,384 (94)	95.3
Has experienced difficulty	2,952 (10.1)	996 (14.7)	70.7
Total	29,272 (100)	7,380 (108.7)	92

Sample is restricted to 6,794 adults with a usual source of care who have indicated their mode of transportation in traveling to usual source of care, No. of observations=29,302. Percentages are unweighted.

The “Overall number and percentage” column shows that 94.5% of the 29,302 observations reported using a car to travel to the usual source of care, 3.6% of the observations reported using bus/train/taxi/other public transit, and 2% reported walking to the usual source of care. The “Between number and percentage” column shows that 95.6% of the 6,794 sampled adults reported using a car to travel to the usual source of

care in at least one of their observations (ever reported using a car), 4.7% reported using bus/train/taxi/other public transit at least once, and 2.7% ever reported walking to the usual source of care. Note that the total of “between number” exceeds the sample size and the total of “between percentage” exceeds 100. This means some respondents changed their answers during different rounds of interview. The “Within percent” shows that of the 180 sampled adults who ever reported walking to their usual source of care, 74.7% of their observations indicated walking; of the 6,496 respondents who ever reported using a car, 98.7% of their observations indicated “drive or offered a ride”; of the 318 respondents who ever reported using public transit, 78.1% of their observations indicated public transit. The within percent measures the stability of the values in “transportation mode” variable over time. Note that a time-invariant variable would have a within percent of 100.

Similarly, 89.9% of 29,272 observations reported not experiencing difficulty in obtaining needed care in the last 12 months, and 10.1% of the total observations reported having experienced difficulty in obtaining needed care in the last 12 months. Also, among the 6,794 sampled adults, 94% reported not ever experiencing difficulty in obtaining needed care, and 14.7% of them reported not ever having experienced difficulty in obtaining needed care.

Table 5.15 presents the demographic and socioeconomic characteristics of the sample adults who have a usual source of care and have indicated their mode of transportation in getting to their usual source of care.

Table 5.15 Characteristics of Sampled Adults, MEPS 2000-2001 Panel 5

Characteristics	Overall No. (%)	Between No. (%)	Within %
Gender			
Male	12,726 (43.4)	3,007 (44.3)	100
Female	16,576 (56.6)	3,787 (55.7)	100
Race and ethnicity			
White	19,328 (66)	4,362 (64.2)	100
African American	3,894 (13.3)	924 (13.6)	100
American Indian or Alaska Native	137 (0.5)	31 (0.5)	100
Asian or Pacific Islander	709 (2.4)	176 (2.6)	100
Hispanic (any race)	5,234 (17.9)	1,301 (19.2)	100
Education attainment			
Less than high school	6,372 (21.9)	1,547 (23)	100
High school diploma	10,339 (35.6)	2,365 (35.1)	100
One to three years of college	4,563 (15.7)	1,048 (15.6)	100
Bachelor's degree	4,081 (14)	931 (13.8)	100
Advanced degree	3,703 (12.7)	843 (12.5)	100
Marital status			
Married	17,599 (60.1)	4,067 (59.9)	98.1
Never married	5,765 (19.7)	1,489 (21.9)	98.6
Divorced/separated	3,446 (11.8)	846 (12.5)	94.7
Widowed	2,492 (8.5)	551 (8.1)	97.1
Employment status			
Employed	19,374 (66.3)	4,868 (71.7)	93.6
Unemployed	9,845 (33.7)	2,673 (39.4)	83.8
Metropolitan residence			

Live outside a Metropolitan Statistical Area (MSA)	6,554 (22.4)	1,544 (22.7)	96.4
Live in an MSA	22,686 (77.6)	5,367 (79)	98.9
Census region			
West	7,017 (24)	1,687 (24.8)	99.4
Northeast	4,920 (16.8)	1,123 (16.5)	99.7
Midwest	6,738 (23)	1,524 (22.4)	99.4
South	10,627 (36.3)	2,491 (36.7)	99.7
Health status			
Poor	1,044 (4)	323 (5.2)	75.1
Fair	3,768 (14.4)	1,167 (18.8)	75.4
Good	8,718 (33.2)	2,658 (42.7)	77
Very good	9,184 (35)	2,802 (45)	77.5
Excellent	3,525 (13.4)	1,142 (18.4)	77.4
Activity limitation			
No activity limitation	20,831 (72)	5,245 (78.2)	93.6
Some activity limitations	8,095 (28)	2,135 (31.8)	84.4
Insurance status			
Uninsured	2,995 (10.2)	878 (12.9)	87.4
Insured	26,307 (89.8)	6,139 (90.4)	98.2
Age	Overall Mean= 47 years old*		
Family income	Overall Mean=\$54738.09 *		

Sample is restricted to 6,794 adults with a usual source of care who have indicated their mode of transportation in traveling to usual source of care, No. of observations=29,302. Percentages are unweighted.

*Mean is calculated using all observations.

Gender, race and ethnicity, education attainment are time-invariant variables, which means the observations of the respondents did not change across the five rounds of

interviews. According to Table 16, 44.3% of the sampled adults are male, and 55.7% are female. The sample adults are mostly non-Hispanic white (64.2%). Hispanic (19.2%) is the second largest population group, followed by non-Hispanic African American (13.6%). Asian or Pacific Islander (2.6%) and American Indian or Alaska Native (0.5%) are the smallest groups. 23% of the sample have less than high school education level, 35.1% have a high school diploma, 41.9% have post-secondary education attainment.

In addition, the majority of the sampled adults have reported ever being married (59.9%), being employed (71.7%), living in a MSA (79%), being in good (42.7%) or very good (45%) health, having no activity limitation (78.2%), and being covered by insurance (90.4%).

5.3.3.2 Transportation Mode and Difficulty in Getting Needed Care

Table 5.16 presents the results of random-effects logistic regression of the difficulty in getting needed care on transportation mode, with covariates being controlled.

Table 5.16 Random-Effects Logistic Regression of Difficulty in Getting Needed Care on Transportation Mode and Covariates, MEPS 2000-2001 Panel 5

Experienced difficulty in getting needed care	Odds Ratio	z	P> z
Transportation mode			
Walk	Omitted		
Drive or offered a ride	0.2***	-4.22	<0.001
Public transit	0.29**	-2.67	0.008
Metropolitan residence			
Live outside a Metropolitan Statistical Area (MSA)	Omitted		

Live in an MSA	1.07	0.36	0.722
Age	1.06*	2.11	0.034
Age²	0.99***	-3.92	<0.001
Gender			
Male	Omitted		
Female	0.97	-0.20	0.844
Race and ethnicity			
White	Omitted		
African American	0.3***	-4.62	<0.001
American Indian or Alaska Native	0.37	-0.78	0.435
Asian or Pacific Islander	0.63	-0.83	0.409
Hispanic	0.32***	-4.74	<0.001
Education attainment			
Less than high school	Omitted		
High school diploma	0.5**	-3.11	0.002
One to three years of college	0.51*	-2.46	0.014
Bachelor's degree	0.57	-1.90	0.057
Advanced degree	0.69	-1.21	0.226
Marital status			
Married	Omitted		
Never married	1.64*	2.11	0.034
Divorced/separated	2.52***	4	<0.001
Widowed	2.22*	2.21	0.027
Employment status			
Employed	Omitted		
Unemployed	0.97	-0.16	0.87
Family income			
Log(Income)	1	0.04	0.966

Census region			
West	Omitted		
Northeast	0.57*	-2.11	0.035
Midwest	0.64	-1.86	0.063
South	0.97	-0.15	0.881
Health status			
Poor	Omitted		
Fair	0.96	-0.16	0.876
Good	0.33***	-3.72	<0.001
Very good	0.14***	-6.38	<0.001
Excellent	0.05***	-8.52	<0.001
Activity limitation			
No activity limitation	Omitted		
Some activity limitations	2.23***	5.33	<0.001
Insurance status			
Uninsured	Omitted		
Insured	0.13***	-10.11	<0.001

Number of sampled respondents = 6,124

Number of observations = 25,692

*p<0.05, **p<0.01, ***p<0.001

Although there is a mismatch between outcome variable and transportation mode, the results still generate some meaningful insights. I assume that family members would have similar access to transportation resources and would exhibit similar travel pattern in accessing healthcare. For example, if a person reported driving a car, it is likely that the person would offer other family members a ride to get needed care. Thus transportation mode in this analysis is viewed as representing the family's access to transportation resources, though it is also possible that every family member uses different

transportation mode. According to the table above, compared with people who walk to their usual source of care, the odds of any family member having difficulty in getting needed care among people who have access to a car are expected to decrease by 80% (Odds Ratio=0.2, $P<0.001$). Also, compared with people who walk to their usual source of care, the odds of any family member having difficulty in getting needed care among people who use public transit are expected to decrease by 71% (OR=0.29, $P=0.008$). The results indicate the importance of having access to transportation resources in getting needed care.

One thing that should be noted is that the choice of transportation mode does not always reflect a person's access to transportation resources; it can also be the result of travel needs. There is possibility that a person walks to the usual source of care because he or she lives within walking distance to the healthcare provider—no need to use motorized transportation. Controlling for travel time can to a great extent rule out this rival explanation: those who walk a long time to get to usual source of care are probably transportation disadvantaged. But unfortunately, travel time is not available during the study period.

This study also tests if there is a difference between people having access to a car and people using public transit. The results show that the difference in the odds of any family member experiencing difficulty in getting care between car users and transit users is not statistically significant.

Meanwhile, the results show that compared with people living outside an MSA, the odds of any family member having experienced difficulty in getting care for those

living in an MSA are expected to increase, although the difference is not statistically significant (OR=1.07, P=0.36). It indicates that no significant difference has been found in the difficulty in getting care between urban residents and their rural counterparts in the analysis. Similar to the findings in previous sections, this result suggests no clear evidence that spatial distance plays an important role in preventing healthcare access, with the assumption that people living in an MSA reside closer to healthcare resources than do people living outside an MSA.

In terms of other covariates, being African American (OR=0.3, P<0.001) or Hispanic (OR=0.32, P<0.001), having a high school diploma (OR=0.5, P=0.002) and some years of college education (OR=0.51, P=0.014), living in Northeast Census region (OR=0.57, P=0.035), being in good (OR=0.33, P<0.001), very good (OR=0.14, P<0.001) or excellent (OR=0.05, P<0.001) health, and being insured (OR=0.13, P<0.001) are associated with decreased odds of having experienced difficulty in obtaining needed care in the last 12 months. While having never been married (OR=1.64, P=0.034), being divorced/separated (OR=2.52, P<0.001), or being widowed (OR=2.22, P=0.027), and having some activity limitations (OR=2.23, P<0.001) are associated with increased odds of any family member having experienced difficulty in obtaining needed care in the last 12 months.

In order to interpret the results more intuitively, predicted probabilities of having experienced difficulty in getting needed care among survey respondents using each of the three transportation modes are calculated. The results are listed in Table 5.17.

Table 5.17 Predicted Probabilities of Having Experienced Difficulty in Getting Needed Care by Transportation Mode, MEPS 2000-2001 Panel 5

	Predicted Probability
People who walk	15.6%
People who have access to a car	10%
People who use public transit	11.4%

Predicted probabilities are calculated using marginal effects with covariates held at the means.

As shown in the table above, the predicted probability of having experienced difficulty in getting needed care among people who walk to usual source of care is 15.6%; the predicted probability among people who drive or are offered a ride to usual source of care is 10%; the predicted probability among people who use public transit is 11.4%.

5.3.3.3 The Effect of Metropolitan Residence

I hypothesize that the impact of transportation mode on healthcare access is different among people living in different built environments. Similar to section 5.2.3.5, the reasoning is that the built environment of an MSA is less dependent on automobiles because of better provision of public transit services and a more walkable environment. In order to test the hypothesis, I calculate the predicted probabilities of having experienced difficulty in getting needed care for people in each combination group of transportation mode and metropolitan residence. The results are listed in Table 5.18.

Table 5.18 Predicted Probabilities of Having Experienced Difficulty in Getting Needed Care by Transportation Mode and Metropolitan Residence, MEPS 2000-2001 Panel 5

	Predicted probability of having experienced difficulty in getting needed care
Walk & Live outside an MSA	16.2%
Walk & Live in an MSA	15.4%
Drive & Live outside an MSA	10.9%
Drive & Live in an MSA	9.8%
Use transit & Live outside an MSA	12.2%
Use transit & Live in an MSA	11.1%

Predicted probabilities are calculated using marginal effects with covariates held at the means.

I further test if the difference between an MSA and a non-MSA is significant within each transportation mode. The results in Table 5.19 show that among each mode users, no significant difference has been found between people living in an MSA and their non-MSA counterparts.

Table 5.19 Difference in Predicted Probabilities of Having Experienced Difficulty in Getting Needed Care by Transportation Mode and Metropolitan Residence, MEPS 2000-2001 Panel 5

	Difference in predicted probabilities of having experienced difficulty in getting needed care
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Walk:	
Those live in an MSA vs those live outside an MSA	-.0079849

Drive or offered a ride:	
Those live in an MSA vs those live outside an MSA	-.0112228

Use public transit:	
Those live in an MSA vs those live outside an MSA	-.0111547

*p<0.05, **p<0.01, ***p<0.001

5.4 Conclusions

Through the analysis of the NHIS 1993-1996 and the MEPS 2000-2001, the impact of mobility on healthcare access is found to be significant. The results show that when holding demographic, socioeconomic, insurance and health characteristics constant, adults who own a private car/truck/other vehicle in the family are more likely to have a usual source of medical care that is not an emergency department (ED). They are also found to be less likely to have forgone needed medical care in the previous year. The transportation mode a person uses for traveling to the usual source of care is viewed as representing a family's access to transportation resources in this chapter (although sometimes the choice of transportation mode is the result of travel needs). Transportation mode is found to have an impact on the likelihood of any family member experiencing difficulty in obtaining needed care. Compared with people who walk, those who use a car and those who use public transit services are all found to be less likely to have experienced difficulty in obtaining needed care. The results of this chapter suggest that having limited access to transportation resources negatively impacts people's healthcare

access. Thus policies aiming at improving people's healthcare access should also take access to transportation resources into consideration.

Although not directly controlling for geographic proximity, the models in this chapter all include "metropolitan residence" (i.e., whether a person lives in a Metropolitan Statistical Area, in the central city or not, or does not live in an MSA) with the underlying assumption being that the healthcare resources are widely distributed in areas outside an MSA and that the spatial distances between healthcare users and healthcare providers are greater in areas outside an MSA than in the central city in an MSA. In this sense, the results of metropolitan residence are suggestive of the impact of spatial distance on healthcare access. Holding such assumption, the results in this chapter suggest no clear evidence that spatial distance plays an important role in preventing people from accessing healthcare: people who live outside an MSA are found to be more likely to have a non-ED place for usual source of care and less likely to have forgone needed care in the last 12 months than people who live in the central city in an MSA. Also, no significant difference has been found in the likelihood of any family member experiencing difficulty in getting care between people living in an MSA and those living outside an MSA.

However, it should also be noted that the assumption "the spatial distance to healthcare resources is greater in areas outside an MSA than in urban areas" does not always hold true. It is possible that some survey respondents outside an MSA are geographically close to their usual source of care through programs such as mobile clinics. Due to the lack of information about the actual spatial distance, the above

conclusion may be an overstatement. Also, essentially, the results of “metropolitan residence” reveal the disparity in healthcare access between the central city and areas outside an MSA, which may have resulted from the combined effects of spatial distance and other factors, such as traffic congestion, speed limits, and/or social capital, that differ significantly between these two areas. That being said, the healthcare access disparity between an MSA and a non-MSA is not exclusively the result of the difference in the spatial distance, so using only the spatial distance to interpret the access disparity may cause bias.

CHAPTER SIX

DELAYED CARE DUE TO TRANSPORTATION DEFICIENCY

6.1 Background, Research Questions and Hypotheses

This chapter also studies mobility-related transportation disadvantage and its impact on healthcare access. Instead of looking into the transportation resources people use, this chapter focuses on those who reported that they have delayed obtaining needed medical care due to a lack of transportation in the last 12 months, and considers them as the transportation disadvantaged group.

By using data from the National Health Interview Survey 2007-2018, this chapter intends to find out the disparities in experiencing transportation deficiency in accessing healthcare services among different demographic/socioeconomic groups. I hypothesize that those who have activity limitations, have lower incomes, are female, and are unemployed are more likely to have transportation deficiency, as previous research finds these groups have higher risk of having limited mobility. Then I try to answer the question as to whether transportation deficiency has an impact on healthcare access, which is measured by the type of usual source of medical care, including clinic or health center, doctor's office or HMO, hospital outpatient department, hospital emergency department (ED), and other places. Those who reported using an ED as usual source of care are considered to have poor healthcare access. This is because relying on an ED for non-emergent care is an inefficient way of using healthcare services and can result in

excessive medical care expenditure, as EDs cannot refuse those who cannot afford the costs (Uscher-Pines et al., 2013; Villani & Mortensen, 2013). I hypothesize that the transportation disadvantaged would be more likely to use a hospital emergency department as the usual source of care, while those who do not have transportation disadvantage would be more likely to use other types of medical resources as their usual source of care.

6.2 Methods

6.2.1 Study Setting

This chapter focuses on the respondents in the National Health Interview Survey that indicated they have delayed getting needed medical care because they did not have transportation during the past 12 months. Data used is pooled from the NHIS from 2007 to 2018. During this time period, the NHIS collected data on 825,397 respondents from 18 years old to 85 years old. Among all the adults, 354,319 have indicated whether or not they have delayed getting needed care because they did not have transportation in the past 12 months. Of the 354,319 adults, 300,282 respondents reported having a usual place to go when sick or in need of advice from health professionals and have specified the types of their usual source of care.

Variables used for analysis are summarized in Table 6.1. Details about the variables are presented below.

**Table 6.1 Variables for Examining Adults with Transportation Deficiency,
NHIS 2007-2018**

Variables of Interest	Covariates	Year
a. Has delayed care due to transportation deficiency in past 12 months 0: No; 1: Yes b. Type of usual place for medical care 0: Clinic or health center 1: Doctor's office or Health Maintenance Organization (HMO) 2: Hospital outpatient department 3: Hospital emergency department (ED) 4: Other places	Age (18-85) Age-squared Gender Race and ethnicity Education attainment Marital status Employment status Family income Census region Health status Activity limitation Insurance status Survey year	2007-2018 NHIS

Variables of Interest. The data of the variable “delayed care due to lack of transportation” is extracted from the answers to the question in the NHIS which asks each respondent if he/she had experience of delaying getting medical care during the past 12 months because he/she "did not have transportation." The answers are coded in a binary format, with 0 indicating the respondent had no such experience and 1 indicating the respondent has delayed care due to a lack of transportation. For the purpose of brevity, the lack of transportation will be referred to as “transportation deficiency” in this chapter.

“Type of usual place for medical care” comes from the answers to the question in the survey asking about the specific type of medical settings the respondents usually went for getting medical care or health advice. The format of the variable is categorical with

groups including clinic or health center, doctor's office or Health Maintenance Organization (HMO), hospital outpatient department, hospital emergency department (ED), and other places. People who reported using ED as usual source of care are considered to have bad healthcare access.

Covariates. Age, age-squared, gender, race and ethnicity, education attainment, marital status, employment status, family income, Census region, health status, activity limitation, insurance status, and survey year are covariates.

Among the covariates, "age" reports the age of each survey respondent, ranging from age 18 to 85. "Race and ethnicity" records the main racial and ethnic background self-reported by the respondents. The categories include white; African American; American Indian or Alaska Native; Asian; multiple race; and Hispanic. Hispanic refers to individuals of Hispanic heritage of any race; other racial groups refer to non-Hispanic individuals. "Education attainment" reports each respondent's highest level of education. Five categories are included in the variable, including less than high school, high school diploma, one to three years of college, Bachelor's degree, and five years of college and more. "Marital status" reports on the marital status of survey respondents, including married, never married, divorced or separated, and widowed. "Employment Status" indicates if a respondent was employed, unemployed, or not in the labor force. "Family income" reports on each respondent's family income in grouped intervals. The data is categorical with 4 groups top-coded at \$100,000: less than \$ 34,999; \$35,000 to \$74,999; \$75,000 to \$99,999; \$100,000 and over. "Census region" reports the region of the U.S. where each survey participant's residence was located. Four categories are included in

the variable that correspond to the classification recognized by the Census Bureau: West, Northeast, North Central/Midwest, and South. “Health status” represents the self-reported health status perceived by the respondents as poor, fair, good, very good, or excellent. “Activity limitation” is a binary variable indicating whether or not the respondent had any activity limitation due to physical or mental conditions. “Insurance status” is a binary variable that indicates whether or not the respondent was covered by health insurance. (IPUMS, 2019b).

6.2.2 Data Analysis

The NHIS collects data on a new sample every year, so data from different survey years can be combined together to obtain a larger sample size. For this chapter, observations from NHIS 2007 to 2018 are pooled to perform cross-sectional analysis. Stata 15.1 (StataCorp LP, College Station, TX) is used for data analysis. The survey modules in Stata (*svy:* prefix) are used to account for the stratification, clustering and sampling weights of the complex sampling design of the NHIS to avoid biased estimates of model parameters and variances.

I first summarize the descriptive statistics of the variables of interest in this chapter, which are delayed care due to transportation deficiency and the type of usual source of care. I am interested in knowing which demographic/socioeconomic groups are more likely to suffer from transportation deficiency in accessing healthcare. To do so, I use cross-tabulations to describe the distributions of each covariate by the experience of delaying care due to transportation deficiency, while accounting for the sampling design.

The unadjusted bivariate associations between each covariate and the transportation deficiency-caused delay care are also examined using a design-based F test, which is converted from the Pearson chi-squared test after correcting for the survey design. Then I construct a logistic regression model of transportation deficiency on all covariates to see which population groups are more likely to suffer from transportation disadvantage when other covariates are controlled.

This section also considers those who have experienced delayed care due to transportation deficiency as the ones facing transportation disadvantage. Therefore, I restrict the sample to those who reported having a usual source of care and use a multinomial logistic regression model to examine if there is any difference in the type of usual source of care between people who have transportation disadvantage and the ones who do not, with all covariates being controlled.

6.3 Results

6.3.1 Characteristics of the Variables of Interest

The descriptive statistics of the variables of interest are presented in Table 6.2.

Table 6.2 Descriptive Statistics of Variables of Interest, NHIS 2007-2018

Variables	Unweighted No.	Weighted Percentage % [†] (95% Confidence Interval)
Delayed care due to transportation deficiency (n=354,319^a)		
No	345,976	97.8 (97.7 — 97.9)

Yes	8,343	2.2 (2.1— 2.3)
Type of usual source of care (n=300,282^b)		
Clinic or health center	74,049	22 (21.5— 22.5)
Doctor’s office or HMO	214,176	74.3 (73.7— 74.8)
Hospital outpatient department	4,700	1.4 (1.3— 1.5)
Hospital emergency department	3,917	1.2 (1.18 — 1.3)
Other places	3,440	1.1 (1.1 — 1.2)

a. Sample is restricted to adults who indicated whether or not they have delayed care due to transportation deficiency in the past 12 months.

b. Sample is restricted to adults who indicated whether or not they have delayed care due to transportation deficiency and also reported having a usual source of care.

†All percentages are weighted to reflect the effects of the sampling design of the National Health Interview Survey and may not add to 100 because of rounding.

Among all sampled adults, 97.8% did not have transportation deficiency-caused delayed care; only 2.2% reported having had the experience in the last 12 months. In terms of the type of usual source of care, 74.3% of the sample reported using a doctor’s office or health maintenance organization (HMO) as usual source of care, 22% reported a clinic or health center, 1.4% reported a hospital outpatient department, 1.2% reported using a hospital emergency department (ED), 1.1% reported other medical resources.

6.3.2 Disparities in Transportation Deficiency

Table 6.3 summarizes the demographic and socioeconomic characteristics of the sample stratified by the experience of transportation deficiency. The bivariate associations between each covariate and transportation deficiency are also examined using a design-based F test.

**Table 6.3 Characteristics of Adults With or Without Transportation Deficiency,
NHIS 2007-2018**

Characteristics	Didn't delay care due to a lack of transportation		Delayed care due to a lack of transportation		p
	Unweighted No. *	Weighted % †	Unweighted No. *	Weighted % †	
Sample size	345,976	100	8,343	100	
Age group					0.3387
18-64 years	266,123	77.3	6,446	76.7	
65 years and above	79,853	22.7	1,897	23.3	
Gender					<0.001
Male	155,356	45.9	2,786	34.4	
Female	190,620	54.1	5,557	65.6	
Race/ethnicity					<0.001
White	216,086	69.3	3,932	54.5	
African American	46,810	11.9	2,048	22.5	
American Indian or Alaska Native	2,220	0.6	151	1.6	
Asian	19,527	4.5	272	2.6	
Multiple race	5,166	1.4	284	3.4	
Hispanic (any race)	55,571	12.4	1,646	15.4	
Education attainment					<0.001
Less than high school	42,736	10.8	2,417	26.8	
High school diploma	96,193	27.5	2,683	32.9	
One to three years of college	105,024	30.9	2,383	30.1	
Bachelor's degree	63,946	19.7	535	6.7	
Five or more years of college	36,406	11.2	270	3.5	
Marital status					<0.001
Married	155,736	45.1	1,573	18.3	
Never married	92,092	27.3	2,937	35.1	
Divorced/separated	63,832	18	2,594	31.5	
Widowed	33,390	9.6	1,221	15.1	
Employment status					<0.001
Employed	204,841	60.2	1,998	24.3	

Unemployed	15,324	4.2	820	9.5	
Not in labor force	125,604	35.6	5,520	66.2	
Family income					<0.001
Less than \$34,999	128,682	38.1	6,612	81.5	
\$35,000~\$74,999	99,573	31.2	1,022	13.2	
\$75,000~\$99,999	34,373	11.1	190	2.5	
\$100,000 and over	58,663	19.7	198	2.8	
Census region					<0.001
West	88,324	22.1	2,076	21.7	
Northeast	56,965	17.5	1,170	14.6	
North Central/Midwest	75,946	23.9	1,811	24.7	
South	124,741	36.6	3,286	39	
Health status					<0.001
Poor	10,989	3	1,501	18.4	
Fair	37,332	10.2	2,568	30.4	
Good	94,773	26.7	2,379	28.5	
Very good	111,353	32.9	1,203	14.7	
Excellent	91,375	27.3	684	8.1	
Activity limitation					<0.001
No activity limitation	284,136	82.5	3,177	37.1	
Some activity limitations	61,626	17.5	5,160	63	
Insurance status					<0.001
Uninsured	49,068	13	1,606	18.1	
Insured	295,689	87	6,710	81.9	

Sample is restricted to 354,319 adults who indicated whether or not they have delayed care due to a lack of transportation in the past 12 months.

*Numbers may not add to the total sample size due to missing values.

†All percentages are weighted to reflect the effects of the sampling design of the National Health Interview Survey and may not add to 100 because of rounding.

By looking into the data distribution of each variable across the two groups, it can be seen that compared with people who did not have a transportation deficiency, people

who have delayed care due to a lack of transportation are more likely to be female (65.6%), to be racial and ethnic minorities (except for Asian), and to be less educated, not married, unemployed or not in the labor force, lower-income, in a worse health, with some activity limitations, and uninsured. The age distribution is about the same across the two groups. The F-statistic of age and transportation deficiency also shows that the bivariate association between these two variables is not significant (P=0.3387).

Table 6.4 shows the results of adjusted logistic regression model of whether or not one has delayed getting needed care in the past 12 months due transportation deficiency.

Table 6.4 Logistic Regression of Transportation Deficiency on Covariates, NHIS 2007-2018

Has delayed getting care due to a lack of transportation	Odds Ratio	t	P> t
Age	1	0.28	0.782
Age²	0.99***	-4.66	<0.001
Gender			
Male	Omitted		
Female	1.44***	13.09	<0.001
Race and ethnicity			
White	Omitted		
African American	1.42***	9.27	<0.001
American Indian or Alaska Native	1.65***	4.19	<0.001
Asian	1.04	0.49	0.624
Multiple race	1.86***	7.34	<0.001
Hispanic (any race)	1.25***	5.19	<0.001
Education attainment			

Less than high school	Omitted		
High school diploma	0.78***	-6.96	<0.001
One to three years of college	0.76***	-6.57	<0.001
Bachelor's degree	0.54***	-9.48	<0.001
Five or more years of college	0.71***	-4.06	<0.001
Marital status			
Married	Omitted		
Never married	1.72***	12.33	<0.001
Divorced/separated	1.88***	14.62	<0.001
Widowed	1.76***	10.26	<0.001
Employment status			
Employed	Omitted		
Unemployed	2.35***	16.32	<0.001
Not in labor force	1.88***	15.75	<0.001
Family income			
Less than \$34,999	Omitted		
\$35,000~\$74,999	0.44***	-17.95	<0.001
\$75,000~\$99,999	0.33***	-11.99	<0.001
\$100,000 and over	0.27***	-14.72	<0.001
Census region			
West	Omitted		
Northeast	0.82***	-3.81	<0.001
North Central/Midwest	0.95	-1.19	0.235
South	0.83***	-4.01	<0.001
Health status			
Poor	Omitted		
Fair	0.68***	-9.18	<0.001
Good	0.47***	-16.03	<0.001
Very good	0.32***	-20.72	<0.001

Excellent	0.23***	-21.20	<0.001
Activity limitation			
No activity limitation	Omitted		
Some activity limitations	3.4***	31.08	<0.001
Insurance status			
Uninsured	Omitted		
Insured	0.89**	-2.76	0.006
Survey year			
2007	Omitted		
2008	1.1	1.09	0.274
2009	1.22*	2.48	0.013
2010	1.2*	2.55	0.011
2011	1.23**	2.83	0.005
2012	1.12	1.55	0.122
2013	1.04	0.47	0.640
2014	1.15	1.82	0.070
2015	1.18*	2.10	0.036
2016	1.23**	2.64	0.008
2017	1.29**	3.22	0.001
2018	1.7***	6.90	<0.001

Number of observations = 326,001

*p<0.05, **p<0.01, ***p<0.001

As expected, being non-Hispanic African American (Odds Ratio=1.42, P<0.001), being American Indian/Alaska Native (OR=1.65, P<0.001), being multiple race (OR=1.86, P<0.001) or being Hispanic (OR=1.25, P<0.001) is associated with being more likely to have experienced transportation deficiency, compared with non-Hispanic white. This is in line with previous research results showing racial and ethnic minorities

have greater difficulty in accessing transportation resources. People who are unemployed (OR=2.35, P<0.001) or not in the labor force (OR=1.88, P<0.001) are more likely to have transportation deficiency than those who are employed. This may be because employed people are more likely to have an automobile for commuting to work and thus are less likely to have experienced transportation deficiency. Those with some activity limitations are more likely to have experienced transportation deficiency (OR=3.4, P<0.001), probably due to the mobility limitations caused by physical problems. Although women do not differ significantly from men in access to transportation resources, Table 6.4 indicates that being female (OR=1.44, P<0.001) is associated with increased odds of having transportation deficiency. Also, having never been married (OR=1.72, P<0.001), being divorced/separated (OR=1.88, P<0.001) or being widowed (OR=1.76, P<0.001) are associated with increased odds of having transportation deficiency, when other covariates are controlled for.

Meanwhile, being better educated, having a higher income, living in the Northeast (OR=0.82, P<0.001) and South (OR=0.83, P<0.001) Census regions, being in better health, and being insured (OR=0.89, P=0.006) are associated with decreased odds of having transportation deficiency, when other covariates are controlled for. As indicated above, people with higher incomes are able to purchase and operate a car and are able to afford public transit fares, thus they are less likely to have experienced transportation deficiency. The public transit systems in the Northeast region are well developed, which may explain the lower odds of transportation deficiency experienced by the people in that region. Healthier people may have fewer or no medical needs in the previous year so

that they did not need to travel to any care provider. Some insurance, such as Medicaid, covers the travel costs to healthcare facilities. Medicaid also subsidizes nonemergency medical transportation for the beneficiaries to increase their access to transportation.

6.3.3 Transportation Deficiency and Type of Usual Source of Care

Table 6.5 presents the results of multinomial logistic regression of the type of usual source of care on transportation deficiency, with covariates held at constant.

Table 6.5 Multinomial Logistic Regression of Type of Usual Source of Care on Transportation Deficiency and Covariates, Compared with Using a Hospital Emergency Department as Usual Source of Care, NHIS 2007-2018

Characteristics	Clinic or	Doctor's	Hospital	Other
	health center	office or HMO	outpatient department	places
	RRR [†]	RRR [†]	RRR [†]	RRR [†]
Transportation deficiency				
Did not delay care due to lack of transportation	Omitted	Omitted	Omitted	Omitted
Had to delay care due to lack of transportation	0.68***	0.49***	0.73**	0.7*
Age	0.99	0.99	1.01	0.95***
Age²	1**	1***	1	1***
Gender				
Male	Omitted	Omitted	Omitted	Omitted
Female	1.49***	1.77***	0.76***	1.02
Race/ethnicity				
White	Omitted	Omitted	Omitted	Omitted
African American	0.42***	0.37***	1.11	0.3***

American Indian or Alaska Native	1.44	0.36***	3.09**	0.85
Asian	1.44*	1.23	2.56***	0.92
Multiple race	0.49***	0.38***	0.96	0.46***
Hispanic (any race)	1.25***	0.71***	1.86***	0.58***
Education attainment				
Less than high school	Omitted	Omitted	Omitted	Omitted
High school diploma	1.23***	1.62***	1.36***	1.94***
One to three years of college	1.72***	2.38***	2.28***	3.89***
Bachelor's degree	2.51***	3.87***	2.98***	7.37***
Five or more years of college	2.79***	4.32***	3.69***	8.16***
Marital status				
Married	Omitted	Omitted	Omitted	Omitted
Never married	0.67***	0.62***	0.79**	1.04
Divorced/separated	0.7***	0.66***	0.92	0.97
Widowed	0.64***	0.7***	0.73*	0.77
Employment status				
Employed	Omitted	Omitted	Omitted	Omitted
Unemployed	0.69***	0.64***	0.99	0.66***
Not in labor force	1.16**	1.1	1.38***	1.12
Family income				
less than \$34,999	Omitted	Omitted	Omitted	Omitted
\$35,000~\$74,999	1.19**	1.87***	1.16	1.37***
\$75,000~\$99,999	1.56***	2.95***	1.44**	1.51**
\$100,000 and over	1.82***	4.02***	1.63**	1.94***
Census region				
West	Omitted	Omitted	Omitted	Omitted

Northeast	0.5***	1.15	1.19	0.58***
North Central/Midwest	1.01	0.75***	0.83	0.55***
South	0.57***	0.95	0.64***	0.61***
Health status				
Poor	Omitted	Omitted	Omitted	Omitted
Fair	1.33***	1.21*	1.36**	0.91
Good	1.6***	1.47***	1.44**	1.12
Very good	1.91***	1.76***	1.49**	1.41*
Excellent	1.8***	1.7***	1.4*	1.41*
Activity limitation				
No activity limitation	Omitted	Omitted	Omitted	Omitted
Some activity limitations	0.86*	0.87*	1.17	0.98
Insurance status				
Uninsured	Omitted	Omitted	Omitted	Omitted
Insured	3.23***	8.00***	3.57***	1.85***
Survey year				
2007	Omitted	Omitted	Omitted	Omitted
2008	0.92	0.82	0.9	0.95
2009	0.81*	0.7**	0.79	0.76
2010	0.94	0.8*	0.85	1.11
2011	0.82	0.62***	0.67**	0.83
2012	0.92	0.7**	0.78	0.92
2013	0.9	0.62***	0.66**	0.97
2014	0.93	0.66***	0.78	0.98
2015	1.04	0.67***	0.66**	0.99
2016	1.07	0.7**	0.68*	0.95
2017	0.86	0.54***	0.55**	0.86
2018	0.81	0.44***	0.55***	0.82

Number of observations = 275,779

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

†RRR refers to relative risk ratio.

As can be seen from Table 6.5, hospital emergency department is omitted as the reference group, which means the results will be explained as the relative risk ratio of using other types of medical resources as the usual source of care relative to using a hospital emergency department as the usual source of care. According to the results, the relative risk of using a clinic or health center as usual source of care is 0.68 times the relative risk of using a hospital emergency department as usual source of care (Relative Risk Ratio=0.68, $P < 0.001$) among the adults who have delayed care due to a lack of transportation, compared with those who did not have experience of delaying care due to transportation deficiency, given that the covariates in the model are held constant. Similarly, relative to using a hospital emergency department as usual source of care, the relative risk of using a doctor's office or HMO is decreased by a factor of 0.49 (RRR=0.49, $P < 0.001$), of using a hospital outpatient department is decreased by a factor of 0.73 (RRR=0.73, $P = 0.005$), and of using other places is decreased by a factor of 0.7 (RRR=0.7, $P = 0.023$) among people who have transportation deficiency.

Generally speaking, the results indicate that adults who experienced transportation deficiency in the past 12 months would be more likely to use a hospital emergency department than to use other medical resources as their usual source of care, compared with the adults who did not have transportation deficiency.

6.4 Conclusions

This chapter examines the transportation deficiency in healthcare access (i.e. have delayed needed care due to a lack of transportation). Results show that women, racial and ethnic minority groups, people who are not married, the unemployed or those who are not in the labor force, and people with some activity limitations are more likely to have experienced transportation deficiency in accessing healthcare. Moreover, adults who experienced transportation deficiency in the last 12 months were more likely to use a hospital emergency department than to use other medical resources as their usual source of care, compared with the adults who did not experience transportation deficiency.

It should be noted that, due to the unavailability of the data in this study period, the variable “metropolitan residence”, i.e., whether or not one respondent was living in a Metropolitan Statistical Area, is not controlled in the analysis of this chapter. This is a limitation.

CHAPTER SEVEN

THE IMPACT OF TRAVEL TIME ON HEALTHCARE ACCESS

7.1 Background, Research Questions and Hypotheses

The objective of this chapter is to examine the impact of accessibility-related transportation disadvantage on healthcare access. Accessibility in this chapter is measured by the self-reported time it takes a person to travel to his/her usual source of care. Long travel times or travel distances may cause natural barriers for people to access destinations (Currie & Delbosc, 2011). Therefore, this chapter considers those who have to travel a long time to get to their usual source of medical care as the transportation disadvantaged. Considering the inconclusive research findings about the impact of travel time or travel distance on people's healthcare access, this chapter can serve as new evidence on this potential association.

By using data from the Medical Expenditure Panel Survey 2002-2016, this chapter aims to examine if the travel time has any impact on the experience of having delayed necessary medical care or having forgone necessary care in the past 12 months. I hypothesize that people who need to travel a longer time to the usual source of care would be more likely to have delayed or even forgone needed medical care in past 12 months.

7.2 Methods

7.2.1 Study Setting

This chapter aims to examine the impact of travel time on healthcare access among the adults who reported having one usual place that is not a hospital emergency department (ED) for medical care. Healthcare access is measured by whether or not one has experienced delayed or forgone needed medical care in the last 12 months. Data is extracted from the Medical Expenditure Panel Survey 2002 to 2016, which includes complete data of Panel 7 to Panel 20. Each panel was surveyed during two years. For example, observations of Panel 7 were collected from 2002 to 2003. During 2002 to 2016, the MEPS collected data on 270,488 survey respondents from 0 to 85 years old. 77,654 are excluded from the sample as they were younger than 18 years old in both survey years. Among the 192,834 sampled adults, 44,890 reported not having a non-ED usual place to go when sick or needed advice from health professionals and are also excluded. Of the 147,944 adults with a non-ED usual source of care, 249 people did not state the travel time to their usual source of care in both survey years and are thus further excluded. This yields a sample size of 147,695 adults with a non-ED usual source of care who have indicated the travel time they usually spend on getting to their usual source of care.

Variables used for analyzing the impact of travel time on having delayed or forgone needed care are summarized in Table 7.1. Details about the variables are presented below.

Table 7.1 Variables for Analyzing Travel Time and Having Delayed/Forgone Needed Care, MEPS 2002-2016 Panel 7-Panel 20

Variables of Interest	Covariates	Year
a. Travel time 0: Less than 15 minutes 1: 15 to 30 minutes 2: 31 to 60 minutes 3: More than 60 minutes	Age (18 - 85) Age-squared Gender Race and ethnicity Education attainment Marital status Family income	2002-2016 MEPS
b. Delay or forgo needed care 0: Did not delay or forgo needed care 1: Has delayed needed care 2: Has forgone needed care	Census region Health status Activity limitation Insurance status	

Variables of Interest. The key independent variable “travel time” contains data from the answers to the question in MEPS asking the respondents who indicated having a usual source of care to report the amount of time it usually took them to travel to that source of care. The data is categorized into four groups: less than 15 minutes, 15 to 30 minutes, 31 to 60 minutes, and more than 60 minutes. Note that the original data format is categorical.

The variable “delay or forgo needed care” is constructed from the answers to the questions in MEPS that ask a respondent to indicate if he/she has delayed getting needed medical care or has experienced unmet medical needs in the last 12 months. The data is grouped into three ordinal categories: did not delay or forgo any needed medical care, test, or treatment in the last 12 months; has delayed getting needed care; and has forgone needed care.

Covariates. Age, age-squared, gender, race and ethnicity, education attainment, marital status, family income, census region, health status, activity limitation, and health insurance status are included as covariates.

“Age” reports each respondent’s age, ranging from 18 to 85. “Race and ethnicity” reports each respondent’s racial and ethnic background. This variable is grouped into non-Hispanic white, non-Hispanic African American, non-Hispanic American Indian or Alaska Native, non-Hispanic Asian or Pacific Islander, multiple race, and Hispanic (any race). “Education attainment” reports each respondent’s highest level of education. It is categorized into less than high school, high school diploma, one to three years of college, Bachelor’s degree, and advanced degree. “Marital status” indicates if a respondent was married, never married, divorced/separated, or widowed during the survey period. “Family income” is a numerical variable reporting each respondent’s family income, top-coded at \$791,260. The natural log of income is taken for analysis. This is because income is skewed right, and the impact of the changes in income on the lower end on healthcare access is likely to be larger than the impact of the changes in income on the higher end on healthcare access. “Census region” records the region of the U.S. where the survey participants’ houses were located. Four categories are included in the variable: West, Northeast, Midwest, and South. “Health status” represents the self-reported health condition perceived by each respondent as poor, fair, good, very good, or excellent. “Activity limitation” is a binary variable indicating whether or not the respondent had any activity limitation because of physical or mental problems. “Insurance status” is a

binary variable that indicates whether or not a respondent was covered by health insurance (IPUMS, 2019a).

Note that some variables that I think are important for the analysis in this chapter are not controlled for, such as transportation mode, employment status and metropolitan residence, due to the unavailability in the dataset during the study period. This is a limitation.

7.2.2 Data Analysis

The MEPS conducted survey interviews with each respondent in each panel over two years. The annual full-year consolidated data is used in this chapter, which contains two observations per respondent across the two-year survey period, had no missing values. I pool observations from Panel 7 to Panel 20 to generate a larger sample size. Therefore, there are 238,732 total observations of the 147,695 sampled adults. Longitudinal analysis methods are used with Stata 15.1 (StataCorp LP, College Station, TX). Similar to Section 5.3, the sampling design of the MEPS is not controlled for the analysis in this chapter as the survey modules in Stata do not support longitudinal analysis.

First, I summarize the descriptive statistics of the variables of interest in this chapter. Next, I describe the demographic and socioeconomic characteristics of the sample, examining the distribution of each covariate. Then, I construct a random-effects ordered logistic regression model to analyze the impact of travel time on the experience of having delayed or forgone needed care in the past 12 months.

7.3 Results

7.3.1 Characteristics of the Sample

The descriptive statistics of the variables of interest in this chapter are illustrated in Table 7.2.

**Table 7.2 Descriptive Statistics of Variables of Interest,
MEPS 2002-2016 Panel 7-Panel 20**

Variables of Interest	Overall No. (%)	Between No. (%)	Within %
Travel time			
Less than 15 min	117,685 (49.3)	83,258 (56.4)	87.4
15 to 30 min	94,878 (39.7)	71,063 (48.1)	82.4
31 to 60 min	21,807 (9.1)	17,870 (12.1)	76
More than 60 min	4,362 (1.8)	3,660 (2.5)	75.6
Total	238,732 (100)	175,851 (119.1)	84
Delay or forgo needed care			
Did not delay or forgo care	225,900 (94.7)	143,258 (97.1)	97.6
Has delayed needed care	6,246 (2.6)	5,923 (4)	64
Has forgone needed care	6,343 (2.7)	5,789 (3.9)	69.6
Total	238,489 (100)	154,970 (105)	95.3

Sample is restricted to 147,695 adults with a non-ED usual source of care who have indicated their travel time to usual source of care, No. of observations= 238,732.

Percentages are unweighted.

The “Overall number and percentage” column shows that 49.3% of the 238,732 observations reported traveling less than 15 minutes to get to their usual source of care;

39.7% reported traveling 15 to 30 minutes to their usual source of care; 9.1% reported 31 to 60 minutes; and 1.8% reported traveling over an hour to their usual source of care. The “Between number and percentage” column shows that 56.4% of the 147,695 sampled adults reported traveling less than 15 minutes to get to their usual source of care in at least one of their observations; 48.1% reported 15 to 30 minutes at least once; 12.1% reported 31 to 60 minutes at least once; 2.5% reported traveling more than 60 minutes at least once. Note that the total of “between number” exceeds the sample size and the total of “between percentage” exceeds 100. This means some respondents changed their answers during the two survey years. The “Within percent” shows that of the 83,258 sampled adults who ever reported traveling less than 15 minutes to their usual source of care, 87.4% of their observations indicated less than 15 minutes; of the 71,063 respondents who ever reported 15 to 30 minutes, 82.4% of their observations remained the same; of the 17,870 respondents ever reported 31 to 60 minutes, 76% of the observations indicated the same; of the 3,660 respondents who ever reported more than 60 minutes, 75.6% of their observations remained the same. The within percent measures the stability of the values in “travel time” variable over time. Note that a time-invariant variable would have a within percent of 100.

For the variable “delay or forgo needed care,” 94.7% of the total observations indicated they did not delay or forgo any needed medical care in the last 12 months; 2.6% of the observations have delayed getting needed care; 2.7% of the observations have forgone getting needed care. Also, 97.1% of the sampled adults reported they did not delay or forgo any needed medical care in at least one of their observations; 4% of the

sample reported having delayed getting needed care at least once; and 3.9% of the sample reported having forgone needed care at least once. The within percent column in the table shows that among the 143,258 respondents who ever reported not delaying or forgoing needed care, 97.6% of their observations remained the same; among the 5,923 respondents who ever reported having delayed needed care, 64% of their observations indicated the same; among the 5,789 respondents who ever reported having forgone needed care, 69.6% of their observations remained the same.

Table 7.3 presents the demographic and socioeconomic characteristics of the sample adults who have a non-ED usual source of care and have indicated their travel time to get to their usual source of care. The reason why I restrict the sample to adults with a non-ED usual source of care is to rule out the rival explanation that a person has delayed or forgone care because the person does not have a reliable usual source of care.

Table 7.3 Characteristics of Sampled Adults, MEPS 2002-2016 Panel 7-Panel 20

Characteristics	Overall No. (%)	Between No. (%)	Within %
Gender			
Male	101,116 (42.4)	63,322 (42.9)	100
Female	137,616 (57.6)	84,373 (57.1)	100
Race and ethnicity			
White	126,177 (52.9)	76,579 (51.9)	100
African American	41,841 (17.5)	25,951 (17.6)	100
American Indian or Alaska Native	1,328 (0.6)	814 (0.6)	100
Asian or Pacific Islander	15,336 (6.4)	9,473 (6.4)	100
Multiple race	3,649 (1.5)	2,274 (1.5)	100

Hispanic (any race)	50,401 (21.1)	32,604 (22.1)	100
Education attainment			
Less than high school	51,928 (21.9)	33,565 (22.9)	99.99
High school diploma	72,470 (30.6)	45,010 (30.7)	99.99
One to three years of college	44,224 (18.7)	26,918 (18.4)	99.99
Bachelor's degree	35,323 (14.9)	21,280 (14.5)	99.99
Advanced degree	33,080 (14)	19,769 (13.5)	100
Marital status			
Married	129,469 (54.2)	79,608 (53.9)	98.8
Never married	56,204 (23.5)	37,427 (25.3)	99.0
Divorced/separated	34,209 (14.3)	21,376 (14.5)	97.6
Widowed	18,846 (7.9)	11,319 (7.7)	98.2
Census region			
West	61,635 (25.8)	38,360 (26)	99.8
Northeast	41,204 (17.3)	25,120 (17)	99.7
Midwest	50,268 (21.1)	30,661 (20.8)	99.6
South	85,623 (35.9)	54,022 (36.6)	99.7
Health status			
Poor	8,399 (3.9)	6,778 (5)	77.3
Fair	32,190 (15)	25,642 (19)	77.5
Good	70,052 (32.6)	55,135 (40.9)	79.4
Very good	70,714 (32.9)	55,367 (41)	80.1
Excellent	33,377 (15.5)	26,886 (19.9)	81.0
Activity limitation			
No activity limitation	162,552 (69)	107,926 (74.1)	94.8
Some activity limitations	72,933 (31)	49,085 (33.7)	88.5
Insurance status			
Uninsured	25,590 (10.7)	19,501 (13.2)	90.6
Insured	213,142 (89.3)	131,850 (89.3)	98.6

Age	Overall Mean= 48 years old*
Family income	Overall Mean=\$63191.9 *

Sample is restricted to 147,695 adults with a non-ED usual source of care who have indicated their travel time to usual source of care, No. of observations= 238,732.

Percentages are unweighted.

*Mean is calculated using all observations.

Table 7.3 shows that gender, race and ethnicity are time-invariant variables, which means the observations of the respondents did not change across the two survey years. 42.9% of the sample are male and 57.1% are female. The sampled adults are mostly non-Hispanic white (51.9%). Hispanic (22.1%) is the second largest population group, followed by non-Hispanic African American (17.6%). 6.4% of the sample are Asian or Pacific Islander; 1.5% are multiple race; and only 0.6% are American Indian or Alaska Native. 13.5% of the sample adults have a graduate degree.

In addition, the majority of the sampled adults reported being married (53.9%), being in good (40.9%) or very good (41%) health, having no activity limitation (74.1%), and being covered by insurance (89.3%).

7.3.2 Travel Time and Delay/Forgo Needed Medical Care

Table 7.4 presents the results of the random-effects ordered logistic regression model examining the impact of travel time on the experience of having delayed or forgone needed medical care in the past 12 months, with all covariates being controlled.

Table 7.4 Random-Effects Ordered Logistic Regression of Having Delayed/Forgone Needed Care on Travel Time and Covariates, MEPS 2002-2016 Panel 7-Panel 20

Delay or forgo needed care	Odds Ratio	z	P> z
Travel time			
Less than 15 min	Omitted		
15 to 30 min	1.05	1.94	0.052
31 to 60 min	1.25***	5.22	<0.001
More than 60 min	1.32**	3.46	0.001
Age	1.08***	16.29	<0.001
Age²	0.99***	-20.89	<0.001
Gender			
Male	Omitted		
Female	1.39***	11.90	<0.001
Race and ethnicity			
White	Omitted		
African American	0.55***	-15.50	<0.001
American Indian or Alaska Native	0.94	-0.38	0.707
Asian or Pacific Islander	0.52***	-9.75	<0.001
Multiple race	1.18	1.79	0.073
Hispanic	0.44***	-20.26	<0.001
Education attainment			
Less than high school	Omitted		
High school diploma	1.28***	6.25	<0.001
One to three years of college	1.66***	11.51	<0.001
Bachelor's degree	1.94***	13.23	<0.001
Advanced degree	2.06***	14.50	<0.001
Marital status			

Married	Omitted		
Never married	1.41***	8.84	<0.001
Divorced/separated	1.76***	15.70	<0.001
Widowed	1.41***	6.05	<0.001
Family income			
Log(Income)	0.78***	-16.76	<0.001
Census region			
West	Omitted		
Northeast	0.73***	-7.29	<0.001
Midwest	0.78***	-6.20	<0.001
South	0.83***	-5.38	<0.001
Health status			
Poor	Omitted		
Fair	0.62***	-9.53	<0.001
Good	0.34***	-21.05	<0.001
Very good	0.21***	-27.93	<0.001
Excellent	0.12***	-30.48	<0.001
Activity limitation			
No activity limitation	Omitted		
Some activity limitations	2.93***	34.61	<0.001
Insurance status			
Uninsured	Omitted		
Insured	0.35***	-28.42	<0.001

Number of sampled respondents= 131,768; Number of observations = 208,266

*p<0.05, **p<0.01, ***p<0.001

The results of the ordered logistic regression model indicate the proportional odds ratios of comparing other groups in “travel time” to the reference group (i.e., less than 15 minutes) in terms of being in higher categories of the outcome variable—the experience

of having delayed or having forgone needed care. Table 30 shows that when all covariates in the model are held constant, compared with people who reported traveling less than 15 minutes, the odds of the combined having delayed and forgone needed care versus did not delay or forgo needed care among those who reported traveling 15 to 30 minutes are 1.05 times greater. Also, the odds of having forgone needed care versus the combined did not delay/forgo needed care and have delayed needed care for those who traveled 15 to 30 minutes are 1.05 times greater than for those who traveled less than 15 minutes, although the difference is not statistically significant (Odds Ratio=1.05, P=0.052).

Similarly, when all covariates in the model are held constant, the odds of the combined having delayed and forgone needed care versus did not delay or forgo needed care among those who reported traveling 31 to 60 minutes are 1.25 times greater, compared with those who reported traveling less than 15 minutes. The odds of having forgone needed care versus the combined did not delay/forgo needed care and have delayed needed care for those who reported traveling 31 to 60 minutes are 1.25 times greater than for those who reported traveling less than 15 minutes (OR=1.25, P<0.001), when all covariates in the model are held constant.

Also, when all covariates in the model are held constant, compared with those who reported traveling less than 15 minutes, among those who reported traveling more than 60 minutes the odds of the combined having delayed and forgone needed care versus did not delay or forgo needed care are 1.32 times greater. Likewise, the odds of having forgone needed care versus the combined did not delay/forgo needed care and have

delayed needed care for those who reported traveling more than 60 minutes are 1.32 times greater than for those who traveled less than 15 minutes (OR=1.32, P=0.001).

The results above show the difference between other categories and the omitted reference category, i.e., less than 15 minutes. I further test if difference exists between other categories of travel time. The results show that the difference between those who travel 15 to 30 minutes and those who travel 31 to 60 minutes are significant ($\chi^2=15.7$, P=0.0001). Difference also exists between those who travel 15 to 30 minutes and those who travel more than 1 hour ($\chi^2=7.87$, P=0.005). However, no difference is found between those who travel 31 to 60 minutes and those who travel more than 1 hour ($\chi^2=0.47$, P=0.49).

In addition to increased travel time, people with some activity limitations are more likely to have delayed or forgone needed care (OR=2.93, P<0.001). This may be due to mobility restrictions caused by physical impairment. Also, being older (OR=1.08, P<0.001), being female (OR=1.39, P<0.001), having higher education levels, having never been married (OR=1.41, P<0.001) or being divorced/separated (OR=1.76, P<0.001) or widowed (OR=1.41, P<0.001), are associated with increased odds of having forgone needed care or the combined having delayed and forgone needed care.

As expected, having a higher log of income (OR=0.78, P<0.001) and being insured (OR=0.35, P<0.001) are associated with decreased odds of having forgone needed care or the combined having delayed and forgone needed care in the last 12 months; these two factors concern the affordability of healthcare services, which is a very important factor influencing people's obtaining of healthcare. Surprisingly, being African

American (OR=0.55, P<0.001), Asian/Pacific Islander (OR=0.52, P<0.001) or Hispanic (OR=0.44, P<0.001) are less likely to have forgone or delayed needed care. This may be explained by the difference in health literacy and perceived medical needs among racial and ethnic groups.

Meanwhile, people living in the Northeast (OR=0.73, P<0.001), Midwest (OR=0.78, P<0.001) or South (OR=0.83, P<0.001) Census region are less likely to have delayed or forgone care. Being in better health is also associated with decreased odds of having forgone needed care or the combined having delayed and forgone needed care in the last 12 months. Similar to all the other models in the dissertation, this may be because healthier people had fewer medical needs.

7.4 Conclusions

This chapter finds that when people need to travel more than 30 minutes to their usual source of medical care, the odds of having experienced delayed or forgone necessary medical care are expected to increase, compared with people who travel less than 15 minutes. However, the difference in the odds between people who travel less than 15 minutes and people who travel 15 to 30 minutes are not statistically significant. Also, those traveling 15 to 30 minutes are found significantly different from those traveling 31 to 60 minutes and those traveling more than 1 hour. But no difference is found between those who travel 31 to 60 minutes and those who travel more than 1 hour. The results partially support the hypothesis and reveal a negative effect of travel time (more than 30

minutes) on healthcare access. These findings may also imply that the impact of every additional travel minute on people's health-seeking behaviors is not constant. That is to say, a travel time of less than 30 minutes to a person's usual source of care does not put extra travel burden on him/her and does not affect the person's health-seeking behaviors. However, once the travel time exceeds 30 minutes, the travel time negatively impacts people's healthcare access.

It should be noted that this chapter does not control for transportation mode, also due to the unavailability of the data in the study. It is reasonable to argue that the effect of travel time on healthcare access may be different for people using different modes of transportation. For example, the perceived travel burden for those who drive 30 minutes to seek care may be different from those who need to walk 30 minutes. Without controlling for transportation mode, travel time alone cannot sufficiently reveal accessibility. Also, employment status and metropolitan residence are not controlled. These are limitations of this chapter.

CHAPTER EIGHT

DISCUSSION OF TRANSPORTATION DISADVANTAGE IN HEALTHCARE ACCESS AND POLICY IMPLICATIONS

This dissertation examines the impact of transportation disadvantage on healthcare access among noninstitutionalized adults in the United States. The analyses in this dissertation find a significant relationship between limited mobility (a lack of vehicle ownership, walking, a lack of transportation), together with travel time, and healthcare access among the non-institutionalized adults in the United States. The results of this dissertation also suggest that there is no clear evidence that spatial distance to healthcare providers plays an important role in preventing people from accessing healthcare in areas outside a Metropolitan Statistical Area.

Based on these findings, policies intending to improve healthcare access by ameliorating transportation disadvantage can target improving people's access to transportation resources.

8.1 Mobility

8.1.1 Increase Automobile Access

There is no doubt that having access to an automobile is very important in fulfilling people's mobility needs in most areas in America. However, there has been a debate over whether or not automobile use should be encouraged. Many researchers does

not support automobile use for reasons such as it worsens traffic congestion, generates air pollution, induces a sedentary lifestyle, facilitates urban sprawl, etc. (Gillham & MacLean, 2002). Some researchers think promoting automobile use will impair the least well-off: the built environment is already overly catering for automobiles, and if this becomes even more widespread low-income people will be increasingly “forced” to own a car to fulfill their mobility needs for daily activities, which would put a large financial burden on their already-limited household budgets (Delbosc & Currie, 2012; Hanson & Giuliano, 2004).

However, this research shows that in the realm of healthcare access the benefits that having access to an automobile brings are considerable and thus increasing automobile access can be very effective in overcoming mobility limitations in accessing healthcare.

It is true that the cost of purchasing and operating a car can be a financial burden, but the automobile is still the primary transportation mode used by the poorest population group in the United States. Examining the 2009 National Household Travel Survey, Renne and Bennett (Renne & Bennett, 2014) found that 78.6% of households whose annual incomes were under \$20,000 owned at least one private vehicle. Moreover, once the household incomes exceeded \$20,000 per year, the proportion of owning at least one vehicle in the family jumped to 93.9% (Renne & Bennett, 2014). The statistics tell us that most families purchase a vehicle as soon as they are financially able to, further indicating that in the U.S., having a car is a necessity for fulfilling mobility needs, even among the poorest (Pucher & Renne, 2003).

As mentioned earlier, it is those with the lowest incomes that lack access to an automobile; plus purchasing and operating a car would put huge financial burden on them. Therefore, strategies can be taken to help promote automobile ownership among the low-income group. For example, some nonprofit organizations have been running affordable car ownership programs, aiming at helping people with low-incomes get a donated car or purchase a car at a very cheap price. Vehicle for Change, Good News Garage, More Than Wheels are some examples of such program. In fact, the benefits that having a car brings exceed the realm of healthcare. Previous research has found that automobile access is positively associated with participation in various out-of-home activities. Policies can be developed to support these nonprofit organizations.

The government could help facilitate automobile ownership by relaxing welfare asset test limits. Cars are considered to be part of a family's asset when the government decides which families are qualified for welfare assistance. Just by owning a car, a low-income family might not be qualified for getting the welfare benefits. What's worse, in order to be qualified for these benefits, a low-income family may choose to sell the car which is needed to travel to work. Therefore, relaxing welfare asset test limits can potentially facilitate automobile ownership among the low-income.

8.1.2 Ridehailing Services

Ridehailing services can increase people's access to an automobile. Ridehailing services, such as Uber and Lyft, have many advantages, among which the biggest being their real-time nature. Users can hail a ride whenever they need. They do not need to

arrange a trip appointment in advance. Compared with using public transit to travel to healthcare providers, using ridehailing services does not require walking or long waiting times. Ridehailing also guarantees a point-to-point route that shortens the travel time, which is very important for some people when looking for healthcare.

Several challenges may face this approach. First, Uber and Lyft are not prevalent in some areas. Ideally, this approach would benefit those who live in suburban and rural areas where the public transit are often not provided. But in order to successfully operate a dynamic ridehailing program, the user pool in an area must achieve a critical mass. Only when enough people are using the service can the system generate appropriate ride matches. Given that Uber and Lyft (and other smaller transportation network companies) are mostly prevalent in most metropolitan areas and suburban areas, the people in small metropolitan areas or rural areas will not benefit from this type of service. Second, the trip fare of ridehailing is still relatively high. Therefore, the question of how to subsidize ridehailing trips for those who are disadvantaged due to low incomes will be a challenge.

It should be noted that Lyft and Uber are already taking actions in collaborating with nonemergency transportation managers to provide transportation to healthcare. The pilot results show it is a very promising approach (Powers, Rinefort, & Jain, 2016). Also, Envoy has been developing electric vehicle-sharing programs for people with no bank accounts.

8.1.3 Develop Public Transit Services

Chapter 5 indicates that people who have access to public transit services have better healthcare access than people who rely on walking. Therefore, I think developing public transit services is also very important in ameliorating transportation disadvantage in accessing healthcare, especially in the urban areas. In particular, I think bus systems in urban areas should be further developed.

Many people may argue that only a small group of population in the United States use public transit. The 2009 National Household Travel Survey showed that only 2.3% of all trips were taken by public transit (Renne & Bennett, 2014). Some people may even claim that in the United States, developing public transit is not economically efficient and cannot serve a large share of trips. For example, Bertaud (2003) found that in order for the metro system in Atlanta to serve the same amount of residents as does the metro system in Barcelona, Atlanta would need to build additional 3,400 km of metro tracks and 2,800 metro stations, which is deemed impossible.

It is true that public transit systems are not profitable in the United States. But it does not mean public transit should be totally abandoned. Providing public transit is very important in promoting transportation equity. All social members have the right to access transportation resources (Pyrialakou et al., 2016). Those who do not have access to a private car may have to rely on the provision of alternative transportation modes. Public transit is a very important mode option for those who would otherwise have none. What's more, research shows that lower-income people use public transit more than do higher-income people (Renne & Bennett, 2014; Taylor & Morris, 2015). Therefore, developing

transit would actually disproportionately benefit the low-income people—those who are also more likely to lack access to an automobile. So developing public transit will be a good approach to ameliorate transportation disadvantage, especially for people with low incomes.

As mentioned before, I conclude urban areas should be the focus of developing public transit services, especially in cities where the land use patterns are congruent with higher transit ridership. The reason is that the development pattern in urban areas makes it more feasible to develop public transit than in suburban or rural areas. The polycentric, low-density, sprawling pattern in common in suburban areas makes it very expensive to build and operate a transit system (Hanson & Giuliano, 2004). Also, most urban areas are already covered by some public transit systems, thus making it more economical to improve current systems than building brand new ones. Also, those with low incomes are disproportionately likely to live in cities as opposed to suburbs (Glaeser, Kahn, & Rappaport, 2008). So developing transit in cities will better serve the most disadvantaged and foster social equity.

One thing should be noted is that instead of developing high-quality rail systems to attract middle- and high-income people to ride transit, improving bus systems will benefit low-income people disproportionately. Research finds that low-income people use bus more than other modes of public transit (Renne & Bennett, 2014; Taylor & Morris, 2015). However, bus has a reputation of low-quality, low-class service (Pucher & Renne, 2003). In one study, low-income people reported the unreliability and inefficiency of the bus system as the primary reason for having rescheduled or missed a medical

appointment (Silver, Blustein, & Weitzman, 2012). The frequency, speed, level of comfort, safety (especially when traveling with children), and information provided to riders were all reported to be problematic (Silver, Blustein, & Weitzman, 2012). Therefore, improving the service quality of bus system may be helpful in ameliorating transportation disadvantage in accessing healthcare. The improvements may include extending multiple bus routes between healthcare providers and residential areas (especially low-income communities), running buses more frequently, guaranteeing reliability, providing more information.

The most obvious challenge that developing public transit services will face is the need to finance operating deficits and investment expenditures (Hanson & Giuliano, 2004). Public transit systems are heavily subsidized by the government. It is not difficult to imagine that such a strategy of developing public transit will arouse political debate. After all, the vast majority of taxpayers are also car-users. Since transit ridership in the U.S. has been declining (Hanson & Giuliano, 2004), it is likely that the expanded transit services will also suffer from low ridership and thus cause greater operating deficits.

8.1.4 Transportation Programs Targeted at Healthcare Access

Another option for ameliorating mobility-related transportation disadvantage in accessing healthcare is developing more transportation programs aiming at serving the transportation disadvantaged specifically for their healthcare needs.

Currently, Medicaid operates the nonemergency medical transportation (NEMT) program for beneficiaries who do not have reliable or affordable transportation because

of income, age, chronic conditions or disabilities. This is designed to overcome transportation barriers to and from non-emergent medical care. NEMT reimburses Medicaid beneficiaries who use public transit to reach healthcare providers; it also contracts with transportation providers to offer transportation services through wheelchair vans, stretcher cars, taxis, automobiles and even air transportation (Musumeci & Rudowitz, 2016). NEMT has proved to be helpful in ameliorating transportation problems in accessing healthcare. Thomas and Wedel (2014) examined the impact of NEMT on 10,824 adult beneficiaries' visits to healthcare providers for managing hypertension, asthma, and heart disease in Oklahoma. Results show that among the Medicaid beneficiaries, those who use NEMT services are significantly more likely to visit healthcare professionals for managing the three types of chronic diseases as recommended, compared with those who do not use NEMT. However, cases of fraud and abuse have damaged the reputation of NEMT and cast doubt on its administration (Adelberg & Simon, 2017). What's worse, some state governments are cutting the benefits of NEMT for Medicaid beneficiaries (Chaiyachati, Moore, & Adelberg, 2018).

8.2 New Technologies

In responding to traffic congestion issue, scholars suggest reducing or even eliminating travel needs by using information technology (IT) to allow people to work at home (Hanson & Giuliano, 2004). The same strategy can be applied to reduce the need

for traveling to healthcare providers, and thus reducing the negative impact of transportation disadvantage on people's healthcare access.

By using telecommunication technologies, such as video conferencing and remote monitoring, people can reach health professionals face-to-face without traveling to healthcare providers and making a physical appearance. Such technology applications are especially useful in overcoming the transportation difficulties for the elderly and people with disabilities.

In fact, the government has been putting effort into applying telecommunication technologies to healthcare delivery, through the Telehealth programs (Institute of Medicine (US), 1996). Telehealth is defined as “the use of electronic information and telecommunication technologies to support and promote long-distance clinical health care, patient and professional health-related education, public health and health administration. Technologies include video conferencing, the internet, store-and-forward imaging, streaming media, and terrestrial and wireless communications” (Health Resources & Services Administration, 2019). By overcoming the transportation barrier to accessing healthcare, Telehealth is considered to be an approach to reduce health disparities for underserved populations (National Conference of State Legislatures, 2016; Totten et al., 2016).

Some challenges exist in the use of delivery healthcare through telecommunication technologies. Applying telehealth will require considerable administration to guarantee the qualifications of healthcare providers. Management issues may also occur when patients seek advice or care from different health practitioners

through telehealth. Also, using telecommunication technologies will raise patient privacy and data security issues. Last, some forms of telehealth, such as video conferencing, would require patients to have appropriate devices at home, such as a computer, which may deter some low-income people who cannot afford such devices from using telehealth. Also, the people in rural areas are more likely to have no or poor access to broadband internet connectivity, which will impair the feasibility of telehealth (Douthit, Kiv, Dwolatzky, & Biswas, 2015).

8.3 Limitations of the Dissertation

There are several limitations in this dissertation.

First, due to the constraints of available resources, some data is not up-to-date. For example, data from the NHIS 1993 to 1996 is used to examine the impact of vehicle ownership on healthcare access because the data of “vehicle ownership” is only available in this period. The same situation applies to the data on “transportation mode” in the MEPS 2000-2001. The reason this is a limitation is that the distribution of medical resources was different decades ago. Also, the extent of Internet use was different. However, the research results can still provide insights for current situation as it is reasonable to argue that the importance of having access to transportation resources in fulfilling people’s mobility needs nowadays is little different from that two decades ago. Other than these, the data used in other analyses is up to date.

Second, there is a threat to construct validity in this research. The measurements used in the dissertation do not operationalize the key constructs, transportation disadvantage and healthcare access, comprehensively. This is because of the complexity of both healthcare access and transportation disadvantage, and the constraints of available data. In terms of the measurements of transportation disadvantage, I wish to observe automobile ownership, transportation mode, travel time to usual source of care, and metropolitan residence at the same time. But many of these variables are lacking in the datasets. About healthcare access measures, I focus on the dimension of realized access in this dissertation and leave out many variables of potential access, such as the distribution of healthcare resources. I also wish to observe more information about the actual obtaining of healthcare among people with certain physical conditions.

Third, there are important variables omitted in the models that may generate rival explanations or bias, since both transportation and healthcare access are complex systems. For example, in Chapter 6, the variable “metropolitan residence”, i.e., whether or not one respondent was living in a Metropolitan Statistical Area, is not controlled due to unavailability; in Chapter 7, transportation mode, metropolitan residence, and employment status are not controlled due to the same reason. Also, in Chapter 5 I do not control for the actual spatial distance to the healthcare providers. Without controlling for these important variables, the results may be biased.

8.4 Conclusions

This dissertation focuses on mobility and accessibility, examining the impact of transportation disadvantage on healthcare access among the noninstitutionalized adults in the United States.

By using secondary data from the National Health Interview Survey and the Medical Expenditure Panel Survey, this dissertation finds that a lack of vehicle ownership, reliance on walking (instead of using a car or public transit services), and a lack of transportation are all associated with worse healthcare access (being less likely to have a non-ED usual source of care, being more likely to have delayed or forgone needed care, and being more likely to have experienced difficulty in getting care), indicating a significant relationship between mobility and healthcare access among the non-institutionalized adults in the United States. The dissertation also finds that a travel time of more than 30 minutes to the usual provider of care is associated with increased odds of having delayed or forgone needed care. My research results contribute to the field by performing detailed analyses to demonstrate the problem, and by providing solid evidence for policy recommendations.

Previous study estimates that transportation problems inhibit about 3.6 million Americans in getting care (Wallace et al., 2005). My research further emphasizes that transportation disadvantage is without doubt a barrier to healthcare access nationwide. Not having reliable healthcare access is problematic: for individuals, it would negatively impact people's health and well-being; for society, it would result in excessive healthcare expenditure and worsen population health. Improving healthcare access is a task that

requires long-term efforts and I believe that addressing transportation disadvantage will contribute to achieving this goal.

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