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Transportation Behavior Among Older Vietnamese Immigrants in the Dallas-Fort Worth Metroplex

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TRANSPORTATION BEHAVIOR AMONG OLDER VIETNAMESE IMMIGRANTS IN THE DALLAS-FORT WORTH METROPLEX: WELL-BEING, GEOSPATIAL MOBILITY, AND POTENTIAL INDICATORS FOR RIDE PROVIDERS' GEOSPATIAL BURDEN

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16. Abstract Nearly 4.6 million immigrants aged 65 and older live in the United States. This population is expected to more than triple in size by 2050. A lack of culturally appropriate transportation solutions for older immigrants creates disparities in access to services for older immigrant populations, increasing their risk of social isolation and reduced physical and mental health. A growing number of older immigrants live in low-density urban environments, which are characterized by high automobile dependency and limited public transportation. In these environments, older immigrants are likely to depend on others to provide private transportation. Negative aspects of this reliance on others are that the private transportation providers may be at risk for caregiver burden and stress, and older immigrants may lack transportation to social or health opportunities if their ride providers are unavailable. This survey research examines the mobility; activity spaces; transportation patterns, resources, and needs; transportation-related support networks; and health and well-being among older Vietnamese adults in		

the Dallas-Fort Worth metroplex. It also investigates the provision of rides from private transportation providers and the impact of providing rides to an older Vietnamese adult in an urban area. It uses geographic information systems (GIS) to construct regular activity spaces for the older adults and their ride providers, and ride-provision activity spaces for the ride providers. Using the ride providers' activity spaces, it proposes three indicators of geospatial burden for providing rides. Findings indicate that the older adults and their ride providers rely on automobiles for transportation. Most of the older adults receive rides for transportation and their ride providers are also Vietnamese and primarily speak Vietnamese. The GIS analyses suggest that constructing activity spaces with self-reports of regular and ride-provision routine activities and locations may be an appropriate assessment tool to provide valuable insights into the burden of providing rides. The best performing burden indicator was the percentage of the ride-provision activity space that was not within the boundaries of the ride providers' regular activity space.

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1.0 EXECUTIVE SUMMARY

1.1 BACKGROUND

Although adequate transportation is critical for the health, social engagement, and well-being of older adults, older immigrants in the United States face a variety of transportation-related barriers. These include heightened risk for physical limitations that add difficulties to using many modes of transportation; greater likelihood of economic insecurity that may reduce access to transportation resources such as private automobile ownership; and language and cultural mismatches between transportation service providers and the older immigrant service user. A tendency for older immigrants to rely on people in their social networks for private transportation exists, which may lead to increased burden for the transportation providers. Despite these generalizations, wide variety among immigrant populations occurs in many dimensions. Vietnamese people make up a substantial portion of the Asian population in the United States, but little is known about the transportation behaviors, resources, and needs of older Vietnamese immigrants in the country.

1.2 METHODOLOGY

This study is a two-phase cross-sectional survey of older Vietnamese immigrants (Phase 1) and people who provide rides to older immigrants (Phase 2). The research site is the Dallas-Fort Worth metroplex (DFW), a low-density, automobile-dependent urban region with many Vietnamese residents.

Phase 1 collected data from 95 Vietnamese participants aged 65 and older. After a random removal process to ensure that data from only one participant per household was analyzed, the final sample was 84 older Vietnamese adults. The Phase 1 questionnaire asked participants about their health, physical functioning, transportation behaviors, automobile ownership, ride providers, knowledge of public transportation and paratransit services, routine activities, location and frequency of activities, and activities missed due to lack of transportation.

Phase 2 collected data from 20 people who provided rides to older Vietnamese adults in DFW. Participants were asked about their transportation behaviors, automobile ownership, and impacts of providing rides. Similar to the Phase 1 participants, they were asked about their routine activities, location and frequency of activities, and activities missed due to lack of transportation. In addition, they were asked about the activities, locations, and frequencies of trips when providing rides to the older adults.

Using the data about routine activities and activities for providing rides, we constructed a *regular activity space* for each Phase 1 and Phase 2 participant. The regular activity space represents the geospatial area related to the person's routine activities. Individuals who travel frequently and far on a routine basis have larger regular activity spaces than those who travel infrequently and to near locations. These regular activity

spaces provide a representation of the individual's mobility, but also of the geospatial area that would be considered accessible to the individual. For the older adults, we used this concept to determine the accessibility of key activities (e.g., healthcare services, religious services, grocery shopping).

For the Phase 2 ride providers, we also constructed *ride-provision activity spaces* to represent the geospatial area of providing rides to an older adult. We develop three burden indicators using the ride providers' regular and ride-provision activity spaces. To assess the performance of the indicators, we analyzed the associations of the performance indicators with each other and various impacts of providing rides.

1.3 MAIN FINDINGS

The older Vietnamese adults in the Phase 1 sample tended to have low levels of income and education, multiple chronic diseases, limitations to instrumental activities of daily living such as managing their household, and many used assistive devices or equipment for mobility. They were all born in Vietnam and spoke Vietnamese at home as their primary language. Most of the older adults indicated they received rides from another person for transportation. All of the ride providers were Vietnamese. Many important activities were inaccessible to a majority of the older adults, and almost a third of the older adults missed activities due to a lack of transportation. Older adults who depended on others for rides compared to those who drove themselves had significantly smaller regular activity spaces, a measure of geospatial mobility that accounts for travel to routine activities. They also reported having a greater number of diagnosed medical conditions; limitations in instrumental activities of daily living; were more likely to use assistive devices or equipment such as canes or wheelchairs; and perceived greater levels of social support than those who drove themselves and didn't get rides with others. Older adults with larger regular activity spaces had significantly fewer diagnosed medical conditions, and lower levels of loneliness and perceived stress.

The ride providers predominantly owned automobiles and drove themselves for transportation. They provided rides to a wide variety of activities. The larger the magnitude of the geospatial burden indicators, the fewer days per month they provided rides. Half of the sample reported impacts of providing rides, with transportation expenses being the most common followed by missed work and increased personal stress. The best performing geospatial indicator was the percentage of the ride-provision activity space that was outside the boundaries of the regular activity space.

1.4 CONCLUSION

This research adds to the transportation-related knowledge base of older Vietnamese adults and their ride providers, and may provide insights into other immigrant groups with similar cultural and socioeconomic characteristics. To our knowledge, it is the first study to use ride-provision activity spaces to explore the geospatial burden of providing rides. It has the potential to inform transportation policymakers seeking to provide culturally appropriate transportation services to older immigrants, or to support private

transportation providers in service areas where public transportation or paratransit services are limited.

2.0 INTRODUCTION

2.1 PROBLEM

Adequate transportation is necessary for older adults to engage in social activities and access health care. Social isolation, particularly a lack of engagement with non-kin (Black et al., 2015), can lead to worse physical health (Valtorta et al., 2016, 2018); mental health (Buetel et al., 2017; Richard et al., 2017); and cognitive functioning (Jang et al., 2021; Curl et al., 2018). With age, functional and cognitive decline can occur; thus, having adequate access to healthcare is essential to an older person's quality of life (Kristiansen et al., 2015). As a result, older adults with transportation-related barriers to social activities and health care risk reduced well-being (Kalavar & Van Willigen, 2005).

Older adults commonly rely on people within their social networks to meet their transportation needs. The same is true for immigrants, especially when the social ties are culturally germane (e.g., between people with the same ethnicity or language). Individuals in high-density immigrant areas have reported relying on close relationships with their neighbors to provide them with transportation to their doctor's office, grocery store, and other important destinations (Liu & Painter, 2010; Almeida et al., 2009). Providing transportation is the most common type of support informal caregivers provide their care recipients. Unfortunately, informal caregivers of immigrants are often occupied with work and other family responsibilities and may not be able to provide adequate or timely transportation to their care recipients or may find providing rides burdensome. Older immigrants have reported experiencing emotional distress because they did not want to burden their adult children caregivers with their transportation needs (Dardas, Willians, Kichen & Wang, 2018; Guzzard0 & Sheehan, 2012; Dong et al., 2010).

Transportation challenges are particularly acute for the approximately 4.6 million immigrants in the United States aged 65 or older (United States Census Bureau, 2020). In part, this is because they report more chronic disease, poorer mental health and reduced physical functioning compared to U.S.-born older adults (Du & Xu, 2016). It is also exacerbated by language, cultural barriers and economic insecurity (Chung et al., 2018; Derose, Escarce & Lurie, 2007). Lastly, a lack of culturally appropriate transportation solutions for older immigrant populations may create disparities in access to services, increasing the risk of social isolation and reduced physical and mental health.

It is important to recognize that different geographies and populations require different transportation solutions. For example, transportation needs in dense urban environments with abundant public transportation are quite different from those in rural areas. Transportation patterns vary by race or ethnicity among immigrants (Hu, 2017). Older immigrants can vary in many ways including by the amount of time they have

lived in the United States, cultural norms, levels of acculturation, socioeconomic status, and health status.

This study collects valuable information about the transportation behaviors and resources, routine activities, health, and well-being of older Vietnamese immigrants in the Dallas-Fort Worth metroplex. It aims to increase the understanding of the characteristics of the population, particularly regarding their transportation and access to social opportunities and health care. The long-term goal of this research is to ensure adequate transportation and improve well-being for older Vietnamese immigrants in low-density urban environments.

2.2 BACKGROUND

2.2.1 Older Vietnamese Immigrants in the United States

Although over two million Vietnamese people live in the United States (Pew Research Center, 2021), research on this population is sparse. Compared to other Asian subgroups of older adults who mainly came to the United States to pursue career opportunities in the 1960s and 1970s or came late in life through family sponsorship, most Vietnamese older adults immigrated to the United States as political refugees following the Vietnam war in the 1970s and 1980s (Trang, 2008). As a result, many Vietnamese refugees experienced war-related trauma (Sangalang & Vang, 2017). Much like other Asian subgroups, Vietnamese older adults live in multigenerational households, and over half of them (55%) live in households where only Vietnamese is spoken (National Asian Pacific Center on Aging, 2013). Furthermore, over 85% of Vietnamese older adult are limited English proficient (National Asian Pacific Center on Aging, 2013).

2.2.2 Transportation among Older Adults and Immigrants

Transportation is important for older adults' well-being, yet for those with diminished health, some transportation options may no longer match their abilities (Levassuer et al., 2015). Many older adults reach a stage in their lives when they no longer drive (Dickerson et al., 2017). Indeed, it is common for older adults to rely on people within their social networks to meet their transportation needs (Dabelko-Schoeny et al., 2021), and evidence suggests the prevalence of getting rides from informal caregivers is particularly high among former drivers (Kostyniuk & Shope, 2003). In fact, providing transportation is one of the most common forms of assistance provided by informal caregivers (Turner & Findlay, 2012; Wolff & Kasper, 2006). Among a predominantly white sample of 268 caregivers to older adults in Michigan (Eby et al., 2017), most drove regularly as a means of transportation, provided transportation to a parent, and lived within 20 minutes from their ride recipient. The most common activities that they provided rides for included medical services (91%); shopping or errands (65%); social or recreational activities (58%); family or personal business (62%); and religious activities (33%). A plurality gave rides one or two times per week (Eby et al., 2017).

Recent immigrants in the United States tend to use public transportation, carpool, or walk more than native-born adults (Chatman & Klein, 2009). However, existing research on immigrants and transit behavior suggests immigrants with limited English proficiency experience significant barriers accessing adequate, reliable transportation (Blumenberg, 2008). There is evidence that immigrants often rely on others for rides or borrow cars for transportation (Blumenberg & Smart, 2010; Lovejoy & Handy, 2011). In spite of this, much of the existing literature on travel behavior among immigrants is focused on other modes of transportation such as public transit, walking, and bicycling (Blumenberg & Smart, 2010).

Although younger immigrants may acclimate to automobile usage over time, non-English speaking older immigrants (as older Vietnamese immigrants tend to be) are more likely to be non-drivers and rely on others to meet their transportation needs (Tan, 2011; Treas & Mazumdar, 2002). Older immigrants face transportation barriers similar to their native-born counterparts; however, their challenges can be exacerbated by a variety of factors including language and cultural barriers, increased risk of disability, and economic circumstances. For example, older immigrants with limited work histories in the United States are often not eligible for government-funded transportation resources that assist with access to care, as these programs are directly linked to Medicaid and Medicare eligibility (Center for Medicare and Medicaid Services, 2022). However, they may be eligible for needs-based community non-emergent transportation services (Center for Medicare and Medicaid Services, 2022) or paratransit. A potential barrier to accessing alternate modes of transportation is the experiences of discrimination faced by ethnic minority passengers when accessing transportation systems (Young & Farber, 2019). There is scant, if any, research about the travel patterns of older Vietnamese immigrants in the United States.

As with all older adults, older immigrants also rely on getting rides from other people (Blumenberg & Smart, 2010). Informal caregivers often provide significant instrumental support to older immigrants, including running errands, making repairs around the house, dealing with medical issues, and managing finances (Weng & Nguyen, 2011). In many immigrant cultures, family members have a strong sense of family obligation, including respect and care for elders (Diwan et al., 2011). Nonetheless, ride providers may feel strained to accommodate the needs of the older adult, while also receiving reciprocal benefits through the acquisition of tangible and in-kind resources, such as childrearing (Weng, 2017). On the other side of the relationship, the older immigrant may oscillate between accessing their social network, which is primarily their family, for help and not making their needs known, as was found in research of older Koreans in the United States (Jang, 2006). Little, if any, published research has described the nature of rides provided to older immigrants and the impact of providing rides.

2.2.3 Low-Density Urban Environments

Low-density urban environments such as the Dallas-Fort Worth metroplex are characterized by high automobile dependency and limited public transportation.

In such communities, private-vehicle transport serves as the primary connector to healthcare and social opportunities (Dabelko-Schoeny et al., 2021). A growing number of older immigrants live in these communities (Adorno et al., 2018). In fact, in the last two decades, much of the Asian population growth in the United States occurred in low-density urban environments (Treas & Mazumdar, 2002).

Living in a low-density urban environment amplifies the likelihood that older immigrants will depend on others to provide private transportation (Adorno et al., 2018; Chung et al., 2017; Luiu, 2018). The limited public transportation options suggest that older immigrants might also have limited knowledge about using public transportation or need to navigate other modes of transportation if they are unable to drive themselves or find a ride provider. However, there is scant, if any, literature illuminating the transportation patterns or knowledge among immigrants in low-density urban environments in the United States.

2.2.4 Mobility and Activity Spaces

Mobility, or "the ability to move oneself (e.g., by walking, by using assistive devices, or by using transportation) within community environments that expand from one's home, to the neighborhood, and to regions beyond" (Webber et al., 2010, p. 443), is critical for older adults' well-being and full participation in life. The concept of life-space (i.e., the geospatial area through which an older person moves) was introduced to understand more precisely older adults' mobility than using assessments of gait or physical functioning (May, Nayak & Issacs, 1985). The life-space approach considers nested zones of movement from a person's bedroom, home, yard or immediate grounds, neighborhood, and beyond. Assessing life-space has been used to evaluate the effects of health care, social support, and other factors on mobility (Baker et al., 2003). Life-space has also been found to be a predictor of healthcare utilization, cognitive health, mortality, and morbidity in older adults (Caldas et al., 2020; Johnson et al., 2020).

One drawback to common measures of life-space such as the University of Alabama at Birmingham Study of Aging Life-Space Assessment (Peel et al., 2005) is the inclusion of non-precise indicators of mobility such as "neighborhood," "outside the neighborhood," and "outside your town." Individuals can have different definitions of what constitutes their neighborhood (Coulton et al., 2001) and sizes of towns can vary widely as well.

Geospatial analysis can consider the actual travel patterns of individuals during their daily activities, including locations and frequency of activity, to create geospatial "activity spaces" (Sherman et al., 2005). An activity space can be a better representation of a person's true neighborhood in terms of movement patterns than the boundaries of a residential neighborhood (York, Cornwell & Cagney, 2017). Activity spaces have also been used to examine geospatial accessibility of services such as healthcare facilities because it helps understand what is accessible, or nearby, in terms of the everyday local environment of a person (Gessler & Meade, 1988).

Activity spaces can be represented in several ways, but a comparison of methods (Sherman et al., 2005) has shown two of the best for understanding accessibility are the one standard deviation ellipse (SDE1) and the road network buffer (RNB). A standard deviation ellipse is an area similar in shape to an ellipse on a map that is centered on the geographic mean location of a person's regular activities (Yuill, 1971). A SDE1 contains approximately 68% of a person's activities (Sherman et al., 2005). The RNB creates a buffer (e.g., one kilometer or a half mile) around the roads connecting the locations of regular activities (Sherman et al., 2005).

To date, there is little known about the activity spaces of older Vietnamese or their ride providers. Likewise, although using activity spaces holds promise for understanding the geographical space for providing rides, this approach is underutilized.

2.3 CURRENT STUDY

This exploratory study examines the mobility; activity spaces; transportation patterns, resources, and needs; transportation-related support networks; and health and well-being among older Vietnamese adults in the Dallas-Fort Worth metroplex. It also investigates the provision of rides from private transportation providers and the impact of providing rides for an older Vietnamese adult in the metroplex. The study's long-term aims are to increase knowledge of the transportation needs of an important population in the region -- older Vietnamese adults -- and to improve their access to healthcare and social opportunities.

The aims of the Phase 1 survey of older Vietnamese adults in the Dallas-Fort Worth metroplex are to:

- **P1 Aim 1**: Describe the transportation resources and behavior among the sample (e.g., household automobile ownership, modes of transportation, frequency of transportation use).
- **P1 Aim 2**: Describe the sample's level of knowledge of public transportation in their community, including paratransit services.
- **P1 Aim 3:** Understand the effects of lack of transportation on key social, health care, and household maintenance activities (i.e., missed appointments and opportunities).
- **P1 Aim 4:** Identify associations between ride dependency among older adults and various indicators of their well-being.
- **P1 Aim 5:** Describe the regular activity spaces among the sample, including types and frequency of routine activities, and accessibility of key activities based on regular activity space boundaries.
- **P1 Aim 6**: Assess the association of ride dependency among older adults and the size of their regular activity spaces.
- **P1 Aim 7:** Identify associations between the size of older adults' regular activity spaces and various indicators of their well-being.

The aims of the Phase 2 survey of people who provide private transportation (i.e., give rides) to older Vietnamese adults in the Dallas-Fort Worth metroplex are to:

- **P2 Aim 1**: Describe the transportation resources and behavior among the sample (e.g., household automobile ownership, modes of transportation, frequency of transportation use).
- **P2 Aim 2:** Describe the types and frequency of rides provided.
- **P2 Aim 3:** Describe the impacts (i.e., financial cost, missed work, missed healthcare appointments, increased personal stress, increased family stress) of providing rides reported by ride providers.
- **P2 Aim 4:** Using regular and ride-provision activity spaces, calculate metrics (i.e., burden indicators) for assessing the geospatial burden of providing rides.
- **P2 Aim 5:** Evaluate the association of the burden indicators with each other and with impacts of providing rides.

3.0 METHODOLOGY

This two-phase, cross-sectional survey research examines transportation-related knowledge and behaviors of older Vietnamese adults and their ride providers in the Dallas-Fort Worth metroplex (DFW). Phase 1 includes Vietnamese adults aged 65 or older throughout DFW. Phase 2 surveys people who provide private transportation to older Vietnamese adults in DFW.

Some of the methodology presented in this section is specific to Phase 1 or Phase 2; other methods apply to both phases. When appropriate, we present the common methods first and then provide methods specific to Phase 1 followed by Phase 2 methods.

All research participants provided informed consent to participate in the research. The research protocols were approved by The University of Texas at Arlington's Institutional Review Board (protocol #: 2019-0454).

3.1 PROJECT REVISIONS RELATED TO COVID-19

Originally, this project was to consist of three phases. Phase 1 was to be conducted in a senior center in Arlington, TX; Phase 2 focused on individuals who gave rides to Phase 1 participants; and Phase 3 consisted of simulations of the social network within the senior center after various network interventions to optimize access to transportation resources and knowledge within the senior center's network of members. These plans were altered in response to the COVID-19 pandemic because the senior center closed.

3.2 RESEARCH SITE - DALLAS-FORT WORTH METROPLEX

The Dallas-Fort Worth-Arlington metropolitan area (DFW metroplex or DFW) is located in north Texas and describes a metropolitan statistical area of 13 counties (Bureau of Labor Statistics, 2020). It is home to over 7.6 million residents (U.S. Census Bureau, 2020e), including more than 606,000 Asian residents. The two most central counties in this region are Tarrant and Dallas counties, home to the cities of Fort Worth and Dallas, respectively. The metroplex has experienced rapid growth over the past decade, adding more than 1.2 million residents (Texas Demographic Center, 2021). Racial and ethnic diversity have increased since 2010, with a greater percentage of the population increase contributed by Black, Hispanic, and Asian residents than white residents and Asian populations growing at the fastest rate (Texas Demographic Center, 2021). The estimated median household income is $72,265 (U.S. Census Bureau, 2019).

3.2.1 Dallas County, TX

Dallas County is 871 square miles with a population of over 2.6 million (U.S. Census Bureau, 2020f). It encompasses 31 cities including the city of Dallas. Approximately 16,000 residents are 65 years or older and identify as Asian, comprising 5.7% of the 65-and-over population (U.S. Census Bureau, 2020j).

Approximately 23,000 Vietnamese immigrants live in Dallas County (U.S. Census Bureau, 2020a).

A large portion (93%) of the households in Dallas County have at least one vehicle available (U.S. Census Bureau, 2020h). Dallas County is home to the Dallas Area Rapid Transport (DART) public transport system, providing bus and rail services throughout the county (DART, 2022). The majority of commuters in Dallas (76%) drive to work alone, 2.3% use public transportation, and 11% carpool, with the remaining walking or using another form of transport (U.S. Census Bureau, 2020m). A smaller portion (74%) of Asian workers in Dallas County drive to work alone and similar portions (11% and 2.2%, respectively) carpool or use transportation (U.S. Census Bureau, 2020c).

3.2.2 Tarrant County, TX

Tarrant County is 863 square miles with a population of approximately 2.1 million (U.S. Census Bureau, 2020g). It is home to Fort Worth, TX, and includes bedroom communities in the DFW metroplex such as Arlington, Grand Prairie, Euless, and Haltom City. Approximately 24,000 Vietnamese immigrants live in Tarrant County (U.S. Census Bureau, 2020b). Almost 12,000 residents are 65 years or older and identify as Asian, comprising 5% of the 65-and-older population (U.S. Census Bureau, 2020k).

A large portion (96%) of the households in Tarrant County have at least one vehicle available (U.S. Census Bureau, 2020i). The county has transit service in Fort Worth, but no public transportation in the periphery of the county. In Tarrant County, the vast majority (80%) of commuters drive themselves and 10% carpool (U.S. Census Bureau, 2020n). Only 0.3% of residents use public transportation to commute (U.S. Census Bureau, 2020n), in contrast to 2.3% who use public transport in Dallas County, and 4.6% nationwide (U.S. Census Bureau, 2020l).

Although a large majority of Asian commuters in Tarrant County (77%) drive themselves to work (U.S. Census Bureau, 2020d), they are slightly overrepresented in those who carpool or take public transportation. Asian commuters comprise 5.8% of all work commuters, but 7.8% of those who carpool and 8.1% of those who take public transportation (U.S. Census Bureau, 2020n).

3.3 RECRUITMENT

3.3.1 Recruitment for Phase 1 (Older Vietnamese Adults)

The inclusion criteria for Phase 1 were (1) being at least 65 years old; (2) being Vietnamese or Vietnamese American; (3) residing or participating in social/health activities in the Dallas-Fort Worth metroplex; and (4) ability to communicate orally in English or Vietnamese. Phase 1 recruitment of older Vietnamese adults began in June 2020. After consulting with influential leaders in the Vietnamese community, we

identified several sites to post Vietnamese- and English-language recruitment flyers, including churches, temples, shopping centers, and gyms. Several organizations that served older Vietnamese people in the region posted electronic versions of the recruitment flyers on their websites, informed their clients of the research, or helped distribute flyers. Employees at two Vietnamese senior centers made referrals to the study for potentially eligible members. A weekly Vietnamese language magazine included information about the study for approximately six weeks. We offered research participants a $20 Walmart gift card for completing the questionnaire.

3.3.2 Recruitment for Phase 2 (Private Transportation Providers)

The inclusion criteria for Phase 2 were (1) being at least 18 years old and (2) providing transportation to any Vietnamese adult aged 65 or older in the Dallas-Fort Worth metroplex. Recruitment for Phase 2 began in June 2020. Potential Phase 2 participants were identified during the interview for Phase 1 data collection, during which participants were asked for the names and contact information of individuals who provided them with private transportation to invite them to participate in the study. Using this information, a data collector contacted the transportation providers to invite them to participate. Due to the low number of participants in Phase 1 who received rides from others, we expanded Phase 2 recruitment efforts to include anyone who provided rides to an older Vietnamese adult in the study area. To recruit these additional Phase 2 participants, we used snowball sampling, connected with student groups at a local university, and included information about Phase 2 on our recruitment flyers. Initially, Phase 2 participants were compensated with a $10 Walmart gift card. This was increased to $20 in October 2020 to assist with recruitment.

3.4 DATA COLLECTION

For both phases, data collection began in July 2020 and concluded in January 2021. The questionnaires were interviewer-administered in either Vietnamese or English as preferred by the participant. The questionnaires were initially developed in English, translated into Vietnamese by a bilingual native Vietnamese research team member, and back-translated into English by another bilingual native Vietnamese research team member. The original and back-translated English versions were compared by the two translators and the Principal Investigator, discrepancies were identified, and the Vietnamese translation was revised by consensus between the two translators.

Due to COVID-19 restrictions, all data collection took place by telephone. Responses were recorded electronically using Qualtrics software. The questionnaires for Phase 1 encompassed several constructs related to well-being, mobility and transportation, and took most participants between 30 and 45 minutes to complete. Phase 2 questionnaires were shorter and took approximately 20 minutes.

We collected complete Phase 1 survey data from 97 older adults, but two did not meet the inclusion criteria of being Vietnamese or Vietnamese American, leaving 95 survey responses. All but three of the Phase 1 interviews were conducted in Vietnamese. We collected Phase 2 survey data from 20 ride providers. Of these, 11 provided rides to a

known Phase 1 participant. Nine of the Phase 2 interviews (45%) were conducted in English; the remaining 11 (55%) were conducted in Vietnamese.

3.5 MEASURES

The questionnaires for Phase 1 and Phase 2 had several constructs in common: (1) demographic information; (2) transportation; (3) activity space; and (4) COVID-19-related changes. We present information about the common constructs first and then present measures exclusive to Phase 1 followed by those exclusive to Phase 2.

3.5.1 Measures Used for both Phase 1 and Phase 2

Each of the common constructs that were measured in Phase 1 and Phase 2 had identical wording for the items. However, in a few instances noted below, the response options differed.

3.5.1.1 *Demographic Information Common to Phase 1 and Phase 2*

Race and ethnicity measures were assessed based on the 2015 National Content Test of the U.S. Census Bureau (2017). Participants were asked "What categories best describe you?" (*white*; *Hispanic, Latino, or Spanish*; *Black of African American*; *Asian*; *American Indian or Alaska Native*; *Middle Eastern or North African*; *Native Hawaiian or other Pacific Islander*; *Some other race, ethnicity, or origin*) and instructed to select as many as applied. Additional options were presented based on the race(s) selected. For example, if the participant identified as Asian, they were presented with a follow-up question(s) related to ethnicity or national origin that asked, "Which categories describe you?" and included (*Vietnamese, Chinese, Filipino, Korean, Asian Indian, Japanese, and Write in, for example, Pakistani, Cambodian, Hmong, etc.*).

Table 3.1 presents information about the other demographic measures on both the Phase 1 and Phase 2 questionnaires.

Table 3.1 Variables measured in both Phase 1 and Phase 2 questionnaires.

Variable	Item	Phase 1 Values	Phase 2 Values
Age	How old are you?	Years (continuous)	
Gender	What is your gender?	0 = *Male;* 1 = *Female;* 2 = *Other*	
Marital status	What is your marital status?	1 = *Single;* 2 = *Married or domestic partnership;* 3 = *Widowed;* 4 = *Divorced;* 5 = *Separated*	
Education	What is the highest level of education you have completed?	1 = *Less than high school* 2 = *high school diploma or equivalent* 3 = *some college or an Associate degree* 4 = *college degree* 5 = *graduate, professional, or doctorate degree*	
Country of birth	Where were you born?	0 = *The United States; 1 = Vietnam;* 2 = *Other* ____	

Length of time in US	If born outside the US: How long (in years) have you lived in the United States?	Years (continuous)	
Language spoken at home	What language do you primarily speak at home?	0 = *English;* 1 = *Vietnamese;* 2 = *Other* _____	
Monthly income	Phase 1: What is your monthly income from all sources (in dollars)? Phase 2: What is your monthly household income from all sources?	1 = Less than $1,000 2 = $1,000 to $1,499 3 = $1,500 to $1,999 4 = $2,000 to $2,499 5 = $2,500 or more	Continuous in dollars ($0-$15,000)

Phase 1 and 2 participants were also asked to provide their home address in an open-ended question in which the participant provided a street address or nearby cross street. Data were collected using Google Maps integration in Qualtrics, which provided latitude/longitude coordinates.

3.5.1.2 *Transportation Items Common to Phase 1 and Phase 2*

3.5.1.2.1 *Automobile Ownership*

One item on the questionnaires asked, "Do you or someone in your household own an automobile?" For Phase 1, the item was binary (1 = *Yes*, 0 = *No*). Phase 2 respondents could select as many of the following options that applied: 1 = *Yes, I own a working automobile*, 2 = *Yes, I own an automobile, but it does not work*, 3 = *Yes, someone in my house owns a working automobile*, 4 = *Yes, someone in my house owns an automobile, but it does not work*, and 5 = *No*.

3.5.1.2.2 *Modes and Frequency of Transportation Used*

Modes of transportation were adapted from the FSU Older Adult Survey (Wood et al., 2017). Participants were asked, "Which of the following modes of transportation do you use? (Select all that apply)" and were presented with the following options:

- walking for transportation
- drive myself
- get a ride with someone else
- city bus or other public transportation
- taxi or ride-sharing services like Uber, Lyft, Via, etc.
- Handi-Tran, ACCESS, DART paratransit, [these were local paratransit services] or other dial-a-ride services
- Other (write in)

For each mode of transportation selected, the frequency of that mode was assessed with a question that asked the frequency of use (1 = *Less than*

once per month; 2 = *Once per month*; 3 = *A few times per month*; 4 = *Once per week;* 5 = More than once per week; 6 = *Once per day*; 7 = *More than once per day*).

3.5.1.2.3 *Monthly Transportation Costs*

To assess monthly transportation costs, the participant was instructed to, "Think about all of the ways you might spend money on transportation. This can include expenses of owning a car like car payments, insurance, parking, and gasoline or fares for riding public transportation, taxis, or ride-shares" and then asked, "Approximately how much money (in dollars) do you spend each month on your transportation?"

The variable for Phase 1 was measured ordinally ($0; $1 to $149; $150 to $299; $300 to $449; $450 to $599; $600 to $749; $750 to $999; $1,000 or more). For Phase 2, monthly transportation costs were measured as a continuous variable with a slider ranging from $0 to $2,000.

3.5.1.3 ***Routine Activities***

To assess participants' regular activity space, the surveys included three dimensions of activity space: residence, routine activity destinations, and healthcare (Sherman et al., 2005). Items similar to those on the VERITAS questionnaire (Chaix et al., 2012) were used to obtain information about the frequency and location of activities over the time span of the previous month. Participants were asked to report on their routine activities with a question that asked, "Which of the following activities do you do routinely, at least once a month?" A list of 20 potential activities such as grocery shopping, visit friend or family member, eat out, church or other religious activity, exercise, health care facility, etc. was provided. Participants could also write in other routine activities or add additional health care facilities that were not on the list.

For each activity selected, participants were asked to provide the frequency (0-30 days/month) and the location of the activity. To collect the location, we used the Google Maps integration feature in Qualtrics. Data collectors were able to type in a precise address if the information was available. They could also search within Google Maps using a business name, cross streets, etc. If the participant was not able or did not wish to provide an exact location, the data collector could place a Google Maps pin at a nearby cross street location. The location data were collected in Qualtrics and stored in the dataset as latitude/longitude coordinates.

3.5.1.4 ***Effects of COVID-19***

Participants were prompted about how they perceived the COVID-19 social distancing protocols affected their mobility with the question: “Thinking back over the information you have provided us, what has changed since the outbreak of

the coronavirus and how has it changed? Can you tell us details about your experiences with transportation since the outbreak?” Responses were written down by the data collector verbatim.

3.5.2 Measures Exclusive to Phase 1

The survey for the older Vietnamese adults in Phase 1 included several measures for health and well-being.

3.5.2.1 *Social Integration*

3.5.2.1.1 *Living Alone*

The older adults who participated in Phase 1 were asked, "Do you live alone or with other people?" (1 = *I live alone*; 0 = *I live with other people*). If they indicated they lived with other people, an open-ended question asked for the relationship of person with whom they lived (e.g., daughter, spouse).

3.5.2.1.2 *Perceived Social Support*

To measure perceived social support, we used four items from the Medical Outcomes Study Social Support Survey (Sherbourne & Stewart, 1991). The items asked how often four kinds of informational and tangible support were available if needed, and were rated on a five-point scale from 1 = none of the time to 5 = all of the time. The types of support assessed were someone to (1) give information to understand a situation; (2) turn to for suggestions; (3) help if confined to bed; and (4) take them to the doctor if needed. The items were summed for a score ranging from 4 to 20, with higher scores indicating greater levels of perceived support. Cronbach's alpha for the four items was .73.

3.5.2.2 *Physical Health*

3.5.2.2.1 *Global Self-Rated Health*

Three items comprised the global self-rated health measure. The first two: “How would you rate your overall health at the present time? Would you say it is excellent, good, fair, or poor?” and “In general, how satisfied are you with your health?“ were rated on a Likert-type scale of 1 to 4, with 1 indicating worse perceived health or satisfaction and 4 indicating better health or satisfaction. The third item, “Would you say your health is better, about the same, or worse than most people your age?” was scored 1 = *Better*, 0 = *About the same*, -1 = *Worse*. The items were summed for a measure of global self-rated health ranging from 1 to 9. In other studies (Assari, 2017; Chen et al., 2021; Mackenzie et al., 2018), this measure for

global self-rated health has demonstrated acceptable Cronbach's alpha estimates of internal consistency of between .68 and 0.85.

3.5.2.2.2 *Multimorbidities*

Disease counts are the most common measure of multimorbidity and have the highest predictive value for quality of life and care utilization (Huntley et al., 2012). We used a disease count to assess multimorbidity in which participants were asked to respond Yes or No (1 = *yes*, 0 = *no*) to having received a diagnosis by a doctor or other health professional for a list of nine categories of disease: arthritis, dementia, depression, diabetes, high blood pressure, kidney disease, lung disease, cancer, and stroke. A 10th category of “other” allowed the participant to include additional diagnoses, which were added to the count for a measure of multimorbidity disease count.

3.5.2.2.3 *Physical Limitations*

To measure physical limitations, we used a common approach (Verbrugge, 2016) of counting limitations in activities of daily living (ADLs) and instrumental activities of daily activity (IADLs). ADLs are fundamental activities needed to live independently such as bathing, dressing, toileting, and feeding oneself. IADLs are more complex activities of living independently such as money and medication management, shopping, and housekeeping.

To assess ADLs, we presented participants with a list of seven ADLs (walking across a small room; bathing; personal grooming like brushing hair, brushing teeth, or washing face; dressing; eating like holding a fork, cutting food, or drinking from a glass; getting from a bed to a chair; using the toilet) and asked if they needed help to perform them (0 = don't need help; 1 = need help; 3 = unable to do). The ADLs a respondent needed help to perform or was unable to do were summed for a number of ADL limitations (range = 0 to 7).

The participants were given a list of 10 IADLs including using the telephone without help, shopping for groceries or clothes without help, preparing your own meals without help (Lawton & Brody, 1969) and were asked if they could "do these activities by yourself without help from anyone else" (0 = *Yes*, 1 = *No*). The responses were summed for a count of the number of IADL limitations (range = 0 to 10). Finally, the number of ADL and IADL limitations were summed for a measure of physical limitations.

3.5.2.2.4 *Use of Assistive Equipment or Devices*

A single item asked, "Do you ever use any assistance, including equipment or devices such as a cane, walker, or wheelchair when crossing a room?" (0 = *No*, 1 = *Yes*). Yes responses indicate a greater level of physical limitation.

3.5.2.3 *Mental Health*

3.5.2.3.1 *Perceived Stress*

We used the four-item perceived stress scale (PSS-4, Cohen et al., 1983) to measure stress. The PSS-4 asks participants to estimate how they felt over the past month on a Likert-type scale of (1) never to (5) very often in response to the following questions about their thoughts and feelings: “How often have you felt that you were unable to control the important things in your life?”; *“How often have you felt confident about your ability to handle your personal problems?”; *"How often have you felt that things were going your way?”; and “How often have you felt difficulties were piling up so high that you could not overcome them?” The questions preceded by an asterisk are reverse coded and the item values are summed. Scores on the PSS-4 can range from 1-20, with higher scores indicating greater levels of perceived stress.

3.5.2.3.2 *Loneliness*

The shortened, three-item version of the UCLA Loneliness Scale (Hughes et al., 2004) was used to measure feelings of lacking companionship, being left out, and social isolation. Participants were asked to rate how often they (1) “Feel that you lack companionship?”, (2) “Feel left out?”, and (3) “Feel isolated from others?” (1 = *hardly ever (or never)*; 2 = *some of the time*; 3 = *often*). The mean of these three items was used as the measure of loneliness for this scale.

3.5.2.4 *Transportation*

In addition to the transportation-related questions that were common to both Phase 1 and Phase 2, the older adults in the Phase 1 sample were also asked about their knowledge of transportation services, their ride providers, and whether they had missed activities due to a lack of transportation.

3.5.2.4.1 *Ride dependency*

Ride dependency (1=*Yes*; 0=*No*) was a calculated variable based on two reported modes of transportation: driving self and getting rides with others. Among those who reported either of these modes, it contrasts those who reported solely driving themselves without getting rides from others (no ride

dependency) from those who reported solely getting rides from others (ride dependency), excluding those who reported both modes of transportation.

3.5.2.4.2 *Transportation Financial Burden*

Transportation financial burden was a calculated variable derived from monthly income and monthly transportation expenditures. Transportation financial burden was conceptualized as spending more than 15% of income on transportation, the mean amount spent by recipients of federal housing assistance in the Dallas-Fort Worth metroplex (Hamidi et al., 2016). Because income and transportation expenditures were measured as ordinal variables, we used the midpoint of the income and expenditure ranges to determine if monthly transportation expenditures divided by monthly income was greater than .15 (0 = *no*, 1 = *yes*).

The value for transportation financial burden was only calculated for participants who had valid responses for monthly transportation costs (n = 79) and monthly income (n = 64). This yielded transportation financial burden values for 59 participants in the Phase 1 sample.

3.5.2.4.3 *Knowledge of Transportation Services*

A participant's knowledge of transportation services was assessed by the following series of questions:

- I know how to use a dial-a-ride service for older adults in my community.
- I am knowledgeable about the rules and regulations for dial-a-ride services.
- If I have questions about using dial-a-ride services in my community, I know how to get the answer.
- I know how to use the bus or train (public transportation) in my community.
- I know the bus routes and schedules in my community.
- I am knowledgeable about the rules and regulations regarding public transportation in my neighborhood.
- If I have questions about using the public transportation in my community, I know how to get the answer.

Reponses were rated on a 5-point Likert-type scale from 1 = *strongly disagree* to 4 = *strongly agree*. If the participant judged the statement as not applicable, then 0 = *does not apply* was indicated as the response. Cronbach's alpha for this measure was .835, indicating good internal consistency.

3.5.2.4.4 *Missed Activities Due to Lack of Transportation*

We assessed activities missed due to lack of transportation. In alignment with the routine activities list used to assess activity space, we provided participants with a list of 20 potential activities (see Section 3.5.1.3) and asked them to select which of the following they had "been unable to do because you did not have transportation?" In addition to the activities on the list, they could select "Other" or "None."

3.5.2.4.5 *Transportation to Healthcare Facilities*

The final transportation-related question asked about the primary mode of transportation when obtaining health services (1 = *walking*; 2 = *drive myself*; 3 = *get a ride with someone else*; 4 = *city bus or other public transportation*; 5 = *taxi or ride-sharing service like Uber, Lyft, Via, etc.*; 6 = *Handi-Tran, ACCESS, DART paratransit, or other dial-a-ride service*; and 7 = *Other*).

3.5.3 Measures Exclusive to Phase 2

The questionnaire included several items to help assess the impact of giving rides across dimensions.

3.5.3.1 ***Rides Provided to Older Adult: Types of Activities***

To assess Phase 2 participants' ride-provision activity spaces, the questionnaires asked participants about the rides they gave the older adult. Specifically, it assessed the frequency of giving rides to the older adult for routine activities and the location of the activity. The Phase 2 participant was presented with the same list of 20 potential activities for ride giving as in the earlier section (3.5.1.3) related to personal routine activities. Participants could also write in other routine activities or add additional health care facilities that were not on the list. For each activity selected, participants were asked to provide the number of days each month (0-30) that they took the older person to the activity and the location of the activity.

To collect the location, we used the Google Maps integration feature in Qualtrics, as described above. The location data were collected in Qualtrics and stored in the dataset as latitude/longitude coordinates.

3.5.3.2 ***Frequency of Providing Rides***

To understand the frequency of providing rides, the questionnaire contained one item that asked, "How many days each month do you give rides to [older adult]?" and collected responses as a continuous variable from 0-30.

3.5.3.3 *Impacts of Providing Rides*

On the questionnaire, we directly assessed potential negative effects associated with providing rides to an older adult. First, we asked ride providers to select as many impacts as applied from a list of potential impacts (0 = no; 1 = yes) that included (1) incurred transportation related expenses; (2) missed work; (3) missed own healthcare appointments; (4) increased personal stress; (5) increased family stress; and (5) other. If at least one of these was selected, we considered there to be an impact of providing rides (0 = no; 1 = yes).

For those who indicated they incurred transportation-related expenses, the questionnaire asked for the total monthly transportation-related expenses incurred as a result of providing transportation to the older adult: *"Approximately what are your total monthly transportation-related expenses (gasoline, tolls, parking, etc.) that you have incurred as a result of providing transportation to [older person]?"* Responses were collected as a continuous variable in dollars per month.

3.6 ANALYSIS

3.6.1 Descriptive Statistics

Our initial dataset of 95 Phase 1 survey responses contained data from individuals who were married and living in the same household. To avoid violating assumptions of independence of observation, we removed one member of each married pair from our final sample. If there was a corresponding Phase 2 survey for one of the married pair (*n* = 4), we retained that participant in the Phase 1 sample. Otherwise, we used a random number generator in Excel to select which participant remained in the sample. With these deletions, the final sample for Phase 1 was 84 older adults.

To describe each sample, we calculated means/standard deviations and frequencies/percentages for study variables for the final Phase 1 sample (*n* = 84) and Phase 2 sample (*n* = 20) as shown in Table 3.2:

Table 3.2. Descriptive statistics calculated for variables to address study's aims.

Phase 1	Variables
Aim 1: Describe the transportation resources and behavior among the sample (e.g., household automobile ownership, modes of transportation, frequency of transportation use)	Automobile ownership Modes of transportation Transportation to healthcare facilities Frequency of using various modes of transportation Transportation costs Transportation burden
Aim 2: Describe the sample's level of knowledge of public transportation in their community, including paratransit services	Public transportation knowledge items
Aim 3: Understand the effects of lack of transportation on key social, health care, and household maintenance activities (i.e., missed appointments and opportunities)	Activities missed due to lack of transportation

Aim 5: Describe…the types and frequency of routine activities	Routine activities, including frequency and location
Phase 2	**Variables**
Aim 1: Describe the transportation resources and behavior among the sample (e.g., household automobile ownership, modes of transportation, frequency of transportation use)	Automobile ownership Modes of transportation Frequency of using various modes of transportation
Aim 2: Describe the types and frequency of rides provided	Ride-provision activity type and frequency
Aim 3: Describe the impacts (i.e., financial cost, missed work, missed healthcare appointments, increased personal stress, increased family stress) of providing rides reported by ride providers	Monthly expense of providing rides Missed work Missed healthcare appointments Increased personal stress Increased family stress

All descriptive statistics were calculated using SPSS version 25.

3.6.2 Bivariate Associations of Ride Dependency with Various Indicators of Well-Being

Our fourth aim for Phase 1 was to identify associations between ride dependency among older adults and various indicators of their well-being. To analyze the data for this aim, we examined the pairwise relationships of ride dependency with various outcomes relating to well-being, including physical and mental health. The physical health outcomes considered were global self-rated health, multimorbidity disease count, number of ADL limitations, number of IADL limitations, and use of assistive equipment/devices. The mental health outcomes and other indicators of well-being considered were perceived stress, loneliness, and perceived social support.

The specific statistical test conducted depended on the scale of dependent variables involved in the bivariate relationship. Linear regression was used for continuous outcomes and logistic regression was used for dichotomous (binary) outcomes. The dependent variables were one of the physical health, mental health, or well-being outcomes. In all cases, the independent variable was ride dependency. Our findings report unstandardized estimates of coefficients for the effect of the independent variable for linear regression analyses and odds ratios for logistic regression analyses.

We set an alpha level of 0.1 for evaluating whether relationships were statistically significant. The bivariate analyses were executed using Stata 15.1.

3.6.3 Geospatial Analysis

Geospatial analyses using ArcGIS were conducted to address the following research aims related to activity spaces and geospatial burden of providing rides:

Phase 1 Aim 5: Describe the regular activity spaces among the sample, including types and frequency of routine activities, and accessibility of key activities based on regular activity space boundaries.

Phase 1 Aim 6: Assess the association of ride dependency among older adults and the size of their regular activity spaces.

Phase 1 Aim 7: Identify associations between the size of older adults' regular activity spaces and various indicators of their well-being.

Phase 2 Aim 4: Using regular and ride-provision activity spaces, calculate metrics (i.e., burden indicators) for assessing the geospatial burden of providing rides.

Phase 2 Aim 5: Evaluate the association of the burden indicators with each other and with impacts of providing rides.

Using the survey data collected regarding the latitude/longitude coordinates of home addresses and routine activities along with the frequency of routine activities, we estimate activity spaces for participants' regular activities (i.e., *regular activity space)*. For Phase 1, we identify bivariate associations between the size of the older adults' regular activity spaces, ride dependency, and various indicators of well-being, including physical and mental health.

In addition to estimating regular activity spaces for Phase 1 and Phase 2 participants, we also estimate a *ride-provision activity space* for Phase 2 participants who provided rides for an older Vietnamese person in the Dallas-Fort Worth metroplex. The ride-provision activity space is estimated using the locations and frequencies of activities for which the Phase 2 participant gave rides to the older adult (e.g., took the older adult to church four times per month).

Finally, to assess the geospatial burden of providing rides, we examine the overlap of the Phase 2 participant's own regular activity space and their ride-provision activity space. Using this geospatial overlap, we describe three different "burden indicators" designed to ground the rides given within the context of the ride provider's own regular activity space (e.g., to what extent is the ride provider leaving their own regular activity space to provide rides?).

In the following subsections, we describe the methods used to created, describe, and analyze the Phase 1 and Phase 2 activity spaces and Phase 2 burden indicators.

3.6.3.1 *Estimating Regular Activity Spaces for Phase 1 (Older Adults) and Phase 2 (Ride Providers)*

We used ArcGIS to translate the survey latitude/longitude responses related to regular monthly destination points into geographic locations. For all participants who provided a home address and at least two routine activity locations (i.e., three geographic locations), we created one standard deviation geospatial ellipse (SDE1), a commonly used Euclidean measure to represent activity space (Sherman et al., 2005). A standard deviation ellipse (SDE) has axes determined by the dispersion of the geospatial locations from the mean center (Yuill, 1971).

A standard deviation ellipse can be weighted by frequency of travel to each location (Gesler & Meade, 1988). A SDE1 contains approximately 68% of the locations within its boundaries (Sherman et al., 2005).

For our analyses, we weighted the activity space by the frequency of the activity (i.e., number of days per month) and gave the home address a weighting of 30 since the respondent lived at that location. After all the activity locations for a respondent were mapped in ArcGIS, we generated the SDE1 using the directional distribution function within the spatial statistics tools in ArcGIS. The SDE creation measures *x* and *y* distance separately and calculates the mean *x* and *y* center point for the activity space. Using the center point, the process rotates the x-axis and creates orthogonal vectors projected from the center point with a length denoted by the standard deviation for this axis rotation. Therefore, two times the minimum standard deviation becomes the SDE1 minor axis length, and two times the maximum standard deviation becomes the SDE1 major axis length (Yuill, 1971). Figure 3.1 provides an example of a SDE1 for an older adult in Phase 1.

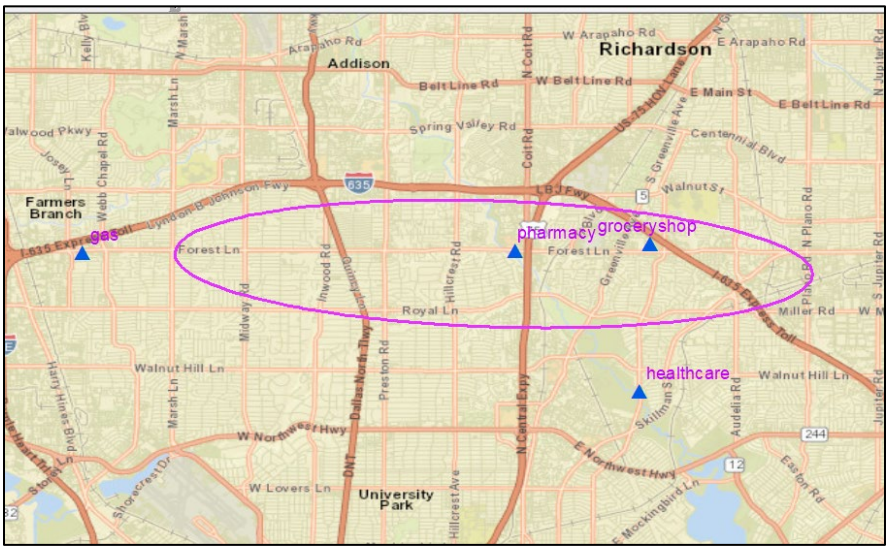

Figure 3.1: A regular activity space represented by a one standard deviation ellipse (SDE1) generated in ArcGIS using destinations of routine activities weighted by frequency of activity. In this example, the boundary of the 1SDE is colored in magenta. The older adult's routine activities are denoted as triangular points on the map in magenta labeled by the type of activity. © 2022, Mahshid Haque

For participants with only two geographic locations (*n* = 6), we represented the activity space with a half-mile road network buffer to approximate the size of the one-kilometer road buffer network used by Sherman et al. (2005). For these cases, we created the shortest path between these two points using the Network Analyst function in ArcGIS. After uploading the node junction (ND junction), edge (ND junction Edges), and point files into ArcGIS, we processed one ID at a time. The Closest Facility option in the Network Analysis tab selects the closest location for one trip end and removes any barriers. The Multiple Ring Buffer tool

creates a 0.5-mile radius “multiple ring buffer” along the shortest path to represent the activity space. An example with only two trip ends and a 0.5-mile buffer is shown in Figure 3.2.

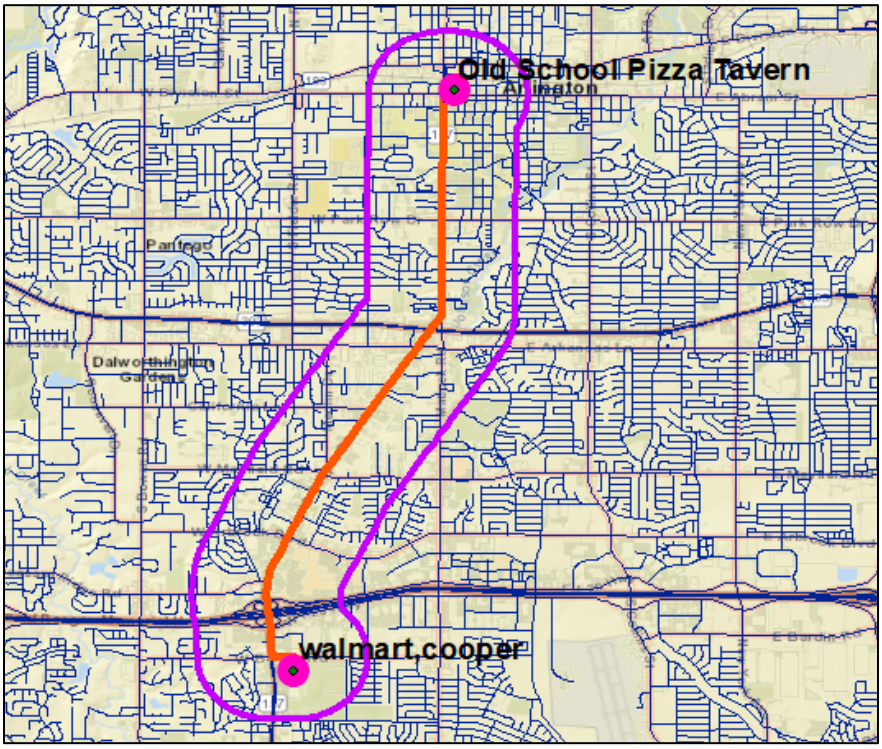

Figure 3.2: Regular activity space consisting of two locations represented by a half-mile road buffer. *Note*: The orange line denotes the shortest path between the two points. The locations are represented by magenta circles and the boundary of the half-mile road buffer is colored purple. © 2022, Mahshid Haque

3.6.3.2 *Describing Regular Activity Spaces for Phase 1 (Older Adults) and Phase 2 (Ride Providers)*

After creating the SDE1s to represent activity space, the study creates some performance measures to evaluate and describe the activity spaces. Primarily, the study measures the activity space size using the area (square miles) inside the SDE1. Once each SDE1 was created, we used automated tools within ArcGIS to calculate the area of the ellipse (i.e., polygon) in square miles.

Because the study is interested in the geospatial accessibility of health services and social opportunities, we also investigated the presence of key health, social, and household maintenance activity types within the activity space. This was determined by a visual inspection of SDE1 and all activity locations for each participant. The result was a dichotomous variable (0 = *no*, 1 = *yes*) for the presence of the following routine activity locations within the older adult's SDE1 regular activity space:

- visit friend or family member
- church or other religious activities
- senior center
- work
- health care facilities
- pharmacy
- exercising
- grocery shopping
- banking

3.6.3.2.1 *Bivariate Association between Size of Older Adults' Regular Activity Space, Ride Dependency, and Various Indicators of their Physical and Mental Health*

The final two aims for Phase 1 (Aim 6 and Aim 7) concerned bivariate associations between the size of the older adult's regular activity space and various outcomes relating to well-being, including physical and mental health. These aims are listed below:

P1 Aim 6: Assess the association of ride dependency among older adults and the size of their regular activity spaces.
P1 Aim 7: Identify associations between the size of older adults' regular activity spaces and various indicators of their well-being.

The distribution of the size of the older adults' regular activity space was highly right-skewed. Therefore, to address these two aims, we log transformed this variable to yield a distribution of values that was more normal in shape.

The physical health outcomes considered were global self-rated health, multimorbidity disease count, number of ADL limitations, number of IADL limitations, and uses of assistive equipment/devices. The mental health outcomes and other indicators of well-being considered were perceived stress, loneliness, and perceived social support.

The specific statistical test conducted depended on the type of variables involved in the bivariate relationship. The dependent variables were one of the physical, mental, and well-being outcomes Linear regression was used for continuous outcomes and logistic regression was used for dichotomous (binary) outcomes. In all cases, the independent variable was the log of the size of the regular activity space. Our findings report unstandardized estimates of coefficients for the effect of the independent

variable for linear regression analyses and odds ratios for logistic regression analyses.

We set an alpha level of 0.1 for evaluating whether relationships were statistically significant. The analysis was executed using Stata 15.1.

3.6.3.3 *Estimating Ride-Provision Activity Space for Phase 2 (Ride Providers)*

The ride-provision activity space considers the locations of the activities where rides are provided to the older adult (see Section 3.5.3.1 for measurement information). The study creates the ride-provision activity space using the locations of the activities where rides were provided and, when available, the older adult's home address (n = 9). The location of each activity was weighted by the frequency of providing rides to that location. In Figure 3.3, we present an example of the regular activity space and ride-provision activity space for one ride provider.

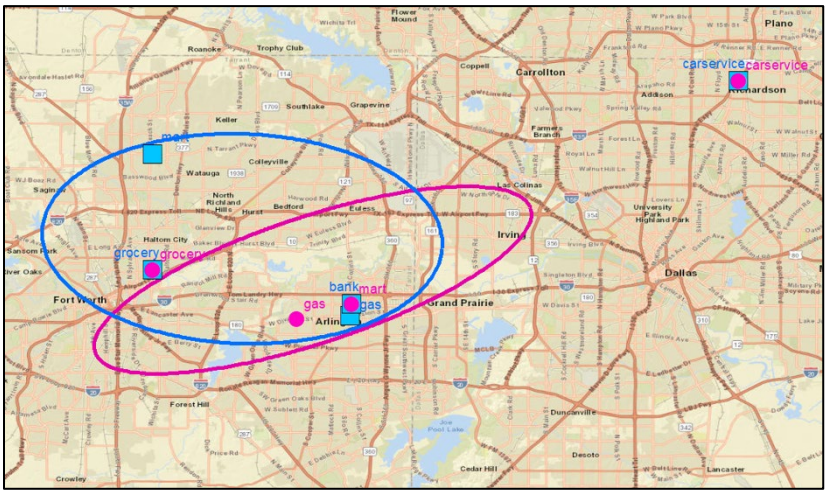

Figure 3.3. Map depicting a ride provider's SDE1 regular activity space (in blue) and ride-provision activity space (in magenta). *Note:* Locations of activities for the ride provider's regular activity space are represented with blue squares and labels. Locations of activities for providing rides to the older adult are represented by magenta circles within blue squares and magenta labels. © 2022, Mahshid Haque

3.6.3.4 *Estimating Geospatial Burden of Providing Rides (Phase 2 only)*

We developed three indicators for the geospatial burden of Phase 2 participants providing rides to an adult. These indicators are presented in the sections below as Burden Indicators A, B, C.

3.6.3.4.1 *Burden Indicator A: Size of Ride-Provision Activity Space*

The size of the ride-provision activity space can indicate a type of geospatial burden for the ride provider. For example, giving rides in a small, clustered area is likely easier than providing rides across a sprawling geospatial area. To account for this, Burden Indicator A calculates the area of the ride-provision SDE1 in square miles. This was done using automated tools within ArcGIS.

3.6.3.4.2 *Burden Indicator B: Percentage of Ride-Provision Activity Space that is Not "Accessible" to the Ride Provider*

The third indicator (Burden Indicator B) is an extension of the concept of accessibility (Sherman et al., 2005) used in Burden Indicator B. Rather than just considering the location of the older adult's home address, it examines the entire ride-provision activity space in relation to the ride provider's regular activity space. To calculate Burden Indicator B, we first determine the overlap of the ride provider's regular activity space SDE1 with their ride-provision SDE1. Figure 3.4 shades areas of the SDE1s to illustrate the components of the activity spaces based on the overlap.

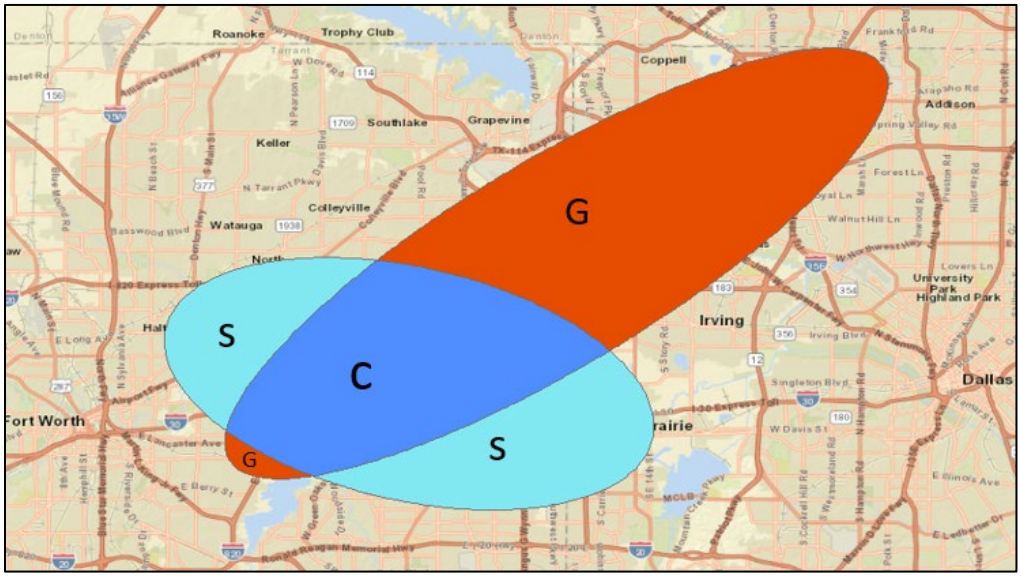

Figure 3.4: Labeling portions of the overlapped SDE1 regular activity space (S+C) and the ride-provision activity space (G+C). © 2022, Mahshid Haque

Burden Indicator B is conceptualized as the percentage of ride-provision activity space not accessible to the ride provider as determined by the boundaries of the ride provider's regular activity space.

As shown in Figure 3.4:

G = Area of rides provided that do not fall within the boundaries of the ride provider's regular activity space; considered "inaccessible"

C = Area that is common to both the ride provider's regular activity space and ride-provision activity space

G+C = Area of the ride provider's SDE1 ride-provision activity space

S+C = Area of the ride provider's SDE1 regular activity space

Using the notation above, the formula (equation 1) for Burden Indicator B (BI_B) is:

$$BI_B = \left(\frac{G}{G+C}\right) * 100 \qquad (1)$$

3.6.3.4.3 *Burden Indicator C: Ratio of Inaccessible Ride-Provision Activity Space to Ride Provider's Regular Activity Space*

The final burden indicator provides an assessment of how large the burden of providing trips outside the ride provider's regular activity space is in respect to the size of their regular activity space. The rationale for this is that if a ride provider has a large activity space, they may be accustomed to traveling long distances for their routine activities. In this case, taking on additional spatial travel responsibilities for providing rides may be less burdensome than for those with smaller regular activity spaces.

To operationalize Burden Indicator C, we divide the area of the ride-provision activity space SDE1 that is outside the regular activity space SDE1 by the area of the regular activity space SDE1. Using the notation presented in the section above, the formula for Burden Indicator C (BI_C) is equation 2:

$$BI_C = G/(S+C) \qquad (2)$$

3.6.4 Correlation of Geospatial Burden Indicators

To meet the Phase 2 research aim, "evaluate the association of the burden indicators with each other and with impacts of providing rides," we compute bivariate correlations among the burden indicators using Pearson's correlation coefficient. Statistical significance is set at $\alpha = .10$ due to the exploratory nature of this research question. Listwise deletion was used to handle missing data.

3.6.5 The Association of the Burden Indicators, Frequency of Providing Rides, and Reported Impacts of Providing Rides

To meet the Phase 2 research aim, "evaluate the association of the burden indicators with impacts of providing rides," we assess the association of each of the burden indicators listed in the preceding section with the following impacts reported by Phase 2 participants:

- frequency of providing rides (number of days/month rides are provided)
- average monthly transportation expenditures for giving rides (continuous variable)
- the existence of transportation-related impacts (incurring transportation expenses, missing work, missing health care appointments, increased personal stress, increased family stress)

We computed Pearson's correlation coefficient to determine the association of the geospatial burden indicators with the frequency of providing rides and the monthly cost of providing rides. We used Mann – Whitney U non-parametric independent samples comparison tests to determine if there is a difference between those who reported an impact and those who did not in the magnitude of the burden indicators. Statistical significance was set at alpha = .10 due to the exploratory nature of the research aim. Listwise deletion was used for cases missing values for a burden indicator.

4.0 FINDINGS

It is worth noting this study took place during the COVID-19 pandemic. Participants were surveyed about the effects of the pandemic, and many of the older adults noted they reduced their outings because of it. A few reported losing a job and a substantial minority indicated no changes. Ride providers most commonly reported increased precautions (e.g., wearing masks, using hand sanitizer), but not a reduction in outings. In fact, several indicated they were no longer curtailing their activities, with only a few reporting fewer outings for themselves or older relatives.

4.1 PHASE 1 (OLDER ADULTS)

All Phase 1 participants were born in Vietnam and identified ethnically as being Vietnamese (one also identified as Chinese). The majority of the sample were female, married, lived with other people, and had a monthly income of less than $1,000. Table 4.1 presents details.

Table 4.1. Descriptive statistics for sample of older Vietnamese adults. *N* = 84.

Variable	*n*	*%*	*M*	*SD*
Gender				
Female	54	64.3		
Male	30	35.7		
Marital Status				
Single	14	16.7		
Married/domestic partnership	43	51.2		
Widowed	14	16.7		
Divorced	7	8.3		
Separated	6	7.1		
Living Situation				
Lives alone	25	29.8		
Lives with others	59	70.2		
Education				
Less than high school	47	56.6		
High school diploma or equivalent	23	27.7		
Some college or Associate's degree	10	12.0		
College degree	3	3.6		
Country of birth				
Vietnam	84	100		
Ethnicity[a]				
Vietnamese	84	100		
Chinese	1	1.2		
Primary language spoken at home				
Vietnamese	84	100		
Monthly income				
Less than $1,000	51	79.7		
$1,000 to $1,499	11	17.2		
$1,500 to $1,999	1	1.6		
$2,000 to $2,499	1	1.6		
Age (65-95 years)	83		74.2	6.5
Length of time in US, if applicable (3-59 years)	82		27.3	10.8

Note. [a]Participants could select multiple options for ethnicity; therefore, total percentage > 100%.

4.1.1 Older Vietnamese Adults' (Phase 1) Health and Well-Being

In general, although the sample rated their general health highly, they demonstrated moderate to high levels of chronic disease and physical limitations. On average, participants reported having three different chronic disease diagnoses, with the most common being high blood pressure (*n* = 60, 76%); arthritis (*n* = 40, 51%); diabetes (*n* = 27, 35%); and dementia (*n* = 24, 31%). Only a minority of the respondents (*n* = 11; 13.6%) indicated they needed help or were unable to perform any of the basic activities of daily living (ADLs) such as bathing, grooming, or feeding oneself. However, two-thirds of the respondents (*n* = 54) indicated being unable to perform at least one instrumental activity of daily living (IADL) such as using the telephone without help, driving or using transportation alone, or doing light housework. A sizeable minority (40%) used assistive devices or equipment, with canes (*n* = 24, 29%) and wheelchairs (*n* = 10, 12%) being the most common types. Table 4.2 provides additional details.

Table 4.2. Health and well-being variables among sample of older Vietnamese adults. *N* = 84.

Variable	*n*	*%*	*M*	*SD*	min	max
Physical Health						
Global self-rated health (1-9)	63		5.0	1.6	1	8
Multimorbidity disease count	81		2.9	1.6	0	7
Number of ADL limitations (0-7)	81		0.3	1.1	0	7
Number of IADL limitations (0-10)	81		2.0	2.3	0	10
Uses assistive equipment or devices	31	40.3				
Walker	2	2.4				
Cane	24	28.6				
Wheelchair	10	11.9				
Holds onto furniture or walls	4	4.8				
Crutches	3	3.6				
Mental Health						
Perceived stress	81		5.3	2.7	0	11
Loneliness (1-3)	80		1.4	.6	1	3
Other Indicator of Well-Being						
Perceived social support (4-20)	81		11.5	3.8	4	20

Note. ADL = activities of daily living; IADL = instrumental activities of daily living

As presented in Table 4.2, most of the sample indicated low levels of perceived stress and loneliness. The average levels of perceived social support (informational and tangible) were relatively low, with average scores indicating that support was available somewhat less than "some of the time."

4.1.2 Older Vietnamese Adults' (Phase 1) Transportation Behavior and Knowledge

4.1.2.1 *Modes of Transportation Used*

The findings reflect a tendency to rely on private automobiles for transportation among the older adults in Phase 1. A majority of the sample (*n* = 69, 82%) lived in a household in which someone owned an automobile, and many (*n* = 41, 49%) drove themselves for transportation. Even more (*n* = 45, 54%) obtained rides from other people. The vast majority of those who relied on others for transportation (*n* = 44, 98%) had only one ride provider. Only a small portion used other forms of transportation such as walking, paratransit, ride sharing, or transportation. Details are provided in Table 4.4.

Table 4.4. Modes of transportation among sample of older Vietnamese adults. *N* = 84.

Variable	*n*	*%*
Drive self	41	48.8
Once per day	7	17.1
More than once per week	23	56.1
Once per week	4	9.8
A few times per month	5	12.2
Once per month	2	4.9
Walk for transportation	8	9.5
More than once per day	2	25.0
Once per day	1	12.5
Once per week	1	12.5
A few times per month	2	25.0
Less than once per month	2	25.0
Get ride with someone else	45	53.6
Once per day	1	2.3
More than once per week	11	25.0
Once per week	10	22.7
A few times per month	14	31.8
Once per month	3	6.8
Less than once per month	5	11.4
Public transportation	1	1.2
Less than once per month	1	100.0
Taxi or ride sharing	3	3.6
More than once per week	1	33.3
A few times per month	1	33.3
Less than once per month	1	33.3
Paratransit	4	4.8
More than once per week	1	25.0
A few times per month	3	75.0

Over half of the sample reported getting rides from someone else (*n* = 45, 53.6%). Only one of the older adults (2.2%) reported having two people who provided rides; the remainder relied on only one ride provider. Of the 37 ride providers whose language information was provided, 36 (97.3%) spoke Vietnamese as their primary language. The majority (*n* = 24, 58.5%) lived with the older adult for whom they provided and were family, including husband (*n* = 10, 23.3%) or wife (*n* = 2, 4.7%); child or child's spouse (*n* = 16, 37.2%); and sister (*n* = 2, 4.7%). Almost one-third of the ride providers were non-relatives such as friends, neighbors, and colleagues (*n* = 8, 18.6%) or paid helpers (*n* = 5, 11.6%).

For the calculated variable of ride dependency, 36 (53.7%) of the older adults who reported either driving themselves or getting rides, but not both, were determined to be ride-dependent.

4.1.2.2 *Modes of Transportation to Healthcare Services*

Over half of the respondents (*n* = 41, 51%) indicated their primary mode of transportation when getting health services was to get a ride with someone else. The next most common response was driving themselves (*n* = 34, 42%). Figure 4.1 below provides additional details.

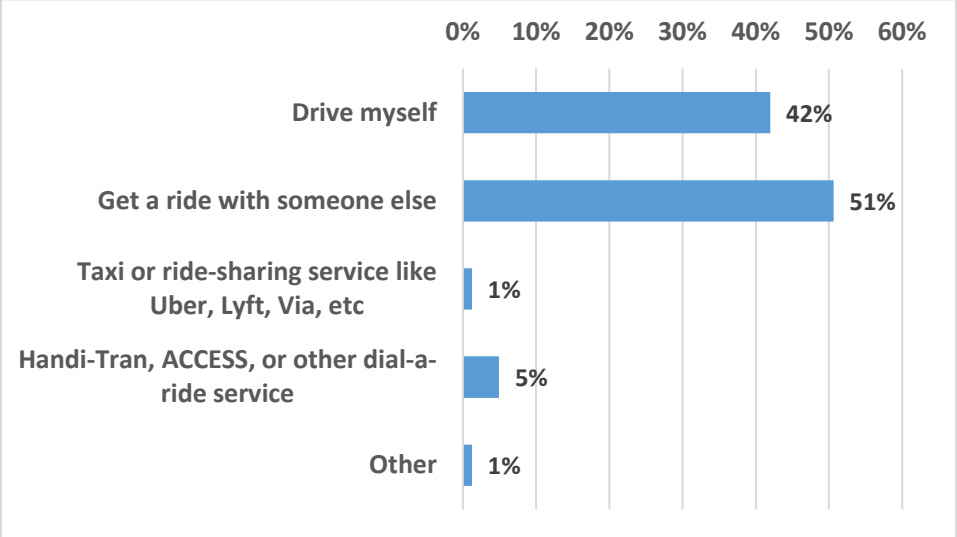

Figure 4.1. Responses for primary mode of transportation when getting health care among sample of older Vietnamese adults (*n* = 81). © 2022, Rebecca Mauldin

4.1.2.3 *Public Transportation Knowledge*

The mean score on the public transportation knowledge scale was 2.3 (*SD* = .57) out of a possible range of 1 to 4. The majority of the sample agreed or strongly agreed that they were knowledgeable about the rules and regulations regarding public transportation in their neighborhood. However, on the other items

regarding public transportation, most disagreed or strongly disagreed that they knew how to use public transportation in their community; knew the bus routes and schedules in their neighborhood; or knew how to get their questions about public transportation answered. Similarly, the older adults indicated a lack of knowledge about paratransit services in their communities. Information about responses for each item are provided below in Figure 4.2

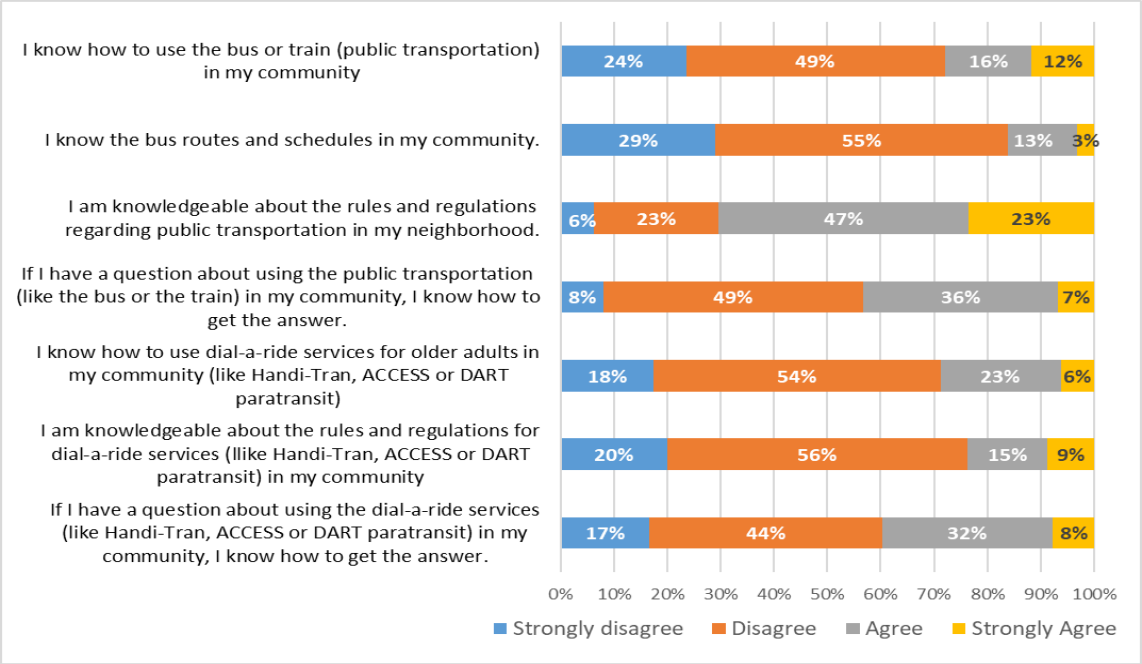

Figure 4.2. Responses to individual items related to public transportation knowledge among sample of older Vietnamese adults in the Dallas-Fort Worth Metroplex (*N* = 84). *Note.* "Does not apply" responses were omitted from analyses resulting in a range of 62-80 valid responses/item. © 2022, Rebecca Mauldin

4.1.2.4 *Transportation Costs and Burden*

A substantial minority (*n* = 28, 48%) of the older adults with valid transportation burden values experienced transportation financial burden as determined by spending more than 15% of monthly income on transportation. This high portion existed in spite of relatively low monthly expenditures on transportation (see Figure 4.3) because of the sample's low monthly income.

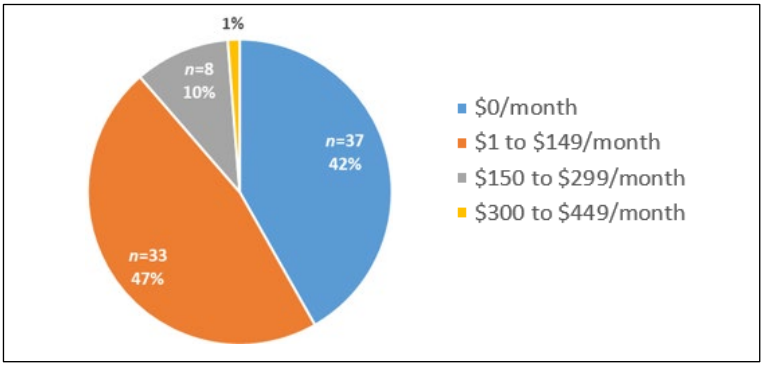

Figure 4.3. Monthly transportation expenditures among a sample of older Vietnamese adults (*n* = 79). © 2022, Rebecca Mauldin

4.1.3 Older Vietnamese Adults' (Phase 1) Routine Activities

The older adults reported many types of ongoing routine activities (see Table 4.5 for details). Grocery shopping was a common activity, reported by 70% of the sample. In contrast, routinely going to the beauty salon/barber was only reported by 2%. Some more common routine activities were cited by approximately one-fourth to one-third or more of the sample and included religious activities (36%), banking (29%), and buying gasoline (26%). There was a substantial variation in the frequency of the activities. For example, although a large majority went grocery shopping routinely, the frequency was only about five times per month, on average, compared to a less common activity, exercising, which was done, on average, 25 days/month by those who exercised.

Table 4.5. Mobility, routine monthly activities, and regular activity spaces among sample of older Vietnamese adults. *N* = 84.

Variable	*n*	*%*	*M*	*SD*	min	max
Area of Regular Activity Space (sq. miles)	73		6.0	9.6	.03	48.7
Current Routine Activities						
Grocery shopping	59	70.2				
Frequency (days/month)			5.1	4.7	1	30
Go to convenience mart	3	3.6				
Frequency (days/month)			3.3	1.2	2	4
Buy gasoline	22	26.2				
Frequency (days/month)			2.8	1.1	1	4
Shop for clothes or other retail items	9	10.7				
Frequency (days/month)			1.7	1.4	0	4
Visit friend or family member	9	10.7				
Frequency (days/month)			2.2	1.0	1	4
Eat out	7	8.3				
Frequency (days/month)			3.6	2.5	1	8
Church or other religious activities	30	35.7				
Frequency (days/month)			6.4	6.7	1	30
Exercise	16	19.0				
Frequency (days/month)			25.1	9.2	5	30
Pharmacy	15	17.9				
Frequency (days/month)			1.7	2.1	0	8
Beauty salon, barber, other personal care services	2	2.4				
Frequency (days/month)			1.0	0.0	1	1
Bank	24	28.6				
Frequency (days/month)			1.1	.5	0	3
Senior center	13	15.5				
Frequency (days/month)			11.2	9.7	1	30
Work	6	7.1				
Frequency (days/month)			19.3	1.6	16	20
Civic club, voting, or other community engagement	3	3.6				
Frequency (days/month)			8.0	6.9	0	12
Health Care Facility	19	22.6				
Frequency (days/month)			1.3	.9	0	4
Other	1	1.2				
Frequency (days/month)			1.0	0.0	1	1

4.1.4 Older Vietnamese Adults' (Phase 1) Regular Activity Spaces

We had sufficient data (i.e., home address and at least one routine activity location) to construct regular activity spaces for 72 of the older adults in the sample. Most (*n* = 57, 79.2%) were constructed using the one standard deviation (SDE1) approach. For the remaining cases with only one routine activity location (*n* = 15, 20.8%), the regular activity space was constructed using the half-mile road buffer method. On average, the regular activity spaces were 7.0 square miles (*SD* = 9.7) square miles, ranging from .03 to 48.7 square miles. As might be expected, the regular activity spaces that were constructed using the half-mile road buffer method (i.e., those with only) were smaller (M_{area} = 5.5 square miles; *SD* = 5.0) than those using the one standard deviation ellipse (SDE1) approach (M_{area} = 7.4 square miles; *SD* = *10.5*), but the difference was not statistically significant, *t*(70) = .559, *p* = .578).

Since ride dependency is a main explanatory variable in the statistical analysis, we also tested mean differences between those who were dependent on others for rides and those who drove themselves. The mean for those who were ride-dependent was 4.7 (*SD* = 5.7) square miles whereas the mean for those who drove themselves was 8.5 (*SD* = 12.0) square miles, a difference that was statistically significant at the 0.1 alpha level, (*t*(58) = 1.557, *p* = .063). Further, the area of activity space was log transformed for the purposes of statistical analysis due to its right-skewed distribution. The mean of the log transformed variable was .505 (*SD* = 1.85) for those who were ride-dependent as opposed to 1.466 (*SD* = 1.20) for those who drove themselves, and the difference was also statistically significant (*t*(58)=2.381, *p* = .021).

4.1.4.1 *Geospatial Accessibility of Routine Activities*

For those cases with a SDE1 regular activity space (*n* = 58), we also investigated whether key social, health care, and household maintenance routine activities were located within the boundary of the SDE1 (i.e., were geospatially accessible). For all participants who routinely went to work or exercise locations, the location was within their SDE1. Pharmacies were also commonly geospatially accessible (54.4%), but for most participants the locations of other key activities were not. Of note is the high prevalence of inaccessible church or religious locations (89%); senior centers (60%); grocery stores (77%); and healthcare facilities (73%). It is particularly striking in light of the importance of social engagement that none of the participants had locations for visiting friends and family that were within their regular activity space. See Table 4.6 for details.

Table 4.6. Prevalence of accessible locations for key routine activities among older Vietnamese adults in the Dallas-Fort Worth metroplex (*N* = 58).

Location for…	*n*	%
Visiting friends and family		
Accessible	0	0.0
Inaccessible	8	100.0
Church or other religious services		
Accessible	3	11.5
Inaccessible	23	88.5
Senior center		
Accessible	4	40.0
Inaccessible	6	60.0
Work		
Accessible	6	100.0
Inaccessible	0	0.0
Health care facility		
Accessible	3	27.3
Inaccessible	8	72.7
Pharmacy		
Accessible	6	54.5
Inaccessible	5	45.5
Exercising		
Accessible	10	100.0
Inaccessible	0	0.0
Grocery shopping		
Accessible	11	22.9
Inaccessible	37	77.1
Banking		
Accessible	5	27.8
Inaccessible	13	72.2

Note. Results presented are for those older adults with at least two routine activity locations in addition to a home address that were used in constructing a one standard deviation ellipse for regular activity space. Geospatial accessibility is calculated for participants who do the key activity routinely by determining if the activity location is within the boundaries of the SDE1.

4.1.4.2 *Activities Missed due to Lack of Transportation*

Almost a third of the sample (*n* = 25, 30%) were unable to participate in at least one type of activity in the previous month due to lack of transportation. In all, the participants cited 13 types of activities that were missed in the previous month due to lack of transportation. Among these, the most commonly missed type of activity was visiting friends or family, which was endorsed by 40% of those who had missed activities because of transportation (*n* = 10). Almost a quarter of those who missed activities (*n* = 6, 24%) missed religious activities, and 20% (*n* = 5) missed health care appointments or health care-related activities. Less substantial minorities reported missing trips for grocery shopping (*n* = 4, 16%); to eat out (*n* = 4, 16%); to the senior center (*n* = 4, 16%); or to the bank or recreational activities (*n* = 3, 12%). Finally, two participants had forgone trips to the convenience mart and one each reported missing opportunities to get their car serviced, exercise, go to the pharmacy, and for civic engagement.

4.1.5 Relationships Between Older Adults' Ride Dependency, Regular Activity Space Size, and Well-Being

In line with the aims of Phase 1, we focused on the role of two key variables – the size of older adults' regular activity space and ride dependency – and their relationships with a series of outcome measures pertaining to well-being, including physical and mental health.

Aim 4 concerned the relationship between ride dependency and well-being. In terms of physical health outcomes, we found statistically significant relationships between ride dependency and multimorbidity disease count (B = .71, p = .052), number of IADL limitations (B = 2.48, p < .001), and use of assistive equipment/devices (OR = 2.97, p = .056), but no statistically significant relationship between ride dependency and global self-rated health nor number of ADL limitations. In terms of mental health outcomes and other indicators of well-being, we found statistically significant relationships between ride dependency and perceived social support (B = 0.629, p =.019), but not between ride dependency and loneliness.

Aim 6 concerned the relationship between our two explanatory variables of interest, size of regular activity space and ride dependency themselves. There was a strong negative relationship between these two variables. Those individuals who reported being dependent on rides had smaller activity spaces compared to those who reported that they drove themselves (B = -0.96, p = .020).

Aim 7 concerned the relationship between size of the older adults' regular activity space and indicators pertaining to physical health, mental health, and well-being. In terms of physical health outcomes, we found a statistically significant negative relationship between size of activity space and multimorbidity disease count (B = -.232, p = .026), but no significant associations between size of activity space and global self-rated health, number of ADL limitations, number of IADL limitations, nor use of assistive equipment/devices. In terms of mental health outcomes and other indicators of well-being, we found statistically significant negative relationships between the size of the regular activity space and perceived stress (B = -0.370, p = .073), and loneliness (B = -0.295, p = .035), but no significant associations between the size of the regular activity space and perceived social support.

4.2 PHASE 2 (RIDE PROVIDERS)

All of the 20 ride providers identified as Vietnamese and almost all spoke Vietnamese as their primary language at home. The sample was fairly evenly distributed in terms of gender, age, and marital status (single or married), and immigrant status. Most had a high school diploma or less education. Their monthly household income was low (*M* = $2,243/month; *SD* = $2,065). For half of the ride providers, we also had information about their relationship with the older adult ride recipient. Most of these were family members who lived with the ride recipient. Details are provided in Table 4.7 below.

Table 4.7. Descriptive statistics for sample of people who give rides to older Vietnamese adults. *N* = 20.

Variable	*n*	*%*	*M*	*SD*	*min*	*max*
Lives with ride recipient	8	80.0				
Relationship to ride recipient						
Husband	5	50.0				
Child	4	40.0				
Neighbor	1	10.0				
Age	19		45.7	22.4	18	79
Less than 25	5	26.3				
25 to 59	7	36.8				
60 or older	7	36.8				
Gender						
Female	10	50.0				
Male	10	50.0				
Marital Status						
Single	10	50.0				
Married/domestic partnership	10	50.0				
Education						
Less than high school	3	15.0				
High school diploma or equivalent	10	50.0				
Some college or Associate's degree	4	20.0				
College degree	3	15.0				
Country of birth						
The United States	9	45.0				
Vietnam	11	55.0				
Length of time in U.S., if not born in U.S.	11		21.8	12.3	5	45
Ethnicity						
Vietnamese	20	100.0				
Primary language spoken at home						
Vietnamese	18	90.0				
English	2	10.0				
Monthly household income	20		2243.1	2065.1	0	7015

4.2.1 Transportation and Regular Activity Space

A large percentage of the ride providers (*n* = 17, 85%) owned a working automobile. One (5%) owned an automobile that did not work, and the remaining two (10%) indicated someone in their household owned an automobile.

All of the ride providers reported driving themselves for transportation. Half (*n* = 10) drove for transportation more than once per day; the remainder reported driving once per day (*n* = 6, 30%) or more than once per week (*n* = 4, 20%). Only one (5%) indicated getting rides with others, and this happened less than once per month. None endorsed using other forms of transportation such as walking, public transportation, or ride sharing.

We had sufficient data to construct one standard deviation ellipses (SDE1s) for the regular activity spaces and ride-provision activity spaces of 18 of the ride providers in the sample. The area of the ride providers' activity spaces ranged from .5 to 185 square miles, and was almost twice the size of the older adults' regular activity spaces (*M* = 44.4 square miles, *SD* = 55.2 square miles).

4.2.2 Providing Rides to an Older Adult

The SDE1 ride-provision activity spaces were constructed using the location and frequency of rides provided to older adults for various types of routine ride provision (e.g., for health services, religious services). The ride providers reported taking the older adult to a range of one to nine types of activities, with a mean of 2.7 types of routine activities per ride provider (*SD* = 2.0). Table 4.8 provides additional details.

Table 4.8. Ride-provision activity space and activities routinely provided rides for older Vietnamese adults among sample of ride providers. *N* = 18.

Variable	*n*	*%*	*M*	*SD*	min	max
Area of Ride-Provision Activity Space (sq. miles)	18		34.1	74.9	.17	279.5
Types of Rides Routinely Provided Each Month	20		2.7	2.0	1	9
Grocery shopping	12	60.0				
Frequency (days/month)	11		4.3	1.9	1	8
Go to convenience mart	2	10.0				
Frequency (days/month)	2		3.5	.7	3	4
Buy gasoline	2	10.0				
Frequency (days/month)	2		4.0	0.0	4	4
Shop for clothes or other retail items	3	15.0				
Frequency (days/month)	3		2.7	1.5	1	4
Visit friend or family member	5	25.0				
Frequency (days/month)	5		2.8	1.5	1	5
Church or other religious activities	7	35.0				
Frequency (days/month)	7		9.0	9.7	4	30
Exercise	1	5.0				
Frequency (days/month)	1		4.0	0.0	4	4

Pharmacy	2	10.0				
Frequency (days/month)	2		3.0	1.4	2	4
Beauty salon, barber, other personal care services	1	5.0				
Frequency (days/month)	1		2.0	0.0	2	2
Bank	2	10.0				
Frequency (days/month)	2		1.5	.7	1	2
Senior center	2	10.0				
Frequency (days/month)	2		15.0	19.8	1	29
Work	3	15.0				
Frequency (days/month)	3		14.7	11.7	6	28
Health care	10	50.0				
Frequency (days/month)	10		2.3	2.3	1	8

The most common type of ride provided was for grocery shopping (*n* = 12, 60%); rides to the grocery store were provided, on average, approximately once per week (*M* = 4.3 rides per month; *SD* = 1.9 rides). Half of the ride providers gave routine rides to a health care facility, with an average of twice per month (*SD* = 2.3). A substantial minority gave rides to religious services (*n* = 7, 35%) and for visiting friends and family (*n* = 5, 25%). Although fewer ride providers gave rides to work, the average number of trips for work was relatively high compared to the other types of rides (*M* = 14.7 rides/month, *SD* = 11.7). Respondents (*n* = 14) reported providing rides between two and 30 days per month, with an average of providing rides 11 days per month (*SD* = 8.5 days). For most (*n* = 13; 72%), the ride-provision activity space was smaller than the regular activity space (*M* = 34 square miles, *SD* = 74.9 square miles).

4.2.3 Impacts of Providing Rides

Half of the ride providers (*n* = 10) indicated they experienced no impact from providing rides to an older adult. The other half reported they had incurred transportation expenses, missed work, and experienced increased personal stress because of providing rides (see Figure 4.4 below). None of the ride providers reported missing their own healthcare appointments or increased family stress because of providing rides.

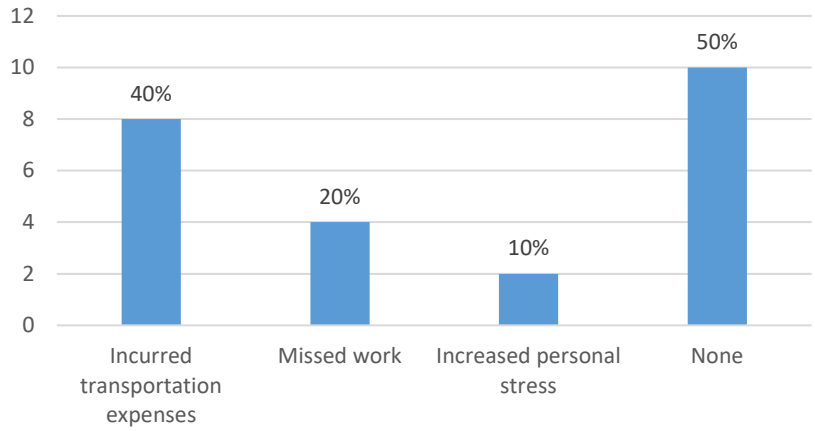

Figure 4.4. Prevalence of various impacts of providing rides among the sample of ride providers. *N* = 20. © 2022, Rebecca Mauldin

Among the ride providers who reported incurring transportation expenses, the average monthly expenditure was $77 per month (*n* = 7, *SD* = $44). The smallest reported monthly expense was $10 and the largest was $120.

4.3 GEOSPATIAL BURDEN INDICATORS FOR PROVIDING RIDES

As described in the Methodology section, we used geographical information systems mapping to create regular and ride-provision activity spaces. We had sufficient data to construct ride-provision activity spaces of 18 ride providers in Phase 2. For 12 of the ride-provision activity spaces, we had at least three locations and created one standard deviation ellipses (SDE1s) to represent the ride-provision activity space. For the other six, we used half-mile road network buffers. Based on the constructed activity spaces, we calculated three different burden indicators (A, B, and C) to assess the geospatial impact of providing rides. Table 4.9 provides descriptive statistics for the indicators among the Phase 2 sample of ride providers.

Table 4.9. Geospatial burden indicators for providing rides to older Vietnamese adults among ride providers. *N* = 18.

Variable	*M*	*SD*	min	max
1. *Geospatial Burden Indicator A* Size of ride-provision activity space (sq. miles)	34.1	74.9	.17	279.5
2. *Geospatial Burden Indicator B* % of ride-provision activity space inaccessible to ride provider	49.4	30.5	0.0	99.6
3. *Geospatial Burden Indicator C* Ratio of inaccessible ride-provision activity space to ride provider's regular activity space	4.4	14.6	<.001	61.8

Burden Indicator C assesses the ratio of the area of the ride-provision activity space that is outside the ride provider's regular activity space to the area of the regular activity space. Most of the ratios (*n* = 13, 72%) were less than 1.0, indicating the area of the inaccessible ride-provision activity space was smaller than the ride provider's regular activity space. However, a substantial minority (*n* = 5, 28%) had Burden Indicator Cs greater than 1, indicating the inaccessible ride-provision activity space was larger than their regular activity space.

4.3.1 Correlations of the Geospatial Burden Indicators

We examined the correlations of the geospatial burden indicators and present results in Table 4.10. There was a large and significant correlation (*r* = .50, *p* = .035) between Burden Indicator B (the percentage of the ride-provision activity space that was outside the boundary of the ride provider's regular activity space), and C (the ratio of the inaccessible portion of the ride-provision activity space to the size of the regular activity space). Although the correlation between Burden Indicator B and A (the total area of the ride-provision activity space) was moderate, it was not statistically significant (*r* = .29, *p* = .247).

Table 4.10. Pearson's correlation of geospatial burden indicators and impacts of providing rides to older Vietnamese adults. *N* = 18.

Variable	*1*	*2*	*3*	*4*	*5*
1. Geospatial Burden Indicator A size of ride-provision AS	-				
2. Geospatial Burden Indicator B % ride-provision AS inaccessible	.29	-			
3. Geospatial Burden Indicator C inaccessible ride-provision AS/regular AS	.01	**.50***	-		
4. Frequency of Providing Rides Days/month	-.08[a]	**-.54†[a]**	-.18[a]	-	
5. Monthly Expenses for Providing Rides	.50[b]	-.26[b]	.02[b]	.94[c]	-

Note. AS = Activity Space; *p<.05; †p<.10; [a]n = 13; [b]n = 7; [c]n = 3

4.3.2 Correlation of Geospatial Burden Indicators with Frequency of Providing Rides and Monthly Expenses for Providing Rides

In general, as geospatial burden and negative impact of providing rides increased, the number of days per month that rides were provided decreased. Specifically, a large negative correlation (r = -.54, p = .059) between geospatial Burden Indicator B (the percentage of the ride-provision activity space that was inaccessible) and the number of days per months providing rides existed. This pattern was also present in the other continuous burden indicators, though not at the level of statistical significance (see Table 4.10 above for details).

For Burden Indicator A (size of the ride-provision activity space) and C (ratio of inaccessible ride-provision activity space to the regular activity space), the direction (though non-significant) of the association with monthly expenses for providing rides was positive. However, the direction of the correlation for Burden Indicator B (percentage of ride-provision activity space that was inaccessible) and monthly expenses was negative, potentially reflecting the fact that fewer rides were provided when a greater portion of the ride-provision activity space was inaccessible.

4.3.3 The Association of Geospatial Burden Indicators and Frequency of Providing Rides with Reporting Impacts of Providing Rides

Ride providers who indicated at least one impact of giving rides (i.e., incurring expenses, missed work, or increased personal stress) had larger values for each of the geospatial burden indicators. However, they reported providing fewer rides per month. None of these differences were statistically significant. Table 4.11 provides details.

Table 4.11. Differences in geospatial burden indicators between ride providers who report no impacts of giving rides and those who report one or more impacts (i.e., incurring expenses, missed work, increased personal stress) among sample of individuals who provide rides to older Vietnamese adults. *N* = 18.

	No impacts reported			One or more impact reported			
Variable	*n*	*M*	*SD*	*n*	*M*	*SD*	*p*
Burden Indicator A Size of ride-provision activity space	10	11.9	10.2	8	61.9	109.1	.696
Burden Indicator B % of ride-provision activity space inaccessible to ride provider	10	43.5	37.4	8	56.8	18.7	.573
Burden Indicator C Ratio of inaccessible ride-provision activity space to ride provider's regular activity space	10	7.6	19.4	8	.52	.72	1.00
Frequency of Providing Rides Days/month	9	13.0	10.0	5	7.0	2.8	.298

Note. *p*-values calculated using Independent-Samples Median Test/Mann-Whitney U Test.

5.0 CONCLUSIONS

This study adds to the transportation-related knowledge of an understudied population, older Vietnamese immigrants in a low-density, automobile-dependent urban area. Consistent with the overall population of older Vietnamese adults in the United States, the older adults who participated in the study tended to have low levels of education and household incomes. They were all born in Vietnam and spoke Vietnamese as the primary language in their homes. Overall, they reported moderate to high levels of chronic disease and physical limitations and low levels of social support. The most common chronic diseases were conditions requiring regular health care appointments or services. These combined factors suggest unique service needs to address culture and language while providing assistance and support related to poor physical health.

The transportation-related behavior of the older adults reflected the automobile-dependent nature of the research setting. Most drove themselves or received rides from others to access healthcare services and conduct their routine activities. Not only did very few use public transportation or paratransit, but they also reported low levels of knowledge about using those modes of transportation. As might be expected from the relatively high levels of automobile use and low levels of income, many of the older adults met the transportation financial burden criterion of spending more than 15% of income on transportation.

Among the older adults who either drove themselves or got rides with others, but not both (i.e., the ride dependency variable), those who were ride-dependent had greater numbers of diagnosed medical conditions (on average, .7 more conditions) and an average of almost 2.5 more limitations in instrumental activities of daily living such as medication management, grocery shopping, or household cleaning. They had almost three times the odds of using assistive equipment such as canes or walkers than those who drove themselves and did not get rides. These differences in physical health are not surprising, but it is of note that the ride-dependent older adults were not utilizing paratransit services for which they would be eligible. Perhaps connected was the fact that the size of their regular activity spaces was significantly smaller than those who drove themselves.

The study quantified the older adults' regular activity spaces, providing a better understanding of the size and locations within their one standard deviation regular activity space ellipses (SDE1s). Several important social, health, and household maintenance activities were often outside the boundaries of the older adults' regular activity space, suggesting inaccessible geospatial locations for visiting friends and family, attending religious services and the senior center, banking, and healthcare facilities. By assessing not only the type of activities that an older person routinely engaged in, but also the frequency and location, we laid a foundation for recognizing nuance in an older adult's mobility. For example, some activities such as grocery shopping were common but relatively infrequent, while others such as work were less prevalent but occurred with a high frequency when they appeared.

There was a broad range in the size of the older adults' regular activity spaces, which ranged from very small (i.e., .004 square miles) to 48.7 square miles. Some of this variability can be explained by ride dependency, which reduced the size of the regular activity space. In addition to ride dependency, physical and mental health (specifically multimorbidity disease count, IADL limitations, perceived stress, and loneliness) are also significantly associated with the size of regular activity spaces. Future research, including qualitative studies, could examine this further to better understand causal directions of the associations (e.g., do larger activity spaces reduce loneliness or do lonely people tend to retreat within smaller activity spaces?) and mechanisms related to the effects.

Many in the sample had missed participating in at least one routine activity in the previous month due to lack of transportation. It is quite possible that the numbers would have been even greater had COVID-19 restrictions not been in place.

Strong indicators of a cultural match between the older adults and ride providers in our sample exist. All the ride providers were of Vietnamese ethnicity and almost all spoke Vietnamese as their primary language at home. On average, the ride providers had low to moderate household incomes and education levels. Even more than the older adults, the ride providers owned automobiles and drove themselves for transportation. Unlike the older adults, none indicated they walked or used public transportation, paratransit, or ride-sharing services.

The ride providers gave rides an average of 11 days per month. This substantial ride provision commonly included trips to the grocery store, healthcare, and important social activities. The value of these rides was evidenced by the fact that the most common mode of transportation reported by over half the older adults was getting rides from other people. Providing rides came at a cost for many of the ride providers. On average, the monthly expenditure for providing rides was $77 and some ride providers had missed work to give the older person a ride.

5.1.1 Geospatial Burden Indicators

Previous studies have paired the concept of regular activity spaces with geospatial analysis to investigate accessibility of services; however, to our knowledge, this study introduces the concept of ride-provision activity spaces to explore the geospatial burden of providing rides. It creates three potential indicators of geospatial burden, compares them to one another, and examines each indicator's association with reported impacts of providing rides. In doing so, it meets the study's research aims Phase 2 Aim 4 and Phase 2 Aim 5. Although exploratory, the study suggests that assessing the geospatial burden of providing rides through a self-report of activities and their locations may be a feasible approach. Future research should further explore a variety of factors associated with greater geospatial burden, including land use policies, cultural variation (e.g., differences in acculturation and sense of filial responsibility), individual circumstances (e.g., financial means) and negative impacts on ride providers.

For each of the burden indicators, greater levels of burden were associated with fewer rides per month. Burden Indicators B (the portion of the ride-giving activity space that was outside the ride provider's regular activity space) had a moderate correlation with Burden Indicator A (the size of the ride-provision activity space) and a large correlation with Burden Indicator C (the ratio of Burden Indicator B to the size of the regular activity space). This indicates that Burden Indicator B may be a reasonable "all-purpose" burden indicator that correlates with other measures of geospatial burden. Burden Indicator B, which considers the area of the ride-provision activity space that is outside the regular activity space, is somewhat analogous to traditional ways of assessing accessibility as locations within a regular activity space (Sherman et al., 2005) with the exception that it examines an area of square miles rather than single geospatial points. Burden Indicator B also outperformed the other burden indicators when looking at the correlation of the burden indicators to the frequency of providing rides. A large and significant negative correlation between Burden Indicator B and the days per month providing rides occurs. A plausible explanation for this is that the percentage of ride-provision activity space that is outside the boundaries of the regular activity space poses a substantial burden for providing rides and reduces the ride provider's ability to give rides.

5.1.2 Implications

Our findings can inform transportation service provision for an important population in DFW and other areas with similar immigrant populations or automobile dependency. First, it is critical to understand that despite eligibility for paratransit services, the older Vietnamese immigrants in the study overwhelmingly relied on receiving rides from other Vietnamese people or driving themselves. The rides provided were for a variety of activities, many of which would have been covered by paratransit. However, possibly related to a lack of uptake of paratransit, many of the older adults had missed health care or social opportunities due to lack of transportation. The greater the geospatial burden for the ride providers the fewer rides they gave each month, suggesting a need to reduce the burden or find alternative culturally appropriate transportation.

A more traditional approach to addressing this problem is to enhance culturally relevant marketing and implementation of public transportation and paratransit. This could include ***marketing and educational materials in Vietnamese, targeted outreach, and hiring employees who speak Vietnamese***. However, this solution does not necessarily overcome barriers to using public transportation or paratransit that are related to comfort with having a well-known person provide rides. A ***policy approach that subsidizes private ride providers*** could overcome this barrier and potentially reduce costs by targeting expenditures where needed without having to build additional infrastructure.

Geospatial evaluation of providing rides is likely an appropriate way to understand the burden of ride provision and assess for eligibility for potential subsidies. To implement subsidies for ride providers, agencies could use ***assessment tools that collect data about routine activities, including the frequency of location of the activities for the regular and ride-provision activity spaces***. Geospatial software tools (e.g., a

ride-provision burden app) could be developed to quickly understand accessibility and burden. The tool could also be programmed to provide alternative options for services such as banking that might be located more conveniently for the ride provider and older person. Aggregated data from such an app could provide valuable data for city planners, housing authorities, and the business sector to locate services and housing for accessibility.

5.1.3 Limitations and Future Directions

There are two main limitations to consider for this study, both related to generalizability. First, all data collection took place with a convenience sample during the summer and fall of 2020, when COVID-19 restrictions and precautions were ever-present. By admission of the older adults in the study, this limited their travel and activities. The older adult's activity spaces, routine activities, and rides taken are likely less in this study's findings than they would have been without the context of the pandemic. This may have inflated the number of inaccessible activities by reducing the size of the regular activity space. The other main limitation is the small sample size of ride providers in Phase 2 of the study. This makes the results preliminary and in need of replication with a larger sample. Not only would a larger sample size increase generalizability, but it would also increase the statistical power of analyses to better understand the significance of the associations of each burden indicator.

Phase 2 was an exploratory examination of ride-provision activity spaces. We began the Phase 2 research by only including people who gave rides to a participant in Phase 1. For these ride providers, we were easily able to link the two sets of data to obtain the home address of the older adult. However, when we extended recruitment to any person who provided rides to an older Vietnamese person, we failed to collect the home address of the older person. This meant that we did not construct those ride-provision activity spaces with the older adult's home address, which would have potentially added more precision to the measure. This is an important lesson learned; future work should ensure that the home address of the older adult is collected in addition to the information about the trips for providing rides.

The next step for this line of inquiry is to use random sampling and increase the sample size of ride providers. Additionally, using qualitative approaches would add context for the transportation behaviors and willingness to use alternate modes of transportation. It would also be valuable to understand more clearly the nature and sequencing of the rides provided. For example, for younger ride providers, many of the trips may be initiated from work rather than home. Rides provided for different activities (e.g., grocery shopping compared to health care) have different flexibility in timing and trip sequencing likely represent different temporal or geospatial burdens. These nuances should be considered in future research.

Related research could examine the feasibility of software applications for creating and assessing regular and ride-provision activity spaces. As the numbers of older immigrants in the United States grow, it is increasingly important to provide transportation services for health care, social opportunities, and overall well-being and

quality of life. This study is an important preliminary investigation of an understudied group of older adults, Vietnamese immigrants. It reinforces findings from other groups of older immigrants of their reliance on others for private transportation. Continued attention to the needs, resources, and solutions for older immigrants will help support their well-being and reduce transportation-related barriers to health care and social opportunities.

6.0 REFERENCES

S. Assari. (2017). "Race, Sense of Control over Life, and Short-Term Risk of Mortality among Older Adults in the United States." Archives of Medical Science 13.5, 1233–1240. 2017.

E. Blumenberg. "Immigrants and Transport Barriers to Employment: The Case of Southeast Asian Welfare Recipients in California." Transport Policy, 15.1, 33-42. 2008.

E. Blumenberg, M. Smart. Getting By with a Little Help from My Friends…and Family: Immigrants and Carpooling.' Transportation, 37, 429–446. 2010.

Bureau of Labor Statistics."OEWS Metropolitan and Nonmetropolitan Area Definitions." Accessed 15 April 2022. https://www.bls.gov/oes/current/msa_def.htm#19100. 2020.

V. Caldas, J. Fernandes, A. Vafaei, C. Gomes, J. Costa, C. Curcio, R.O. Guerra. "Life-Space and Cognitive Decline in Older Adults in Different Social and Economic Contexts: Longitudinal Results from the IMIAS Study." Journal of Cross-Cultural Gerontology, 35.3, 237–254. 2020.

B. Chaix, Y. Kestens, C. Perchoux, N. Karusisi, J. Merlo, K. Labadi. "An Interactive Mapping Tool to Assess Individual Mobility Patterns in Neighborhood Studies." American Journal of Preventive Medicine, 43.4, 440-450. 2012.

D.G. Chatman, N. Klein. "Immigrants and Travel Demand in the United States: Implications for Transportation Policy and Future Research." Public Works Management & Policy, 13.4, 312–327. 2009.

S.X. Chen, J.C.K. Ng, B.P.H. Hui, A.K.Y. Au, W.C.H. Wu, B.C.P. Lam, W.W.S. Mak, J.H. Liu. "Dual Impacts of Coronavirus Anxiety on Mental Health in 35 Societies." Scientific Reports, 11.1, 1-11. 2021.

S. Cohen, T. Kamarck, R. Mermelstein. "A Global Measure of Perceived Stress." Journal of Health and Social Behavior, 24, 385-396. 1983.

C.J. Coulton, J. Korbin, T. Chan, et al. "Mapping Residents' Perceptions of Neighborhood Boundaries: A Methodological Note." American Journal of Community Psychology, 29, 371–383. 2001.

K.P. Derose, J.J. Escarce, N. Lurie. "Immigrants and Health Care: Sources of Vulnerability." Health Affairs, 26.5, 1258-1268. 2007.

A.E. Dickerson, L.J. Molnar, M. Bédard, D.W. Eby, M. Berg-Weger, M., M. Choi, ... , N.M. Silverstein. "Transportation and Aging: An Updated Research Agenda to

Advance Safe Mobility among Older Adults Transitioning from Driving to Non-Driving." The Gerontologist, 59.2, 215-221. 2019.

Y. Du, Q. Xu. "Health Disparities and Delayed Health Care among Older Adults in California: A Perspective from Race, Ethnicity, and Immigration." Public Health Nursing, 33.5, 383-394. 2016.

D.W. Eby, L.J. Molnar, L.P. Kostyniuk, R.M. St. Louis, N. Zanier, N. Characteristics of Informal Caregivers who Provide Transportation Assistance to Older Adults. PLoS One, 12.9, e0184085. 2017.

W.M. Gessler, M.S. Meade. "Locational and Population Factors in Health Care-Seeking Behavior in Savannah, Georgia." Health Services Research, 23.3, 443. 1988.

S. Hamidi, R. Ewing, J. Renne. "How Affordable is HUD Affordable Housing?" Housing Policy Debate, 26.3, 437–455, 2016.

L. Hu. "Changing Travel Behavior of Asian Immigrants in the US." Transportation Research Part A: Policy and Practice, 106, 248-260. 2017.

M.E. Hughes, L.J. Waite, L.C. Hawkley, J.T. Cacioppo. (2004). "A Short Scale for Measuring Loneliness in Large Surveys: Results From Two Population-Based Studies." Research on Aging, 26.6, 655–672. 2004.

A.L. Huntley, R. Johnson, S. Purdy, J.M. Valderas, C. Salisbury. "Measures of Multimorbidity and Morbidity Burden for Use in Primary Care and Community Settings: A Systematic Review and guide." The Annals of Family Medicine, 10(2), 134-141. 2012.

Y. Jang, H. Yoon, J. Park, N.S. Park, D.A. Chiriboga, M.T. Kim. "Health Risks Posed by Social and Linguistic Isolation in Older Korean Americans." Journal of the American Geriatrics Society, 69.11, 3258-3266. 2021.

J. Johnson, M.A. Rodriguez, S. Al Snih. "Life-Space Mobility in the Elderly: Current Perspectives." Clinical Interventions in Aging, 15, 1665. 2020.

L.P. Kostyniuk, J.T. Shope. "Driving Alternatives: Older Drivers in Michigan." Journal of Safety Research, 34, 404-414. 2003.

M. Levasseur, M. Généreux, J.F. Bruneau, et al. "Importance of Proximity to Resources, Social Support, Transportation and Neighborhood Security for Mobility and Social Participation in Older Adults: Results from a Scoping Study." BMC Public Health 15, 503. 2015.

K. Lovejoy, S. Handy. "Social Networks as a Source of Private-Vehicle Transportation: The Practice of Getting Rides and Borrowing Vehicles among Mexican Immigrants in California." Transportation Research Part A: Policy and Practice, 45.4, 248-257. 2011.

C.S. Mackenzie, E.C. Karaoylas, K.B. Starzyk. "Lifespan Differences in a Self Determination Theory Model of Eudaimonia: A Cross-Sectional Survey of Younger, Middle-Aged, and Older Adults." Journal of Happiness Studies, 19.8, 2465–2487. 2018.

D. May, U.S.L. Nayak, B. Isaacs. (1985). The life-space diary: a measure of mobility in old people at home. International rehabilitation medicine, 7(4), 182-186.

National Asian Pacific Center on Aging. "Asian Americans and Pacific Islander in the United States Aged 65 Years and Older: Population, Nativity, and Language." [Data Brief]. Volume 1, Number 3. Accessed 2 May 2022. https://www.napca.org/wp-content/uploads/2017/10/65-population-report-FINAL.pdf. 2013.

C. Peel, P.S. Baker, D.L. Roth, C.J. Brown, E.V. Bodner, R.M. Allman. "Assessing Mobility in Older Adults: The UAB Study of Aging Life-Space Assessment." Physical Therapy, 85.10, 1008-1019. 2005.

Pew Research Center. ("Vietnamese in the U.S. Fact Sheet." Accessed 3 May 2022. https://www.pewresearch.org/social-trends/fact-sheet/asian-americans-vietnamese-in-the-u-s-fact-sheet/. 2021.

C.C. Sangalang, C. Vang, C. "Intergenerational Trauma in Refugee Families: A Systematic Review." Journal of Immigrant and Minority Health, 19.3, 745-754. 2017.

J.E. Sherman, J. Spencer, J.S. Preisser, W.M. Gesler, T.A. Arcury. "A Suite of Methods for Representing Activity Space in a Healthcare Accessibility Study." International Journal of Health Geographics, 4.1, 24. 2005.

J. Tan. "Older immigrants in the United States: The New Old Face of Immigration." Bridgewater Review, 30.2, 28-30. 2011.

Texas Demographic Center. "Demographic Trends and Population Projections for Texas and the North Texas Region." Accessed 14 April 2022. https://demographics.texas.gov/Resources/Presentations/OSD/2021/2021_01_15_LeadershipNorthTexas.pdf. 2021.

A. Trang. "What Older People Want: Lessons from Chinese, Korean, and Vietnamese Immigrant Communities." Generations, 32.4, 61-63. 2008.

J. Treas, S. Mazumdar. "Older People in America's Immigrant Families: Dilemmas of Dependence, Integration, and Isolation." Journal of Aging Studies, 16.3, 243-258. 2002.

A. Turner, L. Findlay. "Informal Caregivers for Seniors." Health Reports, 23.3, 33-36. 2012.

U.S. Census Bureau. "2015 National Content Test: Race and Ethnicity Analysis Report." Accessed 14 April 2022. https://www2.census.gov/programs-surveys/decennial/2020/program-management/final-analysis-reports/2015nct-race-ethnicity-analysis.pdf. 2017.

U.S. Census Bureau. "S1901: Income in the Past 12 Months (In 2019 Inflation-Adusted Dollars, Dallas-Fort Worth-Arlington, TX Metro Area." [2019: ACS 1-Year Estimates Subject Tables]. Accessed 8 May 2022. https://data.census.gov/cedsci/table?q=median%20household%20income&g=310XX00US19100&tid=ACSST1Y2019.S1901

U.S. Census Bureau. "B05006: Place of Birth for the Foreign-Born Population in the United States, Dallas County, Texas." [2020 ACS 5-year estimates detailed table]. Accessed 27 March 2022. https://data.census.gov/cedsci/table?q = B05006&g = 0500000US48113&tid = ACSDT5Y2020.B05006. 2020a.

U.S. Census Bureau. "B05006: Place of birth for the foreign-born population in the United States, Tarrant County, Texas." [2020 ACS 5-year estimates detailed table]. Accessed 27 March 2022. https://data.census.gov/cedsci/table?g = 0500000US48439&tid = ACSDT5Y2020.B05006. 2020b.

U.S. Census Bureau. "B08105D: Means of Transportation to Work (Asian Alone), Dallas County, Texas." [ACS 5-year estimates detailed tables]. Accessed 27 March 2020. https://data.census.gov/cedsci/table?q = B08105D&g = 0500000US48113&tid = ACSDT5Y2020.B08105D. 2020c.

U.S. Census Bureau. "B08105D: Means of Transportation to Work (Asian alone), Tarrant County, Texas." [2020 ACS 5-year estimates detailed table]. Accessed 27 March 2022. https://data.census.gov/cedsci/table?q = B08105D&g = 0500000US48439. 2020d.

U.S. Census Bureau. "P1: Race." [2020 DEC Redistricting data (PL 94-171)]. Accessed 27 March 2022. https://data.census.gov/cedsci/table?g = 310XX00US19100. 2020e.

U.S. Census Bureau. "QuickFacts: Dallas County, Texas, United States." [Table]. Accessed 17 March 2022. https://www.census.gov/quickfacts/fact/table/dallascountytexas,US/POP010220. 2020f.

U.S. Census Bureau. "QuickFacts: Tarrant County, Texas, United States." [Table]. Accessed 17 March 2022. https://www.census.gov/quickfacts/fact/table/tarrantcountytexas,US/POP010220. 2020g.

U.S. Census Bureau. "S0103: Physical Housing Characteristics for Occupied Housing Units, Dallas County, Texas." [2020 ACS 5-year estimates subject table].

Accessed 27 March 2022. https://data.census.gov/cedsci/table?q = S2504&g = 0500000US48113. 2020h.

U.S. Census Bureau. "S0103: Physical Housing Characteristics for Occupied Housing Units, Tarrant County, Texas." [2020 ACS 5-year estimates subject table]. Accessed 27 March 2022. https://data.census.gov/cedsci/table?q = vehicle&g = 0500000US48439. 2020i.

U.S. Census Bureau. "S0103: Population 65 years and Over in the United States, Dallas County, Texas." [2020 ACS 5-year estimates subject table]. Accessed 27 March 2022. https://data.census.gov/cedsci/table?q = S0103&g = 0500000US48113&tid = ACSST5Y2020.S0103. 2020j.

U.S. Census Bureau. "S0103: Population 65 years and Over in the United States." [2020 ACS 5-year estimates subject table]. Accessed 27 March 2022. https://data.census.gov/cedsci/table?q = S0103&g = 0500000US48439&tid = ACSST5Y2020.S0103. 2020k.

U.S. Census Bureau. "S0802: Means of Transportation to Work by Selected Characteristics." [2020 ACS 5-year estimates subject table]. Accessed 27 March 2022. https://data.census.gov/cedsci/table?q = S0802. 2020l.

U.S. Census Bureau. "S0802: Means of Transportation to Work by Selected Characteristics, Dallas County, Texas." [2020 ACS 5-year estimates detailed table]. Accessed 27 March 2022. https://data.census.gov/cedsci/table?q = S0802&g = 0500000US48113&tid = ACSST5Y2020.S0802. 2020m.

U.S. Census Bureau. "S0802: Means of Transportation to Work by Selected Characteristics, Tarrant County, Texas." [2020 ACS 5-year estimates subject table]. Accessed 27 March 2022. https://data.census.gov/cedsci/table?q = S0802&g = 0500000US48439&tid = ACSST5Y2020.S0802. 2020n.

L.M. Verbrugge. "Disability Experience and Measurement." Journal of Aging and Health, 28.7, 1124–1158. 2016.

S.C. Webber, M.M. Porter, V.H. Menec. "Mobility in Older Adults: A Comprehensive Framework." The Gerontologist, 50.4, 443–450. 2010.

S.S. Weng. "Issues of Aging: An Exploration of Asian American Families in the Southern Region of the United States from the Perspective of Community Leaders." Journal of Cross-Cultural Gerontology, 32.4, 461-477. 2017.

S.S. Weng, P.V. Nguyen. "Factors Affecting Elder Caregiving in Multigenerational Asian American Families." Families in Society, 92.3, 329-335. 2011.

J.L. Wolff, J.D. Kasper. "Caregivers of Frail Elders: Updating a National Profile." The Gerontologist, 46.3, 344-356. 2006.

M. Young, S. Farber. "Ride-Hailing Platforms are Shaping the Future of Mobility, but for Whom?" The Platform Economy and the City: Urban Peril and Promise in the New Digital Economy edited by Austin Zwick and Zachary Spicer. McGill-Queens University Press. 2021.

E. York Cornwell, K.A. Cagney. "Aging in Activity Space: Results from Smartphone-Based GPS-tracking of Urban Seniors." Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 72.5, 864-875. 2017.

R.S. Yuill. "The Standard Deviational Ellipse: An Updated Tool for Spatial Description." Geografiska Annaler: Series B, Human Geography, 53.1, 28-39. 1971.