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Transportation Barriers to Vision Care for the Visually Impaired

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16. Abstract

Transportation barriers significantly hinder healthcare access for individuals with disabilities, particularly in rural areas. This study examines these challenges in Nebraska and Kansas, focusing on individuals with visual impairments who require specialized low-vision care. Using a mixed-methods approach, the research integrates qualitative interviews with low-vision patients, caregivers, and clinicians alongside aspatial and spatial analyses to identify and characterize transportation barriers to vision care and areas with high unmet demand for non-emergency medical transportation (NEMT). Qualitative data were gathered through semi-structured interviews with patients and caregivers receiving low-vision rehabilitation services at the University of Nebraska Medical Center's Weigel Williamson Center for Visual Rehabilitation, as well as with clinicians providing low-vision care in the region. These interviews explored transportation challenges, coping strategies, and the impact of mobility constraints on healthcare access. The quantitative component utilized data from the 2022 National Household Travel Survey (NHTS) and the 2018–2022 American Community Survey (ACS) to analyze sociodemographic factors associated with travel-limiting disabilities. Areas with latent demand for NEMT were identified by combining a Disability Index—developed using NHTS data to measure the prevalence of travel-limiting conditions—with ACS Disability Status data and driving time calculations to healthcare facilities. Census tracts with both a high prevalence of disability and significant travel times to healthcare services were classified as having unmet NEMT demand. Findings highlight the significant reliance on informal transportation networks, limited access to public and specialized transportation services, and the burden of long-distance travel for rural patients. Clinicians confirm that these barriers contribute to missed appointments and worsened health outcomes. The study recommends expanding NEMT services, improving coordination between healthcare and transportation providers, and enhancing community awareness of available mobility resources to promote equitable healthcare access for individuals who are blind or have low vision in underserved areas.

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Table of Contents

List of Figures

List of Tables

List of Abbreviations

ADA – Americans with Disabilities Act
ACS – American Community Survey
AFB – American Foundation for the Blind
CDC – Centers for Disease Control and Prevention
CMSA – Consolidated Metropolitan Statistical Area
CTO – Community Transit Organization
DHHS – Department of Health and Human Services
DRT – Demand-Responsive Transport
EMT – Emergency Medical Transportation
GIS – Geographic Information System
HRSA – Health Resources and Services Administration
HPSA – Health Professional Shortage Area
IRB – Institutional Review Board
LVR – Low Vision Rehabilitation
MA – Medicare Advantage
MATC – Mid-America Transportation Center
MSA – Metropolitan Statistical Area
NDOT – Nebraska Department of Transportation
NEMT – Non-Emergency Medical Transportation
NHTS – National Household Travel Survey
NMT – Non-Medical Transportation
QDA – Qualitative Data Analysis
RSA – Rational Service Area
SDoH – Social Determinants of Health
TNC – Transportation Network Company
UNMC – University of Nebraska Medical Center
UNL – University of Nebraska-Lincoln
USDA – United States Department of Agriculture
U.S. DOT – United States Department of Transportation
VA – Veterans Affairs

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Disclaimer

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Abstract

Transportation barriers significantly hinder healthcare access for individuals with disabilities, particularly in rural areas. This study examines these challenges in Nebraska and Kansas, focusing on individuals with visual impairments who require specialized low-vision care. Using a mixed-methods approach, the research integrates qualitative interviews with low-vision patients, caregivers, and clinicians alongside aspatial and spatial analyses to identify and characterize transportation barriers to vision care and areas with high unmet demand for non-emergency medical transportation (NEMT).

Qualitative data were gathered through semi-structured interviews with patients and caregivers receiving low-vision rehabilitation services at the University of Nebraska Medical Center's Weigel Williamson Center for Visual Rehabilitation, as well as with clinicians providing low-vision care in the region. These interviews explored transportation challenges, coping strategies, and the impact of mobility constraints on healthcare access. The quantitative component utilized data from the 2022 National Household Travel Survey (NHTS) and the 2018–2022 American Community Survey (ACS) to analyze sociodemographic factors associated with travel-limiting disabilities. Areas with latent demand for NEMT were identified by combining a Disability Index—developed using NHTS data to measure the prevalence of travel-limiting conditions—with ACS Disability Status data and driving time calculations to healthcare facilities. Census tracts with both a high prevalence of disability and significant travel times to healthcare services were classified as having unmet NEMT demand.

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worsened health outcomes. The study recommends expanding NEMT services, improving coordination between healthcare and transportation providers, and enhancing community awareness of available mobility resources to promote equitable healthcare access for individuals who are blind or have low vision in underserved areas.

Chapter 1 Addressing Transportation Barriers to Low Vision Care Among Individuals with Visual Impairments in Nebraska

1.1 Abstract

Transportation is crucial for accessing essential services and maintaining quality of life, especially for individuals with disabilities. It plays a vital role in enabling access to healthcare, which is necessary for overall well-being. For people with disabilities, transportation is even more critical due to their increased need for medical visits and heightened vulnerability. However, these individuals often face challenges or barriers in accessing transportation, exacerbating their mobility issues.

In the study described in Chapter 1, we characterize the nature and consequences of transportation-related barriers to healthcare faced by low vision patients living in rural and urban areas of Nebraska. We conducted in-depth interviews with a sample of low vision patients receiving care from the University of Nebraska Medical Center (UNMC) clinics in Omaha, Lincoln, and Hastings, Nebraska. Interviews were coded using a flexible coding technique and analyzed for consistency and uniqueness. Our findings indicate that respondents heavily relied on family and friends for transport to and from appointments. They did not find ride-hailing services to be adequately available or affordable. Without the ability to drive, respondents lost their sense of freedom and had increasing feelings of anxiety and burden. These findings provide insight for policymakers to expand medical transportation and support for those with low vision to address these issues.

1.2 Introduction

Transportation problems affecting older adults and people with disabilities living in rural areas pose significant barriers to their ability to access proper healthcare (Cochran et al. 2022; Iezzoni, Killeen, and O'Day 2006; Syed, Gerber, and Sharp 2013). Transportation barriers

include a lack of ability to own, maintain, or operate a private vehicle and a lack of access to alternative transportation options, such as public transit, paratransit, dial-a-ride, and non-emergency medical transportation (Cochran et al. 2022; Syed, Gerber, and Sharp 2013). Potential riders may not be aware of these services where they are available. These services may further offer a low-quality service, often requiring advanced scheduling, long waiting times, and unreliable pickup and drop-off times (Cochran et al. 2022). Moreover, older adults and individuals with disabilities may have unease about using these services due to safety, personal security, and comfort concerns (Cochran 2020b). Rural residents often need to travel farther distances to get medical care, mainly to see specialist physicians (Mattson 2011). Traveling these distances can be burdensome, costly, and potentially dangerous, especially if one's current health or disability may compromise their ability to drive safely (Cochran et al. 2022). Concerns about or problems with transportation acutely affect the large and growing population of people in the United States living with visual impairments, who have been shown in previous studies to lack adequate transportation, keeping them from receiving low vision rehabilitation and other specialized care (Khimani et al. 2021).

Through qualitative interviews, this study aims to characterize the nature and consequences of transportation barriers to healthcare faced by low vision patients in Nebraska's urban and rural areas. It addresses several key research questions: What specific transportation-related challenges do low vision patients encounter when seeking healthcare in Nebraska? How do these barriers impact their health and well-being? What strategies do they use to cope with these challenges? To answer these questions, we conducted in-depth, semi-structured interviews with a sample of low vision patients and caregivers living in Nebraska. Interview data was coded thematically and organized based on key information discussed by the interviewees, reflecting

their lived experiences and highlighting the genuine transportation challenges they face. This qualitative approach offers a unique perspective, allowing us to deeply understand transportation experiences and challenges that are often overlooked or missed in quantitative studies. This study sheds light on the transportation barriers affecting healthcare access for low-vision patients, emphasizing the unique challenges they face. A key contribution is the comparative analysis of rural and urban contexts, which reveals distinct barriers to healthcare access and underscores the need for tailored strategies for each setting. In Nebraska, which is predominantly rural, this research provides timely insights for policymakers, raising awareness of transportation inequities and informing more inclusive and effective solutions for these underserved communities.

1.3 Background

1.3.1 Transportation's Role in Accessing Healthcare

Distance and access to healthcare are fundamental factors in assessing people's medical welfare and overall well-being (Buzza et al. 2011; Dassah et al. 2018; Gesler et al. 1999). The availability of reliable transportation plays a vital role in ensuring one's ability to attend medical appointments (Dassah et al. 2018). Early access to primary care facilitates early diagnosis and treatment of health conditions before they escalate into chronic diseases (Mattson 2011). Effective healthcare management cannot be achieved without adequate transportation to medical facilities.

The importance of transportation in facilitating access to healthcare was underscored during the COVID-19 pandemic. Many people who relied on public transit before the pandemic could no longer use it because transit services were less available, and using these shared services carried a higher risk of getting or transmitting the disease (Chen et al. 2021; Cochran 2020a). Cochran et al. (2022) conducted a survey indicating that 1 in 3 frequent healthcare users

reported transportation issues between June 2020 and June 2021 due to the pandemic. Consequently, more individuals faced transportation barriers that prevented them from getting to their medical appointments (Cochran et al. 2022; Oluyede, Cochran, Wolfe, et al. 2022; Oluyede, Cochran, Prunkl, et al. 2022). The pandemic exacerbated transportation barriers to healthcare, drawing attention to these issues and initiating ongoing discussions. Research now shows that transportation barriers create a heavier burden of illness for those with chronic diseases. In addition to managing their medical conditions, people with chronic illnesses must also navigate concerns related to transportation accessibility and affordability that can exacerbate stress, delay care, and otherwise negatively influence their health (Syed, Gerber, and Sharp 2013).

1.3.2 Importance of Adequate Transportation for Accessing Healthcare for People with Disabilities

In the United States, approximately one out of every four adults lives with a disability; 4.8% of adults are affected by visual impairments (CDC 2023a). People with disabilities often face greater challenges in accessing healthcare compared to the general population. This difficulty may stem from their inability to drive or the unaffordability of alternative transportation options, which is exacerbated by their likelihood of having a lower income than individuals without disabilities. As a result, they rely more on public transit services (Bezyak, Sabella, and Gattis 2017). On the other hand, many studies indicate that individuals with disabilities have more medical needs compared to people without disabilities (Hwang et al. 2009; Allen et al. 2017; Goldstein et al. 2012; Wallace et al. 2005). This causes those with disabilities to experience more transportation barriers when receiving healthcare, mainly because they need to travel more frequently. Fifty percent of people with disabilities in the US are also over the age of 65 and generally have smaller social networks than those without disabilities. They may face

additional challenges in accessing transportation-related assistance from friends or family members, particularly during emergencies (Cochran et al. 2022; Oluyede et al. 2022; Allen et al. 2017; Wallace et al. 2005; Ramsbottom-Lucier et al. 1996). These factors and limited access to transportation create barriers that make accessing healthcare more complex and potentially more costly for those with disabilities (Wallace et al. 2005; Ramsbottom-Lucier et al. 1996; Smith, Humphreys, and Wilson 2008; Starbird et al. 2019). Therefore, to address the transportation barriers faced by people with disabilities, their unique characteristics and needs must be considered. A coordinated approach is necessary because some individuals with disabilities require complex, long-term healthcare and are less likely to have reliable access to transportation (Hwang et al. 2009).

1.3.3 Transportation to Healthcare in Rural America

Twenty percent of the US population lives in rural areas (over 66 million) (USDA 2024). The centralization of health centers in larger urban areas forces rural residents to travel to bigger cities to access care, impacting their health conditions. Some studies have shown that rural residents have more health problems than urban residents (Gesler et al. 1999; Wercholuk, Parikh, and Snyder 2022). Rates of disability in rural areas are higher than in urban areas because of less access to socioeconomic opportunities, including well-paying jobs and quality education as well as essential services and nearby healthcare (Iezzoni, Killeen, and O'Day 2006; Oluyede, Cochran, Prunkl, et al. 2022).

Accordingly, transportation is reported as one of the significant concerns of rural residents when discussing limitations to their access to healthcare or their participation in healthcare (Arcury et al. 2005). People who lack access to a private car, cannot drive themselves, or do not have alternative transportation options are more likely to face challenges accessing

healthcare services (Gesler et al. 1999). Rural areas' lack of public transportation exacerbates difficulties for individuals without car access (Arcury et al. 2005). The US population is aging more rapidly, and the rate of disability is notably higher in rural areas (CDC 2023a; Bureau, n.d.). Although distance is an important factor for those who live in rural areas, some research emphasizes that having access to reliable transportation is as necessary as distance when accessing healthcare (Syed, Gerber, and Sharp 2013). Overall, there exists a substantial need and increasing demand for high-quality transportation alternatives for older adults and individuals with disabilities living in rural settings.

1.3.4 Transportation for People with Visual Impairments

Even among people with disabilities, individuals with visual impairments encounter a higher frequency of transportation barriers for healthcare-related trips, running errands, and socializing (Bezyak, Sabella, and Gattis 2017). Visual impairment presents a significant public health concern in the United States, affecting millions of individuals across various age groups and demographics. As of 2017, over seven million Americans experienced vision loss or blindness, with approximately six million experiencing vision loss and one million with blindness, highlighting the widespread impact of this condition (AFB 2024). More than 1.6 million individuals living with vision loss or blindness are younger than age 40, underscoring the diverse demographic affected by visual impairment (AFB 2024). As the population ages in the United States, the prevalence of visual impairments increases, and the number of older individuals with vision impairment is projected to rise substantially over the next few decades (AFB 2024). Given the treatable nature of many conditions resulting in visual impairment, there is a pressing need to prioritize early detection and intervention efforts, especially for elderly

individuals with comorbidities such as diabetes and hypertension. Visual rehabilitation centers are essential in providing crucial services to low vision individuals (Swenor et al. 2020).

Lack of transportation is a significant barrier for people with visual impairments accessing low vision rehabilitation (LVR) services. Goldstein et al. (2012) demonstrated that approximately 70% of patients seeking such services can no longer drive (Goldstein et al. 2012). Khimani et al. (2021) identified common barriers that visually impaired patients face when accessing LVR services. They found that 53% of respondents needed better transportation to receive low vision medical care. The study emphasized the importance of transportation access for those with low vision (Khimani et al. 2021). Addressing similar barriers in rural and urban Nebraska communities is crucial for enhancing the accessibility and effectiveness of visual rehabilitation centers and for ensuring optimal care for individuals with low vision.

1.3.5 The Role of Telehealth

In recent years, telehealth has gained significant popularity in providing healthcare services remotely, particularly for individuals living in rural areas where access to traditional healthcare facilities may be limited (Vinella-Brusher et al. 2022). Telehealth encompasses a range of services, from virtual consultations with healthcare providers to remote monitoring of health conditions, offering a convenient and efficient way to receive medical care. However, despite its potential to bridge the healthcare access gap, a significant digital divide exists between urban and rural communities (Oluyede, Cochran, Prunkl, et al. 2022; Vinella-Brusher et al. 2022). According to recent data, rural residents are still less likely than those living in suburban areas to report having home broadband (Vogels, 2021). This digital divide hinders the widespread adoption of telehealth among rural populations and exacerbates healthcare access and outcomes (Vogels, 2021). Additionally, it is crucial to recognize that telehealth is not always

a viable option for specific healthcare needs. For instance, in cases requiring hands-on treatments such as physical therapy or diagnostic tests that necessitate specialized equipment, the limitations of telehealth become apparent, further underscoring the challenges rural residents face in accessing comprehensive healthcare services (Oluyede, Cochran, Prunkl, et al. 2022).

Telemedicine has proven a valuable tool in low vision rehabilitation. Bittner et al. (2020) highlighted the significance of telerehabilitation for individuals with low vision and emphasized its ability to overcome geographical constraints and improve access to rehabilitation services. Ihrig (2019) also stressed the practicality and cost-effectiveness of telemedicine solutions in enhancing access to care for individuals with low vision. Using telemedicine technologies, visual rehabilitation centers can extend their reach to a broader population and offer essential support to individuals with low vision. However, evidence exists that individuals over the age of 65 with visual impairments are significantly less likely to use the Internet and are more socioeconomically disadvantaged than normally sighted seniors (Choi et al. 2020). The challenges faced by rural communities in accessing vision care services exacerbate the burden of visual impairment on an individual who depends on others to drive a significant distance to a care facility.

1.4 Methods

1.4.1 Background of the Study Area

According to the 1990 Americans with Disabilities Act (ADA), paratransit services must be provided for people whose disability prevents them from using fixed-routed transportation such as buses (US Department of Justice 2024). In Lincoln, Nebraska, the paratransit service is a door-to-door, shared public service for people with disabilities who cannot utilize fixed-route transportation. Paratransit service operates with specific scheduling requirements and limitations.

Individuals must schedule their rides one to seven days before using this service. The service operates primarily on weekdays, has limited hours on Saturdays, and does not operate on Sundays or major holidays. Each one-way trip on the paratransit service costs $2.50 and operates exclusively within the city limits. The service will take riders to any location within the city limits and within ¾ of a mile of a bus stop (City of Lincoln 2024). The demographics of those with disabilities, such as having, on average, lower incomes and more medical transportation needs, increase the chance of their inability to afford paratransit services and healthcare in general.

1.4.2 Sampling and Data Collection

For this study, we conducted in-depth, semi-structured interviews with patients seeking care at the University of Nebraska Medical Center's (UNMC's) Weigel Williamson Center for Visual Rehabilitation. The center operates a leading clinic in Omaha, the state's largest city, and satellite clinics in Lincoln and Hastings—the latter intended to serve people living in rural and small urban areas in central and western Nebraska. The interview protocol was designed to explore three key areas: 1) the transportation challenges and barriers experienced by individuals with visual impairments in Nebraska, 2) the effects of these barriers on their access to low vision rehabilitation and other healthcare services, and 3) their views on potential solutions to mitigate these transportation issues. The interview questions were developed based on existing literature on transportation barriers to healthcare access, considering various demographic, household, and spatial factors (such as urban versus rural settings). The Institutional Review Board at the University of Nebraska reviewed the interview protocol and approved the study, ensuring it adhered to ethical standards and federal regulations regarding human subjects research. We

interviewed 21 people over 19 years of age from both rural and urban areas of Nebraska. All interviews occurred between October 2023 and February 2024.

Participants were recruited through purposive and snowball sampling techniques. Physicians and staff at the Weigel Williamson Center for Visual Rehabilitation and the satellite clinics were asked to inform patients of this research study through communication channels in person and online. Interested individuals who met the eligibility criteria were encouraged to contact the Principal Investigator via email or phone to express their interest in participating in an interview for the study. Interviews were scheduled at mutually convenient times and were conducted over the phone. All interviews were recorded with the participant's permission and transcribed for analysis.

1.4.3 Data Analysis Using Flexible Coding

After transcribing the interviews, all clean transcript files were anonymized and uploaded into Dedoose, a qualitative data analysis (QDA) software. We used flexible coding, which included applying descriptors (attributes) to transcripts based on key characteristics of the respondent (age, city of residence, living in urban/suburban/rural setting); broad, structural themes (index codes); and more specific codes to each interview transcript (analytic codes) (Deterding and Waters 2018). This software allowed for the transcripts to be qualitatively coded by category and further analyzed to establish relationships between codes. Broad codes were applied based on themes presented in the research questions, such as transportation challenges, dependence, barriers, types and access, demographic characteristics, and scheduling factors. These codes can also be described as index codes, which connect the answers to the interview questionnaire. Each code also has a description or definition to help generate themes across the transcripts (Deterding and Waters 2018). More “fine-grain codes” were applied after the broad

codes to find overlap and connections across the interviews. These codes are described as analytic codes, which can be understood as representing "the concepts to explore in a single paper…to integrate emergent findings" (36, p. 15).

Attributes for this study included respondents' age, city of residence, and whether they had received or were eligible for low vision care. Index codes, derived from the interview questions, covered topics such as the type of transportation respondents typically used to travel to medical appointments, travel difficulties, mode of transport to their most recent appointment, use of public transportation, telehealth, and transportation-related challenges. Analytic codes included themes like accessible vehicles, anxiety, burden, family support, reduced travel, and weather. Additional codes are provided in Figure 1.1.

The codes were applied to the interviews from multiple perspectives to ensure they were unbiased. We also utilized hierarchical coding with parent/child codes to establish depth. The software also allowed us to add more codes as we analyzed the transcripts, maintaining the flexibility of the analysis. This coding process has been used in other transportation research and modeled after those papers (Cochran 2020b; 2020a; Oluyede, Cochran, Wolfe, et al. 2022; Oluyede, Cochran, Prunkl, et al. 2022; Santana Palacios, McDonald, and Iacobucci 2023).

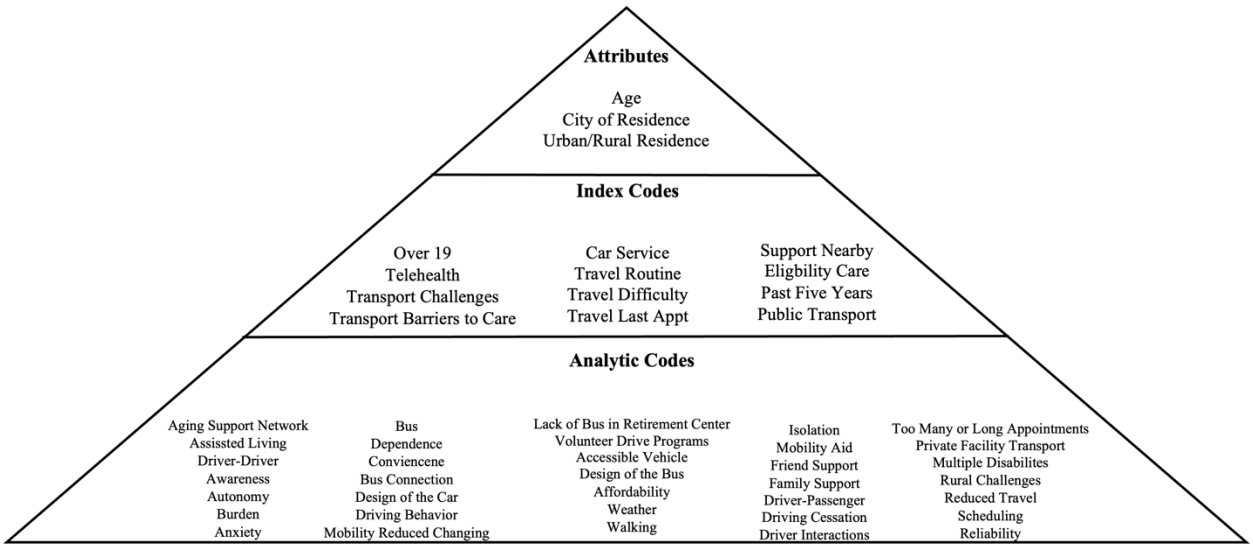


Figure 1.1 Codes used to analyze transcripts of patients by flexible coding categories. Figure adapted from (Oluyede, Cochran, Wolfe, et al. 2022).

1.5 Findings and Discussion

1.5.1 Participant Demographics

The 21 participants in this study primarily consisted of individuals aged over 65 years seeking care for blindness or low vision at the Weigel Williamson Center for Visual Rehabilitation at the University of Nebraska Medical Center. One of the 21 respondents was not receiving care and instead was the child and caregiver of someone receiving care. These participants resided in various geographic locations, encompassing urban and rural areas. Approximately 57% of the participants were residents of Nebraska's largest urban areas, Omaha and Lincoln, highlighting the prevalence of transportation challenges in more densely populated regions. Meanwhile, 19% resided in suburban areas, and 24% lived in rural settings, indicating a wide range of transportation contexts (Figure 1.2). Regarding age distribution, 85% of participants were over 65 years old, with the majority of participants between the ages of 75 and 84 (Figure 1.3). The respondents also varied with living arrangements; some lived in retirement

communities with and without assisted living accommodations, independently, or with family members.

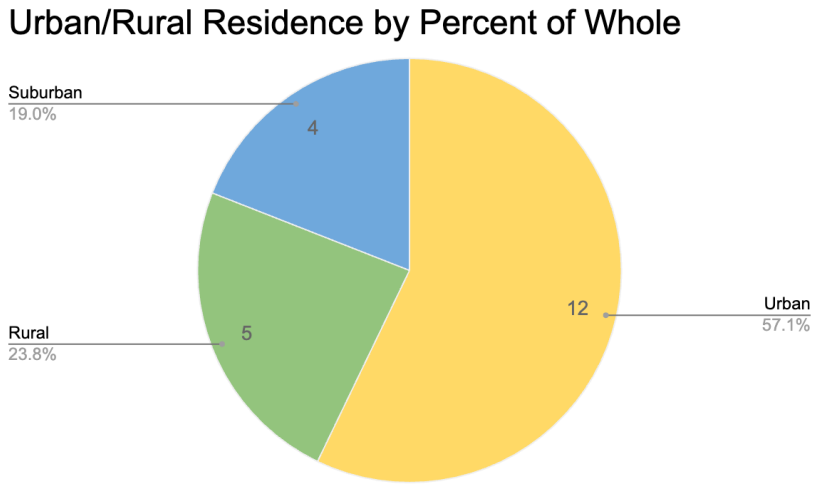


Figure 1.2 Distribution of Respondents by Residency Type (N = 21).

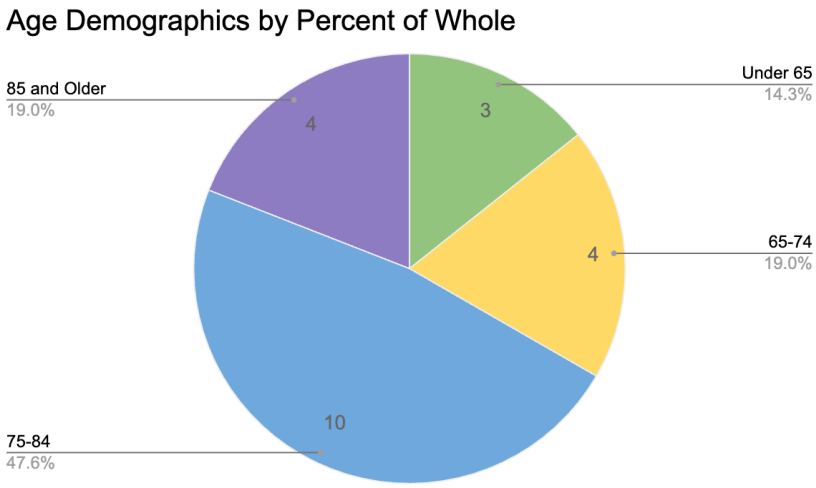


Figure 1.3 Distribution of Respondents by Age Group (N = 21).

Most respondents were over 65 years old and lived in various urban, suburban, and rural locations. This aligns with broader trends, as visual impairments and blindness are more common among older adults. The findings align with previous research and indicate that visual impairments and blindness are significantly more prevalent in older age groups, especially after age 60 (CDC 2023b). Detailed demographic data for respondents is included in Table 1.1.

Table 1.1 Detailed demographics of respondents (N = 21).

Respondent ID	Age	Urban/Rural Residence
R01	90	Urban
R02	82	Urban
R03	63	Rural
R04	71	Suburban
R05	90	Urban
R06	96	Urban
R07	72	Rural
R08	82	Urban
R09	50	Suburban
R10	91	Urban
R11	84	Urban
R12	82	Rural
R13	59	Rural
R14	76	Urban
R15	66	Urban
R16	74	Urban
R17	79	Rural
R18	75	Suburban
R19	82	Urban
R20	77	Suburban
R21	81	Urban

1.5.2 Summary of Interview Findings

Overall, the interviews aimed to identify and characterize transportation barriers faced by individuals with low vision specifically when seeking care as well as more generally. Through in-depth, semi-structured interviews, researchers gained a richer understanding of the lived experiences of those with low vision in Nebraska. After transcribing and cleaning the data, we applied qualitative methods, using flexible coding to classify responses into thematic categories. This approach allowed us to group findings based on recurring themes and identify the most frequently mentioned transportation challenges raised by participants. The following sections present these findings, organized into key thematic categories that emerged from our analysis. These categories highlight the significant transportation barriers that low vision patients encounter when accessing medical care.

1.5.2.1 The Impact of Support Networks on Transportation Barriers

The reliance on family support and the unaffordability of car services were more pronounced in rural areas where public transportation options are limited. Participants' reliance on family support and intentionality of having a support network nearby suggest that household composition and proximity to family members play crucial roles in mitigating transportation barriers. One respondent illustrated this sentiment well: "I live in an apartment. I have ten people that I hang out with all the time. My daughter lives in [a suburb], which is just 10 minutes from where I live. So, I think I am very well blessed with a lot of friends and family to help." This quote provides direct evidence of the importance of a support network nearby and how essential family members and close friends are to support those with low vision. Another respondent describes moving to a retirement facility where they still have friends from church and their

“career days.” They explain how the bus transit at the retirement center is critical to their ability to travel and was a factor in their decision to move to the facility.

Expressed difficulty in scheduling rides with family members may reflect household dynamics and the availability of family members to assist, which could vary significantly between different demographic groups. As mentioned by one rural participant: “I have one daughter. Both sons have passed away, so I have one daughter, and she's still young enough that her employment is a scheduling issue, so I don't feel I can drain her time constantly.” The availability and reliability of family support directly influences transportation and healthcare utilization outcomes for individuals with low vision. Those with a strong support network can more easily attend medical appointments and access necessary healthcare services. Another study emphasizes that car accessibility is as crucial as other factors like distance in accessing healthcare for people with visual impairment (Arcury et al. 2005). For people with visual impairments who cannot drive a car independently, relying on support networks is essential to transportation access. Although these support networks are typically smaller than those without disabilities, it is still the only option for some individuals with low vision.

1.5.2.2 Participants Relied Heavily on Family Members for Car Access

The most common mode of transportation for participants was reliance on a family member who could drive them as a passenger. More than half of the participants expressed that they could depend on their family because they were nearby and were willing to help the participant, if needed. One participant explained her family situation as such: “I have two daughters here in town that are in touch with me every day. And I also have two sons… Both of them are reasonably close.” Participants reported that those in their support networks, typically a spouse or child, had access to a vehicle and could drive participants to and from their medical

appointments, including those at the low vision clinic. One participant described her husband as "my 'go-to guy.' He takes me wherever I need to, as long as it's not on a golf day." Another participant purchased a wheelchair-accessible van for her daughter to drive her in, because she no longer drives. One woman lives with her brother, and they "take care of each other." However, because of the advanced age of the participants, the family members who drive them are also of more advanced age, and several participants expressed concern that their spouses or siblings will drive them to their appointments, but only if they are still able. One respondent whose wife gives him a ride said, "We make it work out. There isn't really any other choice," and the spouse of this respondent also expressed concerns about the future. When asked if she was worried about potential issues, she answered, "I hope that I stay healthy, so that I can continue to take care of my husband. I'm responsible for everything now. So, I do worry." When asked if she had backup plans, she responded, "I know people who could drive him if I couldn't."

Another respondent, whose husband drives her to appointments, expressed a similar sentiment. When asked if her husband would continue providing this support, she simply said, "He would have to." When asked about her transportation-related challenges, she answered, "I don't think I've faced a lot of them right now. I can see that I'm going to have challenges in the future, though. That's because my husband is often sick or unwilling to take me." Also, another respondent who relies on his wife said, "We're going to have some really big challenges eventually. She has some health issues that I don't want to talk about. Anyhow, eventually, I'm going to be isolated."

1.5.2.3 Ride-hailing Services or Taxis Are Not Affordable or Accessible Options

Multiple participants expressed that they would be willing to use ride-hailing services like Uber, Lyft, or taxis to get to their medical appointments if they were affordable or accessible options. While visits to the low vision rehabilitation center occur only occasionally (every six months or more), many respondents mentioned having fairly frequent appointments for various types of healthcare paired with using ride-hailing or taxis, which becomes unaffordable. For instance, one respondent with multiple disabilities shared that she often needs to reschedule her medical appointments because they are very frequent, and her husband cannot take her every day. She explained, “Well, if we don’t change the appointments, he’d be driving me every day. I have them quite often. Three days a week, at least.” She further explained the cost of hiring a cab for each of those trips and the unaffordability of each trip. Another participant described her situation: “I’ve used [ride-hailing services] for other things besides going to the low vision clinic, and there's nothing that I don't like, you know, but it's not cheap. But I have set aside a certain amount every year to pay for transportation.”

Some participants who use wheelchairs expressed concern that they cannot find a driver willing to accommodate their mobility aid. For example, when asked if they would use ride-hailing services, a participant said they did not because they could not find one able or willing to accommodate their wheelchair. Another participant attempted to order a cab following the advice of her doctor and found that the driver did not want to travel outside city limits and could not accommodate her multiple disabilities. This underscores significant issues: ride-hailing services and taxis often do not operate in rural areas or refuse to serve locations beyond city borders, leaving residents in rural and suburban areas with limited or no access. For those in urban areas, while ride-hailing services are generally available, they are often unaffordable, creating another

layer of inequity. This disparity in access is consistent with findings from other studies on transportation barriers to healthcare in rural versus urban areas (Brems et al. 2006). Another participant explains they do not have ride-hailing services where they live and are worried about the costs:

> "I do not have Medicaid, I'm on a private policy. I'm not 65 yet, so I pay for my own private insurance. So, no. [I would not consider using Uber/Lyft]. Regardless, they are not available here…for someone like me. We're in Northeast Nebraska; there's nothing available. I'd be willing to pay an Uber, which would cost me a lot of money. They'd have to come out of Omaha or Lincoln or somewhere."

A participant explained that they typically do more tasks than just going to their appointments at the low vision clinic when they travel for care. Using ride-hailing services potentially makes trip chaining difficult because the participant felt as though they were not a reliable option to get back home:

> "I once had [a ride-hailing service] lined up to take me to a luncheon across town [after my appointment], probably 20 miles from here. And, getting me down there was no problem. It was 20 dollars, but they couldn't guarantee me a car to come home, because they don't have many cars in that area. And if they did it would be 40 dollars to come home. And I thought that was a strange situation. However, I didn't want to go to [my destination] only to be stuck again."

1.5.2.4 Some Participants Felt a Loss of Autonomy and Freedom After Driving Cessation

Literature indicates that driving cessation is prevalent among individuals over the age of 65 and can significantly impact their social lives. For instance, many studies demonstrated that driving cessation increases the risk of social isolation among those over 65 (Qin, Xiang, and

Taylor 2020; Edwards et al. 2009). Our findings align with this body of research, and also show that driving cessation frequently occurs among individuals with visual impairments. Initially, those with visual impairments may still be able to drive in familiar, local areas. However, as their condition worsens, they are forced to stop driving, which profoundly affects various aspects of their lives. This leads to decreased overall travel and compromises their autonomy and independence. One respondent illustrated this challenge by saying,

> "Anyone who gave up driving will tell you that it's the biggest life-altering event you'll have to deal with. Being able to get in the car and drive over to [a bookstore] to get a book you want to read, or thinking, 'well, I'm going to go by Red Lobster and have some clam chowder' or whatever. You just can't do it. It's the loss of the freedom to move around. I just can't get the car and go out and get something to eat."

Some who no longer drove and became dependent on others for transportation shared the feeling of losing freedom. A participant explained, "Last month, my kids took away my car keys. I was driving whenever and wherever I wished until a month ago." A daughter expressed concern over her mother, who would not stop driving despite her worsening eyesight:

> "I told her that there were families in town with kids that played in the street. And that she might hit one of them. She yelled at me and told me that I was being emotional. So, she made an appointment with another doctor; this specialist confirmed that her vision loss had progressed. I asked him about driving, and he had a very pointed conversation with her. 'No way, no how.' She told me before going to the appointment that she'd obey the doctor. So, afterward, I asked her point blank [whether she would stop driving], and she said, 'Well, why would I stop?'"

The reduction in overall travel following driving cessation not only compromises autonomy and independence but also has significant implications for the physical and mental health of people older than 65 (Edwards et al. 2009). Consequently, they become reliant on others and can no longer depend on themselves. As one of our respondents stated, “Well before five years ago, I could drive wherever I wanted to. Now I have to depend on a bus or somebody I know.”

1.5.2.5 Behavioral Changes and Health Impacts

The participants reported that their behavior has changed recently, predominantly because they no longer drive. They no longer travel to nearby small towns; they do all their errands at once in one day; and they express concern and fear about the potential to drive. One participant explained their feelings towards driving as: “I don't feel safe driving. When I pass others in my car, they give me the horn. I thought, well, I am doing it wrong. I guess I shouldn't be driving anymore. I'm at that point where I don't feel comfortable.”

The distance and time of the day when participants drive also changed. For example, some are legally restricted to driving only during the day and cannot drive at night. Other participants claimed they felt uncomfortable driving on highways or in larger cities. For instance, one respondent shared, “I drive in the town, but I will not drive on the highway anymore.” This respondent also mentioned, “I will not drive at night. No, I drive during the day. Normally when it’s not a busy time, so that I don’t have much traffic to put up with. I don’t drive at night at all anymore.” Another respondent noted, “My driving before [cessation] was very limited. I’d drive out to the farm. I’d drive to church and then our other social events in [the small town I lived in]. Going to Lincoln? There was no way that I could have made that drive anymore.”

In some cases, respondents with multiple disabilities have had their mobility behavior even further affected. One respondent, who used to walk more frequently, stated, “Physically, walking has become a bit more challenging. I use a cane now, which has slowed me down a little bit. I’ve very, very cautious of the sidewalks and steps and things I can’t see. So, I’m a lot slower than I used to be.” These behavioral changes are supported by prior research that indicate the way people with disabilities travel changes significantly due to the loss of specific skills and the need to develop new ones (Cochran 2020b). This shift in travel behavior alters their routine and affects their emotional well-being. As they adapt to these changes, their feelings about travel evolve, leading to modified travel behaviors. This adaptation process can impact their overall health, access to medical appointments, and social interactions (Cochran 2020b).

1.5.2.6 Having Anxiety and Feeling like a Burden were Common When Reflecting on Transportation

Most respondents said they felt like a burden or had anxiety when asked about their dependence on family or friends for rides to medical appointments. One respondent said, “I don't like being an old guy that has to depend on someone for a ride.” Another respondent said, “The frustrating part is asking for a ride. I am very humble, and I have been independent most of my life, so it's hard for me.” Another participant feels burdensome towards her friends and family: “Well, I don't ask my son to get the stuff for me. My friend does that. But I feel like I've just about exhausted her.”

When it comes to feelings of anxiety, one participant explained how they stopped driving on the road because people honking and passing them made them anxious. A participant explained their fear of being late to appointments because of having to depend on someone else for a ride: "It is the anxiety that my daughter will be late. Sometimes she comes late. We still end

up getting there, but we're late." Transportation-related stress can lead to reduced travel frequency and missed medical appointments, which can further exacerbate health issues. Consistent stress and anxiety may discourage individuals from seeking necessary medical care, ultimately affecting their health outcomes and quality of life (Cochran 2020b). Another participant who still drives also expressed anxiety and fear about not being able to pass his upcoming driver's exam, describing it as a "big challenge." He was apprehensive about the impact this would have on his ability to care for his spouse, who is experiencing emerging health issues. Since he is the primary caregiver, losing his license would severely limit their ability to access medical appointments and meet their basic needs.

1.6 Conclusion and Policy Implications

The majority of respondents in this study were older adults with visual impairments who have ceased driving, which has significantly limited their ability to meet various needs, including getting to their medical appointments. Most respondents reported relying heavily on nearby family members or friends for transportation. This dependence often leads to scheduling conflicts and impacts their sense of independence and autonomy. Although relying on family members is not ideal, it remains a better option than alternatives like ride-hailing services and taxis, which are often unaffordable for frequent travel for those living in urban areas and inaccessible for those living in rural areas, since they do not operate or refuse to serve locations beyond city borders. These limitations have yielded negative experiences for many respondents due to their specific needs. Individuals with visual impairments experience anxiety and changes in travel behavior. Driving cessation also leads to a decline in their overall travel frequency. They tend to only travel when necessary, given the lack of alternative, accessible transportation

options. This behavioral change can negatively impact their overall well-being, leading to feelings of isolation from society and hesitation in attending medical appointments.

This study does not represent all individuals with low vision in Nebraska or beyond. However, it highlights the unique transportation barriers experienced by this population, particularly in rural and urban contexts. By examining these challenges, the study bridges a critical gap between transportation inequities and healthcare access for low vision individuals, offering insights often overlooked in quantitative research.

A key contribution of this study is its focus on the lived experiences of individuals with low vision, providing a nuanced understanding of the differential challenges they face across Nebraska. In rural areas, the absence of ride-hailing services and limited transportation options create significant barriers, while in urban areas, affordability and availability for frequent travel pose major challenges. These insights shed light on how transportation barriers manifest differently depending on the geographic context, emphasizing the need for tailored solutions to address the unique needs of low vision individuals in both rural and urban settings. This research offers a fresh perspective on transportation challenges in Nebraska, particularly in its rural areas, where studies of this kind have been limited. Much of the existing research in transportation relies on quantitative methods, which may overlook the nuanced, experience-based challenges faced by populations with specific needs. By providing these new insights, this study can serve as a valuable resource for policymakers in Nebraska and similar regions, helping them understand the transportation barriers faced by low vision individuals and consider these challenges in future policy and planning decisions.

The variation between rural and urban respondents regarding transportation barriers provides an opportunity for policy improvements in accessing transportation and healthcare. This

can be accomplished by ensuring low-cost options for paratransit in urban areas and similar alternatives in rural areas, such as state- or federally-funded medical transportation services operating from key rural satellite clinics rather than from all medical facilities. This targeted approach addresses the unique needs of individuals with visual impairments living in rural settings, who often cannot drive and rely heavily on accessible public transportation services. Non-emergency medical transportation (NEMT) also plays a critical role. NEMT provides tailored transportation for medical appointments, offering door-to-door service and accommodation of specific medical requirements. However, the costs of maintaining these services, particularly in remote areas, can be significant (Starbird et al. 2019). Expanding NEMT around the rural areas of satellite low-vision clinics may help those with low vision have a more reliable source of transportation to their appointments or therapy sessions. Subsidized transport through ride vouchers, including those for Uber and Lyft, could also be an option, providing flexibility for riders who prefer these services over traditional paratransit or public transit alternatives (Oluyede, Cochran, Prunkl, et al. 2022).

Some participants mentioned that a community-based transport system existed where they lived (e.g., a volunteer driver program, subsidized transit/paratransit program) before the COVID-19 pandemic in 2020. Funding and support for these transport options may provide transportation and social resources for those with low vision. For example, a community-based service in northwest Minnesota coordinates local transit offerings with a network of volunteer drivers to offer residents of a rural, eight-county area rides to medical appointments. The program receives funding from the state Department of Health and Human Services but mainly depends on volunteers to provide rides that "fill in the gaps," or are otherwise unavailable through the scheduled bus service (Rural Health Information Hub 2023). A similar program

could be implemented in Nebraska to provide healthcare access for individuals with visual impairments living in sparsely populated areas. This volunteer transportation system could be implemented by working with local community organizations with existing social groups like Veterans of Foreign Wars (VFW), quilting/knitting clubs, or Rotary Clubs. This type of transport could also offer social engagement opportunities for those who no longer drive. It could alleviate the feelings of loneliness from others and burden on their families and friends. However, implementing such programs in Nebraska would come with its own challenges and opportunities. One of the main challenges would be to ensure consistent funding and support for these services.

Additionally, the low-density nature of many rural areas in Nebraska might make it challenging to maintain a sufficient network of volunteer drivers. On the other hand, opportunities include partnerships with existing community networks and fostering relationships with local organizations to create a sustainable model for community transit organizations (CTOs). In learning from other states like North Carolina, states and local communities should consider implementing technology to operate demand-response services using dynamic, semi-structured routes. Standard booking procedures for NEMT and CTOs should be implemented to alleviate confusion and double-booking (Santana Palacios, McDonald, and Iacobucci 2023). CTOs in Nebraska may help fill the gaps in rural areas where NEMT is not as familiar or accessible.

In conclusion, a multifaceted approach that combines low-cost paratransit options, subsidized ride vouchers, community-based transport systems, and NEMT services could significantly improve healthcare access for individuals with low vision in both urban and rural areas of Nebraska. By addressing transportation barriers, these strategies can enhance the overall

well-being of this group, providing them with greater independence, access to healthcare and other essentials, and reducing social isolation.

Chapter 2 Clinicians' Perspectives on Transportation Barriers to Low Vision Care in the Rural Midwest

2.1 Questions

Transportation barriers prevent nearly 50 million low-vision Americans from accessing medical appointments and rehabilitation services ("Facts and Figures on Adults With Vision Loss" 2024; Khimani et al. 2021; Lam & Leat 2013). These challenges arise because many individuals with low vision cannot drive due to their disability, limiting their access to reliable transportation options. Alternative transportation is particularly scarce in rural areas, exacerbating residents' transportation challenges (Goldstein et al. 2012; Starbird et al. 2018).

The study described in Chapter 2 investigates clinicians' perspectives on transportation barriers to low vision care, encompassing medical appointments and services such as occupational therapy. It makes a significant contribution to the limited body of work highlighting clinicians' viewpoints, representing a novel and underexplored area of transportation research (Fields et al. 2020; Oluyede, Cochran, Prunkl, et al. 2022; Oluyede, Cochran, Wolfe, et al. 2022). Our work specifically focused on clinicians in Nebraska and Kansas—both predominately rural states. Since specialty care, such as low-vision rehabilitation, is often concentrated in larger urban areas, these clinicians have extensive experience working with low-vision patients from rural, urban, and suburban settings. This experience enables clinicians to provide insights into the challenges faced by suburban and, importantly, rural populations, which have been underrepresented in prior research.

This study advances existing literature by incorporating clinicians' perspectives on transportation barriers to healthcare for individuals who are blind or have low vision in largely rural Midwestern states. The research addressed three key questions:

1. What specific transportation-related challenges or barriers do low-vision patients encounter when seeking healthcare?
2. How do these barriers impact their health and well-being?
3. What strategies do patients use to cope with transportation barriers?

2.2 Methods

Following similar methods used in prior research on transportation barriers to healthcare, we conducted eight semi-structured interviews with clinicians who provide care to low-vision patients in Nebraska and Kansas. Qualitative techniques using open-ended interviews offer opportunities to understand "complex, multifaceted challenges," and clinicians provide nuanced insights into financial, geographical, social, and infrastructural barriers (Ballantyne et al. 2019; Fields et al. 2020; Oluyede, Cochran, Prunkl, et al. 2022). This work employed purposive and snowball sampling of clinicians recruited through emails and phone calls using publicly available contact information and recommendations from other clinicians. Our sample included occupational therapists (3), optometrists (2), and ophthalmologists (3), all of whom worked with low-vision patients. We conducted the interviews between October and December 2024. The Institutional Review Board at the University of Nebraska-Lincoln approved the study.

All interviews were recorded and transcribed for analysis. Transcripts were coded using a flexible coding approach in Dedoose, a qualitative data analysis (QDA) software, to identify recuring themes. These codes, shown in Figure 2.1, were applied in three hierarchical categories: *attributes or descriptors* that describe characteristics of the interviewee; *index codes* that are directly related to interview questions; and *analytic codes* that are more specific, capturing fine-grain concepts (Deterding and Waters 2018).

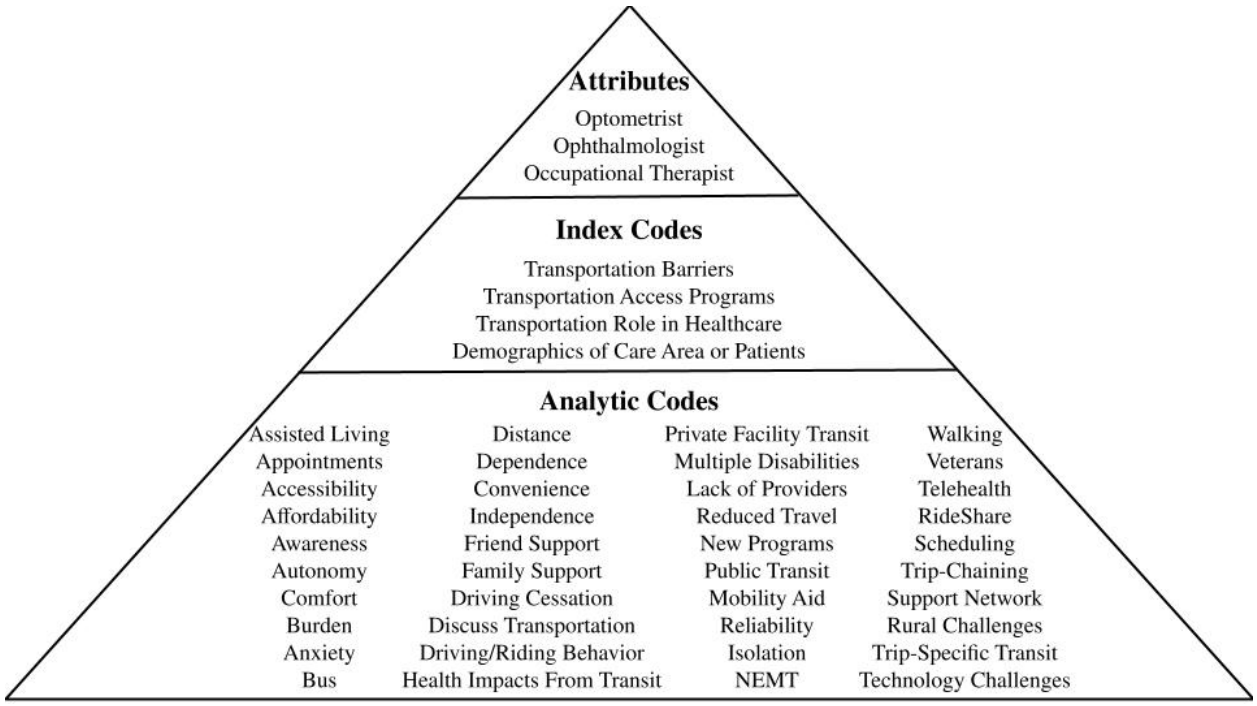


Figure 2.1 Codes used to analyze transcripts of clinicians using flexible coding. Figure adapted from (Oluyede, Cochran, Wolfe, et al. 2022).

2.3 Findings

2.3.1 Transportation Barriers Result in Cancellations, Rescheduling, and Long Wait Times

Despite the significant distances traveled by rural low-vision patients, appointments are frequently canceled and rescheduled for therapy and check-ups. This is due to their dependence on others for transportation—typically family members, transportation services operated by private facilities (e.g., assisted living facilities), or local transit agencies. These options can also leave patients waiting at clinics for hours for a ride to pick them up (Table 2.1). Patients who use public transit, apart from paratransit, do not experience the same wait times associated with private facility transport or reliance on family members. As noted by occupational therapists and in previous research, the care provided to individuals facing transportation barriers is negatively impacted when appointments are delayed or missed (Oluyede, Cochran, Prunkl, et al. 2022).

2.3.2 Relying Heavily on a Support Network Causes Feelings of Being a Burden

A recurring theme mentioned by clinicians was that individuals with low vision rely heavily on their support networks, such as family or friends, for transportation. These friends and family members assist with both medical and non-medical activities, leading to greater dependence among individuals with low vision. This dependence often carries feelings of being a burden, which clinicians have observed (Table 2.1). Additionally, this reliance can be inconsistent or unreliable as patients must navigate others' schedules with no guarantee of commitment to rides. Finally, this dependence extends beyond transportation, as many older adults face challenges using technology such as telehealth platforms and ride-hailing applications to access healthcare.

2.3.3 Rural Challenges

Clinicians providing low-vision care are sparse, especially in rural areas. As a result, some patients must travel 3-6 hours for a single visit, typically relying on private cars because rural public transportation is limited or unavailable (Table 2.1). Patients unwilling to ask family or friends for such long rides may forego care entirely. These trips can also impose significant financial burdens on families. Furthermore, smaller populations in rural areas are often unaware of resources available for individuals with low vision. For example, when someone in a family loses their vision, there is frequently limited awareness within the community about how to seek help or access support.

Table 2.1 Clinician interview excerpts discussing key issues regarding healthcare and transportation for individuals with low vision.

Cancellations, Reschedules, and Wait Times
"I would think a lot of our cancelations are probably transportation-related."
"We often hear that transportation is the issue, and sometimes that's why they're not coming to our clinic, is because they just can't get transportation."
"One thing I always noticed and felt bad about is they [private facility transit] bring several people to appointments, so the patients would be almost at our office for over four hours, and sometimes in the afternoon, they're still waiting for their ride to pick them up."
"I remember one lady told me 'I'll probably be here really early for my appointment, because I kind of just, you know, go when they can get me.'"
"It's the car is broken down. They don't have money for gas. Their daughter had another appointment."
"They're reliant on a family member to drive them, and that family member may have other conflicts, so they end up just not going."
Support Networks and Burden
"They're completely reliant on friends and family to drive them if they're unable to drive themselves."
"The ones who still have a living spouse that can drive have an easier time with transportation, but those that rely on family members or friends really struggle."
"Most of my patients either have a friend that they rely on or a family member, just because it's not only getting here but, you know it's doing other things too."

“You’ll have patients that say, well, my friend could drive me today, but I don’t know if they can drive me next time."
"Many of my older patients don’t even have a smartphone. You know, they have maybe a flip phone… I would say my older patients, some are comfortable with it [technology] if they have a grandkid."
Rural Challenges
"I have someone who came yesterday for four hours to see me. They came by private car, but they had to make arrangements to stay overnight because of the distance."
"In western Nebraska, it’s going to take somebody hours and hours to get to that client or get to that patient."
“[If] they don’t ask their family members to take them, they don’t come to an appointment."
"[There is a] lack of knowledge in the rural communities of what low vision and blindness is. For example, we might have a child that is the first person ever in a school to have low vision or multiple disabilities."
"They don’t have a system [to use public transportation] in place, because there hasn’t been a need for that."
"They’re not used to public transportation, so relying on public transportation is a very new thing outside of their comfort zone."
Program Observations
"[Paratransit’s] not reliable. It’s not a dependable type of thing. They have an appointment, and then they have to be there at a certain time."

"People don’t have the resources… it would be more challenging if they don’t have the money to pay for things, pay for the rides… people that don’t have close family or friends to help them.”

2.3.4 Program Observations and Conclusions

Clinicians expressed concerns about the transportation challenges reported by their patients, citing reliability and affordability as significant issues. Unreliable public transit and costly ride-shares were frequently mentioned (Table 2.1). To address these concerns, Omaha, Nebraska, has implemented a “Share A Fare” program that provides a 50% refund for ride-share services to individuals with low vision. In Kansas City, occupational therapists visit patients in their homes within a 60-mile radius of the clinic, eliminating the need for transportation. One clinician shared, “My sister lives in San Francisco; she is disabled, and they have a very inexpensive service provided by the city.” This highlights an aspirational model for Nebraska and Kansas to enhance accessible transportation services for individuals with disabilities and facilitate access to care.

Chapter 3 Latent Demand for Non-Emergency Medical Transportation

3.1 Abstract

Due to Nebraska's vast rural areas and low population density—where about 90% of incorporated places have fewer than 3,000 residents—the state has 120 designated Health Professional Shortage Areas. These conditions of low accessibility necessitate innovative and effective solutions to facilitate access to healthcare services for rural residents, particularly those with travel-limiting conditions or disabilities. The research described in Chapter 3 aims to identify areas of latent demand for medical trips, which may also present opportunities for local transit services to participate in non-emergency medical transportation (NEMT). We employed both aspatial and spatial analytical approaches to identify latent demand areas for NEMT. These areas were identified by combining a Disability Index, which quantifies the prevalence of sociodemographic factors strongly associated with travel-limiting disabilities, computed using the 2022 National Household Travel Survey, with data on the prevalence of disability (or Disability Status) from the 2018-2022 ACS 5-year estimates at the census tract level. We then addressed the assumption that individuals within a tract have equal geographical accessibility by measuring driving times. Ultimately, areas where driving time to a hospital or rural health clinic exceeds 30 minutes, within tracts identified as having a high prevalence of disability, were classified as latent demand areas for NEMT. These areas are predominantly situated in rural regions where healthcare and transportation services are limited or unavailable. We identify a significant need for NEMT to serve residents of these areas and suggest regions that would benefit from offering or expanding medical and general-purpose transportation services.

3.2 Introduction

Transportation accessibility for people with disabilities in the U.S. has significantly improved since the passage of the 1990 Americans with Disabilities Act (ADA), which was

designed to protect their rights and ensure equitable access to public services (Whaley et al. 2024; Sabella and Bezyak 2019). However, substantial barriers to accessibility remain, particularly in rural areas. These barriers are complex and multifaceted, encompassing aspatial factors such as sociodemographic characteristics and spatial factors like geographical distance and insufficient transportation infrastructure (Kuzio 2021). Individuals with disabilities face longer travel times for both work-related and non-work-related trips (Jansuwan et al. 2013) and make 10–30% fewer trips than those without disabilities (Park et al. 2023). Health problems are the primary factor discouraging travel and contribute to their significantly higher likelihood of limiting trips outside the home or forgoing travel altogether (Shen et al. 2023). The impact of disability on travel becomes more pronounced with age. According to data from the 2022 National Household Travel Survey (NHTS), individuals aged 65 and older with disabilities took significantly fewer trips for all purposes, except for medical trips, which they made at twice the rate of their counterparts without disabilities (Firestine 2024). Due to physical challenges, they are more likely to travel as passengers in private vehicles or rely on public transportation services when available, compared to those without disabilities (Ermagun et al. 2016).

Transportation services can be categorized into three primary types: emergency medical transportation (EMT), non-emergency medical transportation (NEMT), and non-medical transportation (NMT). EMT is provided in emergency situations, typically through the 911 system, and includes medical care during transport by trained personnel in ambulances (Shekelle et al. 2022). NEMT, on the other hand, is designed for non-emergency situations and is offered by non-medically trained drivers using vehicles such as vans or cars. It serves eligible individuals with low incomes or disabilities who lack alternative means of transportation to access healthcare services (Cherrington et al. 2018). NEMT is a required service for Medicaid

beneficiaries and is also available to enrollees of Medicare Advantage plans. This benefit is particularly critical in rural areas, where access to healthcare providers is often limited.

NEMT services differ from other rural transit options by prioritizing transportation for medical appointments, often offering door-to-door services with specialized vehicles and equipment. However, due to factors such as low awareness of the NEMT benefit, insufficient numbers of providers or qualified drivers, and challenges with advance scheduling, only 4–5% of Medicaid beneficiaries used NEMT services annually from 2018 to 2021 (U.S. Department of Health and Human Services 2023; Silow-Carroll et al. 2021). To improve healthcare access in rural regions, it is essential to implement more effective and innovative NEMT services.

This research seeks to identify areas with latent demand for NEMT services, enabling local stakeholders—including individuals, organizations, and transportation agencies—to expand existing transportation services or establish new NEMT programs. Additionally, the study aims to propose effective strategies for operating NEMT services to enhance healthcare access for users in these underserved areas.

We employed both aspatial and spatial analytical methods to identify areas with latent demand for NEMT. For the aspatial analysis, we created a Disability Index, computed using data from the 2022 NHTS, to quantify the prevalence of sociodemographic factors strongly associated with travel-limiting disabilities. This index was then combined with Disability Status data from the 2018–2022 ACS 5-Year estimates at the census tract level. In our spatial analysis, we addressed the assumption that individuals within a tract have equal geographical accessibility by measuring driving times to healthcare facilities.

Using Census block group data, we recalculated the Disability Index and Disability Status for areas based on whether they were within or beyond a 30-minute driving time to the

nearest healthcare facility. We additionally evaluated the impact of the presence of existing public transportation services in these areas to refine our analysis. The identified latent demand areas for NEMT services were predominantly in rural regions, characterized by significantly higher proportions of residents aged 65 and older, individuals with low incomes, limited educational attainment, and lengthy driving times to healthcare facilities. To support the effective and efficient operation of NEMT services in resource-limited rural areas of Nebraska, we recommend improved coordination between NEMT brokers and local transportation providers. Additionally, diversifying vehicle options through partnerships with Transportation Network Companies (TNCs) and local organizations can enhance service delivery and better address the transportation needs of these underserved rural populations.

3.3 Background

3.3.1 Transportation Barriers to Healthcare

The timely utilization of healthcare services is vitally important for maintaining one's health (Shannon 2018; Millman 1993). Accordingly, reliable transportation to and from healthcare facilities is crucial for ensuring individuals can meet their medical needs. Transportation barriers disrupt adherence to medical appointments, resulting in adverse health outcomes (Syed et al. 2013). Facilitating easy access to healthcare services—particularly for vulnerable populations such as older adults, individuals with disabilities, and people with low incomes—has long been a priority for health professionals (Wan et al. 2012) and is recognized as a key domain within the Social Determinants of Health (SDoH) framework outlined by the U.S. Department of Health and Human Services (2021). However, disparities in individuals' resources and transportation affordability influenced by demographic and socioeconomic characteristics (aspatial factors), along with the uneven distribution of population and healthcare facilities

(spatial factors) (Joseph and Phillips 1984), can impose significant challenges to healthcare access for certain groups. These groups include people with disabilities (Cochran et al. 2022; Chen et al. 2021), females (Roy et al. 2024; Blumenberg et al. 2024), older adults (Center for Disease Control and Prevention 2024; Mattson 2012), low-income people (Syed et al. 2013), those lacking access to a vehicle (Silver et al. 2012; Arcury et al. 2005), people with lower educational attainment (Davis et al. 2022; Wolfe et al. 2020a), and people living in nonurban areas (Henning-Smith et al. 2017; Douthit et al. 2015).

The impacts of transportation barriers are particularly pronounced for people with travel-limiting conditions or disabilities. A recent study found that adults aged 18–64 with disabilities were over three times more likely to forgo necessary healthcare than those without disabilities due to transportation barriers (Smith et al. 2023). As using public transportation can pose significant physical and logistical challenges, particularly in rural areas where transit services are less available, seeking rides from other people may be a preferable alternative. However, relying on family members, friends, neighbors, and others for rides to and from healthcare facilities can place a substantial burden on both the drivers and the riders (Cochran 2020). Indeed, 3.6 million Americans with travel-limiting disabilities rarely leave their residences (Brumbaugh 2018). As such, transportation barriers experienced by those with travel-limiting conditions or disabilities may also lead to the underrepresentation of healthcare-related transportation demand among people with disabilities, as they often have fewer opportunities to participate in or are excluded from public health programs and services (Krahn et al. 2015).

Nebraska exhibits a markedly uneven population distribution across counties and within individual counties (Wills 2024), necessitating significant travel distances for residents of sparsely populated areas to access healthcare services. Demand-responsive transport (DRT) as a

public transportation option in these areas is often limited or nonexistent, and even when available, reservations must be made well in advance to secure the desired pickup time. To address the challenges of low healthcare accessibility in rural areas, Nebraska has implemented various strategies, including telehealth services (Nebraska Legislative Bill 559 Sec 2 (5) 1999), mobile clinics, and policy initiatives such as financial incentives to attract healthcare providers (Nebraska Legislative Bill 400 1991).

Nevertheless, rural residents still need to travel to urban centers to receive many healthcare services (Nolan-Isles et al. 2021). To fully understand transportation demand for healthcare services, it is essential to consider geographical factors such as distance or travel time to care.

3.3.2 Impact of Distance or Travel Time on Healthcare Accessibility

Perceptions of distance or time required to access healthcare services can vary significantly based on individuals' demographic and socioeconomic characteristics, making it difficult to generalize a specific threshold for distance or time that influences decisions to seek care. Because they have unstable incomes and rely on others for transportation assistance, both children and older people may be more affected by distance or travel time (Russell and Doggett 2019). Women may be more reluctant to travel due to family obligations or traditional gender roles, such as taking care of children and household chores (Roeters and Gracia 2016). The increase in travel costs may shorten the feasible distance or time for low-income populations with limited resources to travel (Cochran et al. 2022).

Bosanac et al. (1976) proposed a 30-minute travel time standard to a general hospital, a benchmark supported by various states' health plans of the era, including the states of Wisconsin, Pennsylvania, and Kentucky. However, perceptions of distance may exhibit spatial variability,

demonstrating a potential inverse relationship with population density. In densely populated urban settings, where healthcare facilities are more proximate, people may perceive shorter distances or travel time as a threshold to use compared to sparsely populated rural areas where distances to healthcare facilities are typically greater. The 30-minute distance remains widely used for measuring spatial accessibility to healthcare because the Health Resources and Services Administration (HRSA) adopted it to define rational service area (RSA) in the guidelines for Health Professional Shortage Area (HPSA) designation (Delamater 2013; Luo and Wang 2003). A recent meta-analysis of 135 studies found that the threshold of distance or travel time for people to healthcare service occurs as short as 30 minutes and as great as 60 minutes (Mseke et al. 2024).

3.3.3 Non-Emergency Medical Transportation (NEMT)

NEMT is a transportation service provided to eligible individuals for travel to and from medical facilities in non-emergency situations (Dow 2018). It is compulsory for the state to ensure necessary transportation for Medicaid recipients to and from medical providers by the Consolidated Appropriations Act of 2021 (Varghese 2024). The cost of transportation is reimbursed to the transportation providers through the Medicaid program, reducing or eliminating the financial burden on riders. Cost-effective analysis (CEA) encompassing 12 preventative and chronic conditions demonstrated that the provision of NEMT is a cost-effective approach to improving all 12 types of patient care (Hughes-Cromwick et al. 2005). Although specific data on Medicaid NEMT costs is unavailable, Garrity and McGehee (2014) estimate an annual expenditure of approximately $3 billion, which accounts for less than 1% of the total annual Medicaid program expenditure. Those who used NEMT services expressed high levels of

satisfaction with the program, reporting that it has helped them feel less financially burdened, safer, and more in control of their health (Berkowitz et al. 2022).

Recognizing the positive impact of providing transportation to healthcare on health outcomes, NEMT services are increasingly being expanded beyond Medicaid programs (Adelberg and Simon 2017). While traditional Medicare has not covered NEMT services for beneficiaries, Medicare Advantage (MA) plans with supplemental benefits cover NEMT to mitigate transportation barriers. Approximately 48.1% of all MA plans offered NEMT in 2024 (Shen et al. 2024). For eligible veterans, the U.S. Department of Veterans Affairs (VA) offers transportation services and a reimbursement program for travel to medical services.

In some regions, particularly rural areas, the limited number of NEMT providers remains a significant challenge, making it difficult to meet travel demand adequately. To address this issue, some states are forming partnerships with TNCs to carry NEMT trips, but TNCs, such as Uber and Lyft, may still be unavailable in rural areas (Smith et al. 2017). In 2021, Nebraska recorded 3,533 annual NEMT ride days per 10,000 Medicaid beneficiaries, significantly lower than the national average of 6,504, likely due to the state's extensive rural areas and low population density (U.S. Department of Health and Human Services 2023). This disparity highlights a potential need to increase the number of NEMT providers in Nebraska to better meet the transportation needs of Medicaid beneficiaries. These findings underscore the importance of this research, which seeks to identify areas where NEMT demand is unmet and explore opportunities for local transportation agencies or individuals to offer or expand transportation services.

3.4 Method

In this study, we analyzed data from the 2022 NHTS to explore factors associated with travel-limiting conditions or disabilities. Additionally, we utilized data from the 2018-2022 American Community Survey (ACS) 5-year estimates to examine relationships between demographic variables and Disability Status, i.e., having or not having one or more disabilities. We assume that areas with a higher prevalence of disability will exhibit greater demand for healthcare services and NEMT (Cochran 2022; Silow-Carroll et al. 2021).

We employed both aspatial and spatial analytical approaches to identify latent demand areas for NEMT. First, we conducted an aspatial analysis to understand the prevalence of select factors associated with travel-limiting conditions or disabilities in the 2022 NHTS, combined with Disability Status data from the ACS estimates at the census tract level. These factors were expected to influence the demand for medical trips (Kong and Kim 2020). Tracts with over 80% of the population living in group quarters were excluded, resulting in an analysis of 548 tracts in Nebraska. In the spatial analysis, we measured driving times to healthcare facilities to address the assumption of uniform healthcare accessibility within a tract. This helped differentiate accessibility within the tracts and allowed us to identify latent demand areas for NEMT—tracts with a high prevalence of disability and low accessibility to healthcare facilities.

3.4.1 Data

The NHTS, the only source of national-level multimodal statistics on personal travel, has been conducted every five or eight years since 1969 for the purpose of providing an inventory of daily personal travel in the U.S. (2022 NHTS Data User Guide). The 2022 NHTS data were collected using a stratified random sampling method of U.S. households from January 2022 to January 2023, resulting in completed surveys from 16,997 individuals aged five and over across

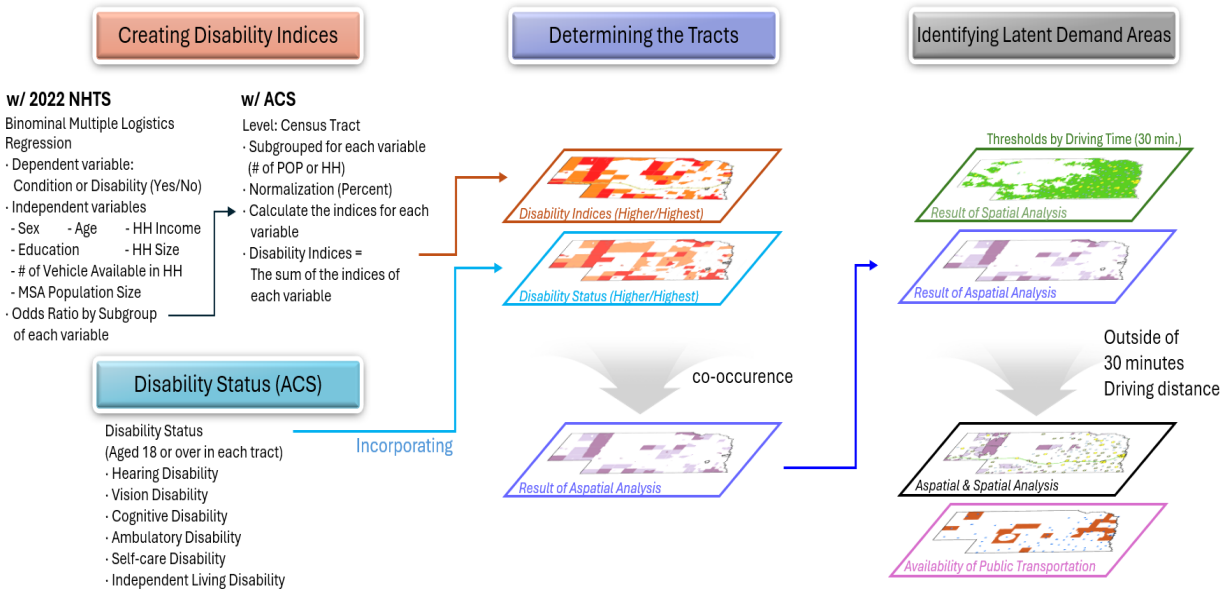
7,893 households. The NHTS data are organized into five files: Household, Person, Vehicle, Trip, and Long Distance. These files contain data on the individuals, trips, vehicles, and locations associated with each surveyed household. Within the Person file, a variable labeled MEDCOND, a binary response (yes/no) to the question of having a condition or disability that makes it difficult to travel outside of the home, was used as a proxy indicator for disability. Healthcare facility data for Nebraska, including information on the locations of hospitals and rural health clinics (RHCs), were obtained from the Nebraska Department of Health and Human Services (NE DHHS). NE DHHS publishes Hospital and RHC rosters and frequently updates them, ensuring timeliness and reliability. The Hospitals and RHCs used in this study were updated in May 2024 and included 101 hospitals and 126 RHCs.

3.4.2 Variables

Among the variables included in the Person table of the 2022 NHTS, those widely recognized as Social Determinants of Health (U.S. Department of Health and Human Services 2021) were selected to predict disability. Additionally, variables were chosen based on their availability in ACS data at the census tract level in Nebraska, allowing for the application of their association with travel-limiting conditions or disabilities as determined in the analysis. The chosen variables were sex, age, household income, educational attainment, household size, number of vehicles in the household, and metropolitan statistical area (MSA) size for the household address, which is classified by population size. Typically, younger people have lower levels of educational attainment, which may introduce distortion into the research findings, so this study confined the sample to individuals aged 18 years and older to mitigate such distortion.

3.4.3 Methodology

To understand the distribution of travel-limiting conditions and disabilities in the 2022 NHTS, we initially generated descriptive statistics to understand the prevalence of select aspatial factors that were expected to influence demand for medical trips. Fisher's exact test and the chi-squared test were used to assess the statistical independence of the variables. We then conducted both aspatial and spatial analyses to identify latent demand areas for healthcare and NEMT services among Nebraska residents, following these steps: creating Disability Indices, incorporating Disability Status, determining the tracts with high Disability Index and Status, and identifying latent demand areas based on driving time to healthcare facilities and the availability of public transportation services (Figure 3.1).



The Disability Index, Disability Status, and Determining of Tracts are results of Aspatial Analysis, while Thresholds by Driving Time for Identifying Latent Demand Areas are results of Spatial Analysis.

Figure 3.1 Aspatial and Spatial Analysis Procedure

3.4.3.1 Creating Disability Indices

We constructed a binomial multiple logistic regression model to examine the influence of the seven predictors on travel-limiting conditions or disabilities included in the NHTS. Each variable was categorized, and dummy-coded and unweighted estimates were used, as presented in Table 3.1.

Table 3.1 Variables included in the logistics regression model and their categories

Variables	Category	Reference
Condition or Disability (2)	Yes, No	Unweighted
Sex (2)	Male, Female	Male
Age (3)	18-34, 35-64, 65 or older	18-34
Household Income (4)	Less $25k, $25-50k, $50-100k, $100 or more	Less $25k
Educational Attainment (3)	Less High, High/Associate, Bachelor's & up	Less High
Household Size (4)	1, 2, 3, 4 or more	1
Vehicles in Household (4)	0, 1, 2, 3 or more	0
MSA Size (6)	Not in MSA, Less 250k, 250-500k, 500k-1M, 1-3M, 3M or up	Not in MSA

Concerning the categorization of variables, the age variable was determined based on the slowing growth rate of first marriages and the age at which individuals become eligible for Medicare—35 and 65 years, respectively (Goodwin 2009). For household income, the poverty thresholds of 100%, 200%, and 400% of the three-person household standard, as outlined by the 2023 Poverty Guidelines, were applied. The educational attainment variable was categorized according to significant differences observed in the 2023 Earnings by Educational Attainment data from the U.S. Bureau of Labor Statistics. Household size and number of vehicles in the household were categorized in increments of one unit and set into four categories to minimize interaction effects between categories. The MSA Size followed the classification used by the U.S. Census Bureau.

The odds ratios computed through our regression model were applied to the corresponding population subgroup for each tract to produce indices for each variable (equation 3.1). The Disability Indices for each tract were then created by summing these indices (equation 3.2). The 548 tracts included in the analysis were divided into sextiles based on the Disability Index.

$$I_{var\,iT} = \underset{j \in \{Category\ 1\}}{PH_{ijT}\,OR_{ijT}} + \underset{j \in \{Category\ 2\}}{PH_{ijT}\,OR_{ijT}} + \cdots\cdots + \underset{j \in \{Category\ n\}}{PH_{ijT}\,OR_{ijT}} \quad (3.1)$$

$$I_{dis\,T} = I_{var\,iT} + \cdots\cdots + I_{var\,nT} \quad (3.2)$$

$I_{var\,iT}$: Index of variable i of the tract

PH_{ijT}: Percent of POP or HH of the tract corresponding to category j of the variable i

$I_{dis\,T}$: Disability Index of the tract

OR_{ijT}: Odds Ratio (OR) of the tract corresponding to category j of the variable i

In this process, the reciprocal or inverse odds ratio (based on the least) was applied if the odds ratios were less than 1.0. For example, if the odds ratios for each household income category are 1.0 (base, the lowest income), 0.5, 0.4, and 0.2 (the highest income), the reciprocal or inverse odds ratios were calculated using the lowest odds ratio (i.e., 0.2) as the denominator, resulting in odds ratios of 5.0, 2.5, 2.0, and 1.0, respectively. This indicates that the highest household income category has five times greater odds of exhibiting the dependent variable—in this case showing prevalence of travel-limiting conditions or disabilities—than the lowest income category. This approach provides a more intuitive understanding of how travel-limiting conditions or disabilities are influenced by the categories of each variable.

3.4.3.2 Incorporating Disability Status

Previous research has demonstrated that individuals with disabilities may choose not to travel to avoid potential challenges or barriers (Firestine 2024). To enhance our analysis, we incorporated the Disability Status of each tract—i.e., the prevalence of disability in the population—stratified by age, using data from the 2018-2022 ACS five-year estimates. The Disability Status values for each tract were further categorized into sextiles, applying the same classification method used for the Disability Indices.

3.4.3.3 Determining Tracts with High Disability Index or Status

As a final step of the aspatial analysis, demand tracts for NEMT services were determined by intersecting and identifying those with high levels of both Disability Indices derived from the 2022 NHTS and Disability Status calculated using the ACS estimates. Specifically, tracts falling within the highest or second-highest quantiles for both the Disability Index and Disability Status were classified as high-demand areas.

3.4.3.4 Identifying Latent Demand Areas

We performed a spatial analysis to identify areas where driving times to a hospital or RHC exceeded 30 minutes, focusing on census tracts identified in the aspatial analysis as high latent demand areas for NEMT. Driving times to hospitals and RHCs were calculated using ArcGIS Online Network Analysis Services. To further address healthcare accessibility in these high-demand areas, we geocoded the public transportation agency list provided by the Nebraska Department of Transportation (NDOT) and overlaid it onto the identified regions. This allowed us to pinpoint potential locations where NEMT services might need to be established, expanded, or improved.

3.5 Results

3.5.1 Prevalence of Travel-Limiting Conditions or Disabilities in the Population

Using weights provided for the 2022 NHTS dataset, we generated and analyzed the prevalence of travel-limiting conditions or disabilities in the U.S. population. The percentage of people with travel-limiting conditions or disabilities was slightly higher for females compared to males at 8.0% and 6.1%, respectively. The prevalence of travel-limiting conditions or disabilities increases dramatically with age, with the percentage point difference between those aged 65 and over and the 35-64 age group (8.1 percentage points) being more than three-fold that between the 35-64 and 18-34 age groups (2.5 percentage points). Consistent with previous literature (Houtenville et al. 2023; Ho et al. 2022; McDonough et al. 1995), variables such as household income, educational attainment, household size, and number of household vehicles show an inverse relationship with the prevalence of travel-limiting conditions or disabilities; lower or smaller values in these variables are associated with a higher prevalence of travel-limiting conditions or disabilities. Notably, the percentages of travel-limiting conditions or disabilities in those with a household income below $25,000, less high school, and no available vehicle in the household are close to or well over 15%. While the MSA Size shows no significant differences between MSA categories, people with travel-limiting conditions or disabilities are less prevalent in large metropolitan areas with populations of one million or more. See Table 3.2 for full descriptive statistics of each variable.

Table 3.2 Select demographics for 2022 NHTS respondents aged 18 or over by presence or absence of travel-limiting disability

	Weighted (N = 250,896,121)	
Variable	**Disability**	**No Disability**
	7.1%	92.9%
Sex		
Male	6.1%	93.9%
Female	8.0%	92.0%
Age		
18-34	3.5%	96.5%
35-64	6.0%	94.0%
65 or older	14.1%	85.9%
Household Income		
Less than $25,000	18.4%	81.6%
$25,000 - $49,999	8.7%	91.3%
$50,000 - $99,999	6.4%	93.6%
$100,000 or more	3.5%	96.5%
Education Attainment		
Less High school	14.7%	85.3%
High school / Associate degree	7.9%	92.1%
Bachelor's degree or higher	3.5%	96.5%
Household Size		
1	10.6%	89.4%
2	7.7%	92.3%
3	5.7%	94.3%
4 or more	5.6%	94.4%
Number of Vehicles in Household		
0	16.7%	83.3%
1	10.8%	89.2%
2	5.8%	94.2%
3 or more	3.9%	96.1%
MSA Size		
Not in MSA or CMSA	7.9%	92.1%
MSA of Less than 250K	9.1%	90.9%
MSA of 250K - 500K	7.4%	92.6%
MSA of 500K - 1M	7.8%	92.2%
MSA or CMSA of 1 - 3M	6.8%	93.2%
MSA or CMSA of 3M or more	5.6%	94.4%

3.5.2 Regression Analysis and Creating Disability Indices

Results of our controlled logistic regression model indicate that older age, lower household income, limited educational attainment, and less vehicle availability are more likely to be correlated with an increased likelihood of travel-limiting conditions or disabilities (Table 3.3). To intuitively understand the maximum differences in disability odds between subgroups of each variable, we applied inverse odds to those with negative coefficients. Our analysis revealed that individuals aged 65 and older have 463% higher odds of experiencing travel-limiting conditions or disabilities compared to those aged 18-34. Similarly, individuals with less than a high school education have 376% higher odds compared to those with a Bachelor's degree or higher, individuals with a household income below $25,000 have 271% higher odds compared to those earning $100,000 or more, and individuals without access to a vehicle in their household have 308% higher odds compared to those with three or more vehicles.

Although the prevalence of travel-limiting conditions or disabilities decreases with the number of people in the household (Table 3.2), we found that the odds of travel-limiting conditions or disabilities are higher for all subgroups than the base subgroup (live alone). Further analysis revealed significant interactions between household size and other variables, including household income, the number of cars available in the household, and educational attainment. They should be investigated in future studies, as the interaction effects of these variables associated with disability are beyond the scope of the current research.

Females and people having addresses in MSAs with populations less than 250,000, as well as in MSAs or CMSAs with populations between one and three million, exhibited slightly higher odds of having travel-limiting conditions or disabilities compared to males and those in

other MSA categories, respectively. However, these probabilities were not statistically significant and, therefore, were excluded from the creation of the Disability Indices.

Table 3.3 Logistics regression results

	estimate	*std. error*	*p-value*	*odds (95% CI)*	
Sex (base: Male)					
Female	0.101	0.065	0.115	1.110	(0.976, 1.260)
Age (base: 18-34)					
35-64	0.858	0.109	3.2E-15	2.360***	(1.910, 2.930)
65 or older	1.530	0.114	4.5E-41	4.630***	(3.710, 5.810)
Household Income (base: Less than $25,000)					
$25,000 - $49,999	-0.658	0.098	1.6E-11	0.518***	(0.428, 0.627)
$50,000 - $99,999	-0.928	0.098	2.9E-21	0.395***	(0.326, 0.479)
$100,000 or more	-1.320	0.114	2.5E-31	0.266***	(0.213, 0.332)
Education Attainment (base: Less than high school)					
High school / Associate degree	-0.410	0.115	3.6E-04	0.664***	(0.531, 0.834)
Bachelor's degree or higher	-0.997	0.128	8.3E-15	0.369***	(0.287, 0.475)
Household Size (base: 1)					
2	0.295	0.094	0.002	1.340**	(1.120, 1.620)
3	0.483	0.122	8.1E-05	1.620***	(1.270, 2.060)
4 or more	0.374	0.122	0.002	1.450**	(1.140, 1.840)
Number of Vehicles in Household (base: 0)					
1	-0.432	0.122	4.0E-04	0.649***	(0.512, 0.827)
2	-0.902	0.133	1.2E-11	0.406***	(0.313, 0.528)
3 or more	-1.120	0.148	3.6E-14	0.325***	(0.243, 0.435)
MSA Size (base: Not in MSA)					
MSA of Less than 250K	0.142	0.145	0.329	1.150	(0.871, 1.540)
MSA of 250K - 500K	0.085	0.164	0.607	1.090	(0.790, 1.510)
MSA of 500K - 1M	0.056	0.157	0.721	1.060	(0.780, 1.440)
MSA or CMSA of 1 - 3M	0.128	0.146	0.382	1.140	(0.858, 1.520)
MSA or CMSA of 3M or more	-0.030	0.146	0.836	0.970	(0.732, 1.300)

Notes: * $p < 0.05$; **$p < 0.01$; *** $p < 0.001$

3.5.3 Identifying Latent Demand Areas for NEMT

Among the 127 tracts where both the Disability Index and Disability Status are higher (5th quantile) or highest (6th quantile), applying the same sextile classification method (i.e., 1st quantile - lowest, 2nd quantile - lower, 3rd quantile - low, 4th quantile - high, 5th quantile -

higher, 6th quantile - highest), we determined 53 tracts, highest in both, as Demand 1 tracts, and the remaining 74 tracts as Demand 2 tracts (Figure 3.2).

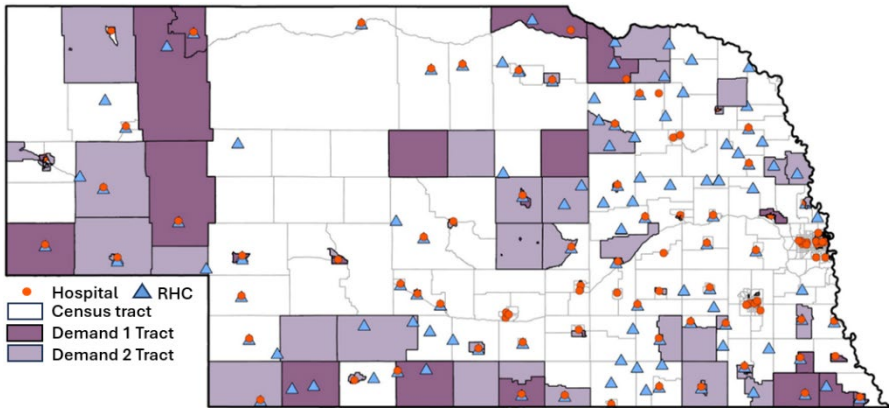


Figure 3.2 Demand 1 and 2 Tracts

Areas that are less and more than a 30-minute drive to hospitals or RHCs within both Demand 1 and 2 tracts were evaluated using the statistically significant variables among the predictors used in our logistic regression model. Nebraska's relatively wide census tracts are likely divided by the 30-minute driving distance catchment, so we utilized block group data to derive more accurate outcomes. In this process, for variables where the same data were unavailable (such as the number of vehicles in a household, educational attainment, and Disability Status), we used tract data adjusted by the population, number of households, and area ratio of the block groups. Figure 3.3 depicts areas where the travel time to the nearest hospital or RHC exceeds 30 minutes by car, encompassing a total of 10,755 residents aged 18 or older.

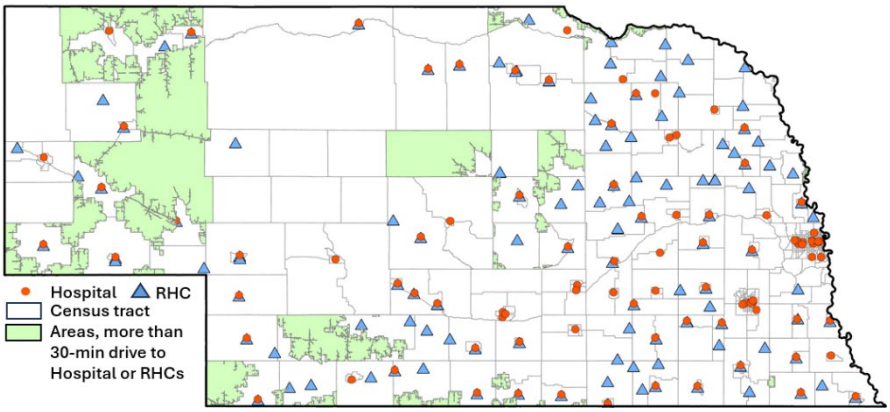


Figure 3.3 Areas that are more than a 30-minute driving time to Hospitals or RHCs within both Demand 1 and 2 tracts

Areas within Demand 1 and 2 tracts that are more than 30 minutes driving time to Hospitals or RHCs exhibit a more than 1.5 times higher prevalence of people aged 65 or older (33.53%) than that of the state, which is slightly over 20%. The percentage of available vehicles in households, however, exceeds those of the state (i.e., the percentage of subgroups without available vehicles is low, and with three or more vehicles is high), as there may be no means of transportation other than a private vehicle to meet daily travel needs in more rural areas (Berg and Ihlström 2019; Pucher and Renne 2004). In terms of household income, which positively influences health service use as a facilitator, the disparities in the percentage of households with incomes less than $25,000 and $25,000–$49,999 compared to those of the state are substantially larger, well exceeding four percentage points (Columns 1 and 3 in Table 3.4). The Disability Index and Disability Status of Demand 1 and 2 tracts were calculated to be much higher at 9.316 and 21.78%, respectively, compared to the state's 8.686 and 14.69%, respectively.

Table 3.4 Prevalence of Socio-demographic characteristics by driving time to healthcare service and public transportation availability

Variable	State	Demand 1 and 2 tracts	Areas within Demand 1, 2 tracts that are more than 30-min drive to Hospitals or RHCs	Areas within Demand 1, 2 tracts that are more than 30-min drive to Hospitals or RHCs and have no public transportation	Areas within Demand 1, 2 tracts that are more than 30-min drive to Hospitals or RHCs and have public transportation
Population (18 or older)	1,430,713	290,650	10,755	2,148	8,607
Age					
18-34	29.55%	26.74%	18.35%	15.21%	19.14%
35-64	49.13%	46.78%	48.11%	47.25%	48.33%
65 or older	21.32%	26.47%	33.53%	37.54%	32.53%
Household Income					
Less than $25,000	14.71%	23.43%	18.79%	18.84%	18.78%
$25,000 - $49,999	19.57%	23.92%	23.88%	22.52%	24.22%
$50,000 - $99,999	31.66%	31.43%	34.28%	34.24%	34.29%
$100,000 or more	34.06%	21.23%	23.05%	24.40%	22.72%
Education Attainment					
Less High school	8.53%	11.74%	7.96%	5.53%	8.57%
High school/Associate	60.35%	67.92%	72.03%	73.84%	71.58%
Bachelor's or higher	31.12%	20.33%	20.01%	20.64%	19.85%
Household Size					
1	16.29%	21.05%	17.46%	17.43%	17.46%
2	27.52%	27.86%	36.53%	41.23%	35.36%
3	15.65%	15.03%	12.60%	13.37%	12.41%
4 or more	40.54%	36.06%	33.41%	27.98%	34.76%
Number of Vehicles in Household					
0	5.05%	8.71%	3.51%	4.31%	3.31%
1	29.77%	33.74%	23.41%	18.50%	24.64%
2	38.50%	33.13%	32.72%	30.95%	33.17%
3 or more	26.68%	24.42%	40.36%	46.25%	38.87%
Disability Index	8.686	9.316	9.235	9.289	9.222
Disability Status	14.69%	21.78%	20.74%	20.29%	20.86%

As the final step in identifying latent demand areas for NEMT, we considered the availability of public transportation services. Figure 3.4 highlights areas without public transportation that are also more than a 30-minute drive from hospitals or RHCs within Demand

1 and 2 tracts. These areas span six counties and have a total population of 2,148, with nearly 38% of residents aged 65 or older. Notably, areas lacking public transportation services have a 5% higher proportion of residents aged 65 or older compared to areas with public transportation services (see Columns 4 and 5 in Table 3.4).

A map of Nebraska showing areas with public transportation services available and public transportation services unavailable among those that are more than a 30-minute drive to hospitals or RHCs within Demand 1 and 2 tracts . Locations of Hospitals and RHCs are also indicted.

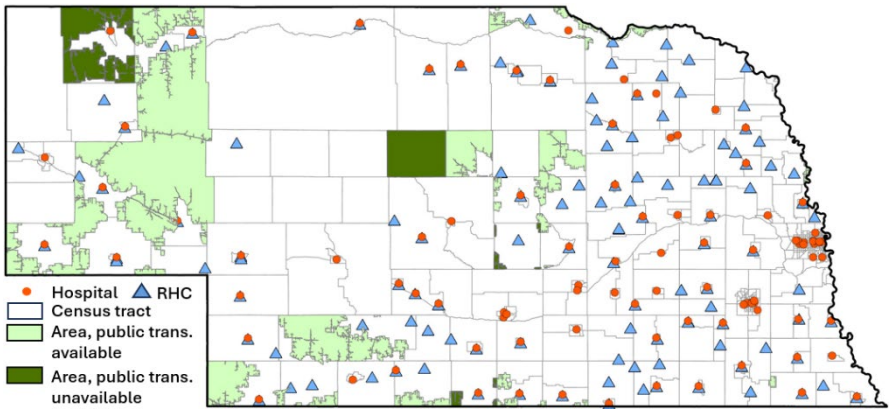


Figure 3.4 Areas with public transportation services available and public transportation services unavailable among those that are more than a 30-minute drive to hospitals or RHCs within Demand 1 and 2 tracts

Rural public transportation, which operates with a small fleet of vehicles across large counties (Laska 2021), did not result in significant differences in Disability Status or the Disability Index, which measures travel-limiting conditions (Columns 4 and 5 in Table 3.4). The limited spatiotemporal availability of public transportation services highlights the need for additional mobility options to adequately address the demand for transportation to healthcare services. Ultimately, we identified areas within the Demand 1 and 2 tracts where travel times to

the nearest hospital or RHC exceed 30 minutes as those with potentially high latent demand for NEMT (Figure 3.5).

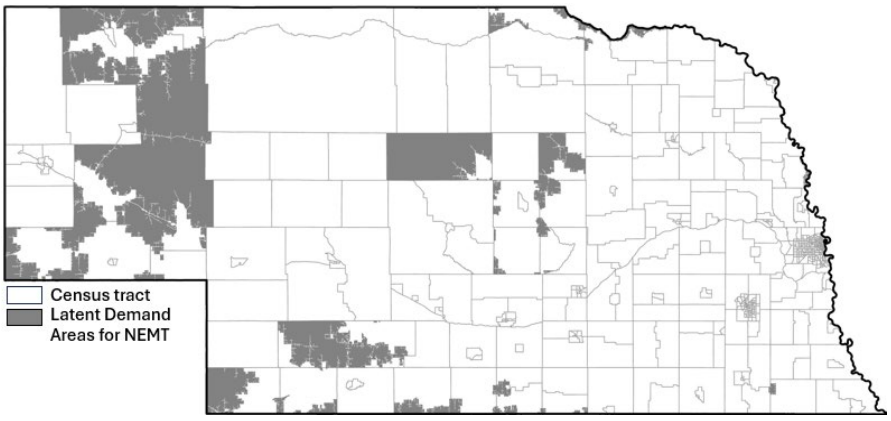


Figure 3.5 Identified latent demand areas for NEMT

3.6 Discussion

Our analysis of data from the 2022 NHTS reveals that 17.7 million adults, or 7.1% of those aged 18 and over, report travel-limiting conditions or disabilities. This figure is less than half the prevalence of disability in the adult population reported by the American Community Survey (ACS), which estimates 38.6 million individuals, or 15.3% of the same age group, have disabilities (ACS 2018–2022 5-year estimates).

Consistent with previous research, we found that sociodemographic characteristics such as gender, age, household income, educational attainment, household size, the number of vehicles in the household, and MSA size influenced the prevalence of travel-limiting conditions or disability (O'Driscoll et al. 2024; Akinlotan et al. 2023). The prevalence of travel-limiting conditions or disabilities among individuals aged 65 years and older in the NHTS sample was 14.1%, which was 10.6 and 8.1 percentage points higher than those aged 18–34 and 35–64,

respectively. This suggests that physiological, cognitive, and psychological changes associated with aging (Chihuri et al. 2016) can reduce older adults' driving abilities, often leading to driving cessation and creating significant transportation barriers for this age group. Subgroups with the lowest household incomes and lacking access to private vehicles also encounter substantial transportation barriers. Significant prevalences of travel-limiting conditions or disabilities are observed among these groups, reaching 18.4% and 16.7%, respectively. These high rates are likely attributable to the underdevelopment of existing transportation infrastructure, including public transit systems, which encourages excessive reliance on personal vehicles for travel needs (Mattioli et al. 2020). Additionally, owning and operating personal vehicles imposes substantial economic burdens, particularly on low-income households (Myers et al. 2022).

A significant disparity in travel-limiting conditions or disabilities was observed across different levels of educational attainment. Respondents with less than a high school education reported a prevalence of nearly 15%, whereas this figure was markedly lower among those with a bachelor's degree or higher, at only 3.5%. The significant disparities observed may be attributed to the associations between incomplete high school education and limited employment prospects, low income, and poverty (Truman et al. 2015; Wilson et al. 2013). These socioeconomic factors can subsequently exacerbate personal perceptions of disadvantages, further contributing to increased transportation barriers (Myers et al. 2022).

While most variables exhibited generally linear patterns, either positive or negative, MSA size did not follow this trend. The slightly higher prevalence of travel-limiting conditions observed in smaller MSAs (population < 250,000) compared to rural areas likely reflects a complex interplay of factors, including transportation availability and vehicle ownership. As population size increases, the greater availability of diverse transportation options typically

correlates with a lower prevalence of travel-limiting conditions (Bezyak et al. 2017). Conversely, despite limited transportation services, rural areas may experience lower prevalence rates due to higher levels of vehicle ownership, which support essential daily travel needs (Wang et al. 2023; Dargay 2002).

The binomial regression analyses revealed significant disparities in the experience of travel-limiting conditions or disabilities. Older adults aged 65 and over, individuals with low incomes, those with less than a high school diploma, and people without access to a household vehicle were significantly more likely to report conditions or disabilities that made traveling outside their homes difficult. Travel-limiting conditions or disabilities were significantly associated with age, particularly the odds of those aged 65 or over were 4.6 times higher than those aged 18-34, with controlling for other variables. This suggests that older adults aged 65 or over encountered higher transportation difficulties with a dramatic escalation, given that the odds for those aged 35-64 were 2.3. Consistent with previous research, higher household income, higher educational attainment, and a greater number of vehicles in the household were significantly associated with a lower likelihood of having travel-limiting conditions or disabilities.

To improve the intuitive understanding of odds ratios less than one, we inverted the odds, using the subgroup with the highest odds as the reference within each variable, and analyzed the inverse odds across the units of each variable. The subgroups exhibiting the largest differences in inverse odds compared to the next higher subgroup were households with incomes below $25,000, individuals with less than a high school education, and those without vehicle access. Their respective differences in inverse odds were 1.8, 0.9, and 1.1, indicating that individuals in these subgroups are significantly more likely to encounter transportation difficulties compared to

those in the next higher subgroups. This finding underscores the more pronounced travel-limiting conditions or disabilities experienced by these populations. Addressing these disparities requires focused attention and targeted policy interventions to alleviate transportation challenges and promote equitable access for these vulnerable groups.

A priori, a negative association between household size and travel-limiting conditions or disabilities was hypothesized, predicated on the assumption that those with travel-limiting conditions or disabilities could rely on other household members for mobility (Choi and DiNitto 2016). However, our regression model computed unexpected odds ratios of household size 2, 3, and 4 or more. Additional analysis revealed an interaction effect related to household size. The significant interactions identified were: 1) household size and household income and 2) household size and the number of vehicles in the household. The observed increases in odds for larger household sizes can be explained by disparities between aggregate household resources and their per capita availability. For example, a single-person household with an annual income of $30,000 would have significantly different economic circumstances compared to a three-person household with the same income, where the per capita income would be $10,000. In such cases, the odds of experiencing travel-limiting conditions or disabilities may be higher for the larger household.

Future research should further explore these interaction effects and incorporate measures of per capita resource availability to provide a clearer understanding of the dynamics. While some studies, such as Ibukun and Alam (2024), have identified significant associations between gender and MSA size with travel-limiting conditions, our model did not yield similar findings. In our analysis, the odds for gender and MSA size showed no significant differences compared to the base category (Not in MSA) and were not statistically significant.

To identify latent demand areas for NEMT in Nebraska, we considered both Disability Index, quantifying the prevalence of sociodemographic factors significantly associated with travel-limiting disabilities, computed using the 2022 NHTS, and Disability Status, data on the prevalence of disability from the 2018-2022 ACS 5-year estimates at the census tract level. We incorporated Disability Status into our analysis to more accurately capture the transportation needs of people with disabilities. Demand estimated solely from the NHTS may underestimate trips due to this population's generally lower daily trip frequency (Henly and Brucker 2019) and reduced participation in web-based surveys. This underrepresentation is likely influenced by a digital divide, as only 78.4% of individuals with disabilities live in households with internet access, compared to 91.5% of those without disabilities (Office of Disability Employment Policy 2022). Demand 1 tracts (53 tracts, ranked in the highest—6th quantile—for both Disability Index and Disability Status) and Demand 2 tracts (74 tracts, ranked in the higher or highest—5th or 6th quantile—for both Disability Index and Disability Status, but not both in the highest) are predominantly located in non-metropolitan counties, as defined by the USDA Rural-Urban Continuum Codes. These tracts account for 63% (83 out of 127) of all Demand tracts. Among the 548 tracts included in this study, a significantly higher proportion of those in non-metropolitan (rural) counties were classified as Demand tracts (38%, 83 out of 218) compared to those in metropolitan (urban) counties (13%, 44 out of 330).

As the latent demand area for NEMT, we identified the areas within the Demand tracts (comprising Demand 1 and 2 tracts) where it takes more than 30-minute driving time to reach a hospital or RHC. According to a study conducted recently examining primary healthcare access, most participants considered travel times of 6–15 minutes (36%) and 16–30 minutes (33%) to be acceptable. However, only 7% of the participants were willing to travel more than one hour (Cao

et al. 2022). In terms of costs, Rocque et al. (2019), who studied travel time to cancer care sites for Medicare beneficiaries aged 65 years or older, found that patients who traveled more than one hour had 14% and 10% higher Medicare spending and patient cost, respectively, compared to patients who traveled less than 30 minutes. Additionally, in accordance with several studies that have used a 30-minute travel distance as a measure of spatial accessibility to healthcare (Stacherl and Sauzet 2023), we also implemented a 30-minute threshold in our study.

The Disability Index and Disability Status within and beyond the 30-minute driving distance catchment area are nearly identical. However, the prevalence of individuals aged 65 and older is 7.3% higher outside this catchment area, indicating a potentially greater demand for transportation services to access healthcare. Older adults often face an increased risk of chronic health conditions requiring frequent healthcare visits (Ofori-Asenso et al. 2019). Additionally, compared to small population centers (areas with populations between 1,000 and 29,999), rural regions experience a 10%–32% lower availability of public transportation options (Krasniuk and Crizzle 2023). These disparities span various modes of transportation, including taxis (32%), shuttle services (13%), handi-van/bus services (18%), and private transportation services (10%).

Geographical distance or travel time to healthcare facilities remains a critical factor in estimating travel demand. Qualitative studies have consistently identified travel distance or time as the most significant barrier to healthcare access for rural older adults (Buzza et al. 2011; Goins et al. 2005). These findings strongly suggest that demand for NEMT services is likely higher in areas beyond the 30-minute driving distance catchment area identified in our study. Furthermore, we analyzed the availability of public transportation beyond the 30-minute driving distance catchment area by categorizing these areas based on the presence of public transportation services. The results revealed no significant differences in the Disability Index and

Disability Status (less than 0.1% and 1%, respectively) between areas with and without public transportation. This finding suggests that the presence of public transportation services outside the 30-minute driving time to the nearest healthcare facility is not a critical determinant of latent demand for NEMT services.

The observed similarity in the Disability Index and Disability Status between these two areas (i.e., with or without public transportation services) may be attributed to the generally limited availability of transportation services in such regions, even where public transportation options exist. This limited availability likely diminishes the overall impact of public transportation on meeting the needs of individuals in these areas. Due to low population density and significant distances between communities, most public transportation providers in Nebraska operate DRT services (Kaufman et al. 2021). As of 2019, Nebraska had 56 DRT providers operating a total of 253 vehicles. While only six providers operated fleets of 10 or more vehicles, the majority managed smaller fleets (Nebraska Department of Transportation 2020). Since DRT services are also used for purposes such as shopping, employment, meals, and education, the availability of these services for healthcare purposes when needed is likely to be highly constrained. DRT providers are often based in rural centers, and their limited fleet sizes can lead to operational challenges. For instance, serving a single passenger in a remote rural area may prevent providers from accommodating a larger number of passengers closer to rural centers. This scenario can increase lead times for service delivery to remote residents, significantly reducing the availability of transportation services for individuals in these areas.

This study has several limitations that should be acknowledged. First, in examining aspatial factors to identify demand areas for NEMT, the current research analyzed sociodemographic factors associated with the prevalence of travel-limiting conditions or

disabilities using data from the 2022 NHTS dataset and Disability Status from ACS estimates. However, insurance data was not included in the analysis. Insurance coverage is a significant factor, as individuals with insurance are more likely to utilize healthcare services compared to those without (Sommers et al. 2017). Additionally, transportation costs play a critical role in influencing individuals' intent to access healthcare services (Cochran et al. 2022; Jang et al. 2020). NEMT services, as noted earlier, enable Medicaid and Medicare Advantage beneficiaries to access transportation for healthcare without incurring costs. Understanding the prevalence of eligible individuals for NEMT services residing in areas without public transportation is essential for accurately identifying demand areas. Future research should incorporate insurance data and examine its implications to provide a more comprehensive understanding of the multifaceted impact of insurance on transportation barriers and healthcare access.

Nebraska's vast area and low population density result in large block groups that often straddle the boundaries of the 30-minute driving distance catchment area. To compute the Disability Index and Disability Status for areas both inside and outside this catchment within demand tracts (Demand 1 and Demand 2), we used block group data. These metrics were calculated by proportionally weighting the sociodemographic values of each block group based on its area, under the assumption of uniform population distribution within the block groups. However, this approach may not accurately reflect reality, as population distribution within a block group is often uneven and influenced by various physical, social, and environmental factors. As a result, the calculated values may not fully capture the true characteristics of the population in these divided block groups.

3.7 Conclusion and Implications

Nebraska, situated in the central Midwest, is characterized by a low population density spread over a vast geographical area. Of its cities, towns, and villages, 388 (66%) have populations of fewer than 500 residents, with these small communities scattered sparsely across the state. Latent demand areas for NEMT have been identified in this study using both aspatial and spatial analyses. The aspatial analysis combines data from the Disability Index, derived from the 2022 NHTS, and Disability Status estimates from the 2022 American Community Survey (ACS, 5-year estimates). The spatial analysis incorporates a 30-minute driving distance to the nearest healthcare facility. These analyses reveal that NEMT demand is concentrated in rural areas, where populations face significant transportation challenges. Factors such as cessation of driving due to age, greater distances to healthcare facilities, insufficient transportation infrastructure and services, and unaffordable transportation costs contribute to inequitable access to healthcare-related transportation in these regions.

As of December 2024, Nebraska has 432,707 Medicaid beneficiaries and Medicare Advantage enrollees who are eligible for NEMT services, representing 22% of the state's population (Centers for Medicare and Medicaid Services 2024). A significant portion of residents in identified Demand areas are likely to qualify for NEMT services. To facilitate their access to healthcare services and ensure the efficient use of the limited resources available to transportation providers, the following transportation policy implications warrant consideration.

First, there is a critical need to expand the service areas of existing transportation providers. Currently, most providers in Nebraska operate within county or municipal boundaries, leaving gaps in coverage for certain regions. For example, Blaine County lacks local transportation providers and receives no services from neighboring counties. Despite its small

population of just over 400, Blaine County has the highest Disability Index and Disability Status in the state, indicating a significant prevalence of travel-limiting conditions or disabilities. Without alternative transportation options, residents face significant barriers to accessing essential activities such as employment, grocery stores, community engagement activities, and, most critically, healthcare services. Expanding the service areas of city-based providers to encompass all county regions could significantly alleviate these transportation challenges for rural residents. However, such an expansion would likely require additional resources, including more vehicles and drivers. As a result, the potential benefits and feasibility of this approach should be carefully evaluated to ensure efficient resource allocation and service delivery.

Second, transportation providers, particularly those operating in rural areas, should have the flexibility to manage their fleets efficiently. In Nebraska, transportation providers with small fleets deliver Medicaid NEMT services at the request of brokers (MTM and Modivcare) while also serving the public through various programs designed to assist transportation-disadvantaged populations, such as those with mobility impairments, low incomes, too old to drive, or without reliable vehicles, predominantly in rural areas (Combs et al. 2016). Research on NEMT services in North Carolina, which introduced a system similar to Nebraska's, highlights that insufficient coordination with NEMT brokers can hinder route optimization, making it difficult for providers to balance operational costs with revenue (Palacios et al. 2023). For example, requiring pick-up requests far in advance (e.g., three days) without alignment with providers' route planning creates challenges in scheduling shared trips, limiting the ability to maximize vehicle occupancy and restricting potential revenue growth. Additionally, Palacios et al. stress the importance of granting local transportation providers the right of first refusal (ROFR) for in-county NEMT trips. This contractual agreement ensures providers have the first opportunity to accept trips

before other entities are considered (Bikhchandani et al. 2005). Since NEMT services represent a critical revenue source for many rural providers, the absence of ROFR could jeopardize their financial stability and operational sustainability.

Third, diversifying vehicle types in rural service areas is essential. Given the small fleet sizes of rural transportation providers, recruiting private service providers or establishing collaborative partnerships with transportation network companies (TNCs), such as Uber and Lyft—which currently operate only in Omaha, Lincoln, and nearby areas—is necessary. In rural Nebraska, more than 50% of vehicles in service have a seating capacity of 10 or more, and 80% of providers operating a single vehicle rely on one with a similar capacity (2022 National Transit Database). This reliance on high-capacity vehicles creates challenges in accommodating NEMT patients' schedules while also meeting the transportation needs of other residents. In rural areas, households are often scattered beyond a 30-minute driving distance to healthcare facilities but are relatively clustered within smaller catchment areas. Deploying high-capacity vehicles for NEMT services is not always practical or efficient. Instead, utilizing low-capacity vehicles for long-distance NEMT trips at patients' preferred times could enhance both efficiency and accessibility without compromising service to others. Engaging local individuals and organizations such as faith-based groups and charities (Seekins et al. 2008) or forming partnerships with TNCs to provide NEMT services in rural areas offers a promising solution. While NEMT services delivered by TNCs could improve cost-effectiveness and patient access, their financial feasibility in rural settings requires additional investigation (Wolfe et al. 2020b). Addressing these issues demands further research to account for the complexities among key stakeholders, including local governments, transportation providers, and insurers. Tailored

solutions must be developed to effectively address the unique needs of rural patients in Nebraska and beyond.

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Interview Questionnaires for Chapters 1 and 2

A.1 Transportation Barriers to Low Vision Care Study Interview Questions: Patients

1. Introduction

Hello! I am *[name]* and I am conducting a study on transportation-related barriers to seeking low vision rehabilitation services. If you are 19 years of age or older and are currently or have previously received low vision rehabilitation care or cared for someone who has, you may be eligible to participate in this research. The purpose of this research is to understand how transportation facilitates or hinders people's ability to seek or otherwise access low vision care.

2. Pre-Screening Questions

Before we begin the interview, I need to ask you a few questions to confirm you are eligible to participate in this study.

a. Are you 19 years of age or older?
    i. If yes—continue to interview.
    ii. If no—not eligible to participate.
b. Are you currently receiving, or have you previously received low vision rehabilitation care?
    i. If yes—continue to interview.
    ii. If no—Are you currently serving as a caregiver for someone currently receiving or who has previously received low vision rehabilitation care?
        1. If yes—continue to interview.
        2. If no—not eligible to participate.

3. Interview (if eligible to participate)

Thank you for your answers. Participation in this study will require approximately 30 minutes. You will be asked to answer some questions about your experiences traveling to seek low vision rehabilitation services.

Participants will not receive any direct benefits from participation in this study. However, society may benefit from this study insofar as it advances understanding of transportation barriers facing individuals living in urban and rural settings with visual impairments and assess strategies to address these barriers. This may promote access to care among people seeking low vision rehabilitation services and, potentially, health outcomes among this group.

Reasonable steps will be taken to protect the privacy and the confidentiality of your study data; however, in some circumstances we cannot guarantee absolute privacy and/or confidentiality. Research records will be stored electronically through University approved methods. Records will only be seen by the research team and/or those authorized to view, access, or use the records during and after the study is complete.

If you have questions about this project, you may contact Dr. Abigail Cochran at [redacted] or acochran@unl.edu.

If you have questions about your rights or complaints about the research, contact the Institutional Review Board (IRB) at (402) 472-6965 or irb@unl.edu.

You can decide not to be in this research study, or you can withdraw at any time before, during, or after the research begins for any reason. Deciding not to be in this research study or deciding to withdraw will not affect your relationship with the investigator, the University of Nebraska-Lincoln, or any other persons or institutions. You will not lose any benefits to which you are entitled.

You are voluntarily making a decision whether or not to be in this research study. By completing the interview, you are giving your consent to participate.

Are you interested in participating?

a. If yes—continue interview.
b. If no—end conversation and do not continue to interview.

4. Preliminary Information
    a. Please tell me about yourself. Can you tell me a little about the city where you live?
    b. Do you have friends, family, or other people you can depend on who live nearby?

5. Last Experience Seeking Low Vision Care
    c. Please think back to the last time you went to a doctor's appointment to receive low vision rehabilitation services. How did you get to your appointment? How did you get home from your appointment?

d. Do you usually get to and from low vision care appointments in the ways you just described?
    i. What do you like about traveling this way?
    ii. What do you dislike, or otherwise find challenging or frustrating about traveling this way?
e. Do you ever feel like you can't get to your low vision appointments, or can't schedule more appointments because it's difficult to get to the clinic?
    i. Inquire here about why – Scheduling? Relying on others? Relying on timetables/particular services? Cost? Etc.
f. Have you ever:
    i. Arrived late to a low vision care appointment because of transportation problems?
    ii. Delayed making a low vision appointment because you were not sure you would be able to get to the clinic?
    iii. Missed a low vision appointment that was scheduled because transportation problems prevented you from getting to the clinic?
        1. Inquire, if yes to i–iii, as to what the transportation problems were.

6. General Transportation Barriers, Telehealth, and Wrap-Up Questions
    g. What kinds of challenges do you face traveling for doctor's appointments or medical treatments, or simply trying to get where you need to go in the day-to-day?

h. Have you ever used Telehealth? In what ways do you think Telehealth might make it easier for you to receive low vision rehabilitation services? In what ways might Telehealth make things harder?
i. Have you ever used public transportation or another service, like Medicaid transportation/NEMT or paratransit, to get to a medical appointment or treatment?
    i. If so, what did you like about the service? What did you dislike about it?
    ii. Would you consider using one of these services to get to future medical appointments, including low vision rehabilitation care appointments?
j. Have you ever used a taxi or a service like Uber or Lyft to get to medical appointments?
    i. If so, what do you like about the service? What did you dislike about it?
    ii. If so or not, would you consider using one of these services to get to future medical appointments, including low vision rehabilitation care appointments?
k. How has the way you travel around routinely changed in the past 5 years?

Thank you for your time. If you know of anyone that you think might be interested in participating in an interview for this study, please feel free to pass along my contact information (which we've been using to schedule this interview, and which can be found in the initial recruitment materials you received). If I have any follow-up questions or concerns about the information you have provided during this interview, may I contact you for clarification?

Thank you, again.

A.2 Transportation Barriers to Low Vision Care Study Interview Questions: Clinicians

1. Introduction

Hello! I am *[name]* and I am conducting a study on transportation-related barriers to seeking low vision rehabilitation services. If you are 19 years of age or older and currently work, or have previously worked, as a healthcare provider (e.g., doctor, nurse, rehabilitation specialist) who provides care to patients with low vision, you may be eligible to participate in this research. The purpose of this research is to understand transportation challenges from the perspective of providers who assist low vision patients in accessing care.

2. Pre-Screening Questions

Before we begin the interview, I need to ask you a few questions to confirm you are eligible to participate in this study.

   a. Are you 19 years of age or older?
      i. If yes—continue to interview.
      ii. If no—not eligible to participate.
   b. Are you currently or have you previously worked as a provider of low vision rehabilitation services (e.g., doctor, nurse, rehabilitation specialists)?
      i. If yes—continue to interview.
      ii. If no—not eligible to participate.

3. Interview (if eligible to participate)

Thank you for your answers. Participation in this study will require approximately 15-45 minutes. You will be asked to answer some questions about your experiences observing or

addressing transportation challenges your patients face when seeking low vision rehabilitation services.

Participants will not receive any direct benefits from participation in this study. However, society may benefit from this study insofar as it advances understanding of transportation barriers facing individuals living in urban and rural settings with visual impairments and assesses strategies to address these barriers. This research may promote a better understanding of transportation barriers faced by patients from the provider's perspective, leading to strategies that can enhance access to low vision rehabilitation services, potentially improving health outcomes for patients.

Reasonable steps will be taken to protect the privacy and the confidentiality of your study data; however, in some circumstances we cannot guarantee absolute privacy and/or confidentiality. Research records will be stored electronically through University approved methods. Records will only be seen by the research team and/or those authorized to view, access, or use the records during and after the study is complete.

If you have question about this project, you may contact Dr. Abigail Cochran at [redacted] or acochran@unl.edu.

If you have questions about your rights or complaints about the research, contact the Institutional Review Board (IRB) at (402) 472-6965 or irb@unl.edu.

You can decide not to be in this research study, or you can withdraw at any time before, during, or after the research begins for any reason. Deciding not to be in this research study or deciding to withdraw will not affect your relationship with the investigator, the University of Nebraska-Lincoln, or any other persons or institutions. You will not lose any benefits to which you are entitled.

You are voluntarily making a decision whether or not to be in this research study. By completing the interview, you are giving your consent to participate.

Are you interested in participating?

a. If yes—continue interview.
b. If no—end conversation and do not continue to interview.

4. Can you explain your role in caring for or treating individuals with low vision?
5. How would you describe the community that you serve/where you live?
    a. Does it include some or all urban, suburban, and rural areas?
6. In broad terms, which vulnerable groups are represented among your clients for example, persons with multiple disabilities or chronic conditions, individuals with low incomes, communities of color, seniors, non-English speakers, etc.?
    a. Are any other vulnerable groups included among your clients?
7. How would you explain the role of transportation for your patients? Is transportation a challenge for your clients? How often do you hear about transportation issues from clients?

a. Is transportation frequently a reason for cancellations or late arrivals, and how does this affect your clients' access to care?

8. From your experience, what types of transportation challenges and barriers are your clients dealing with? What are common complaints from your clients or colleagues?
    a. Issues with access—Securing/maintaining private vehicles, public transit availability, etc.?
    b. Issues with connectivity—Are there particular destinations that they have trouble traveling to, such as jobs, schools, childcare, grocery stores, etc.?
    c. What about healthcare specifically (e.g., clinics, hospitals, etc.)?
    d. Complications with traveling across geographic boundaries (e.g., municipal, county, or state boundaries)?
    e. Issues with trip planning—How well do they understand the transportation options available to them? Do they consider planning to get to and from their destination?
    f. Issues with transportation costs—Are clients able to afford the transportation options available?
    g. Issues with emotional barriers—Do some of your client’s express discomfort or reluctance about using the services available? For example, public transit or Uber/Lyft?
    h. In your experience, how big of an issue is the qualification process for various services? For example, ADA paratransit requires specific approval processes. Can you talk about this and other approval processes that either expedite, or hinder,

access for your clients? Is the turnaround time for the application process an issue?

   i. Are there other issues that you've seen, related to transportation challenges and barriers, that we haven't yet discussed?

9. Of the various transportation challenges and barriers, you mentioned, are there certain challenges that pertain to one vulnerable population versus another?
10. Have you seen differences between those who live in rural areas and those who live in more urban areas when it comes to accessing care for their low vision?
11. Are there specific barriers that you have noticed that prevent those who live in rural or urban areas from receiving care?
12. Are there new programs or initiatives outside the ones you mentioned?
13. [If there are not any new programs and initiatives, then skip to question 19.] What obstacles prevent these types of innovative programs and initiatives from being implemented in your area?
14. Which of these programs or initiatives serve urban areas? Suburban areas? Rural areas?
15. What feedback, both good and bad, have you received from your clients or from colleagues about each of these programs or initiatives?
16. In your opinion, how has the introduction of these programs or initiatives impacted your clients?
    a. Particularly, has there been an impact on how they access health care services?
    b. Of the vulnerable groups we talked about earlier, are some more likely than others to utilize these programs or initiatives, from your experience? Why is that?

17. What role does technology play in using these programs or initiatives and how does this affect your clients?
    a. Is a smartphone, tablet, or computer with Internet required?
18. Are there any barriers to your clients utilizing these new programs and initiatives?
    a. In your opinion, are there any changes that could be made to better serve your clients and vulnerable populations, in general?
19. Do you have other thoughts or comments that you'd like to share about anything we've talked about today?

Appendix B Supplemental Information for Chapter 3

B.1 Data Used and Collected in Aspatial and Spatial Analyses

Table B.1 Data list collected and used for Chapter 3 research

Data	Sources
2022 NHTS Person Data Household data	Federal Highway Administration, DOT
2018-2022 ACS Estimate (5-Year) B01001. Age by Sex B08201. Household Size by Vehicles Available B09018. Relationship to Householder for Children Under 18 Years in Households B09019. Household Type (Including Living Alone) by Relationship B09021. Living Arrangements of Adults 18 Years and Over by Age B11016. Household Type by Household Size B15001. Sex by Age by Educational Attainment for the Population 18 Years and Over B18101. Sex by Age by Disability Status B26001. Group Quarters Population B18101. Age by Disability Status (B18102 to B18107. Detailed table by type of Disability) S2503. Financial Characteristics	Census Bureau
Healthcare Facility Hospital Roster Rural Health Clinic Roster	NE DHHS
Public Transit Provider List	NE DOT
Revenue Vehicle Inventory	2022 National Transit Database
Service Vehicle Inventory	

B.2 Average Time and Distance from Demand Tracts to Nearest Hospital

Table B.2 Average time and distance from Demand tracts (centroid) to nearest hospital

	Demand 1 Tracts (*N* = 53)	**Demand 2 Tracts (*N* = 53)**	**No Demand Tracts (*N* = 421)**
Straight Line (Miles)			
In CMAS	1.93	2.36	3.02
In MSA	1.42	4.05	4.79
Not in MSA	8.39	7.56	9.74
Driving Distance (Miles)			
In CMAS	2.39	3.06	4.09
In MSA	1.82	5.36	6.24
Not in MSA	11.22	10.05	13.13
Driving Time (Minutes)			
In CMAS	6.14	7.76	8.64
In MSA	5.08	9.01	11.01
Not in MSA	15.42	15.10	18.11