Travel Behaviors of the Transportation-Disabled Population and Impacts of Alternate Transit Choices: A Trip Data Analysis of The Handitran Paratransit Service in Arlington, TX

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ABSTRACT

The growing number of disabled and senior citizens in the United States encourages cities to provide this population with paratransit services. This study explores the travel patterns of a paratransit service while considering age-based trip characteristics of riders. We utilize a paratransit trip dataset specialized for seniors and disabled people in the City of Arlington, TX. While a small number of eligible users take most trips, the ridership is significantly higher in adults under 65 years of age. Younger users mostly ride paratransit service for work/school trips while older adults have a higher tendency for medical and recreational trips. Older adults tend to have fewer and shorter trips with a different temporal pattern than younger users. The results suggest that the availability of alternative modes negatively influences paratransit usage. This study could be also useful for future AV planners seeking to predict individuals' travel patterns of the proposed AV service.

INTRODUCTION

Mobility and access to special transport services are important for the quality of life of the elderly and transportation dependent populations (Boschmann & Brady, 2013). Recently, the population of elderly and transportation-dependent people has grown significantly in the United States, in absolute and proportional terms, with over 35% of senior citizens having some disability (ACS-2019). With the increasing population of transportation disabled people and the higher vulnerability of senior citizens to negative impacts of the COVID-19 global pandemic, the need for providing adequate mobility options to such people is substantial.

Many cities in the United States already provide door-to-door special transit services to the transportation disabled population. The ridership, number of vehicles, schedules, and other aspects of paratransit may vary by the size of the city, demographic characteristics of the population, and alternative modes of mobility fixed-route public transit. Cities and transportation agencies often have to decide whether new services are needed as opposed to optimizing the existing services. It

is, therefore, valuable for them to understand the travel patterns and factors that influence ridership. It is also important to understand the relationship between paratransit and other public transit modes in the presence or absence of alternative transit options. Understanding these patterns and relationship enables the city administrations to make data-driven decisions and further optimize the existing services.

The traveling characteristics of the transportation-disabled population and the usage patterns of ride services are studied using a wide range of techniques (Böcker et al., 2017; Rahman et al., 2016; Szeto et al., 2017). Some studies focus on socio-demographic characteristics of travelers (Cui et al., 2017), while others focus on spatial and geographic factors that influence the traveling behavior of the elderly (Arcury et al., 2005).

Boschmann & Brady (2013) studies the traveling characteristics of older adults in the Denver, CO metro area and finds that different age groups show different traveling behaviors. Their findings show the number of trips and trip distances decreases with increasing age. They also suggest that the factors related to travel behaviors in older adults are complex and not solely dependent on socio-demographic characteristics. Another study by Lynott & Figueiredo (2011) finds that the number of older non-drivers rose by one million in the United States from 2001 to 2009, highlighting serious challenges about the mobility needs of senior citizens.

While the traveling characteristics of older adults in large metropolitan cities have been studied in the past, less research has focused their attention on smaller cities and the interactions of paratransit ride services with other public transit services. With the rapidly changing needs and demographics for the transportation-disabled population, it is essential to identify the usage patterns of paratransit services in smaller cities and compare them with the identified patterns in other communities. Toward this goal, this paper aims at examining the travel behaviors of the users of Handitran, a specialized paratransit service in the city of Arlington, TX, using its trip data for 2019.

The city of Arlington is launching a pilot program for an autonomous vehicle (AV) rideshare service, called Arlington RAPID (Rideshare, Automation, and Payment Integration Demonstration). This service is planned to operate in the Downtown and the surrounding area of the University of Texas at Arlington, and it will include a wheelchair accessible AV. In this study, we also compare the usage patterns of the Handitran service in and outside the proposed AV service area for the Arlington RAPID project to understand the likely demand and ridership patterns for the new service. This study helps AV planners to predict the probability of AV service usage by identifying the actual users of the paratransit service.

To perform our study, we use trip data from the Handitran platform for all rides requested during 2019. We describe data, methodology, the study area, and services of Handitran in Section I. The descriptive analysis of trip data describing the usage patterns, the different of trip characteristics of the two categories of Handitran users, namely senior citizens above the age of 65 and users with disabilities under 65 years, and the trip distribution for both groups by the time of the day are provided in Section II. In this section, we also compare the usage patterns of Handitran within and outside the RAPID service zone.

Finally, we describe the difference in trip characteristics when there is an alternative mode of public transit available in Section III. Currently, Via, an on-demand rideshare service, is the only alternative option available within the City of Arlington, TX. However, it does not serve the entire

Handitran Service zone. Therefore, we investigate whether there is a difference in trip characteristics within and outside the Via service area. A regression model is constructed using the total number of trips by each user to determine the influencing factors of trips made by individuals. A discussion and summary of the results are given in Section IV.

DATA AND METHODOLOGY

Study Area

This study focuses on the City of Arlington, TX. While some findings may not be directly generalized to cities of all types and characteristics, it provides valuable insight for cities of comparable size and demographics to Arlington, TX. The City of Arlington, TX, is a medium-sized city located in the middle of the Dallas-Fort Worth Metropolitan Area (DFW). DFW is one of the fastest-growing metro areas in the country. As of 2019, the City of Arlington has a population of 392,462, a 7% increase from 365,438 in 2010 (ACS-2019). The number of people age 65 or above in 2010 was 29,752 (8.1% of the total population), but it has increased to 40,101 (10.2% of the total population) in 2019 (American Community Survey 2019). Due to its strategic location at the heart of the fast-growing metro area, Arlington is expected to increase its residents. The City of Arlington, TX, is unique for being one of the largest cities in the United States without a mass-transit service (Harrington, 2018), although its existing Via on-demand rideshare service provides a public transportation option in Arlington.

Handitran Service and Trip Data

The City of Arlington-Handitran is a Federally assisted transportation program from Title VI of the Civil Rights Act of 1964 and related statutes that provide rides to eligible people ("City of Arlington Handitran" 2014). To be eligible for Handitran service, an individual must be either a "senior citizen" or "transportation" disabled. Senior citizens are defined as persons 65 years of age or older. "Transportation-disabled" is defined as a person who, because of a functional limitation (caused by either a physical, medical, or mental condition), cannot independently operate a motorized vehicle, either on a permanent or temporary basis. Such functional limitations include:

a. Loss of sight
b. Lack of or loss of muscle control
c. Inability to use his/her arms to turn a steering wheel or exert any amount of force
d. Inability to use his/her legs
e. Inability to turn his/her head
f. Seizures

The trip data for this paper is provided by Handitran, which comprises all the rides requested during 2019. Figure 1 shows the distribution of Handitran trips based on the origin of the trips. In 2019, there were 373,202 trips requested from Handitran service, with an average of 231 trips per passenger.

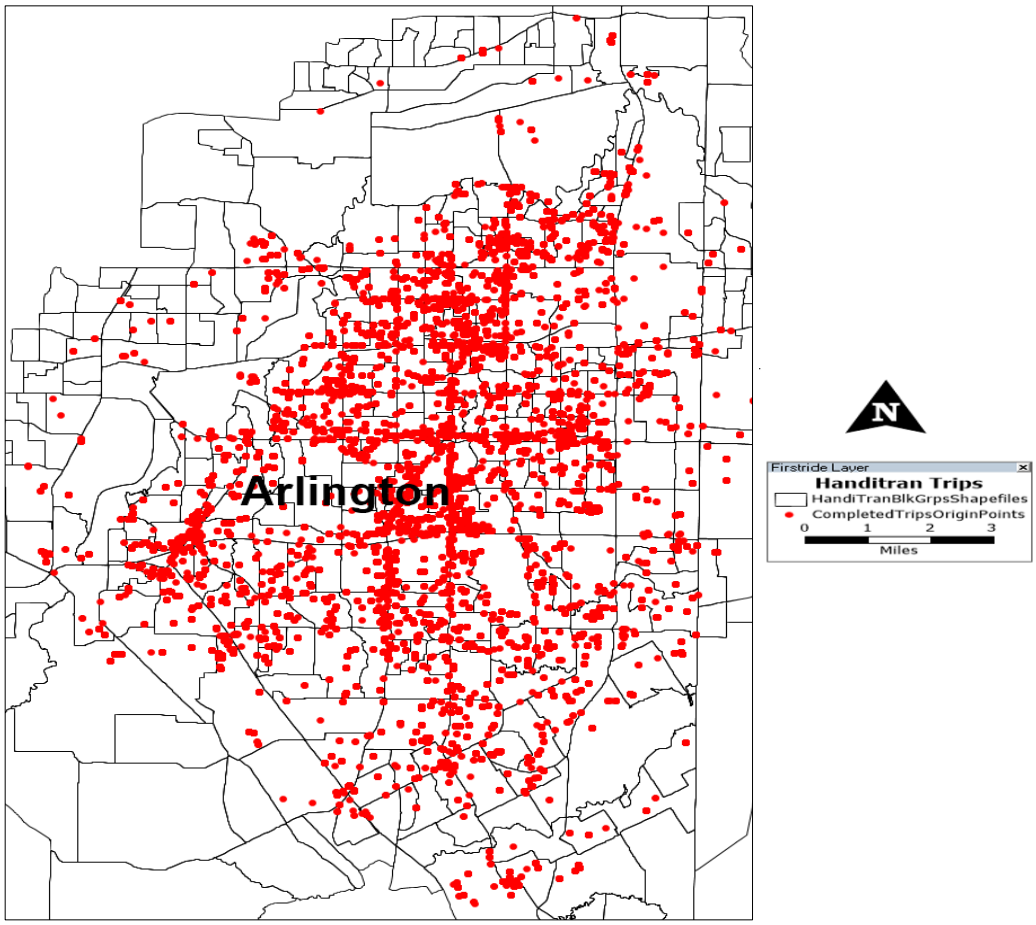

Figure 1. Spatial Distribution of Handitran Completed Trips in 2019

DATA ANALYSIS AND RESULTS

Descriptive Analysis of Trip Data

- **Handitran Travel Pattern**

Research shows that paratransit services do not operate at their maximum capacity, mainly because of the lack of coordination between paratransit agencies and contractors hired to provide services on the ground (Gupta et al., 2010). Table 1 shows the usage patterns of the Handitran service in 2019. Only 1618 customers used the service, which is less than 2% of the population eligible to use this service based on their age or disability status. Not only is the number of active users is low, but most of the trips are also only taken by an even smaller number of users. Data shows that only 12% of all active users have been responsible for 50% of all trips in 2019.

Table 1. Handitran Trip Data Summary (2019)

Attribute	Data
Total Population in Handitran Zone	573,867
65+ Population (ACS- 2014-2018) without Disabilities	35,368
People with Disabilities	57,386 (10% of overall population has some kind of disability: City of Arlington)
Eligible People	92,754
Total Users	1,618 (~ 1.74 % of Eligible Users)
Total Trips	373,202
Average Trips per Customer	231
• Only 12% of the users make over 50% of all trips	

- **Trip Characteristics by Age Group**

Research shows that the frequency of trips decreases after age 65 (Boschmann & Brady, 2013). Table 2 shows the distribution of users in each age category (over and under 65), the total and average number of trips, and the average distance and duration of trips using Handitran data. Total number of trips Overall, the ridership is significantly high in the group under 65 years of age. The data also shows that older adults relatively take shorter trips, thus shorter average duration for trips for them than users under 65 years of age.

Table 2. Trip data summary by age group

	Age Group		
	Under 65	Over 65	Total
Users			
Number of users	422	277	699
Percentage	60%	40%	100%
Trips			
Total Number of Trips	75,580	30,206	105,786
Percentage	71%	29%	100%
Average Number of Trips	179.10	109.05	151.34
Distance and Duration			
Average Distance (miles)	6.42	5.44	649,544
Average Duration (minutes)	17.90	15.32	1,815,638

- **Trip Purpose by Age Group**

Figure 2 shows the distribution of trips by the trip purpose for the two age groups. The trip purposes include work, school, medical, ESP (Essential Personal Trips such as going to a bank, grocery store, pharmacy, etc.), and recreational. There is a clear difference between the two age groups. As evident from the pie-chart, users under 65 have a higher share of work and school trips while older users have a higher share of medical and recreational trips.

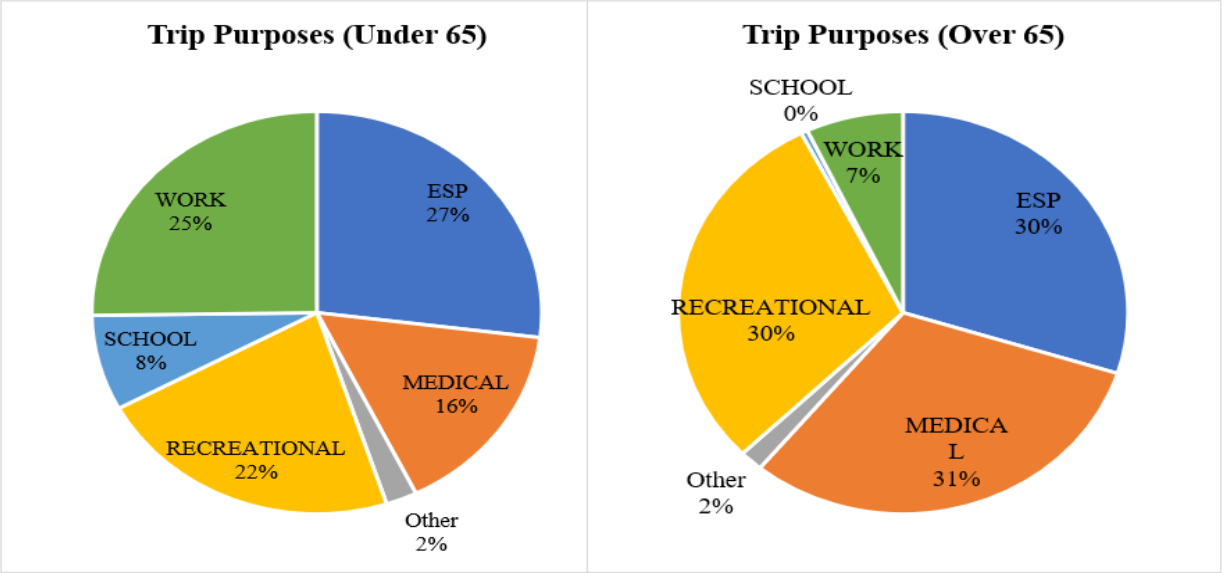

Figure 2. Trip distribution by purpose by age group

- **Trip Time by Age Group**

In addition to the aforementioned trip characteristics, it is important to understand the distribution of trips by the time of the day for optimal allocation of resources. Understanding the temporal usage patterns of the Handitran service is vital to uncover certain characteristics of passengers' daily activities. Such temporal usage patterns can be effectively understood via a spider/radar graph, as illustrated in Figure 3.

The plots (a-d) of Figure 3 display the temporal patterns of usage for both age groups and further divide the two groups of trips into two categories, weekdays and weekends. The plots show the distribution of trips during the service hours of Handitran (7 AM to 10 PM on weekdays; 8 AM to 9 PM on Saturdays) and highlight a clear difference in the temporal usage patterns between the two age groups and between the days of the week. During weekdays, users tend to have early trips in the early morning with a peak between 8-9 AM for both age groups, respectively. During weekends, the trips peak almost one hour later (9 and 10 AM) than the weekdays for both age groups. Contrary to the morning peaks, evening peaks are very different between the age groups and the two temporal categories. Evening peaks tend to last longer during weekdays, starting at 1 PM for older adults while beginning at 2 PM for younger users.

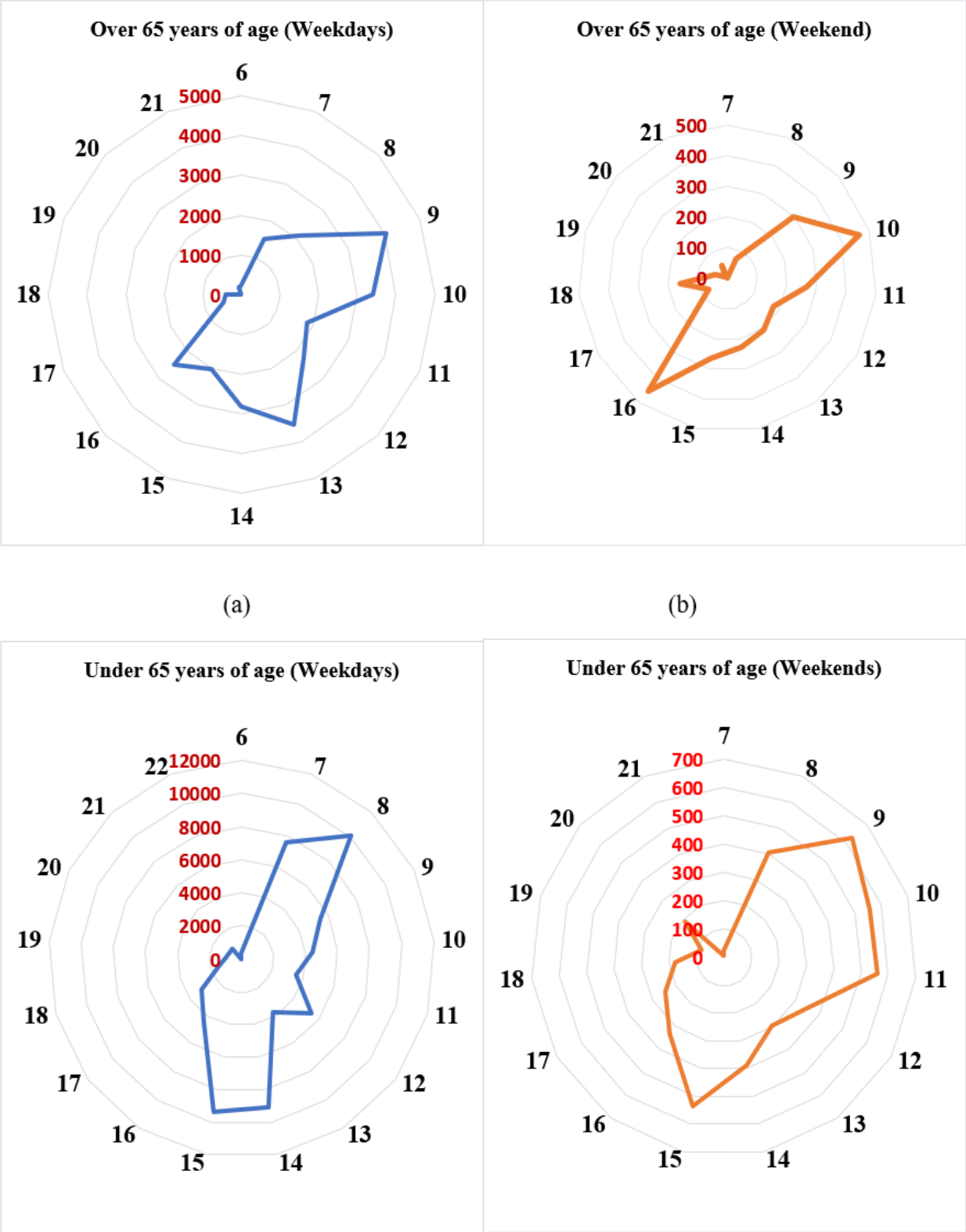

Figure 3. Spider charts for temporal distribution patterns

Comparison of Trip Patterns in Handitran and RAPID service Zones

Handitran provides services in the entire city of Arlington, while the proposed Arlington RAPID services will only be available in the UTA campus and downtown area. Although, the service area for RAPID is very small as compared to Handitran, it will serve some of the biggest activity centers in the city. Since the population numbers for RAPID service area are not known, we use number of trips per square mile to compare both service zones.

Table 4. Comparison of Handitran service usage within and outside RAPID service area

Service Zone	Total Land Area (sq miles)	Total Trips in 2019	Trips per square mile
Handitran (existing)	104.247	149,012	1,410
RAPID (proposed)	1.09	1,972	1,809

Table 4 shows that there was an average of 1,410 trips per square mile in the entire Handitran zone while 1,809 trips per square mile within the RAPID zone indicate a comparatively higher number of usage. These numbers indicate that there is a comparatively higher demand for a ridersharing service in this area showing a potential for higher ridership for the future AV users of RAPID service.

Figure 4 shows the distribution of trips and hotspots for Handitran trips in Arlington. The red rectangle shows the approximate service area for Arlington RAPID. The hotspot maps shows clustering of hotspots in and surround the RAPID service area, which validates the numbers shown in the table above.

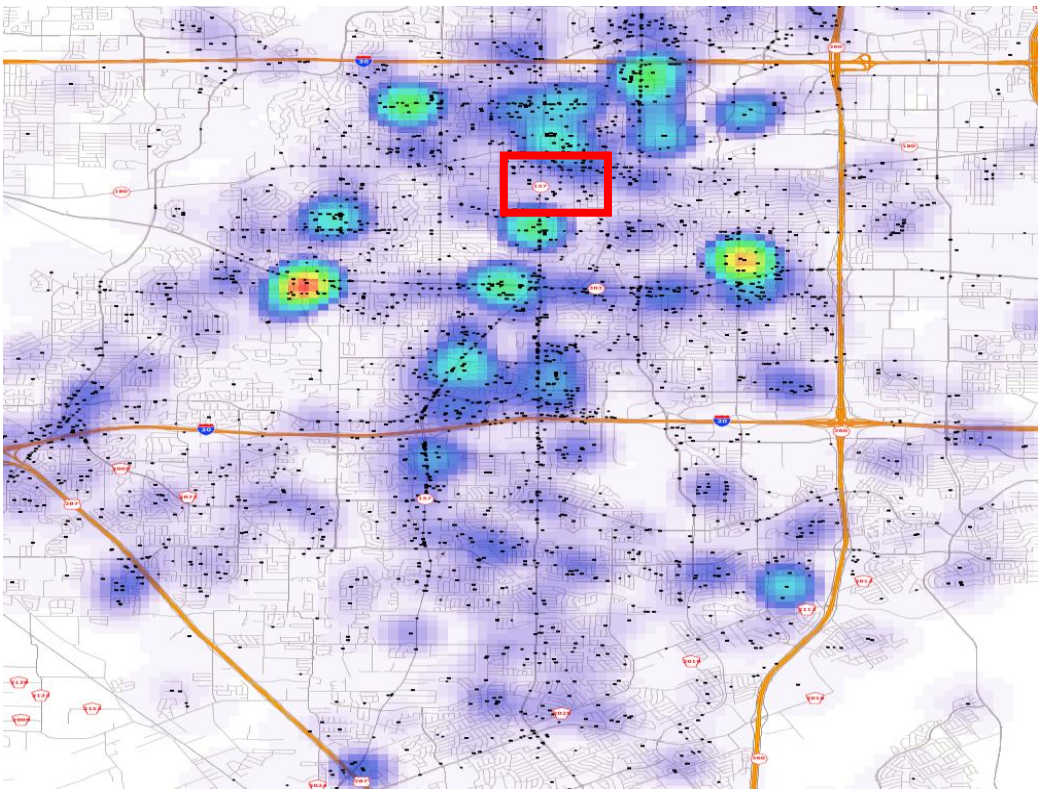

Figure 4. Handitran trips and hotspot map

Effect of the Availability of Alternative Transit Modes

Contrary to other cities of the same size, Arlington does not have a fixed-route public transit system, so transit-dependent populations are left with few available mobility options. Handitran serves only the transportation-disabled population, while the Via on-demand rideshare service is available to anyone in the city. While Handitran serves the entire City of Arlington plus 1.5 miles outside the city boundaries, Via's service area is limited to only some parts of the city. Therefore, it is important to understand the impact of the availability of an alternative transit option on the usage of the Handitran service. Table 3 shows a comparison of the trips over areas where Via is available or otherwise. It is evident that the areas without Via services produce higher numbers of trips and longer trips. 62% of Handitran trips come from areas where Via services are unavailable, while only 37% of trips originate from block groups served by Via.

Table 3. Trip comparison based on the availability of Via services

	Availability of Via Services		
	NO	YES	Total
Average Distance	7.13	5.36	6.46
Total Number of Trips	80,541	48,766	129,307
Trip Distribution Percentage	62.29%	37.71%	100%

Determinant Factors of Handitran Ridership

Table 4 shows summary statistics of an Ordinary Least Squares (OLS) model, which we used to determine the primary (or influential) factors of ridership, keeping the total number of trips per user as a dependent variable. Consistent with the literature (Boschmann & Brady, 2013), the model does not identify the primary factors of ridership (resulting in an adjusted R-squared of 0.09), highlighting the complex nature of rider behavior by Handitran users, which is likely influenced by several hidden factors. However, the coefficients exhibit the expected signs, indicating that age and availability of the Via service negatively correlate with Handitran ridership. User's age and availability of Via services are significant at 95% level while average distance is significant at 90% level. The model shows that, the block groups with Via services produce 0.30 times less Handitran trips than the blockgroups without Via services.

Table 4. OLS model for determinants of trips

Dependent Variable	Total No of trips per user, N= 699		
	Estimate	P-value	Sig
(Intercept)	5.17	< 2e-16	***
Age(years)	-0.016	9.54E-10	***
Availability of Via Services	-0.306	0.0052	**
Average Distance (miles)	0.035	0.02935	*
Adjusted R^2		**.08892**	

Significance codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '0' 1

DISCUSSION AND CONCLUSION

Overall, older citizens tend to take fewer and shorter trips by Handitran paratransit as compared to younger users. These findings are consistent with the observed national trends in the United States (Collia et al., 2003). We also find a unique usage pattern for Handitran services, where only a small proportion of the eligible population use the service. At the same time, the majority of trips come from only a small group of users. This is potentially due to the lack of information, communicationand awareness among residents about Handitran and highlights the importance of continued enhanced outreach efforts by the service provider. Comparing the trip purposes of Handiitran rides indicate different patterns across the two age groups (over and under 65 years of age). Younger users tend to take Handitran for work and school trips, while older users mostly take recreational and medical trips. This finding can also help the service providers understand the distribution of demand accordance with supply resources during different times of the day and the week for optimal functioning.

Another important aspect is the temporal distribution of Handitran trips. According to our findings, older adults tend to ride Handitran to start their daily activities later in the morning than younger users but use the service to finish their daily activities sooner than younger users in the evening. In addition, the temporal distribution of younger users shows longer, more dispersed, peak periods, suggesting different trip purposes, unlike the elderly whose peak usage times are consistent and short. These temporal patterns are consistent with the findings in the literature in bigger cities (Kuo et al., 2013). These findings in temporal patterns can help in optimizing scheduling and vehicle routing plans to allocate necessary resources for each age group according to their needs related to the time of the day.

One key finding of our study here is that the presence of Via services impacts the ridership of Handitran, as 62% of Handitran trips originate from block groups without Via services. Since Via provides faster and efficient services, we expect users to prefer Via over Handitran if they have the option available.

The regression analysis in this paper provides new insights towards understanding of different travel patterns across different age groups and the impact of the presence of alternate modes of on-demand ride services. Although the models do not show a strong influence of the independent variables on the usage patterns, our findings are qualitatively consistent with the trends observed in other big metro areas as in Denver, CO (Boschmann & Brady, 2013).

The comparison of Handitran usage within and outside RAPID service zones shows a major difference. There is clearly a higher demand for Handitran within the RAPID service area which could result for a similar higher demand for the AV service as well. However, these number could be highly effected by personal preferences of users in terms of riding autonomous vehicles versus traditional vehicles.

The findings from this analysis can be used by Handitran or the City of Arlington to further optimize the services and enhance the public outreach or awareness efforts. Increased coordination between Handitran and Via could also improve the overall quality of services for both agencies and deliver better and more efficient services to customers.

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