- ***Service cost***

Participants asked about the possibility of having an integrated payment system for riders who request their AV rides through Via on-demand ridesharing service. The city official explained that AV riders could benefit from the Weekly Pass of Via service integrated into the AV service's payment system. One participant stated that people might be less likely to combine the AV rides into on-demand ridesharing services for a whole trip if they perceive the service integration will impose them extra charge.

General focus group preferences towards AV service

- ***Accessibility***

Participants believed that AV transportation could complement the existing Via on-demand ride sharing operating hours by providing late night rides after 9 pm. Besides, participants indicated a great interest in regular rides to special events and recreational centers in Arlington. A participant commented that her main concern in terms of the future AV service's accessibility is whether this service can reduce senior adults' mobility barriers in the future. Other participants mentioned that the population of older adults in Arlington would increase in the future, and they will be more dependent on public transit. Accordingly, they expected that urban and transportation planners consider older adults' mobility needs in while planning and designing the AV service.

- ***Cost-saving***

According to the public group participants, cost-saving is an essential factor that can encourage people to ride the AV service. One participant stated that offering monthly passes or quarterly passes can motivate people to use the AV service regularly. The possibility of having discounted trips while riding the service to get to health care providers was among the alternatives that participants suggested about AV service cost-saving.

- ***Information***

One of the prominent people's expectations of future transportation was marketing the AV service to every group of people living in Arlington. They believed that lack of information about the current transportation alternatives have limited their mobility options.

DISCUSSION AND CONCLUSION

The findings of this study reveal that spatial accessibility, disability friendliness, and the proposed service's capacity could be among the most critical concerns of potential users of future AV services. Participants had a positive inclination towards adoption of the AV service; however, they were concerned that the potential advantages of AV service would be accessible only for the university campus and downtown Arlington due to the limited service area covered by a pilot program for a technology that is still being perfected. Moreover, since people with disabilities need different mobility needs, our results reconfirm that AV vehicles should be equipped in a disability-friendly way such as adjusting the space of the AV vehicles with wheelchairs, or increasing the

boarding time for pick up people with disabilities (Butcher, 2018). Therefore, to meet the mobility needs of people with disabilities, AVs should be diverse and flexible in vehicle size and communication-aids (Hwang et al., 2020). Results reveal that the service's capacity, in terms of the number of vehicles and the number of seats, can influence AV users' perception about the efficiency of the service. Similarly, the university participants had a concern about the frequency of rides in the future AV service. Studies have revealed that although increasing the service capacity raises its operating cost, the users' cost decreases due to the reduction in riders' waiting time (Hatzenbühler et al., 2020). The results revealed that the university participants perceived the AV service safer than other services because of its slow speed. However our results suggest that potential riders of AV services are less tolerant of accidents caused by self-driving vehicles than human errors (Salonen & Haavisto, 2019).

Regarding the AV preferences, our findings reveal that both university and general public participants expected the AV service to reduce the mobility barriers of the current transportation services in terms of accessibility at late night hours and special events. This finding shows that people are usually engaged to use shared AV service in the same way as conventional public transportation (Salonen & Haavisto, 2019). Our findings also indicate that providing access to the AV service for older adults was highly recommended by public participants. Participants expected that the AV service could improve the mobility of seniors in Arlington. This result contrasts with the previous studies suggesting that older adults in the US are more likely to drive their private vehicles rather than shifting to AVs (Gurumurthy & Kockelman, 2020). However, some studies reveal that older adults have more positive perceptions of AVs than young people (Hilgarter & Granig, 2020). Results revealed that willingness to use ridesharing increases by offering discounted fares. This finding is in line with a study's results assessing Americans' willingness to pay for sharing trips in a shared AV fleet vehicle. The study suggests that shared AV services can increase individuals' willingness to pay while providing smart prices (Gurumurthy & Kockelman, 2020). Our results offer that general public group expect that AV service will be publicized through public communication. Positive information regarding driverless vehicles impacts public group willingness to ride AVs. In comparison, lack of information or negative information about autonomous vehicles reduces willingness to adopt AVs (Anania et al., 2018). Besides, technology improvements were considered by both group of participants as an essential factor that increases the reliability of AV service. Exploring the individuals' preferences towards the AV service indicates that individuals believe enhancing the AV service application to integrate multiple destinations in a single trip and improve mapping system may increase the proposed AV service's adoption. This result supports the idea that technology-savvy individuals are more likely to adopt AVs (Lavieri et al., 2017).

This study provides valuable information to city and transportation planners about the adoption of autonomous vehicles while developing AV services. Our results offer that public awareness and knowledge play an important role in successful implementation and acceptance of newly emerging technologies. Therefore, the local government should carry out educational campaigns regarding AV technology to explain its advantages such as reducing car crashes, traffic congestion, and fuel consumption while increasing mobility options for the elderly, disabled, and non-drivers. The government could also provide subsidies and tax incentives to customers to encourage the use of autonomous vehicles as an alternative mode of transportation.

There are a few limitations to this study. Firstly, the sample size of this study is limited, though participants were chosen to represent target population groups. Nevertheless, it is suggested that future studies be developed based on a the sample size representing more diversity. Secondly,

further studies are needed to identify the AV concerns and preferences of all segments of the society such as people with disabilities and senior adults. Moreover, since the economic, social, environmental, technological, and legal aspects of the other cities or places are different, more studies should be conducted to recognize spatial difference in AV adoption. This will be possible as more cities begin to implement AV transit services. Future research can use a similar framework with a large sample size representing different segments of the population to explore the public's perception of AVs in various cities around the US, considering different aspects of their locality.

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Exploring Preferences towards Integrating the Autonomous Vehicles with the Current Microtransit Services: A Disability Focus Group Study

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ABSTRACT

This study explores how people with disabilities perceive and accept autonomous vehicles (AVs) as a technology to improve their mobility. A focus group discussion was conducted to explore individuals' preferences towards integrating level 4 AVs into the existing microtransit service in Arlington, Texas. Participants demonstrated a positive perception towards the integration of AVs into the current microtransit infrastructure. The results suggest that accessibility to a well-designed built environment is vital in adopting AVs by people with disabilities. Moreover, AVs' accessibility to healthcare facilities is one of the main concerns identified by focus groups of persons with disabilities. In particular, participants with visual impairment were hopeful that future AV services could improve their mobility through advanced apps, booking systems, and vehicle equipment. This study offers several implications for designing AV service in line with the needs of persons with disabilities while combining with the current microtransit service.

INTRODUCTION

According to the Social Security Supplement Survey of Income and Program Participation, 85.3 million people in the United States recorded a disability in 2014 (Taylor, 2018). The National Household Travel Survey (2017) indicates that 25.5 million people; 5 to 64 years of age in the United States; have a disability that impairs their ability to travel(Sprung & Chambers, 2016). Moreover, people older than 65 years of age will be 20 percent of the total population of the United States by 2030 and their demand for riding public transportation services by them will increase rapidly in the coming years (Kaufman et al., 2016).

The emerging autonomous vehicle (AV) technology is expected to disrupt the existing modes of transportation and improve the mobility options (Hwang et al., 2020). Autonomous vehicles that is classified six levels of autonomy ranging from Level 0 "No Automation" to Level 5 "Full Automation"(Shuttleworth, 2019), has the potential of upgrading conventional personal vehicles

and revolutionize transportation. The benefits of this new technology can be optimized while the relationship between the AV system and existing public transit be considered(Shen, Zhang, and Zhao 2018). Integration of the shared autonomous vehicles (SAVs) into the existing on-demand rideshare services could effectively reduce total travel time while the app-based services have the potential to schedule the pick-ups and drop-offs SAVs and collect or distribute the rides (Levin et al. 2019).

A significant number of US cities such as Arlington, TX, Boston, MA, Portland, OR, Pittsburgh, PA, San Jose, CA and Chandler, AZ have already initiated Level 4 AV pilot projects (Perkins et al., 2018). Studies suggest that using level 4 AVs could significantly reduce fatal accidents, traffic congestion, and fuel consumption (Woldeamanuel & Nguyen, 2018).

People with disabilities, particularly those who are visually impaired could benefit the most from AVs due to more comprehensive and convenient transportation options (Bennett et al., 2019). The literature has investigated the general public's attitudes, perceptions, and preferences for autonomous vehicle technology (Kassens-Noor et al., 2020; Hulse et al., 2018; Bezyak et al., 2017). Nonetheless, very little has been written about the perceptions of people with disabilities towards AVs as a public transportation mode.

To address these gaps, this study explores features contribute to the adoption of AVs by people with disabilities while considering their preferences towards integrating a wheelchair accessible AV fleet into the current microtransit service in the city of Arlington, TX. To achieve the objectives of this research we focus on a planned AV service pilot project known as RAPID (Rideshare, Automation, and Payment Integration Demonstration) in the City of Arlington, Texas. The City of Arlington will incorporate autonomous vehicles into its current app-based Via microtransit service under this initiative. Microtransit; introduced in 2012 in the US; is similar to city-operated paratransit or flexible route services using mobile apps and wireless connectivity to enhance the riders' accessibility to its' vans or small buses (Eby et al., 2018). Little is known about the factors influence the AV ridership due to the novelty of its operating system and the technology; less is known about the potential for adoption of emerging AVs by people with disabilities integrated in the service into microtransit transportation. Finding of this study provides insights into establishing and developing the AV service in line with the mobility needs expressed by people with disabilities. The interaction between the perspective AV players such as riders and the operating system plays a crucial role in the success of integration (Shen, Zhang, and Zhao 2018). Accordingly, identifying the transportation needs of the potential AV users can provide opportunities in recognizing how the performance of the overall system after the integration of AV into current transportation services can be improved.

LITERATURE REVIEW

Excessive dependence on personal vehicles for transportation in many US cities has caused mobility challenges for people with disabilities, making them dependent on others unless their city has an accessible public transportation system (Hwang et al., 2020). Previous studies indicate that lack of transportation is a significant barrier for people with disabilities when searching for employment (Sabella & Bezyak, 2019). People with disability are less likely to access healthcare facilities due to inadequate access to transportation and well-designed built environment (Jones et al., 2018; Pharr et al., 2019). Although access to public transportation has improved dramatically for people with disabilities since the enaction of the American with Disabilities Act of 1990, some

accessibility barriers persist for people with disabilities while using public transit modes (Bezyak et al., 2017).

Autonomous vehicle technology has the potential of revolutionizing the transportation industry (Anderson et al., 2016). Autonomous vehicles (AVs) could serve those who are unprivileged (e.g., elderly and disabled), making it convenient for them to travel from one point to another with lower travel costs and better navigation (Freemark et al., 2019). The emergence of AV technology will lead to developing a new business model of shared autonomous vehicles, which could provide first and last-mile solutions through low-cost mobility services (Krueger et al., 2016). Due to the higher cost of sensors and complicated technology, most vehicles on the roads include only up to Level 3 autonomy (Van Brummelen et al., 2018).

To understand the rate of adoption and integration of the AV technology into existing modes of transportation, it is vital to understand the potential users' perception towards AV's (Penmetsa et al., 2019). Multiple studies have investigated the general public's perception of autonomous vehicles by focusing on the demographic and psychological factors (Kyriakidis et al., 2015; Portouli et al., 2017; Hudson et al., 2019; Wang et al., 2020). According to Kyriakidis et al., (2015), most people from developed countries had significant concerns regarding software hacking and data misuse. People with high incomes are less likely to share an AV ride, while young people are more likely to share AV ride (Wang et al., 2020). Some scholars have studied the general public perception after riding a Level 3 autonomous shuttle and suggested that individuals perceive AVs as a travel option that could complement and not substitute for existing means of transportation (Hilgarter & Granig, 2020). Their results also revealed that older adults were more optimistic about AV's as compared to younger people, while males were more positive towards AV's as compared to females. Although many studies discuss the general public perception and acceptance of AV's, less attention has been given to their impacts on the mobility of people with disabilities (Hwang et al., 2020; Bennett et al., 2019; Bennett et al., 2020; Bansal et al., 2016).

Reviewing the literature indicates that very little is known about the preferences and acceptance of autonomous vehicles for people with disabilities. This study aims to 1) explore the perceptions of people with disabilities towards the adoption of AV's, and 2) identify the factors affecting the successful integration of AV service into the existing microtransit services from the perspective of people with disabilities. Finally, this study provides insights to guide policymakers developing AV policies and regulations for people with disabilities.

METHODOLOGY

Case Study

Arlington, TX is the first city to employ AV technology as public transit for a pilot test, and therefore makes a meaningful case study for academics and practitioners to learn from. Arlington has also been implementing a traditional app-based, on-demand microtransit service (Via) since 2017, meaning that people in the city are familiar with the concept of on-demand transit, and can respond to many of the questions about AV services. This study investigates the potential users' perceptions of a proposed AV fleet in the Arlington, Texas. According to the United States Census Bureau (2019), the City of Arlington, with a land area of approximately 96 sq. miles, had a population of 398,854 in 2019, and people with a disability (less than 65 years old) represented 7.1% of its population in 2018. The mean travel time to work per day for workers with 16 years of age and older in the city of Arlington was estimated at about 27.4 minutes from 2015 to 2019 (U.S.

Census Bureau, 2019). The median household income of Arlington was recorded $52,094 in 2010 (City of Arlington, 2019). Although the city has not been served by fixed-route transit network, a microtransit service called Via provides ridesharing trips for the general public, including wheelchair accessible vehicles as necessary, in a portion of the city's area, including Downtown Arlington, University Campus, the Entertainment District, the Shopping Malls, and a commuter railway station. From its start in December 2017 through November 2020, the Via rideshare service has provided over 450,000 rides in Arlington, with a high of 1,055 rides on a weekday and 615 rides on a weekend. The Via service area has expanded incrementally and covered approximately 40% of the City's area in November 2020 (Ann Foss, personal communication, November 16, 2020).

To identify how people with disabilities adapt to future transportation options, we focus on a planned AV service pilot project known as RAPID (Rideshare, Automation, and Payment Integration Demonstration) in the City of Arlington, Texas. The Arlington RAPID project has been funded from the Federal Transit Administration under the Integrated Mobility Innovation program and conducted through a partnership between the City of Arlington, Via Transportation, Inc., May Mobility, and the University of Texas at Arlington. Under this project, the City of Arlington will integrate autonomous vehicles into its existing app-based Via microtransit service. This project serves as a demonstration project for the use of autonomous vehicles in public transit, integrating separate booking services, and implementing accessibility in AV service technologies.

Sampling and Data Collection

Rider acceptance is a potential limitation to use of a new service, especially a new technology, and understanding potential challenges for riders with specialized needs like those with accessibility limitations is key. Understanding this requires in-depth conversation with riders, and therefore, focus groups were used, rather than surveys, which would not produce a complete understanding of rider decision processes. Focus groups were chosen over interview formats as well, because of their usefulness for situations where all participants have experienced a similar situation (in this case, trying to get around Arlington, TX with a disability). Comments by one participant can trigger others to remember a similar situation they have undergone, providing the research team with a more complete picture. A seven-step approach was adopted for this study, as shown in Fig 1. People with disabilities who resided or worked in the City of Arlington were shortlisted for the focus group discussion, both from a general email to Via riders, and from members of the disability community recommended by city staff, who had worked on advocacy projects in the past. A screening survey was distributed among the shortlisted people to invite the focus group participants, who were chosen based on either their accessibility challenges, and/or their experience using microtransit. The research team scheduled the dates and times for the session and sent a doodle link to the selected participants to confirm their focus group discussion availability. While the authors recognize that an in-person focus group might have advantages in terms of helping participants feel comfortable talking about their experiences, the Covid-19 pandemic did not make face-to-face interactions possible. Due to the on-going Covid-19 pandemic and lockdown restrictions, the research team decided to virtually conduct the focus group discussion on the Microsoft Teams platform with the participants who accepted the focus group's invitation. However, it is noteworthy that only those people with access to the internet could participate in the focus group discussion as it was conducted virtually. The virtual format had certain advantages as well-making it easier for participants with mobility challenges to attend. A

follow-up survey questionnaire was sent to the focus group participants. Focus group attendees were informed and consented to the recording of the session , in order to prepare a detailed transcript. Finally, the collected data were analysed by performing descriptive and conventional content analysis.

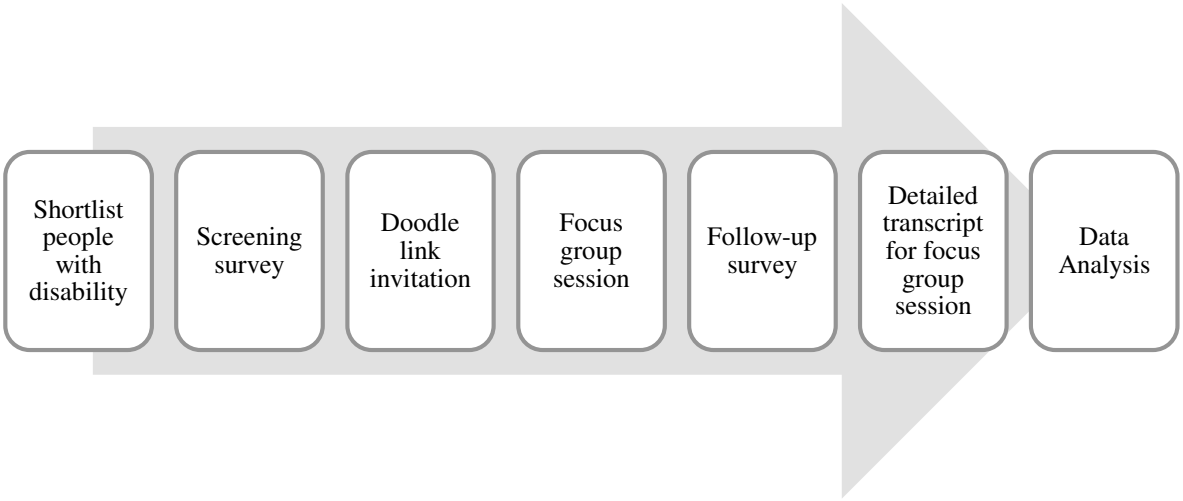

Fig. 1 Research methodology

While the sample size was limited, so was the number of persons with disabilities in the City of Arlington. This limitation was mitigated by the fact that this was designed to be a qualitative study, based on in-depth responses of potential riders regarding existing microtransit services in the city, and AV services being proposed at the time of the focus group. The research team conducted the focus group session in August 2020, with the people with disabilities. A total of four participants with disabilities accepted the team's invitation. The focus group session was conducted by two moderators using a semi-structured guide of questions. The questions were designed to allow the participants to discuss their experience and ideas about the current and future transportation reasonably. Apart from the research team, an official member from the City of Arlington also attended the focus group discussion to answer any questions about the city's proposed AV service. At the beginning of the focus group, verbal consent was obtained from all the participants. After the focus group discussion, the research team sent a follow-up survey questionnaire to all the focus group participants to obtain information about their sociodemographic characteristics. The Institutional Review Board (IRB) approved the survey at the University of Texas at Arlington, prior to the implementation of the focus group session.

Data Analysis

This study utilized the qualitative content analysis method to analyse the collected data from participants. Qualitative content analysis is defined as the systematic classification process of coding and identifying themes or patterns as a research tool to subjectively interpret the content of text data (Hsieh & Shannon, 2005). Qualitative content analysis is one of the most used methods used by the urban and transportation scholars, which focuses on the contextual meaning of the text obtained from focus groups, open-ended survey questions, interviews, articles, etc. (Hsieh & Shannon, 2005). The content analysis method provides researchers to explore the trends and

patterns that are hidden inside a large unorganized text data and allows them to evaluate the quantities of concerns underlying the textual contents (Das et al. 2017). The methodology of content analysis requires detailed steps, including designing the research questions and hypothesis, identifying the sample, defining the unit of analysis, choosing the enumeration systems, constructing the categories and sub-categories, and checking the validity of categories (Cullinane and Toy 2000). Using conventional content analysis method, the research team reviewed the focus group discussion transcript. After reviewing the transcript, the discussion themes were extracted in terms of preferences towards combining the proposed AV service into the existing microtransit service. Furthermore, different categories and sub-categories of each theme were extracted based on the information provided by the participants during the focus group discussion and the handwritten notes of the discussion.

RESULTS

Results from follow up survey indicated that participants were white American females, with full-time or part-time employment, three of them had visual impairment and one had a physical disability. The focus group participants provided valuable information to the research team about their travel patterns and behaviors, mobility issues, and attitudes towards using Arlington's transportation services. The research team asked a question in the follow-up survey regarding the level of control of the autonomous vehicle with which participants were most comfortable with. Two participants were pleased with a shared control between the driver and the self-driving car, while the other participants choose not to answer it. The following sections describe the detailed results regarding the participants' main concerns and issues about the proposed RAPID autonomous vehicle service in Arlington.

Preferences of Autonomous Vehicle (AV) Service

The participants stated their preferences towards different attributes of the proposed AV service. Table 1 shows the disability focus group's preferences of the proposed AV service in Arlington.

- ***Accessibility***

People with disabilities preferred that the proposed AV services be spatially accessible by different residents living in various neighborhoods. When shown the map of service area, people with disabilities stated that it seems the AV service is inaccessible to the healthcare facilities and hospitals in North Arlington. One participant also expressed that it seemed the proposed AV service had focused too much on the campus area, and not on the areas of the city outside it, where they felt more of the disability community lived.

- ***Safety***

The participants showed a great preference towards an onboard safety assistant to help them during an emergency. Boarding an autonomous vehicle would be more convenient for people with disabilities if they perceive there would be someone to aid them. For the convenience and safety of disabled people, one out of the five AVs would be wheelchair accessible and equipped with a