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Advancing Social Equity with Shared Autonomous Vehicles: Literature Review, Practitioner Interviews, and Stated Preference Surveys

Final Report

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This report examines preferences and attitudes regarding the implementation and design of a hypothetical publicly-funded Shared Automated Vehicle (SAV) system in the Twin Cities metro area. We provide a brief literature review before delving into our main findings. First, we discuss a series of interviews in which officials at local planning agencies were asked about their vision for SAV in the Twin Cities. According to these interviews, SAV could be especially useful in solving first-and-last-mile problems and connecting with already existing transit and on-demand transportation infrastructure. We then analyze data sourced from an originally designed digital survey instrument implemented over social media in 2020 and specifically targeted at Twin Cities residents. Data from the survey emphasize that people who currently experience barriers to transportation are more likely to value SAV highly. The data also give insight into design considerations, emphasizing flexibility in payment and booking and the importance of security features. Finally, we examine data from a similar survey administered at the 2021 Minnesota State Fair, which we use to gauge preferences toward SAV among people living in the Twin Cities exurbs and Greater Minnesota.</td></tr>
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ADVANCING SOCIAL EQUITY WITH SHARED AUTONOMOUS VEHICLES: LITERATURE REVIEW, PRACTITIONER INTERVIEWS, AND STATED PREFERENCE SURVEYS

FINAL REPORT

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EXECUTIVE SUMMARY

This study examines equity concerns and considerations around the rollout and regularized use of a hypothetical Shared Automated Vehicle (SAV) system in the Twin Cities metropolitan area. This system would be a fleet of shared driverless cars or buses, likely funded through a public-private partnership and integrated into already-existing public and private regional transportation systems and networks. The study includes several specific components:

1. A survey of the literature surrounding equity considerations and SAV technology
2. Qualitative research based on interviews of several public agencies in the Twin Cities, and their priorities and concerns about the rollout of an SAV system
3. Data analysis from three originally designed survey instruments that gauge public attitudes and preferences around SAV systems and identify differences in opinion and concern based on race, gender, socioeconomic status, and currently existing travel behavior.

The study generates several findings and policy recommendations:

- SAV systems should be designed to provide both full "point-A-to-point-B trips" as well as "first-and-last-mile trips." This is because spatial mismatch is still a serious transportation equity issue in the Twin Cities, especially when all travel purposes (not just work) are considered.
- SAV systems could play a role in promoting racial transportation equity because Black and Hispanic individuals in the Twin Cities currently face the highest rate of difficulty in their transportation behavior and also expressed the highest valuation of an SAV service compared to other groups.
- SAV systems should be designed to ensure flexibility in booking and paying to make sure populations without smartphone access can use the systems.
- To ensure SAV systems promote gender equity in transportation, individual vehicles should have robust security features. In all three surveys, women significantly preferred security cameras or onboard attendants to no security option.
- State agencies should consider the extent to which SAV systems could serve people outside of the Twin Cities urban core.

Ultimately, an SAV system could transform the Twin Cities metro area's transportation infrastructure system. However, public agencies must carefully consider different uses of the system and the specific onboard features of vehicles to ensure maximum use and thus positive equity outcomes.

CHAPTER 1: INTRODUCTION

Transportation contributes to many broad societal outcomes, such as employment, wealth, and health. It plays a critical role in connecting people to destinations—where they want to be—including offices, schools, hospitals, and shopping centers, among others. Geographical mismatch between where people live and where jobs, schools, healthcare facilities, and stores are located—coupled with no or limited transportation means—contribute to the inequity in income, education, health, and social mobility. Addressing equity in transportation is critical to achieving social equity in general, i.e., a fair and just society in which all population groups can participate and prosper in all aspects of social, economic, and political life. However, due to historical and ongoing power imbalance and exclusivity in transportation decision-making, transportation policy has had a disparate impact on certain communities and resulted in an existing system in which some communities are favored over others.

Although emerging autonomous vehicles (AVs) offer the potential to transform both public and private future transportation services, without careful design and planning, these new technologies by themselves may reinforce the inequity issues plaguing the existing transportation system, rather than solving the issues. In this report, we focus on examining the potential roles of shared AVs (SAVs) in addressing transportation equity challenges. We envision that SAVs as a future transportation mode may replace, complement, and integrate various modes of both public and private transport in a unified, on-demand fashion, providing passengers of all socioeconomic strata with a fast, convenient, affordable, and multimodal mobility service. Specifically, SAVs could be one particularly beneficial application of driverless vehicle technology (Krueger et al. 2019) that is characterized by vehicle sharing, multimodal connection to existing transportation networks, and demand responsive interdependent networks of vehicles (Fagnant and Kockleman, 2014).

Further, the anticipated AV benefits on safety and the environment make the case for widespread adoption (Golbabaei et al. 2020; Levinson et al. 2016). With the anticipated costs of driverless vehicles—adding up to $50,000 to the cost—SAV technology could provide on-demand service at a much lower cost than owning and maintaining a private driverless vehicle (Merfeld et al. 2019). If well designed, communities employing pools of SAVs of varying sizes with efficient connections to high-quality public transit could bring about far-reaching societal changes such as providing inexpensive mobility services to all people (including people with disabilities and the elderly), building stronger family and community ties, and boosting economic productivity and equity by removing mobility as a constraint. All in all, SAVs have the potential of enabling smart and connected communities where everyone benefits.

Across the US, the SAV technology has been rapidly developing, with several manufacturers collaborating in developing and demonstrating these vehicles (Table 1).

Table 1: Shared Electric Automated Shuttle Examples (not exhaustive list)

Manufacturer	Shuttle	US Demonstrations	Link(s)
Navya	Autom Shuttle Evo	Michigan	https://navya.tech/en/solutions/moving-people/self-driving-shuttle-for-passenger-transportation/
Local Motors	Olli	Yellowstone National Park, Los Angeles, Maryland	https://localmotors.com/meet-olli-3/
Easy Mile	EZ10	Minnesota, Dallas-Fort Worth	https://easymile.com/vehicle-solutions/ez10-passenger-shuttle
May Mobilty	GEM by Polaris, others	Detroit, Grand Rapids, MI	https://maymobility.com/technology/GM
GM / Honda	Origin	California	https://gmauthority.com/blog/2021/06/first-batch-of-pre-production-cruise-origin-avs-are-being-built-video/
Amazon	Zoox	California	https://zoox.com/

Early demonstrations of these SAV services include testing and demonstration of the EZ10 shuttle in Minnesota as shown in figure 1, and the SAV pilot program using Local Motor's Olli in Yellowstone National Park as shown in figure 2.

Figure 1: EasyMile Shuttle in Minnesota in 2018

Figure 2: The Electric Driverless Demonstration in Yellowstone (TEDDY) in June-August 2021

This report aims to help transportation practitioners understand the potential of SAVs in mitigating existing transportation inequities and further identify potential policies and strategies that could guide an equitable rollout of the new technology. To that end, our research efforts include literature review, practitioner interviews, and stated preference surveys among diverse samples. These efforts focus on uncovering sociodemographic differences in attitudes toward the SAV technology, as well as in preferences of possible features of SAV services. To generate social equity implications, we pay specific attention to the role of gender, race, income levels, health status, existing transportation disadvantages, and residential location in shaping attitudes and preferences toward future SAV systems. The remaining chapters are organized as follows:

- Chapter 2 describes the state of the literature on the topic of AV and SAV services.
- Chapter 3 describes findings from our regional stakeholder analysis and practitioner interviews focusing on various government agencies that have explored the future potential of introducing SAVs in the Minneapolis-St. Paul metropolitan region.
- Chapter 4 describes the stated preference survey we conducted in the Minneapolis-St. Paul metropolitan region, including survey method and findings.
- Chapter 5 describes the stated preference survey we conducted among downtown Minneapolis commuters—specifically commuters who had used the ABC Ramps in downtown Minneapolis. The same survey method was used as in Chapter 4. Chapter 5 focuses on summarizing the findings from the downtown Minneapolis survey sample.
- Chapter 6 describes the stated preference survey we conducted at the Minnesota State Fair. The survey sample include a significant number of elderly respondents from Greater Minnesota.
- Chapter 7 offers major conclusions from this research and discusses future directions and policy implications of the major findings.

CHAPTER 2: LITERATURE REVIEW

Most of the literature surrounding SAVs has centered around their potential uses and benefits, the current obstacles to their widespread use, and current attitudes toward SAV technology Merfield et al., 2019; Schwartz, 2018). However, the rollout of SAV technology is not yet guaranteed to benefit everyone. Transportation equity, a key component of social equity, is a critical challenge facing many cities and communities today. As a new transportation mode, shared autonomous vehicles have the potential of disrupting the existing transportation system, which may narrow or widen existing social inequities.

Although studies with a particular focus on SAV and social equity are limited, we find two emerging bodies of literature that are highly relevant to SAV and social equity: one focus on equitable implementations of AV technology and another focus on determinants of AV adoption. These two bodies of literature are summarized below.

2.1 TRANSPORTATION EQUITY AND AUTONOMOUS VEHICLES

Transportation researchers have called for an equitable implementation of autonomous vehicle technology. It benefits AV proponents to develop an equitable process because much of the hailed positive externalities of AV systems will only be realized with widespread use (Scwartz, 2018). In addition, many of the benefits from AV systems could have substantial impact addressing the negative externalities of our current transportation system disproportionately laid upon low-income communities and communities of color (Levinson et al, 2016; Butler, Yigitcanlar, & Paz, 2020; Fleming, 2018; Martin, 2019; Rojas-Rueda et al., 2020). These benefits include increased mobility; reduced air pollution from vehicle emissions; reduced transportation costs; and increased safety, particularly for pedestrians and bike users.

Few researchers explicitly detail an equitable deployment of AV technology; however, much of the existing literature on increasing transportation equity with existing technology can be easily applied to an AV deployment. An important element of transportation equity is community engagement, specifically grounding decision-making power within the impacted community (Van Dort et al., 2019; Hwang, 2020; Creger, Espino, and Sanchez, 2018; Sanchez, Stolz, & Ma, 2003; Karner & Marcantonio, 2018). In addition, there is increased attention to who should lead an equity process; there is doubt whether government agencies and business leaders can effectively implement equity when many of today's barriers were constructed by these groups (Karner et al., 2020).

AV technology researchers have acknowledged that many of the potential benefits for disadvantaged communities will not be realized without a SAV implementation; in addition, many of the potential harms of AV technology are more likely with private ownership of AVs that more closely matches our current transportation system (Levinson et al., 2016; Butler, Yigitcanlar, & Paz, 2020; Fleming, 2018; Martin, 2019; Rojas-Rueda et al., 2020). SAV deployment will greatly reduce the per ride cost of an AV and allow for more immediate deployment in low-income communities. SAV deployment and fleet electrification can ideally reduce emissions from vehicle miles traveled (VMT) within disadvantaged communities; however, if the ease of AV travel is too great, VMT could increase, generating more non-exhaust emission (from tires, brakes, road construction, etc.), and offset potential gains from electrification.

AV technology researchers have also called for policy makers to take immediate action to guide an equitable deployment of AVs; there is a substantial risk that AVs will only perpetuate today's inequalities if deployed without specific legislation (Butler, Yigitcanlar, & Paz, 2020; Fleming, 2018; Martin, 2019; Rojas-Rueda et al., 2020). Jiao and Wang (2021) examined the deployment of on-demand ride services in New York City during 2015—an early stage of service provision—and found that services were more concentrated in areas of wealth and that the high-cost reduced the practical impact of these ride-sharing services in low-income communities. Although AV experts and planning officials are optimistic about the potential benefits of AV technology, few U.S. cities have plans in place guiding the deployment toward this positive future (Freemark, Hudson, and Zhao, 2019). Policies are required to guide an equitable access to AVs and prevent discrimination in the provision of services persistent in today's shared mobility services (Fleming, 2018). Evaluation measures and priority frameworks will also be critical for guiding resources equitably (Anderson et al. 2017).

2.2 DETERMINANTS OF AUTONOMOUS VEHICLE ADOPTION

Although not specific to an equitable deployment of AV technology, many researchers are investigating the demographic variables and service design variables that could impact the adoption of AV technology. Much of the literature on AV adoption suggests a gender gap in the perceptions of AV technology, particularly that women exhibit a lower preference for AV technology than men (Charness et al 2018, Hudson et al 2019, Hand and Lee 2018; Hohenberger et al., 2016 Abraham et al., 2016). There is a critical difference in the decision-making of transportation choices, with consideration to one's safety, and mobility patterns between men and women that must be considered while implementing AVs (McDonnell, 2020).

The gender differences in the perception of the general AV technology may not apply for that of the SAV technology. Nonetheless, in many studies of shared transportation, researchers have noted a hesitancy among women. A study was conducted by Ait Bihi Ouali, Graham, Barron, and Trompet (2019) on how perception of safety on public transportation differs along gender lines. Women are 10% more likely than men to feel unsafe in metros and 6% more likely to feel unsafe in buses. Additionally, the authors found that perception of safety is an important dimension of overall satisfaction. Hsu, et al. (2018) found similar results: attitudes towards environmental concerns related to transit use did not differ along gender lines, but women had markedly higher safety concerns than men in the study.

The research also illustrates that younger respondents are more likely to hold favorable views of AV technology and be willing to give up their vehicle (Menon et al, 2019; Charness et al. 2018; Hudson et al, 2019). Both Moody, Bailey, Zhao (2019) and Abraham et al. (2017) found that young, high-income, highly educated males were the most optimistic about AV safety. A study by Hulse, Xie, and Galea (2018) found that 43% of their participants had a positive attitude towards them, 46% were uncertain, and 10% had a negative attitude. Those who were significantly more likely to have a positive attitude towards autonomous vehicles were male and younger. Older participants were the most likely to have a negative attitude towards autonomous vehicles. However, one's positive relationship with their current vehicle and their joy of driving could reverse some of these aforementioned demographic patterns (Haboucha, Ishaq, and Shiftan, 2017; Menon et al., 2019). There is some evidence that awareness campaigns and peer-to-peer communication can counteract demographic difference in perception and willingness to adopt AV and other new technologies (Bennet, Vijaygopal, & Kottasz, 2019; Charness et al., 2018; Jiao and Wong, 2021; Penmetsa et al., 2019; Talebian and Mishra, 2018).

Researchers have also identified differences in perception of AV technology based on physical disability. One study identified positive perceptions of AV technology in regard to its opportunity to address current transportation service inequities for people with disabilities, particularly among those with negative views of public transit (Hwang, 2020). Although, another study identified a more negative perception of AV technology among physically disabled respondents compared to abled respondents (Bennet, Vijaygopal, & Kottasz, 2019).

For the design of AV services, research demonstrates that cost, travel time, and waiting time play an important role in predicting AV adoption (Kruger et al., 2016; Kyriakidis et al., 2015; Talebian and Mishra, 2018). One study found that 22% of respondents would only ride an AV if they could do so at no cost and highlighted concerns about data privacy, data issues, and safety (Kyriakidis et al., 2015). Another study found that even if SAV services were available at no cost, only 75% of the respondents would use the service (Haboucha, Ishaq, & Shiftan, 2017). A meta-analysis of willingness to pay studies shows that most people still find AV services too expensive (Elvik, 2020).

Our research contributes to the limited literature that is available on SAV in particular. It investigates socio-demographic differences in the perception of SAV technology, including the design considerations of the potential service (e.g., preferred wait-time, payment, vehicle design, safety considerations, etc.). This research can help practitioners guide awareness campaigns and better plan for equitable rollout of SAV technology.

CHAPTER 3: STAKEHOLDER ANALYSIS AND PRACTITIONER INTERVIEWS

To understand risks and opportunities of using SAV to create a more equitable transportation system, we conducted practitioner interviews centered around shared autonomous vehicles and the associated equity issues. Specifically, in-depth interviews were conducted with twelve transportation practitioners in the Minneapolis-St. Paul (Twin Cities) metropolitan region. These practitioners are thought leaders in the field of transportation equity. We interviewed senior leaders at both urban and suburban transit agencies as well as senior transportation planners in city and state offices. All interviews were conducted in spring 2019.

3.1 SAV AND EQUITY STAKEHOLDERS

One of the questions we ask our interviewees is “Who needs to be at the table as SAV policies, programs and partnerships get created?” The identified individuals and communities in this question are considered as equity stakeholders to be affected by shared autonomous vehicles. Our interviews suggest three groups of people to be considered as equity stakeholders when it comes to designing and implementing SAV programs:

- People who are not well served by the current transportation system,
- People who may be negatively affected by shared autonomous vehicles, and
- People who may benefit from shared autonomous vehicles.

Figure 3 summarizes the equity stakeholders that have been mentioned by our interviewees.

Figure 3: Equity stakeholders to be affected by shared autonomous vehicles (Note: POC indicates persons of color.)

Our interviews also suggest three important principles when it comes to engaging the equity stakeholders:

- Continuity: Ensure continuity of communication to build long-term relationships with community members and organizations;
- Co-creation: Build the engagement plan together with the communities and challenge the status quo for how things often go; and
- Community leadership: Create space for the communities to direct the questions and discussions to where they feel they need to go.

3.2 SAV AND PUBLIC TRANSPORTATION

Multiple interviewees mentioned the 2017 Twin Cities Shared Mobility Action Plan developed by the Shared-Use Mobility Center, a nonprofit organization based in Chicago. The plan highlighted the opportunities associated with new shared mobility modes when it comes to addressing disparities in transportation access. The plan also highlighted the potential of new shared mobility initiatives in supporting urban, suburban, and rural transit services. Public transit is the backbone of an equitable transportation system. It serves as the primary transportation option for people who cannot drive or do not have access to private vehicles, enabling them to reach work, access health care, and participate fully in social and political life. Interviewees who mentioned the 2017 Twin Cities Shared Mobility Action Plan agreed with the Action Plan's premise that shared autonomous vehicles providing shuttle services could be used to augment existing public transportation services. Specifically, interviewees mentioned three major benefits that shared autonomous vehicles may bring to public transit services:

- Filling first- and last-mile gaps in the existing high-capability transit networks,
- Replacing low-volume transit routes with smaller vehicles to improve the cost efficiency of transit services, and
- Providing on-demand services with flexible timetables and service routes that are more responsive and less expensive than the existing paratransit services.

Besides expressing strong interest in identifying how shared autonomous vehicles may improve and augment existing transit services, interviewees suggested that the Twin Cities region has already implemented pilot projects and/or initiatives that are indicative of the high potential of future shared autonomous vehicles options in improving public transportation services in the region. In the following text, we will describe these pilot projects and/or initiatives.

3.3 METRO TRANSIT

Metro Transit, a division of the Metropolitan Council, operates the primary public transit system in the Twin Cities—Minneapolis–St. Paul, Minnesota. The public transit system includes buses, light rail, and commuter rail services. Their service also includes resources for carpool, vanpool, and a guaranteed ride home program. As one of the largest systems in the county, they provided 78 million rides in 2019, across over 907 square miles and 125 routes. Based on a 2016 survey, about half trips are work-related while another 10 percent are school-related.[1]

Metro transit established the Strategic Initiatives Department in 2014 to build partnerships inside and outside the transit industry. The department has added analytic and planning capacity to innovative ideas that individual departments within Metro Transit may want to deliver but lack capacity to deliver. Within Metro Transit, there is satisfaction with the new Strategic Initiatives Department and its commitment toward data and technology innovations. For example, Metro Transit has expanded use of its automatic vehicle location (AVL) system to pinpoint service delays and to provide improved real-time transit arrival and departure information to transit riders via smartphone apps, which significantly improves customer experiences when compared to phone lines and pocket schedules to check when the next bus/rail is.

Metro Transit is watching closely to foresee the implications of shared autonomous vehicles on fixed route transit services. In particular, they are eager to see how combining dynamic routing and shared autonomous vehicles could offer greater flexibility than fixed bus/rail services, allowing agencies to be responsive to customer needs. Metro Transit has also recognized that the addition of autonomous fleets

[1] https://metrocouncil.org/Transportation/Services/Metro-Transit.aspx

may lead to a change in workforce. The agency is interested in maintaining positive labor relations, given that the majority of the current employees are transit operators. Depending on the scale and speed of adoption, there may be fewer transit operator jobs when shared autonomous vehicles become available. At the same time, new roles, and more jobs, in operations management and customer service may emerge over time. These workforce changes are an important social equity issue to address when considering shared autonomous vehicles.

3.4 SOUTHWEST TRANSIT

Southwest Transit provides transit service in the southwest suburbs of the Twin Cities Metro area. The suburbs of Chaska, Chanhassen, and Eden Prairie opted out of the Metropolitan Transit Commission in 1986, instead signing an agreement to operate an independent system. However, they are subjected to regional transit policies adopted by the Metropolitan Council. One such policy is a regional fare strategy that allows cross-jurisdictional trips and the sharing of capital resources.

Services include commuter routes to and from Downtown Minneapolis, the University of Minnesota, and Best Buy Headquarters; an on-demand ride service in the suburban service region; and special rides to downtown sporting events and the state fair among others. Southwest Transit provides about 1.3 million trips per year with about 150 one-way express bus trips and over 400 demand-response vehicle trips per operating day.[2]

Southwest Transit can quickly mobilize resources to start pilot programs and make quick adjustments if the initiatives do not meet expectations. An example of these pilot programs is the dedicated bus service between the southwest suburbs in the region and the Target Corporate office in Brooklyn Park, MN. The program was implemented in 2011. However, this dedicated bus service ended less than a year into operation due to unsustainably high per rider costs and the lack of interest at Target for promoting the service. This demonstrates the importance of engaging employers in the process of promoting transit and shared mobility services in suburban areas without a strong transit culture.

Another quick service implementation was Southwest Prime (SW Prime); the on-demand service started in 2015 with just a few months from ideation to implementation. Service continued to grow in 2019 by 10 percent after the service added a new non-emergency medical service (SW Prime MD) in coordination with a regional hospital (Ridgeview) that provides discounted rides to Ridgeview facilities in the service area. The on-demand service also implemented a new software managed by Spare Labs that improves

[2] https://swtransit.org/about/our-annual-report/

reliability of automatic driver assignment. Original software was not well-suited to a suburban area, allowing manual assignment to cut average waiting time by 5 minutes. The new software allows users to book a trip with a few clicks; then automatically assigns and routes vehicles in real-time, reducing the average wait time and trip duration further. Such a service lays the groundwork for what users and regional businesses would expect from an on-demand automated vehicle service.

The new southwest light rail expansion operated by Metro Transit will allow Southwest Transit to divert more resources to local SW Prime service. They are working on an autonomous vehicle pilot with MnDOT to connect suburban business parks with the new southwest light rail stations. First/last mile connections to high quality transit are a particularly beneficial application of AV technology.

3.5 MINNESOTA DEPARTMENT OF TRANSPORTATION

The Minnesota Department of Transportation (MnDOT) works at the largest scale of the mentioned transportation agencies. MnDOT supports many efforts to control growth in vehicle miles traveled and is also involved in promoting several AV initiatives.

The ABC Ramps in downtown Minneapolis. The three parking ramps on the west side of downtown were built in 1992 as part of the construction of Interstate 394, using federal and state funds. Operation of ABC Ramps is dictated by both federal and state requirements; one primary charge is to pursue congestion mitigation and air-quality improvements using transportation demand management and transit-oriented development (TOD). This facilitates experimentation and innovation in pursuit of TOD goals as technology evolves.

MnDOT pilots at ABC Ramps have focused on providing incentives to carpooling and ridesharing programs. For example, ABC Ramps offers deeply discounted parking rates for carpools. ABC Ramps has also encouraged transit use via park and ride among its parking contract holders, distributing Go-To cards—the farecard for Metro Transit and other Twin Cities public transit—so customers could drive to a Park-and-Ride when their carpool partner was unavailable. MnDOT is currently examining whether downtown commuters are interested in a combined parking and transit contract that returns savings for driving less.[3] Consequently, the ramps are a logical opportunity to consider adding AVs as part of other initiatives to combine mobility services.

[3] https://flexpass.umn.edu/sites/flexpass.umn.edu/files/2020-09/FlexPass%20Summer%202020%20Report.pdf

MnDOT's Office of Connected and Autonomous Vehicles (CAV-X) leads these efforts to navigate the autonomous vehicle shift in Minnesota in support of the Governor's Advisory Council on CAV and the CAV Strategic Plan.[4] CAV-X is coordinating CAV pilots around the state, several of which are discussed in its 2020 annual report.[5] The current initiatives are wide and varied, including some transit-related projects. However, in interviews, Metro Transit and MnDOT staff both expressed a desire to see more deep coordination in pursuit of cross agency engagement and programming, seeking an opportunity for growth as inter-modal, cross-agency pilots become the norm in the complex transportation sector.

3.6 CITY OF MINNEAPOLIS

The City of Minneapolis has supported testing and demonstration of SAV's since 2018, when they hosted demonstrations of an EZ10 vehicle on the Nicolet Mall and Midtown Greenway. Since that time, the City has articulated several actions it can take in the next 10 years that would deploy SAV's in support of the Minneapolis Transportation Action Plan, which was adopted in December 2020.[6]

The foundations for these actions lie in Technology actions 1.4 and 2.2. The former simply notes the City's interest in continuing to provide testing opportunities for automated vehicles and learn from other cities doing similar work. However, the second part of this action states that these tests should be limited to shared travel modes.[7] This part of action 1.4 ties to action 2.2, which states that city will also require that these shared modes provide equitable access, including low-price options, education, and outreach about how to access services, geographic distribution with a focus in areas of concentrated poverty with majority people of color, non-English resources, non-smartphone access, ADA access to vehicles and services and multiple payment methods including options for the unbanked.[8]

These actions are complemented by additional actions that support mobility hubs and other shared mobility efforts. In particular, the City plans to evaluate the impacts of SAV's on street design (technology action 1.5) and incorporate that information into design guidance for transit curbside use needs and travel

[4] http://www.dot.state.mn.us/automated/strategicplan.html (last accessed July 22, 2021)

[5] http://www.dot.state.mn.us/automated/docs/2021-gac-on-cav-annual-report.pdf , pp 11 - 13(last accessed July 22, 2021)

[6] http://go.minneapolismn.gov/ (last accessed July 21, 2021)

[7] http://go.minneapolismn.gov/final-plan/technology/strategy-1 (last accessed July 22, 2021)

[8] http://go.minneapolismn.gov/final-plan/technology/strategy-2 (last accessed July 22, 2021

lane impacts. (Design action 1.7).[9] The City also commits to support transit applications of SAV's in technology action 1.11.[10] Finally, the City has committed to developing data sharing and partnering opportunities that are intended to increase partnering between operators and also with government entities.

[9] http://go.minneapolismn.gov/final-plan/design/strategy-1#sub7 (last accessed July 22, 2021)

[10] http://go.minneapolismn.gov/final-plan/technology/strategy-1 (last accessed July 22, 2021

CHAPTER 4: STATED PREFERENCE SURVEY – THE TWIN CITIES METRO SAMPLE

Our examination of public perceptions and preferences about SAV technology uses a sample gathered from across the Twin Cities metro area. Specifically, we used various recruitment methods including using Facebook advertisements targeting Minneapolis and surrounding 15-mile radius as well as using the Double-Opt-In Market Research Panels at Qualtrics.

We designed and administered an original online survey instrument with two novel components: participant mapping and conjoint survey questions. Participant mapping was used to gauge spatial mismatch/transportation hassle problems and conjoint survey analysis was used to identify prioritized features of SAV systems. In this section we describe the survey instrument, outline our outreach process, and provide summary statistics and geographic analysis of our final sample of participants.

4.1 SURVEY INSTRUMENT

The primary data source for this report was an originally-designed survey instrument. The survey was administered through Qualtrics between July 3, 2020 and January 9, 2021. Our survey is comprised of an introduction followed by three sections of questions. All survey methods and associated documentation were approved by the University of Minnesota IRB.

The survey opens with a page providing information about the survey's approval, IRB approval and research contact information. After participants provide their consent at the bottom of this page, they watch a minute-long introductory video created by the research team. The introduction video is available at https://www.youtube.com/watch?v=6synaoSx3nY, which describes SAVs using a series of short sentences shown to footage of SAV prototypes in action:

- *"Welcome to the Shared Automated Vehicle (SAV) Transportation Survey."*
- *"SAVs are driverless vehicles that transport multiple people at once."*
- *"Imagine a driverless bus that could pick you up and drop you off where and when you need."*
- *"You could hail this vehicle on-demand with your phone."*
- *"SAVs could look like vehicles we are familiar with or they could be very different."*
- *"Nobody is sure what these systems will look like."*
- *"We would like your help to design a SAV system for the Twin Cities."*

4.1.1 Basic demographic and transportation questions

After the introduction, respondents were asked a 5-point Likert Scale question gauging their level of comfort if they were to hypothetically ride an SAV similar to those shown in the introduction video. Responses ranged from "very uncomfortable" to "very comfortable", with "neutral" in the middle. Specifically, we asked participants "how comfortable would [they] be riding the automated vehicle technology shown in the video?" Participants were also asked to rank their comfort riding any vehicle with strangers ("people you do not know"), both at the current time and before the COVID-19 pandemic, using similarly worded 5-point Likert Scale response categories. Following these comfort-related questions, we asked two questions intended to gauge respondents' willingness to pay (WTP) for a single SAV ride from their home to downtown Minneapolis. The first of these questions captured economic WTP, asking respondents to identify their maximum price for such a ride. The next question captured temporal WTP, asking respondents to identify their maximum wait time for a SAV to pick them up for the same ride downtown. WTP for AV technology has been examined before using similar survey methods, so this approach fits with previous literature (Liu et al 2019, Elvik 2020).

Following the comfort and WTP questions, respondents were asked a series of demographic questions about their age, cohabitation/household structure, race/ethnicity, country of birth, gender, income bracket, and general health. In addition, a set of transportation access questions were included: whether participants had a valid driver license, how often respondents had access to an automobile, and how difficult it was to reach ten different areas within the Twin Cities metro area, including Downtown Minneapolis, Downtown St. Paul, and several first and second-ring suburbs.

4.1.2 Interactive participant mapping

Following the basic demographic and transportation questions, we ask respondents to mark their home location on an interactive and searchable map, using the Open Street Maps interface. To identify correct locations, users could search up addresses or location names and or pinpoint the exact place on the map. Figure 4 shows the mapping interface for the home location question, including the search and pinpoint functions.

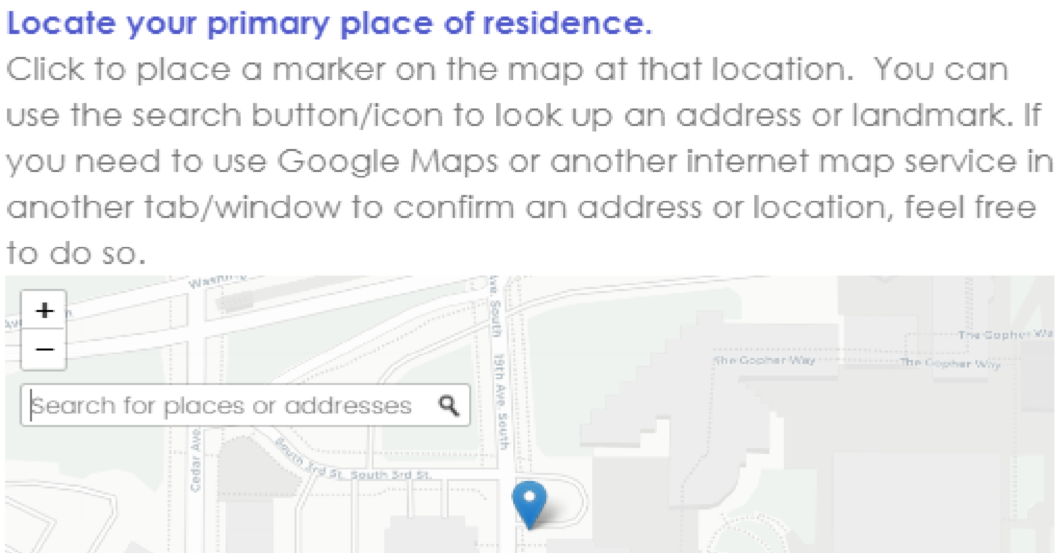

Figure 4: Survey Instrument Participatory Mapping Interface

Then, respondents were asked to indicate whether they made specific type of trips around the metro over the last week, from a predetermined set of possible trip purposes:

- Work
- Your own education
- Childcare/ family member's education
- Grocery Shopping
- Other Shopping
- Restaurant / Bar
- Gym / Indoor Physical Activity
- Park / Outdoor Physical Activity
- Community Meeting
- Art / Music / Library
- Medical Clinic / Pharmacy
- Attend Religious Services
- Visit Friend or Family / Social Gathering
- Government/Social Services

The survey then loaded an additional interactive map for each trip purpose category and respondents were asked to identify each location they travelled to for each trip purpose category. Once each location was identified using the map's pinpoint and/or search features, respondents answered a set of follow-up questions in a pop-up box. First, they list each mode of transportation they used during the trip, before identifying the number of times they took the given trip over the past week. Possible modes include:

- Personal Auto (driver)
- Personal Auto (passenger)
- Carshare
- Ride-Hailing (Uber, Lyft, etc)
- Taxi
- Rail
- Bus
- Personal Motorcycle
- Personal Scooter
- Personal Bike
- Bikeshare
- Scooter Share
- Walk

Participants then answer whether they would make the trip more frequently if it was less difficult and list any possible hassles made during the trip. This process repeats for each location listed for each trip purpose category. Specifically, we ask if respondents "would describe the trip as any of the following [hassles]":

- Logistically inconvenient
- Unaffordable
- Personally uncomfortable
- Unsafe

Figure 5 shows the pop-up window asking the above follow-up questions once a location has been marked. Once respondents identified all trip destinations, they were then asked if there are any locations they would visit more frequently if transportation were less of a hassle. If their answer was yes, they then identify any locations they would travel to if transportation were less burdensome. For each location, they then state the purpose of the trip, how many times they would visit it weekly given less of a transportation burden and the current hassle(s) (using the same list of hassles as before) that restricts their travel to the given location. Figure 6 shows a screenshot of this question in the survey, along with the mapping interface and follow-up question pop-up.

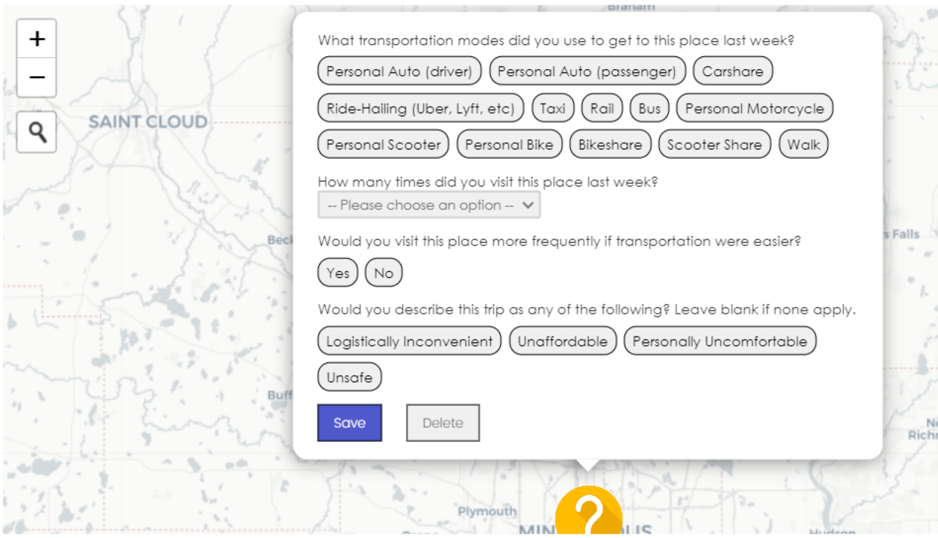

Figure 5: Location Follow Up Questions Pop-Up Window

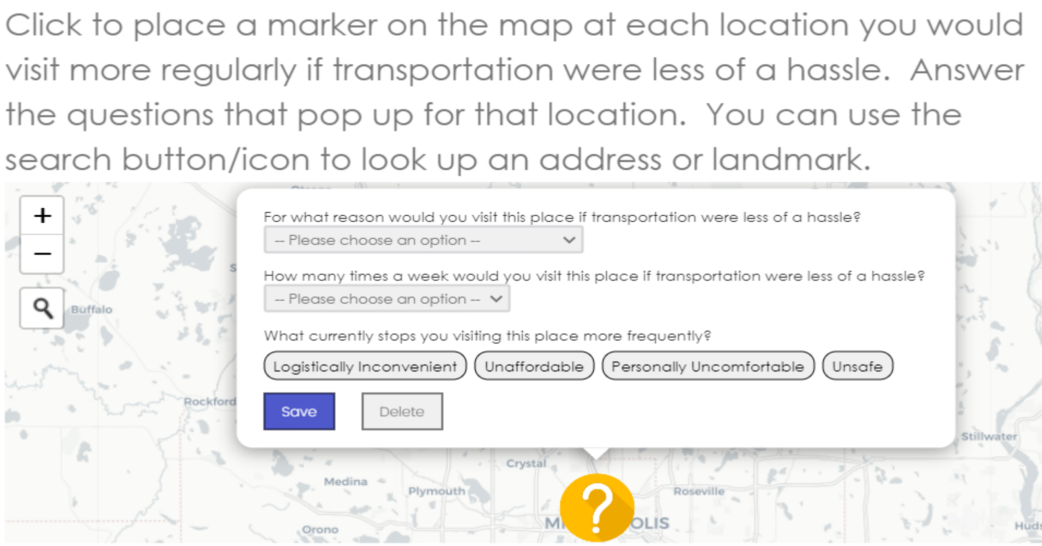

Figure 6: Hypothetical Location Question

4.1.3 Conjoint survey

The final portion of the survey was comprised of five questions asking respondents to select their preferred set of features between two randomly generated sets. This approach is known as paired conjoint survey analysis, and its use of randomization allows for more consistent causal inference in survey research (Knudsen and Johannesson 2019).

Sets were randomly populated with features from seven categories using self-designed computer algorithms. The seven categories and the associated features are outlined in Table 1. Randomization was conducted such that at least two differences had to exist between the two competing sets and such that the same two sets could not reappear. Note that each category includes a baseline feature – considered the most basic possible specification for said category.

Table 2: Conjoint Survey Categories and Features

Category	Description	# Features	Features
Payment System	How a use pays for rides on the SAV system	2	App only (b) App and onboard payment
Booking System	How a user hails an SAV/books a trip	2	App only (b) App, text, and call booking
Storage Space	Possible options for dedicated space on board an SAV	4	No storage space (b) Storage for strollers Storage space for bikes Storage space for bags
Security Measures	Possible options for security on board an SAV	3	None (b) Camera Onboard attendant
Sitting Room	How much sitting room on board an SAV	2	Limited seating (b) Ample seating (b)
Seating Layout	How the seating on board an SAV will be laid out	2	Seats face each other (b) Seats face same direction
Extra Amenities	Possible options for additional conveniences	3	None (b) Wi-Fi Power Outlines
Notes: Baseline features are presented first in numbered lists in Column 3 and indicated as (b).			

Respondents then selected one of two randomly generated sets of features, with one feature per category appearing in each set. Figure 7 shows a conjoint question from the survey.

Choose the set of features you prefer.

	Option A	Option B
Payment System	App / Onboard	App only
Booking System	App / Text / Call	App / Text / Call
Storage Space	Bikes	Bags
Security Measures	Attendant	Camera
Sitting room	Ample	Ample
Seating	Face forward	Face forward
Extras	Free wi-fi	Free wi-fi

Figure 7: How Feature Bundles Were Shown to Survey Respondents

4.2 SAMPLE RECRUITMENT AND STATISTICS

We recruited survey participants through several methods. First, between July 3rd and August 18th, 2020, we ran a series of advertisements on Facebook and Instagram, targeted to users who resided in the seven Metro Area. We ran ads during two-week intervals and intermittently checked the composition of our sample to ensure that it was representative. After the first set of ads had run, our sample was overwhelmingly white and female, so we focused on recruiting participants living in specific majority-minority areas in South Minneapolis, North Minneapolis, and the Northwest first-ring suburbs, and Midway St. Paul. Facebook's advertisement settings allow for specific geographic targeting by radius so we set target circles that included majority-minority neighborhoods or low-income areas. This improved sample representativeness slightly, so we readjusted our parameters after running another two weeks of ads, this time focusing on people who were parents, people who worked in service sector jobs, and people with lower levels of education since these groups were less prominent in the sample.

After running these ads, we completed the sample by recruiting participants through Qualtrics. Qualtrics works with paid panels of survey-takers intended to be representative of local area demographics. We recruited a Qualtrics panel primarily composed of people of color and skewed toward male participants to fully diversify our sample. We screened out Qualtrics panel participants who lived outside Hennepin, Ramsey, Anoka, Carver, Scott, and/or Washington Counties because those seven counties are used by local policy bodies such as the Metropolitan Council to define the urban area's boundaries.

After survey administration completed, our data included 469 completed responses. Out of these responses we removed participants who did not live in the Twin Cities or disclose a home location, leaving 413 total responses in our final sample. Notably, some of these participants skipped a few questions and several preferred not to disclose certain demographics. Generally, participant item-specific nonresponse occurred only for a few questions and never exceeded 5% of the total final sample.

The home locations of the 413 participants living in the seven-county area are shown below in Figure 8, which also identifies the jurisdictions of Minneapolis and Saint Paul, county boundaries, and major highways. We specifically identify Minneapolis and Saint Paul because as the central cities of the metro area, they have the most robust transit infrastructure and the densest urban form of any municipality in the region. Most participants live within Minneapolis of Saint Paul or “first ring” suburbs like St. Louis Park or Edina (the clusters of homes respectively to the West of central Minneapolis and South of Southwest Minneapolis).

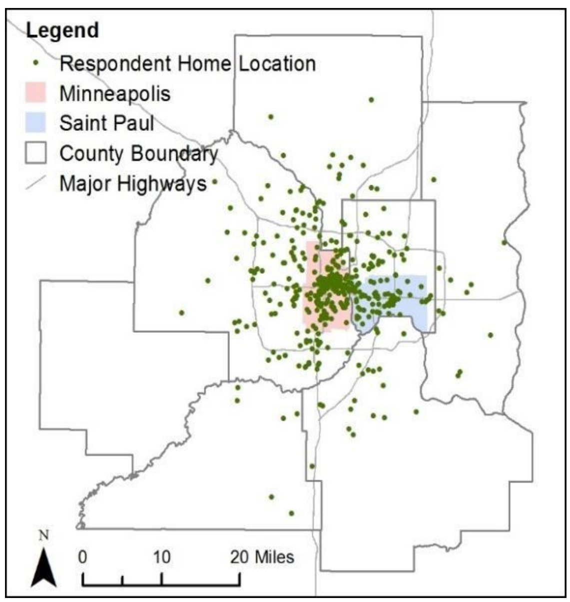

Figure 8: Map of Home Locations

Table 3 shows summary statistics for both dependent and independent variables for all observations in the final sample. The variables include continuous and binary ones. Notably, the sample is balanced across gender, and its racial breakdown generally reflects that of the entire Twin Cities Metropolitan Area, as defined by the aforementioned seven counties.

Table 3: Summary Statistics of Dependent and Independent Variables

	Variable	N	Mean	SD	Min	Max
Dependent Variables	Maximum Wait Time (Minutes)	381	15.950	7.319	0	30
	Maximum Payment (Dollars)	407	12.545	8.279	0	30
	Comfort with SAV (Likert)	413	3.959	1.152	1	5
Independent Variables	Current Comfort with Shared Vehicles (Likert)	413	2.768	1.460	1	5
	Pre-COVID Comfort with Shared Vehicles (Likert)	413	3.852	1.155	1	5
	Age	412	35.500	15.251	18	80
Income	<10k	413	0.058	0.234	0	1
	10k-25k	413	0.109	0.312	0	1
	25k-50k	413	0.194	0.396	0	1
	50k-75k	413	0.203	0.403	0	1
	75k-100k	413	0.186	0.390	0	1
	>100k	413	0.213	0.410	0	1
	PNS	413	0.036	0.187	0	1
Health	Poor	413	0.019	0.138	0	1
	Fair	413	0.104	0.306	0	1
	Good	413	0.278	0.449	0	1
	Very Good	413	0.378	0.485	0	1
	Excellent	413	0.215	0.412	0	1
	PNS	413	0.005	0.070	0	1
Automobile Access	Rare	413	0.094	0.293	0	1
	Sometimes	413	0.215	0.412	0	1
	Always	413	0.690	0.463	0	1
Race	Asian or Pacific Islander	413	0.111	0.315	0	1
	Black	413	0.065	0.247	0	1
	Mixed	413	0.048	0.215	0	1
	White	413	0.538	0.499	0	1
	Hispanic (any Race)	413	0.232	0.423	0	1
	PNS	413	0.005	0.070	0	1
Gender	Female	413	0.484	0.500	0	1
	Male	413	0.458	0.499	0	1
	Non-binary	413	0.041	0.199	0	1
	PNS	413	0.017	0.129	0	1
Cohabitation	Spouse	413	0.499	0.501	0	1
	Children Under the Age of 5	413	0.165	0.371	0	1
	Children Between 6 and 17	413	0.252	0.435	0	1
	Child Over 18	413	0.077	0.268	0	1
	Roommate	413	0.189	0.392	0	1
	No One	413	0.138	0.345	0	1
	Other	413	0.104	0.306	0	1

Nativity	Not Foreign Born	413	0.785	0.412	0	1
	Foreign Born	413	0.215	0.412	0	1
	Table 3 (cont.)					
Travel Patterns	# of Total Trips	410	9.400	9.186	0	102
	Central City Resident (Minneapolis or St. Paul)	413	0.538	0.499	0	1
	Activity Space (sq miles)	413	101.957	160.073	3.141	1197.449
	Location Hassle Ratio	410	0.384	0.420	0	1

Notes: Not all variables appear the same way in regressions as we make appropriate adjustments and transformations.
"PNS" indicates participants who declined to disclose or "preferred not to say".

The set of variables describing participant geography and travel patterns necessitates further explanation. The average participant listed 9.4 trips taken during the last week, taking frequency of location visits into account. The average activity space, defined by the minimum convex polygon bounding box of all locations listed by each participant surrounded by a 1-mile buffer, was about 102 square miles. Additionally, nearly 54% of participants lived in Minneapolis or St. Paul. Finally, the gauge the extent to which travel presented hassles, we computed the Location Hassle Ratio – each participant's raw ratio of the number of locations that induced any travel hassle to their total number of listed locations.

Additionally, Figure 9 shows a kernel density map of all activity locations, weighted by trip frequency. The densest areas of travel are in Downtown Minneapolis and St. Paul. These activity spaces include home locations and 1,973 activity locations listed by the 413 respondents during the second part of the survey.

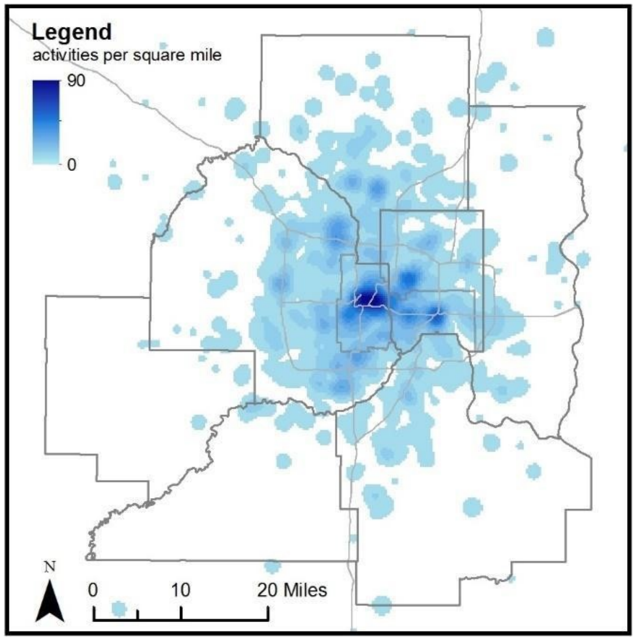

Figure 9: Kernel Density Map of Activity Spaces

4.3 ANALYSIS ON TRANSPORTATION HASSLES/BARRIERS

The first set of statistical tests using data from the survey examines peoples' current transportation barriers or difficulties, dubbed "hassles" here, using data drawn from the pop-up window questions for each location listed by participants. We use the models to identify which groups of participants faced transportation barriers, and for which reasons. Specifically, we estimate logit models on trip level data, gathered in the second part of the survey, as shown in Column A of Table 4. Each observation corresponds to a specific trip, with participant identification retained. The dependent variable is the probability that a specific trip caused its participant to experience a hassle.

Table 4: Models of Trip Difficulty

Variable	A: Probability Trip is Hassle (Logit)			B: Hassle Count Per Person (Poisson)		
	OR	SE	p<z	OR	SE	p<z
Gender						
Female	0.828	0.180	0.385	0.006	0.116	0.956
Non-binary	0.841	0.384	0.705	0.393	0.315	0.212
Race						
Asian Pacific Islander	0.738	0.314	0.475	0.100	0.262	0.704
Black	**2.382***	1.124	0.066	**0.457***	0.250	0.068
Mixed Race / Other	1.208	0.583	0.695	0.272	0.297	0.360
Hispanic/Latino	**2.409*****	0.790	0.007	**0.585*****	0.186	0.002
Income						
Mid ($50,000-99,999)	0.745	0.203	0.280	-0.044	0.153	0.774
High ($100,000+)	0.997	0.331	0.993	-0.071	0.165	0.667
Auto Access						
Sometimes	1.105	0.438	0.801	0.023	0.252	0.927
Always	0.691	0.273	0.350	-0.240	0.244	0.325
Age Decade						
20s	0.554	0.280	0.244	-0.386	0.278	0.166
30s	0.764	0.403	0.610	-0.241	0.280	0.390
40s	0.423	0.256	0.154	-0.501	0.342	0.142
50s	0.431	0.289	0.209	-0.524	0.348	0.133
60s	**0.312***	0.186	0.051	-0.443	0.326	0.174
70s & 80s	1.363	0.859	0.623	-0.043	0.314	0.892
Cohabitation						
Child under 17	1.177	0.343	0.577	0.148	0.164	0.365
Live Alone	1.045	0.319	0.887	0.155	0.181	0.393
Misc						
Driver License	1.007	0.366	0.984	-0.044	0.193	0.818
Central City Resident	**1.870*****	0.414	0.005	0.233*	0.123	0.059
Log Activity Space	**1.293****	0.128	0.010	**0.131*****	0.048	0.006
Good Health	0.570	0.175	0.067	**-0.231***	0.138	0.094
Foreign Born	**1.928****	0.600	0.035	0.128	0.167	0.445
Vehicle-share Now	**1.733****	0.405	0.019	**0.489*****	0.145	0.001
Vehicle-share Pre-COVID	1.030	0.248	0.903	-0.142	0.137	0.299
Purpose						
Art	1.225	0.504	0.621			
Childcare	1.029	0.378	0.937			
Community-Meeting	1.554	0.680	0.314			
Government	0.867	0.403	0.759			
Groceries	**0.469*****	0.094	0.000			

Gym	0.552	0.209	0.117	
Medical	0.775	0.203	0.330	
Park	0.905	0.197	0.646	
Place-of-Worship	**0.435****	0.152	0.017	
Restaurant	**0.614****	0.150	0.046	
School	**2.271***	0.990	0.060	
Shopping	0.695	0.170	0.136	
Social	0.746	0.167	0.191	
N		1,973		387
Pseudo-R^2		0.247		

Notes: Odds ratios displayed. Logit model also controls for trip purpose, mode of transportation used, and number of modes used. Standard errors are clustered at the respondent level. Poisson model uses total number of trips as exposure. Both models exclude respondents who reported only a home location. An asterisk is added if statistically significant at 90% confidence, two asterisks are added for coefficients that are significant at 95% confidence, and three asterisks for 99% confidence

Only a few variables were significantly associated with the problem that a trip was a hassle. Notably, trips Black and Hispanic participants were more likely to find a trip a hassle. Similarly, central city residents, people currently comfortable with sharing vehicles with strangers, and foreign-born participants were also more likely to take a trip with a hassle. However, people who reported good health are less likely to find a given trip a hassle.

Column B of Table 4 shows results from a Poisson regression, using the total count of hassles experienced as a dependent variable and the total number of trips as exposure. In this case, data is aggregated by participants, so each observation in the regression is a survey participant. With aggregation and the transformation of our dependent variable into a hassle count by participant, rather than a trip-specific binary, results in Column B largely mirror those of Column A. One major difference between the two models is that central city residence and foreign nativity are no longer statistically significant. While trips taken by central city residents and foreign-born participants are more likely to be hassles, these participants do not necessarily have higher hassle counts than others, accounting for their total trip exposure.

Additionally, a trip taken by a Black or Hispanic participant was about 250% more likely to present a hassle than a trip taken by a non-Hispanic white participant. Hispanic participants also experienced a nearly 75% higher hassle count than white participants. Although there were no statistical differences in either model associated with income, automobile access or age, trips taken by people living in Minneapolis or St Paul, people who were born outside of the United States and people who are currently comfortable with sharing a vehicle with strangers were more likely to present hassles. However, people with good health reported about 43% fewer hassles in the poisson model.

The logit model additionally includes a set of variables for trip purpose, using work trips as a baseline. Most trip purposes are less likely to present a hassle than a work-related trip, with the exception of travel for one's own schooling. It is important to recall that these trips took place during the COVID-19 pandemic. Commutes to work during the pandemic induced more frequent hassles than trips for other purposes.

The results of this model suggest evidence of inequities in transportation access among our study sample, especially by race. While income was insignificant, the finding about work commutes being more of a hassle than other trips, especially in the context of the COVID-19 pandemic suggests that transportation hassles vary by occupation, if not by socioeconomic status. It is possible that people who had to commute during the pandemic experience this commute to be a hassle generally.

4.4 ANALYSIS ON COMFORT USING SAV, WILLINGNESS TO PAY, AND MAXIMUM WAIT TIME

The next set of statistical models examines the determinants of individual attitudes toward SAV technology. We measure attitudes with the three dependent variables provided in Table 3.

We regress each dependent variable on a full set of demographic indicators, as shown above, as well as city-of-residence fixed effects and each respondents' activity space. We transform the Likert scale "SAV Comfort" Variable into a binary valued 1 if participants reported being comfortable or very comfortable with SAV technology and 0 otherwise. We similarly transform the two variables gauging general comfort sharing vehicles with strangers. We use Ordinary Least Squares models for participants maximum payment and waiting time and a logit model to examine the determinants of SAV comfort.

Table 5 presents results of these models. Maximum payment increases with income and is positively correlated with Black and Hispanic race and non-binary gender. While people who live alone report a higher maximum payment, people in their fifties report a significantly lower maximum payment by about $4.00.

Although results are similar across different ways to measure attitudes toward SAVs, there are a few notable differences. First, although maximum wait time is positively correlated with participant automobile access, it is not significantly associated with other dependent variables. Similarly, having a driver license increases maximum wait time by about 3.5 minutes but does not significantly affect the two other dependent variables. This suggests that perhaps those who have reliable personal transportation options may see SAVs as an interesting concept, one they would be okay with waiting for, but not necessarily paying a lot of money for.

Foreign born individuals and respondents who live with at least one child under 17 years of age also exhibit longer maximum wait times and higher payments, but membership in those groups is not significantly associated with general SAV comfort level. It is plausible that people with children value the convenience of travel associated with SAV technology and thus are more willing to wait longer and pay higher amounts for a trip. Another important distinction occurs with gender. Although women do not significantly differ from men in their maximum payment or wait times from men, they are about 50% less likely to report being somewhat or very comfortable with taking an SAV ride in Column C. This aligns with findings of gendered perceptions toward SAV technology. The next section provides potential explanations for some of these findings by examining differences in preferences for certain possible features of a hypothetical SAV, gauged by the conjoint section of the survey instrument.

Table 5: Results of Willingness to Adopt SAV Models

	A-Max. Payment (OLS)			*B-Max. Wait Time (OLS)*			*C-SAV Comfort (Logit)*		
Variable	Coef.	SE	P>t	Coef.	SE	P>t	O.R.	SE	P>z
Gender									
Female	0.372	0.749	0.620	-0.820	0.776	0.292	0.568*	0.177	0.069
Non-binary	3.296	2.133	0.123	1.017	2.022	0.615	0.561	0.351	0.356
Race									
Asian Pacific Islander	0.561	1.522	0.713	-1.889	1.250	0.132	0.694	0.378	0.502
Black	6.480***	1.382	0.000	2.310*	1.387	0.097	0.845	0.541	0.792
Mixed Race / Other	-0.339	1.977	0.864	-1.278	1.823	0.484	0.616	0.455	0.512
Hispanic/Latino	5.357***	1.164	0.000	1.898*	1.016	0.063	1.288	0.537	0.544
Income									
Mid ($50,000-$99,999)	1.699**	0.832	0.042	0.095	0.898	0.916	0.753	0.252	0.396
High ($100,000+)	3.715***	1.069	0.001	0.140	1.129	0.901	0.679	0.300	0.380
Automobile Access									
Sometimes	1.876	1.414	0.185	2.719**	1.379	0.049	2.008	1.032	0.175
Always	2.044	1.372	0.137	2.695*	1.438	0.062	1.178	0.532	0.717
Age Decade									
20s	-0.827	1.715	0.630	-1.284	1.618	0.428	0.528	0.348	0.332
30s	-2.060	1.845	0.265	-1.380	1.740	0.428	1.055	0.738	0.939
40s	-1.929	2.032	0.343	-2.398	1.936	0.216	0.186*	0.146	0.032
50s	-3.408	2.086	0.103	-0.640	1.892	0.736	0.769	0.595	0.734
60s	0.129	2.333	0.956	0.667	2.006	0.740	1.867	1.898	0.539
70s & 80s	1.483	2.413	0.539	2.558	2.363	0.280	0.241	0.200	0.086
Cohabitation									
Live with Child	1.552	0.968	0.110	2.245**	1.008	0.027	1.792	0.673	0.121
Live Alone	0.267	1.016	0.793	-0.368	1.133	0.745	0.570	0.245	0.191
Misc.									
Vehicle-share Now	2.717***	0.917	0.003	2.716***	0.913	0.003	2.417**	0.972	0.028
Vehicle-share Pre-COV	1.301*	0.785	0.099	0.933	0.810	0.250	4.445***	1.311	0.000
Driver License	1.558	1.289	0.227	2.893**	1.155	0.013	1.028	0.506	0.956
Foreign Born	2.793**	1.144	0.015	2.382**	1.056	0.025	0.866	0.363	0.731

Good Health	-0.955	1.121	0.395	-0.389	1.149	0.735	1.345	0.575	0.488
Central City Resident	-0.301	0.754	0.690	0.464	0.790	0.557	0.710	0.220	0.268
Log Activity Space	0.214	0.315	0.498	-0.319	0.295	0.281	1.103	0.154	0.485
Hassle-Trip Ratio	0.114***	0.043	0.009	0.050	0.038	0.189	1.072*	0.042	0.078
N	386			361			390		
R^2	0.397			0.273			0.196		

Notes: Models A and B are OLS models with continuous dependent variables. Model C is a logit regression, with Odds Ratios displayed. R^2 for Model C is actually a pseudo-R^2. Sample sizes fluctuate because some participants skipped dependent variable questions. An asterisk is added if statistically significant at 90% confidence, two asterisks are added for coefficients that are significant at 95% confidence, and three asterisks for 99% confidence

4.5 CONJOINT ANALYSIS ON PREFERENCES OF SAV FEATURES

The section includes a set of models that looks at preferences for SAV technology features, drawing data from the survey's conjoint segment. To analyze the results of the conjoint survey segment of the online survey instrument, we run ordinary least squares regressions of the probability a collection of features was selected on indicators of the presence of each feature, omitting the baseline feature from each category. Thus, models capture the marginal effect of a given feature's presence on the likelihood a collection is selected, specifically relative to the presence of the baseline feature within the relevant category.

Table 6 shows the main model run on the full sample and separate models run for men and women separately. For the full model, most features significantly affect collection selection. The presence of more flexible options for payment and booking in a collection increases its likelihood of selection. Compared to the no additional storage space options, the bag option increases the odds of selection by about 35% and the bike option increases the odds of selection by 64%. By contrast, the presence of stroller options has no effect on selection. The presence of each security measures about doubles a given collection's chance of selection compared to a collection that featured no security measure. On average, participants valued ample sitting room over limited sitting room and preferred to face forward rather than to face each other. For extra amenities, the presence of power outlets and free wi-fi increased a collection's section odds by about 50% and 97% respectively.

Partitioning the sample by gender shows notable difference in preferences between men and women. First, men do not exhibit any significant preferences regarding payment and booking flexibility, with women driving the effect found among the full sample. Although neither gender exhibits a significant preference for strollers, women's preference for bags and bikes was slightly higher than that of men. Stark differences occur for security preference, with the camera and attendant option increasing women's likelihood to select a given collection by 130% and 140% respectively. By contrast, those same features increased men's likelihood to select a bucket by only 68% and 52%, suggesting that women value security measures more than men. Women exhibit slightly more distaste toward facing each other than men and slightly more of a preference for ample seating room. Finally, while the presence of power outlets in a collection increases selection odds by about 92% for women, it only increases men's selection odds by about 25%. Wi-fi is strongly valued by both genders but women exhibit slightly higher preference for it.

Table 6: Conjoint Analysis by Gender and Full Sample

	Full			Women			Men		
Variable	Coef	SE	P>t	Coef	SE	P>t	Coef	SE	P>t
Payment System									
App / Onboard	**1.208****	0.082	0.005	**1.446****	0.138	0.000	0.931	0.091	0.469
Booking Space									
App / Text / Call	**1.215****	0.081	0.003	**1.294****	0.131	0.011	1.090	0.101	0.352
Storage Space									
Bags	**1.346****	0.132	0.003	**1.420****	0.208	0.017	**1.280***	0.180	0.080
Bikes	**1.644****	0.156	0.000	**1.743****	0.233	0.000	**1.537****	0.216	0.002
Strollers	1.019	0.094	0.839	1.096	0.149	0.501	0.898	0.119	0.415
Security									
Camera	**2.012****	0.166	0.000	**2.319****	0.284	0.000	**1.684****	0.202	0.000
Attendant	**1.918****	0.166	0.000	**2.401****	0.307	0.000	**1.522****	0.183	0.000
Sitting Room									
Ample	**1.266****	0.093	0.001	**1.342****	0.146	0.007	**1.235****	0.131	0.046
Seating									
Face each other	**0.729****	0.050	0.000	**0.685****	0.072	0.000	**0.809****	0.075	0.023
Extra									
Power outlets	**1.503****	0.132	0.000	**1.920****	0.242	0.000	**1.253***	0.171	0.098
Free wi-fi	**1.972****	0.161	0.000	**2.115****	0.263	0.000	**1.897****	0.221	0.000
Constant	**0.313****	0.036	0.000	**0.212****	0.036	0.000	**0.474****	0.081	0.000
N	4,120			2,000			1,888		
Pseudo R^2	0.046			0.067			0.045		

Notes: Log Odds Ratios displayed from logit regressions. Participants who chose not to disclose gender or were non-binary not included in the partitioned samples but are included in the full sample. The sample size of non-binary participants is too small to conduct valid analysis on. An asterisk is added if statistically significant at 90% confidence, two asterisks are added for coefficients that are significant at 95% confidence, and three asterisks for 99% confidence.

The next set of models splits up the sample by race, as shown in Table 7. Most of the effects estimated in the full sample regressions are driven by white respondents. In fact, the magnitude of the effect on selection associated with each feature's presence in a collection is higher for white participants than for participants of color (defined here as nonwhite and/or Hispanic participants). Although for some features such as free wi-fi, the difference in effect magnitude between participants of color and white participants is very slight, for other features such as the presence of power outlets or an attendant, presence increases selection odds substantially more for white respondents than for others. Further, people of color do not exhibit any preferences across payment or booking systems, not for ample seating while white respondents do.

When Black and/or Hispanic participants are further partitioned, even fewer features significantly affect selection at 95% confidence. The presence of an attendant, forward facing seating, and power outlets do not affect collection selection for Black and/or Hispanic participants.

Table 7: Conjoint Analysis by Race/Ethnicity

	White Participants			All Participants of Color			Black			Hispanic		
Variable	Coef	SE	P>t	Coef	SE	P>t	Coef	SE	P>t	Coef	SE	P>t
Payment												
App / Onboard	1.384**	0.129	0.000	1.057	0.105	0.579	0.949	0.269	0.855	1.029	0.138	0.833
Booking												
App / Text / Call	1.284**	0.122	0.009	1.158	0.108	0.116	0.988	0.278	0.964	1.073	0.133	0.569
Storage												
Bags	1.575**	0.223	0.001	1.169	0.159	0.250	1.498	0.456	0.185	1.326	0.250	0.135
Bikes	1.949**	0.244	0.000	1.431**	0.204	0.012	1.385	0.544	0.408	1.438**	0.266	0.049
Strollers	1.064	0.143	0.644	0.979	0.124	0.867	1.161	0.378	0.648	1.023	0.184	0.897
Security												
Camera	2.333**	0.256	0.000	1.768**	0.223	0.000	2.178***	0.650	0.009	1.171	0.203	0.363
Attendant	2.514**	0.310	0.000	1.438**	0.174	0.003	1.865**	0.579	0.045	1.045	0.171	0.788
Sitting Room												
Ample	1.399**	0.135	0.000	1.136	0.130	0.264	0.972	0.255	0.915	0.898	0.137	0.483
Seating												
Face each other	0.661**	0.063	0.000	0.815**	0.080	0.036	0.851	0.209	0.511	0.948	0.138	0.716

Extra												
Power outlets	1.762**	0.212	0.000	1.276*	0.168	0.063	2.157**	0.834	0.047	1.129	0.195	0.482
Free wi-fi	1.965**	0.216	0.000	1.963**	0.242	0.000	2.129**	0.745	0.031	1.773***	0.277	0.000
Constant	0.215**	0.033	0.000	0.454*	0.080	0.000	0.335	0.128	0.004	0.654	0.157	0.076
N	2,220			1,880			270			950		
Pseudo R^2	0.071			0.029			0.046			0.016		

Notes: Log Odds Ratios displayed from logit regressions. Participants who chose not to disclose income not included in the partitioned samples but are included in the full sample. An asterisk is added if statistically significant at 90% confidence, two asterisks are added for coefficients that are significant at 95% confidence, and three asterisks for 99% confidence

Next, we partition the sample by health status, as shown in Table 8. Unhealthy participants include those who reported poor or fair health in the survey. The presence of flexible booking, bicycle space, security cameras, and ample sitting room (compared to their respective baseline features) increase the likelihood of selection more for unhealthy participants than for healthy participants. By contrast, the inclusion of a flexible payment system, security attendant, and both extra amenities increase the odds of selection more for healthy participants than for unhealthy participants.

Table 8: Conjoint Analysis by Health Status

	Unhealthy Participants			Healthy Participants		
Variable	Coef	SE	P>t	Coef	SE	P>t
Payment System						
App / Onboard	1.407	0.324	0.138	**1.194****	0.084	0.012
Booking Space						
App / Text / Call	**2.601*****	0.533	0.000	1.110	0.077	0.131
Storage Space						
Bags	1.436	0.433	0.230	**1.344*****	0.141	0.005
Bikes	**2.132****	0.693	0.020	**1.624*****	0.160	0.000
Strollers	1.239	0.350	0.449	1.004	0.098	0.964
Security Measures						
Camera	**2.277*****	0.631	0.003	**1.971*****	0.172	0.000
Attendant	1.299	0.303	0.262	**2.024*****	0.190	0.000
Sitting Room						
Ample	**1.821****	0.438	0.013	**1.229*****	0.096	0.008
Seating						
Face each other	**0.670***	0.142	0.059	**0.743*****	0.054	0.000
Extra						
Power outlets	1.185	0.279	0.471	**1.566*****	0.150	0.000
Free wi-fi	**1.701****	0.460	0.049	**2.011*****	0.174	0.000
Constant	**0.187*****	0.075	0.000	**0.323*****	0.040	0.000
N		500			3,600	
Pseudo R^2		0.090			0.045	

Notes: Log Odds Ratios displayed from logit regressions. Participants who chose not to disclose income not included in the partitioned samples but are included in the full sample. An asterisk is added if statistically significant at 90% confidence, two asterisks are added for coefficients that are significant at 95% confidence, and three asterisks for 99% confidence

Table 9 shows conjoint results partitioned by income. Low-income participants value payment and booking flexibility slightly more than mid-income participants, although high income participants value payment flexibility about the same as low-income participants, while not exhibiting significant preference across booking options. Preference for bag space is positively correlated with income, and while preference for bike space is similar between low-and-middle-income participants, high income participants exhibit more preference than their lower-income counterparts. Preferences for security features are consistent across income brackets, with low-income participants exhibiting slightly more preference for an attendant and lower preference for cameras than high income and mid-income participants. Preference for ample seating room is also positively correlated with income, although preferences are similar between low- and mid-income participants. For extra amenities, although preferences are consistent across income brackets, there is a slight positive income correlation in preference for power outlets and a slight negative income correlation in preference for free-wifi. Preference for forward facing seating is notably consistent in all income groups.

Table 9: Conjoint Analysis by Income

	Income <50000			Income >=50000 & <=99,999			Income 100,000+		
Variable	Coef	SE	P>t	Coef	SE	P>t	Coef	SE	P>t
Payment System									
App / Onboard	**1.281****	0.154	0.040	**1.192***	0.119	0.078	**1.246****	0.132	0.038
Booking Space									
App / Text / Call	**1.396*****	0.152	0.002	**1.198***	0.122	0.076	1.178	0.125	0.122
Storage Space									
Bags	1.233	0.201	0.200	**1.368****	0.202	0.034	**1.450****	0.221	0.015
Bikes	**1.582*****	0.256	0.005	**1.584*****	0.229	0.001	**1.749*****	0.267	0.000
Strollers	0.939	0.142	0.676	1.043	0.149	0.769	1.132	0.169	0.405
Security Measures									
Camera	**1.911*****	0.268	0.000	**2.147*****	0.265	0.000	**2.102*****	0.270	0.000
Attendant	**1.861*****	0.279	0.000	**1.752*****	0.233	0.000	**1.775*****	0.248	0.000
Sitting Room									
Ample	**1.354****	0.174	0.019	**1.399*****	0.145	0.001	**1.447*****	0.156	0.001
Seating									
Face each other	**0.701*****	0.075	0.001	**0.696*****	0.074	0.001	**0.697*****	0.078	0.001
Extra									
Power outlets	**1.494*****	0.206	0.004	**1.503*****	0.211	0.004	**1.531****	0.228	0.004
Free wi-fi	**2.159*****	0.293	0.000	**2.038*****	0.254	0.000	**1.970*****	0.263	0.000
Constant	**0.293*****	0.061	0.000	**0.309*****	0.051	0.000	**0.285*****	0.050	0.000
N	1,480			1,610			880		
Pseudo R^2	0.054			0.050			0.042		

Notes: Log Odds Ratios displayed from logit regressions. Participants who chose not to disclose income not included in the partitioned samples but are included in the full sample. Coefficients given an asterisk if statistically significant at 90% confidence and two asterisks are added for coefficients that are significant at 95% confidence.

Finally, we partition the sample by location hassle ratio in Table 10 First, we show results for respondents who reported a location hassle ratio of less than 50%. Preferences were very significant for this group, except for stroller space, which did not affect a collection's chances of selection. By contrast, participants who reported a hassle ratio of over 50%– exhibit fewer preferences between features. Bike space, security cameras, and free wi-fi all increased the odds of selection, although at lower magnitudes than the full sample or the low location hassle ratio group. This suggests that people who experience higher amounts of transportation related stress care less about possible features of SAV systems.

Table 10: Conjoint Analysis by Trip Hassle Ratio

	Hassle Ratio <0.5			Hassle Ratio b/w 0.5 and 1		
Variable	Coef	SE	P>t	Coef	SE	P>t
Payment System						
App / Onboard	1.335***	0.112	0.001	1.038	0.118	0.744
Booking Space						
App / Text / Call	1.242**	0.105	0.011	1.189	0.130	0.113
Storage Space						
Bags	1.479***	0.194	0.003	1.200	0.179	0.222
Bikes	1.825***	0.227	0.000	1.437**	0.211	0.014
Strollers	1.021	0.128	0.868	1.042	0.141	0.763
Security Measures						
Camera	2.504***	0.271	0.000	1.454***	0.186	0.003
Attendant	2.546***	0.294	0.000	1.205	0.152	0.138
Sitting Room						
Ample	1.506***	0.142	0.000	0.950	0.109	0.657
Seating						
Face each other	0.638***	0.057	0.000	0.887	0.094	0.258
Extra						
Power outlets	1.753***	0.199	0.000	1.210	0.172	0.180
Free wi-fi	2.113***	0.215	0.000	1.836***	0.256	0.000
Constant	0.218***	0.033	0.000	0.538***	0.099	0.001
N	2,570			1,550		
Pseudo R^2	0.075			0.021		

Notes: Log Odds Ratios displayed from logit regressions. Participants who chose not to disclose income not included in the partitioned samples but are included in the full sample. Coefficients given an asterisk if statistically significant at 90% confidence and two asterisks are added for coefficients that are significant at 95% confidence.

Finally, we partition the sample by COVID-induced changes in general vehicle sharing in Table 11. Generally, participants whose comfort sharing vehicles reduced with the COVID-19 pandemic demonstrated more significant preferences across feature categories than those whose comfort remained the same or those whose comfort increased. The only exception to this is for security features, where people whose comfort increased during the pandemic demonstrated slightly higher preferences for additional features, compared to those whose comfort decreased. Those whose comfort was the same before and during the pandemic exhibited relatively high preference for storage space, preferring bags more strongly than both other groups, but exhibiting slightly lower preference for bike space than the COVID-induced comfort reduction group. For other categories, the same comfort group's preferences were lower than the comfort-reduction group. Most participants reported lower comfort during the pandemic than before, with only 37 participants feeling more comfort sharing a vehicle with others after the beginning of COVID-19.

Table 11: Conjoint Analysis by COVID-Induced Changes in General Vehicle Sharing

Table 11: Conjoint Analysis by COVID-Induced Changes in General Vehicle Sharing									
	Comfort Lower After COVID			Same Comfort Before&After			Comfort Higher After COVID		
Variable	Coef	SE	P>t	Coef	SE	P>t	Coef	SE	P>t
Payment									
App / Onboard	1.293***	0.119	0.005	1.086	0.127	0.479	1.110	0.223	0.603
Booking									
App / Text / Call	1.229**	0.104	0.015	1.197	0.152	0.158	1.148	0.241	0.512
Storage Space									
Bags	1.293**	0.169	0.049	1.654***	0.280	0.003	0.954	0.317	0.888
Bikes	1.752***	0.223	0.000	1.601***	0.245	0.002	1.181	0.441	0.656
Strollers	1.050	0.126	0.681	1.156	0.193	0.385	0.614*	0.166	0.071
Security									
Camera	2.206***	0.242	0.000	1.656***	0.226	0.000	2.380***	0.748	0.006
Attendant	2.039***	0.235	0.000	1.629***	0.241	0.001	2.468***	0.754	0.003
Sitting Room									
Ample	1.388***	0.132	0.001	1.172	0.152	0.223	0.968	0.236	0.893
Seating									
Face each other	0.637***	0.057	0.000	0.786**	0.095	0.046	1.310	0.289	0.221
Extra									
Power outlets	1.703***	0.204	0.000	1.344**	0.191	0.038	0.933	0.303	0.831
Free wi-fi	2.023***	0.226	0.000	1.913***	0.259	0.000	1.955***	0.497	0.008
Constant	0.274***	0.043	0.000	0.366***	0.069	0.000	0.384**	0.162	0.023
N	2,420			1,330			370		
Pseudo R^2	0.059			0.035			0.059		

Notes: Log Odds Ratios displayed from logit regressions. Participants who chose not to disclose income not included in the partitioned samples but are included in the full sample. Coefficients given an asterisk if statistically significant at 90% confidence and two asterisks are added for coefficients that are significant at 95% confidence.

4.6 DISCUSSION

Analysis of data from the stated preference survey provides several important and related takeaways. First, although gender was not significantly correlated with trip difficulty, women exhibit notably less comfort with SAV technology, compared to men. Results from conjoint analysis offer some potential explanations for this gendered comfort gap. For nearly all categories of features in the conjoint questions, women exhibited less indifference between alternatives and the baseline option. Women especially exhibited higher preference for both security measure options compared to men. This finding aligns with research on women's overall safety experiences on public transportation (Ait Bihi et al, 2019). The technology initially shown in the video did not noticeably feature any security measures, which could have contributed to female participants' overall reduced comfort with the technology.

By contrast, although Black and Hispanic participants were more likely to experience hassles during their current travel, they did not significantly differ from other racial/ethnic groups in their general comfort with SAV technology. However, they were willing to pay more, potentially reflecting a higher economic valuation of SAV technology because of its possible transport comfort and efficiency advantages, compared to currently existing modes. This is notable given established gaps in Black and Hispanic automobile ownership associated with the United States' historical development of automobile infrastructure for White suburban dwellers, resulting in poorer transportation connectivity in Black and Hispanic neighborhoods (Van Dort et al, 2019). Black and Hispanic participants, as well as other participants of color, demonstrated higher levels of indifference between possible SAV system features, suggesting that the overall transportation ease benefits of SAV may dominate other features when it comes to ultimate preferences and assessments of the technology.

It is also important to analyze other demographics. Good health was associated with a reduction in individual total hassle count, but not the probability a given trip was a hassle for a participant. However, it did not significantly affect any of the three willingness to adopt measures. Notably, unhealthy participants deviated in the conjoint section from their healthy counterparts by revealing higher preference for flexible booking system (compared to app only) and for ample sitting room. This suggests that although health does not necessarily affect willingness to adopt, public health policy must advise the features included in a final SAV system. After controlling for other factors, income was uncorrelated with either measure of trip difficulty. However, wealthier individuals exhibited a higher willingness to pay for a given SAV trip, which makes sense given their higher financial ability. While there were a few income differences in preferences, people with incomes under $50,000 exhibited more indifference toward all features but free wi-fi and security attendants than their middle-income counterparts, suggesting that feature flexibility may appeal more to middle-or-high-income participants. However, it is important to note that low-income individuals did exhibit significant preferences regardless in many cases. Finally, the extent to which people experienced travel hassles affected willingness to pay for an SAV trip but not the other two willingness to adopt measures. Further, people with high hassle ratios exhibited substantially more indifference between features than those with lower hassle ratios, but not more than those who took no trips.

Overall, the results of the stated preference survey present several lessons to policymakers First, SAV technology can feasibly serve the purpose of reducing transportation inaccessibility, especially for Black and Hispanic people. The indifference exhibited in conjoint analysis by people with high transportation hassle ratios and by Black and Hispanic people should not necessarily indicate that onboard features are irrelevant to these groups of people, but that overall efficiency gains are more important. To ensure gender equity in willingness to adopt this new technology, it will be important for public providers to ensure adequate onboard security and flexibility in payment and booking.

CHAPTER 5: STATED PREFERENCE SURVEY—THE DOWNTOWN COMMUTER SAMPLE

As discussed in the MnDOT section of Chapter 3, the ABC Ramps, located on the western edge of downtown Minneapolis, are one of MnDOT's most notable transportation demand efforts, serving as a mobility hub that provides parking for cars, facilities for bicyclists, connections to transit, and other services.

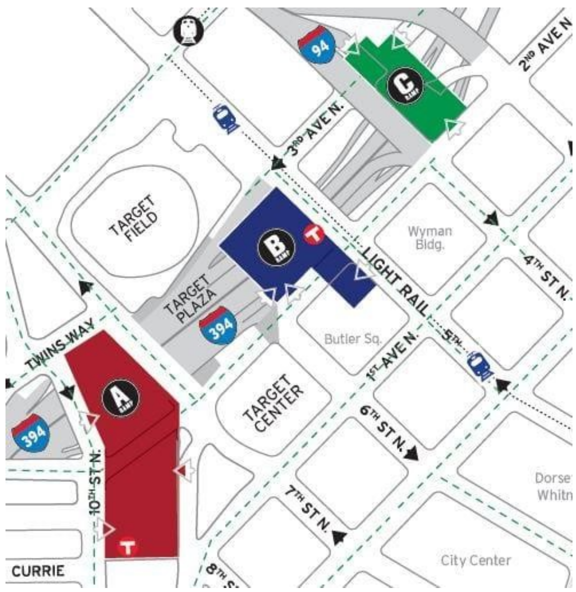

Figure 10: Reference Picture of ABC Ramps in the Survey

The three structures were constructed in 1992, as part of the construction of Interstate 394, with using federal and state funds. Operation of ABC Ramps is dictated by both federal and state requirements; one primary charge is to pursue congestion mitigation and air-quality improvements using transportation demand management and transit-oriented development (TOD). Consequently, the ramps are a logical opportunity to consider adding AVs as part of other initiatives to combine mobility services. To better understand the possible users of such a service, we re-deployed the on-line survey used in Chapter 4 with the following goals:

- How comfortable would people be with an autonomous shuttle service coming to and from the ABC Ramps?
- How do demographic segments differ in attitudes towards it and autonomous vehicles in general?
- How much money would people be willing to pay for such a service and how long would they be willing wait for a ride?

- What features would people like to see in a shuttle service such as the one proposed and what features are preferred by different demographic groups?

The main changes from the earlier survey were the geographic area for the sample, and that we only asked about the origin and destination of their most recent trip using the ABC Ramps (we did not ask about trip purpose).

5.1 SAMPLE RECRUITMENT AND STATISTICS

The survey was launched on December 1, 2020. We paid for a Facebook advertisement that began running the same day. The Facebook ad was a photograph of the ABC ramps, a University of Minnesota logo and read "Take a University of Minnesota survey on transportation options to and from the ABC ramps in Downtown Minneapolis for a chance to win a $50 gift card! This research study is sponsored by the National Science Foundation." When creating the ad, we chose to target the ad to people aged 18 - 65+ living in Minneapolis, MN. The ad ran until December 31, 2020, which is the day that the survey closed. 65% of respondents who completed at least half of the survey found it through the Facebook ad. The survey was also advertised in a social media post from Move Minneapolis, a nonprofit consulting team specializing in sustainable transportation. The survey was also distributed through the ABM mailing list (the company that manages the ABC ramps) as well as a social media post on the ABC Ramps' page.

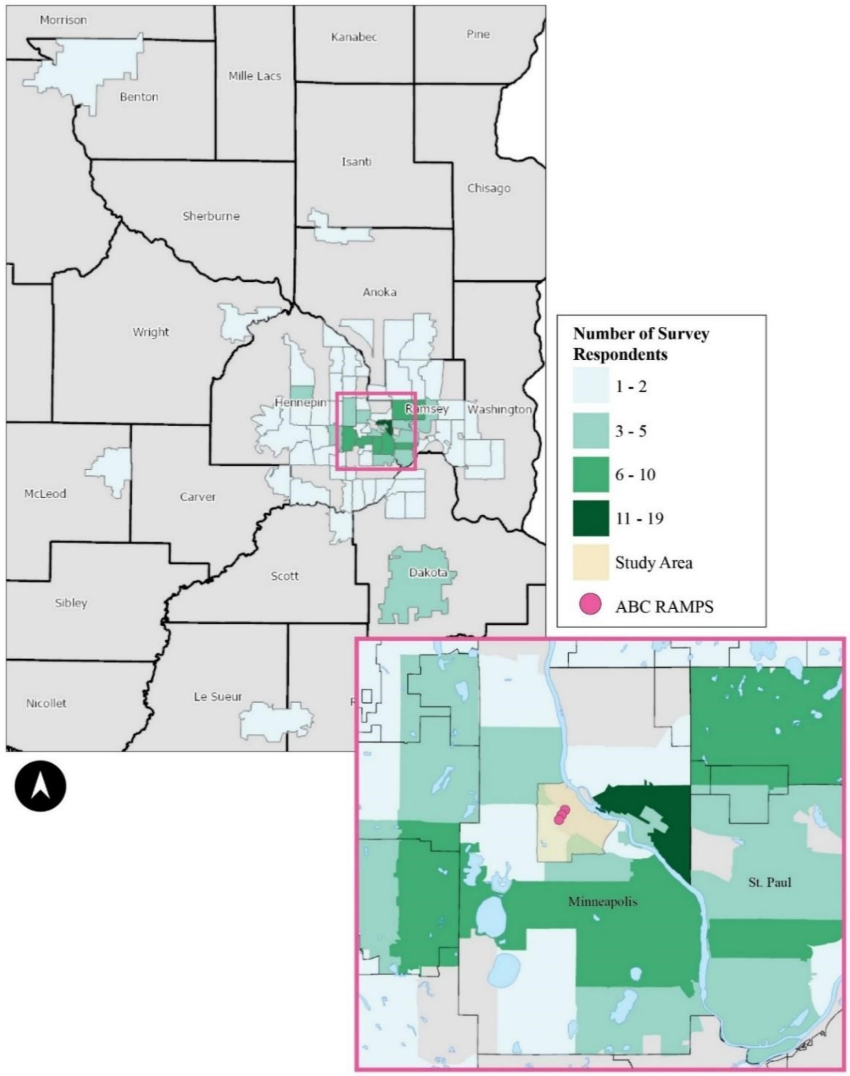

Figure 11: Home Zip Codes of Survey Respondents

Of the 333 people that started the survey, 210 completed at least half of it. As shown in Figure 11, 88% of respondents live in either Minneapolis or St. Paul, 6% live elsewhere in Hennepin County, and another 6% live outside Hennepin County. The demographics of the 210 survey respondents were compared to the nine census tracts that make up "Central Minneapolis" which includes the neighborhoods Loring Park, Steven's Square, Elliot Park, North Loop, Downtown East, and Downtown West. Most notably the survey respondents were significantly less racially and ethnically diverse than the residents of the study area. A larger percentage of respondents had college degrees and earned higher wages. Since the target of the study is users of the ABC ramps, however, and not necessarily a representative sample of the neighborhoods surrounding the ramps, we note this distinction for descriptive purposes only. Another notable aspect of our sample was the high number of respondents in the zip code immediately northeast of downtown (55414). This area is a popular location for University of Minnesota students, who may have been more attracted to the survey by our use of the U of M logo, offer of gift cards and use of social media than other parts of the population. Table 12 supplements the map with data on sample demographics and income. The sample was majority male, with a plurality of respondents aged 25 to 34. A large majority (166 out of 210 respondents) were white. About 40% of respondents reported income over $75,000.

Table 12: Gender, Age, Race/Ethnicity, and Income of Survey Respondents

	Survey Respondents		Study Area	
	N	%	N	%
Gender				
Female	91	43%	11,986	43%
Male	121	57%	16,049	57%
Age				
18 - 24	38	18%	7,057	25%
25 - 34	55	26%	8,073	29%
35 - 44	31	15%	3,690	13%
45 - 54	38	18%	3,878	14%
55 - 64	28	13%	2,804	10%
65+	22	10%	2,533	9%
Race				
Black or African American	2	1.00%	7,008	19.80%
American Indian or Alaska Native	0	-	337	1.00%
Asian	20	9.80%	2,400	6.80%
Hispanic/Latinx	4	2.00%	1,645	4.70%
Other Race	4	2.00%	141	0.40%
Two or More Races	8	3.90%	1,423	4.00%
White	166	81.40%	22,358	63.30%
Income				
Less than $10,000	9	4.10%	2,802	12.70%
$10,000 to $24,999	19	8.60%	3,123	14.20%
$25,000 to $50,000	38	17.2	4,771	21.70%
$50,000 to $74,999	35	15.80%	4,305	19.60%
$75,000 or more	90	40.70%	7,010	31.80%
Prefer not to say	30	13.60%	0	

5.2 THE ABC RAMPS: USERS, TRAVEL MODES, & BARRIERS

Survey respondents were asked if they are familiar with the ABC Ramps. If they responded no or unsure, they were directed to a page with a map and a short description of the ramps.

> *The ABC ramps are the largest parking ramps in Downtown Minneapolis. The ramps also connect people to a variety of transit options including the light rail, commuter rail, and bus service. For more information, you can visit https://abc-ramps.com.*

Those who responded yes skipped the description and went straight to the questions about the ABC ramps. According to Table 13, 67.9% of all survey respondents were familiar with the ABC Ramps and 51.4% used them. Of those already using the ABC ramps, 74% would be slightly more comfortable using the shuttle service than those who were not at the time of the survey (69%). Then, respondents were asked for all the modes of travel they used to get to the ABC Ramps. Half of responses were by personal vehicle. 13.4% of responses were walk and 12.4% carpool. The rest of the mode options made up less than 10% of responses.

Most (77.6%) people have an easy time parking in the ABC Ramps. Only 4 respondents find it to be somewhat difficult or extremely difficult. Those who responded that they get to the ABC Ramps via personal vehicle or carpool were asked whether it is difficult to park in the ABC Ramps and to check all the reasons for that difficulty. 42.4% of the responses said that the ramps were too expensive. 25.9% of the responses said that it was too hard to find parking. Only 12.9% of responses were that the ramps are too far. Half of the 18.8% "other" responses wrote that they do not like driving in Downtown Minneapolis. Some specified that it is difficult to drive to or from the ramps during major events. Some said that it is not difficult at all to park at the ramps.

Table 13: Survey Responses Regarding ABC Ramp Usage

Are you familiar with the ABC ramps? N=221		
Yes	150	67.90%
No	45	20.40%
Unsure	26	11.80%
Do you use the ABC ramps? N=218		
Yes	112	51.40%
No	106	48.60%
How do you get to the ABC ramps? (Check all that apply) N=194		
Personal vehicle	99	51.00%
Walk	26	13.40%

Carpool	24	12.40%
Bus	17	8.80%
Bicycle	13	6.70%
Ride Share (Uber/Lyft)	10	5.20%
Electric Scooter	4	2.10%
Other	1	0.50%
How hard is it for you to park in the ABC ramps? N=103		
Extremely easy	47	45.60%
Somewhat easy	33	32.00%
Neutral	19	18.40%
Somewhat difficult	3	2.90%
Extremely difficult	1	1.00%
Why is it difficult to park in the ABC ramps? N=85		
Too far	11	12.90%
Too expensive	36	42.40%
Hard to find parking	22	25.90%
Other	16	18.80%
Are you familiar with the ABC ramps? N=221		
Yes	150	67.90%
No	45	20.40%
Unsure	26	11.80%
Do you use the ABC ramps? N=218		
Yes	112	51.40%

No	106	48.60%
How do you get to the ABC ramps? (Check all that apply) N=194		
Personal vehicle	99	51.00%
Walk	26	13.40%
Carpool	24	12.40%
Bus	17	8.80%
Bicycle	13	6.70%
Ride Share (Uber/Lyft)	10	5.20%
Electric Scooter	4	2.10%
Other	1	0.50%
How hard is it for you to park in the ABC ramps? N=103		
Extremely easy	47	45.60%
Somewhat easy	33	32.00%
Neutral	19	18.40%
Somewhat difficult	3	2.90%
Extremely difficult	1	1.00%
Why is it difficult to park in the ABC ramps? N=85		

Too far	11	12.90%
Too expensive	36	42.40%
Hard to find parking	22	25.90%
Other	16	18.80%

Survey respondents who answered that they used the ABC Ramps were asked to think of their most recent trip to or from the ABC Ramps. Table 14 shows that the vast majority of respondents were going to or from work (67%). Social gatherings and art/music/library activities were 7.3% of trips each. Most people used a personal vehicle to get or from the ABC Ramps, with walking being a distant second. Because this survey was taken during the COVID-19 pandemic, it is more likely that trips are for essential activities such as going to work. If the survey was taken before the pandemic, we would likely see more trips were for leisure given the ramps' location near major entertainment venues, including sports arenas, theaters, restaurants, and clubs.

72.4% of users thought their most recent trip was either extremely convenient or somewhat convenient and only 9.5% found it to be inconvenient. Nevertheless, half of these users would make this trip more regularly if transportation were less of a hassle. This indicates that a shuttle service such as the one described in the survey could be a more convenient option.

Table 14: Survey Responses Regarding Most Recent Trip to or From the ABC Ramps

What was the purpose of your MOST RECENT trip to or from the ABC ramps? N=109		
Work	73	67.00%
Your Own Education	1	0.90%
Non-grocery shopping	4	3.70%
Restaurant / Bar	6	5.50%
Park / Outdoor Physical Activity	6	5.50%
Art / Music / Library	8	7.30%
Government / Social Services	1	0.90%
Medical Clinic / Pharmacy	2	1.80%
Visit Friends or Family / Social gathering	8	7.30%
From that trip, how did you get to and from the ABC ramps? N=106		
Personal vehicle	75	70.80%
Carpool	7	6.60%
Walk	15	14.20%
Bus	4	3.80%
Bicycle	2	1.90%
Electric Scooter	1	0.90%
Rideshare (Uber/Lyft)	2	1.90%
How much of a hassle was this trip? N=108		
Extremely convenient	29	27.60%
Somewhat convenient	47	44.80%
Neutral	19	18.10%
Somewhat inconvenient	10	9.50%
Extremely inconvenient	0	-
Would you make this trip more regularly if transportation were less of a hassle? N=108		
Yes	55	50.90%
No	28	25.90%
Unsure	25	23.10%

Convenience and utility are only part of the reasons why someone would use this service. Comfort and appeal are also important, and overall, survey respondents indicated they would be comfortable using the automated vehicle technology shown in the video at the beginning of the survey. 71.0% responded that they would be very comfortable or somewhat comfortable using it, while 16.7% responded that they would be very uncomfortable or somewhat uncomfortable. Part of the reason for this high comfort level may be due to survey respondents also showing a particularly high level of comfort taking transit. 78.2% responded that they were very comfortable or somewhat comfortable taking transit, while only 10.7% responded that they are very uncomfortable or somewhat uncomfortable taking transit. This percentage, however, could be influenced by apprehension taking public transportation during the COVID-19 pandemic.

5.3 ANALYSIS ON COMFORT USING SAV

Respondents were also asked how comfortable they felt sharing a vehicle with someone they do not know currently versus before the COVID-19 pandemic, with results provided in Table 15. Only 25.0% felt very comfortable or somewhat comfortable sharing a vehicle with someone they do not know as of December 2020, versus the 59.3% who felt very comfortable or somewhat comfortable before the pandemic. The high level of comfort with the shuttle service compared to the low level of comfort with sharing a vehicle during a global pandemic indicate that the concerns related to the shuttle service are likely related to the pandemic, rather than other factors intrinsic to the shuttle service itself and supports the potential success of such a service after the pandemic recedes.

Table 15: Survey Responses Regarding Comfort Using Shared Transportation

How comfortable would you be riding the automated vehicle technology shown in the video? N=221		
Very comfortable	63	28.50%
Somewhat comfortable	94	42.50%
Neutral	27	12.20%
Somewhat uncomfortable	31	14.00%
Very uncomfortable	6	2.70%
How comfortable do you feel taking transit? N=215		
Very comfortable	87	40.50%
Somewhat comfortable	81	37.70%
Neutral	17	7.90%
Somewhat uncomfortable	18	8.40%
Very uncomfortable	5	2.30%
I don’t take transit	7	3.30%
Currently, how comfortable do you feel sharing a vehicle with people you do not know? N=220		
Very comfortable	10	4.50%
Somewhat comfortable	45	20.50%
Neutral	49	22.30%
Somewhat uncomfortable	56	25.50%
Very uncomfortable	60	27.30%
Before the COVID-19 pandemic, how comfortable did you feel sharing a vehicle with people you did not know? N=221		
Very comfortable	47	21.30%
Somewhat comfortable	84	38.00%
Neutral	37	16.70%
Somewhat uncomfortable	40	18.10%

A linear regression analysis, shown in Table 16, also showed a strong link between comfort using the shuttle service and comfort using transit or sharing a car before COVID-19. Overall, respondents who identify as female were less comfortable using the shared transportation than respondents who identify as male. 67% of female respondents and 77% of male respondents would feel somewhat comfortable or very comfortable using the shuttle service. However, only 11% of female respondents would feel very comfortable, which is in stark contrast to the 43% of male respondents who would feel very comfortable. This pattern is also shown in comfort levels using transit. While the percentage of those who feel very comfortable or somewhat comfortable using transit is very high (74% for female respondents, 82% for male respondents), only 27% of female respondents feel very comfortable, while 50% of male respondents feel very comfortable.

Additionally, while comfort sharing a vehicle in December 2020 was low for both genders, a much higher percentage of male respondents were comfortable sharing a vehicle with someone they did not know then (31% vs. 19%). Similarly, 66% of male respondents were very comfortable or somewhat comfortable sharing a car with some they do not know prior to the COVID-19 pandemic vs. 54% of female respondents. Three survey respondents identify as non-binary or another gender. All three feel somewhat comfortable or very comfortable taking transit while all three feel somewhat uncomfortable or very uncomfortable sharing a car with someone they don't know as of December 2020. Comfort levels using the shuttle service and sharing a car with someone they do not now before the pandemic were mixed among the three non-binary respondents.

Table 16: Comfort Using Shared Transportation by Gender (Linear Regression)

	Comfortable Using the Shuttle Service	Comfortable Using Transit	Comfortable Sharing a Vehicle Now	Comfortable Sharing a Vehicle Before COVID
Female	0.37 ** (0.15) n = 61	0.13 *** (0.14) n = 66	0.09 (0.14) n = 17	0.34 ** (0.16) n = 49
Male	0.47 ** (0.15) n = 93	0.19 *** (0.14) n = 96	0.21 (0.14) n = 37	0.46 ** (0.16) n = 80

Age had little effect on respondents' levels of comfort using the shuttle service as well as the other shared transportation options. The percentage of respondents who were very comfortable or somewhat comfortable using the shuttle service were between 67% and 79% across all age brackets. Likewise, comfort levels across different income brackets also showed greater range with no clear trend.

Comfort using the shuttle service remained high across all educational attainment categories. Only seven respondents had a high school diploma or less, so their results are not necessarily statistically significant.

Because 81% of respondents are white, we cannot draw any conclusions on respondents of other races. The largest non-white racial/ethnic group were Asian (10%). They responded similarly to white respondents with a high level of comfort with the shuttle service and a slightly higher level of comfort with transit.

Comfort level using the shuttle service remained high even for respondents who lived outside Hennepin County. However, because the survey was primarily advertised to residents of Minneapolis, only 21 respondents lived outside the Twin Cities. We also analyzed how comfortable respondents would be using the shuttle service by whether they lived in Downtown Minneapolis or not. It did not seem like this made a difference since 73.8% of those who live in Downtown Minneapolis were very comfortable or somewhat comfortable with the shuttle service and 70.2% of those who do not live in Downtown responded the same way.

5.4 ANALYSIS ON WILLINGNESS TO PAY AND MAXIMUM WAIT TIME

Participants were asked the maximum amount of time they would be willing to wait to be picked up to and from the ABC ramps by this shuttle service and how much money they would be willing to pay for the shuttle service. Respondents chose their answer by moving a slider that went from 0 to 30 with 15 in the middle as the default. The 0 - 30 range was the same for both wait time and shuttle cost.

Figure 12 shows the relatively high willingness to wait and low willingness to pay. The maximum wait time had a mean of 10.21 and median of 10. The maximum cost had a mean of $4.65 and a median of $3.00. These thresholds are similar to what one would to wait and pay to ride transit. The local bus fare in Minneapolis is $2.00 ($2.75 during peak hours). The wait time for a local bus or the light rail is anytime between 5 minutes and an hour but is typically between 10 and 15 minutes. This is an indication that respondents view the shuttle service more as an enhanced transit service, rather than a rideshare car service such as Uber or Lyft.

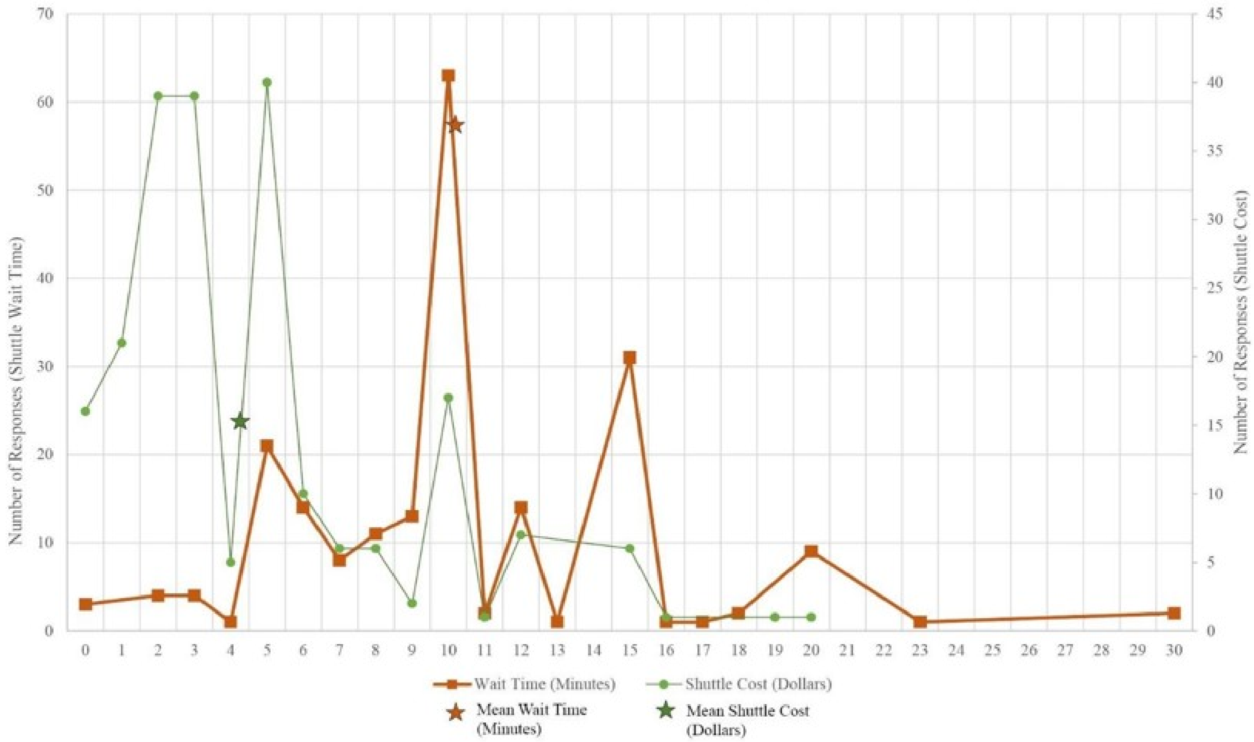

Figure 12: Willingness to Pay and Willingness to Wait

As shown in Table 17, female respondents were willing to wait slightly longer and pay slightly more than male respondents for this shuttle service. There was not much wait time variation across age groups except that the youngest group (18 - 24) and the oldest group (65+) were willing to wait longer for the shuttle service. The shuttle cost across age group showed no clear pattern. For respondents grouped by household income, typically the higher the household income, the less time a person was willing to wait for the shuttle. There was no pattern for the cost across income groups. In addition, as one might expect, respondents who said they would be uncomfortable using the shuttle service were willing to wait less time and pay less than those who said they would be comfortable with it.

Table 17: Shuttle Wait Time and Cost by Comfort Using Shared Transportation

			Shuttle Wait Time		Shuttle Cost	
	Variable	N	Mean	Median	Mean	Median
Gender	Female	91	10.9	10	5.1	3
	Male	121	9.8	10	4.3	3
Age	18 - 24	40	12.1	10	5.2	5
	25 - 34	57	9.6	10	4.8	3
	35 - 44	33	9.8	10	6.0	5
	45 - 54	38	9.6	10	4.1	3
	55 - 64	29	9.2	10	3.5	2.5
	65+	24	11.2	10	3.6	3
Household Income	Less than $25,000	28	13.4	12.5	5.8	5
	$25,000 to $49,000	38	10.8	10	3.4	3
	$50,000 to $74,999	35	11.3	10	5.4	5
	$75,000 to $99,999	27	9.0	10	6.3	5
	$100,000+	63	9.3	10	4.3	3

5.5 CONJOINT ANALYSIS ON PREFERENCES OF SAV FEATURES

For conjoint analysis of this downtown commuter sample, we run linear regressions with the probability a collection of selected features is selected as an outcome variables and full sets of factor variables in each feature. Regression coefficients capture the marginal effect of the presence of a given feature on the probability a collection is selected, compared to its category's baseline. A summary of results is illustrated in Figure 13.

Security measures were by far the biggest deciding factor for all respondents as they decided whether to choose that option. An attendant in the autonomous vehicle had a coefficient of 0.39 and a camera had a coefficient of 0.29. Female respondents were more likely to weigh security features more heavily in their option decision, with a particular preference for a human attendant. Along gender lines, security measures were the only statistically significant deciding factors.

Security measures were even more influential in choosing a feature bundle for those who were uncomfortable using shared transportation. For those who said they would feel very comfortable or somewhat comfortable using the shuttle service, security was the most preferred feature, but other features also played a deciding role. The same is true for those who feel comfortable using transit or sharing a car with someone they do not know. What stands out, though, is that for those who said they would feel somewhat uncomfortable or very uncomfortable using the shuttle service, security measures were the only deciding factors of any statistical significance. For those who feel uncomfortable taking transit, security measures and one free Wi-Fi were deciding factors of statistical significance. The same is true for those who felt uncomfortable sharing a car before the COVID-19 pandemic. For those who felt somewhat uncomfortable or very uncomfortable sharing a car with someone they do not know in December 2020, security measures were the main deciding factors, but a few other features had influence. This supports the idea that those who felt uncomfortable sharing a car in December 2020 were primarily concerned about COVID-19, rather than some other factors.

Safety features were also the main deciding factor for all age groups except for ages 55 - 64, which favored convenience related features. The coefficient stayed roughly the same (between 0.25 and 0.30) across age groups. This was also true across income and educational attainment groups, but the range was 0.20 to 0.30. In addition, safety features were the primary deciding factors across all home zip code groups. However, respondents who live in Downtown Minneapolis prioritized safety features as much as some convenience and comfort features.

There were only two features that those who rarely have access to a vehicle were of statistical significance (free Wi-Fi and ample seating room). This is likely due to this group only having ten people so statistically significant conclusions could not be drawn there. Those who rarely have access to a vehicle did not use safety features to decide on their option bundle. Those who sometimes have access to a vehicle prioritized safety features but not as much as they used convenience features to weigh their decision. The regression analysis for people who always have access to a vehicle had high coefficients for safety features, which makes sense considering this group is 83% of survey respondents.

	All	Gender: Female	Gender: Male	Using Shuttle Service: Comfortable	Using Shuttle Service: Uncomfortable	Using Transit: Comfortable	Using Transit: Uncomfortable	Sharing a Car Now: Comfortable	Sharing a Car Now: Uncomfortable	Sharing a Car Before COVID-19: Comfortable	Sharing a Car Before COVID-19: Uncomfortable
App/Onboard	**	**		**	*	*	**		**	*	**
App/Text/Call	**		**								
Bags	***	**	**	***		**	*		**	**	
Bikes	***	**	***	***		***			**	**	
Strollers			**	**							
Camera	***	***	***	***	***	***	***	**	***	***	***
Attendant	***	***	***	***	***	***	***	**	***	***	***
Ample	***	**	**	**	*	***			***	**	**
Face each other	**	**	*	*		**			***	**	
Free wifi	***	**	***	***	*	**	**	*	***	***	**
Power outlets	**	**	**	**		**		*		**	
Respondents	214	87	119	153	35	163	30	53	113	126	52

	Age: 18 - 24	Age: 25 - 34	Age: 35 - 44	Age: 45 - 54	Age: 55 - 64	Age: 65+	Annual Household Income: Less than $25,000	$25,000 - $49,999	$50,000 - $74,999	$75,000 - $99,999	$100,000	Educational Attainment: HS Diploma or Less	Some College or Associate Degree	Bachelor's Degree	Graduate Degree
App/Onboard				**	**	**		*					**	**	**
App/Text/Call	*					*	**	*					*		**
Bags	**		*			**				**	**		***	***	
Bikes	**		***		**					**	**		***	***	
Strollers			**								*				
Camera	***	***	***	***		***	**	***	**	***	***		***	***	***
Attendant	***	***	***	***		***	**	***	***	**	***	*	***	***	***
Ample				**	*				**		**		***	**	**
Face each other		**							*		**		**	**	**
Free wifi	***				***		**	*			***			**	**
Power outlets	**				**		**		***		**		*	**	
Respondents	39	57	32	37	25	24	28	36	34	26	61	6	41	104	61

	Lives in Downtown Minneapolis: Yes	Lives in Downtown Minneapolis: No	Home Zip Code: Minneapolis	Home Zip Code: St. Paul	Home Zip Code: Hennepin Suburb	Home Zip Code: Metro Area	Access to an Automobile: Always	Access to an Automobile: Sometimes	Access to an Automobile: Rarely	Uses the ABC Ramps: Yes	Uses the ABC Ramps: No	Why it is Difficult to Park in the ABC Ramps: Too Far	Too Expensive	Hard to Find Parking
App/Onboard		**	**				**	*			**			
App/Text/Call	***										*			
Bags	**	**		**			**			**	**		**	**
Bikes	**	***	**	**	*		**	**		**	**		**	**
Strollers					**					*			**	*
Camera	**	***	***	***	**	***	***	**		***	***	**	***	**
Attendant	**	***	***	***		***	***	**		***	***	**	***	***
Ample		***	**	**			***		*	**	**	*	*	
Face each other	*	**			**		**			**		**		
Free wifi	**	***	**	**			***		**	**	**	*		*
Power outlets		**	*	**			**			**	*	*		**
Respondents	42	171	102	45	10	5	170	24	10	112	106	11	35	20

- (dark green) regression coefficient >= 0.25
- (medium green) regression coefficient 0.15 - 0.249
- (light green) regression coefficient 0.10 - 0.149
- *** $p < 0.001$
- ** $p < 0.01$
- * $p < 0.05$

Figure 13: How Feature Bundles Were Shown to Survey Respondents

5.5.1 Camera Versus Attendant

Because security features were the primary deciding factor for choosing one bundle of features over another, we took a closer look at them. The two features were a camera in the autonomous vehicle or an attendant who would stay in the vehicle. For groups that valued security features over others, we looked at whether they chose the camera or the attendant. This was done by comparing the correlation coefficient of the features (disregarding coefficients that were not statistically significant). If the difference was less than 0.05, it was not counted. Table 15 shows which groups of respondents preferred the camera vs the attendant. When looking at all respondents, the regression coefficient was the same (coef. = 0.26) indicating that there was not a noticeable preference of one security feature over another.

There was a pronounced difference along gender lines, however. Female respondents preferred the attendant (coef. = 0.39 vs 0.29) while male respondents preferred the camera (coef. = 0.24 vs 0.17). Younger respondents (age 18 - 24) had a slight preference for the camera (coef. = 0.29 vs 0.22), while older respondents (age 65 and older) preferred the attendant (coef. = 0.35 vs 0.30).

While there was no clear preference in features among those who said they would be comfortable using the shuttle service, those who said they would be uncomfortable using the shuttle service preferred the attendant by a wide margin (coef. = 0.40 vs. 0.28). The same pattern showed for respondents who were uncomfortable sharing a car before the COVID-19 pandemic. They preferred the attendant (coef. = 0.48 vs. 0.31), while there was little difference for those were comfortable sharing a car before the pandemic.

Respondents who live in Downtown Minneapolis had a slight preference for the camera (coef. = 0.19 vs. 0.13), but security features were less of a deciding factor for that group – on par with storage space and free Wi-Fi. Respondents who lived outside Hennepin County greatly preferred the attendant over the camera (coef. = 0.83 vs. 0.65) and it was the only deciding factor when choosing feature bundles. However, there were only five respondents in this group, so it is not clear how significant this finding is. For those who use the ABC Ramps and find it hard to find parking there, an attendant was preferred (coef. = 0.33 vs 0.24). We can see that groups that are typically more apprehensive riding in autonomous vehicles preferred the attendant over the camera. Notably, female respondents, those who said they would be uncomfortable using the shuttle service, and those who were uncomfortable sharing a car with a stranger before the pandemic all preferred the attendant.

5.5.2 Comfort

Features under the comfort category related to seating: the option of ample seating vs limited seating and the option to sit facing other passengers vs facing forward. Comfort features played a small role in choosing feature bundles. For respondents aged 45 - 54, there was a slight preference for ample seating (coef. = 0.16). Respondents who live in a Hennepin County suburb preferred facing other passengers over facing forward (coef. = 0.22). Respondents who use the ABC Ramps but find it inconvenient because it’s too far preferred ample seating (coef. = 0.19) and facing other passengers (coef. = 0.20). Other than these three groups, the correlation coefficient for comfort features were no larger than 0.149.

5.5.3 Convenience

Features related to convenience were the payment options, the booking system, what kind of storage space was available, and what extras were in the shuttle. For payment options, survey respondents chose between paying for rides only on a phone app, or for having the additional option of paying on board. For the booking, respondents chose between only being able to book rides on a phone app or having the additional options of texting or calling a number to book a ride. The options for storage space include room for bags, bike, strollers, or no storage space. For extra features, respondents could choose free wi-fi, power outlets, or no extras.

Payment options were rarely a deciding factor for choosing a bundle of features. People aged 45 - 54 weighted payment systems a bit (coef. = 0.15), but it was less important than security features and ample seating. The same is true for respondents who have obtained graduate degrees (coef. = 0.10). A more flexible booking system for the shuttle service was also less desirable than other features. Those who live in Downtown Minneapolis weighted it heavily (coef. = 0.20), second only to more storage space. The booking system was a deciding factor for respondents with a household income less than $25,000 (coef. = 0.16), second only to security features. For payment options and the booking system, the baseline is app only. Because these two features were not a significant deciding factor in choosing feature bundles, we can ascertain that people are comfortable booking and paying for rides with only the app.

Another option for survey respondents was what kind of storage space they would want out of this shuttle service: bags, bikes, strollers, or none (baseline). These options are not significant deciding factors for the survey respondents as a whole. Certain groups, however, did weigh them more heavily. Respondents who are comfortable with taking transit preferred bike storage (coef. = 0.16). Bag storage was a priority for age groups 18 - 24 (coef. = 0.15) and 65+ (coef. = 0.18). Respondents with a household income of $75,000 to $99,999 also used bag storage as a deciding factor (coef. = 0.20) and were the only income group to prefer it. Respondents with bachelor's degrees were the only educational attainment group that preferred bag storage (coef. = 0.16). Bag storage was the greatest deciding factor for respondents who live in Downtown Minneapolis (coef. = 0.21). It was also important for those who live in St. Paul (coef. = 0.16). Bag storage (and convenience features in general) were favored by those who find parking in the ABC Ramps too expensive (coef. = 0.21) or too hard to find (coef. = 0.22). Bike storage was among the top deciding factors in selecting an option bundle for those who are comfortable taking transit (coef. = 0.16) - second only to security measures. Bike storage was also a priority for age groups 18 - 24 (coef. = 0.16), 35 - 44 (coef. = 0.30), and 55 - 64 (coef. = 0.21). In fact, for age groups 35 - 44 and 55 - 64, bike storage was among the top deciding factors in choosing a feature bundle. Bike storage was also a significant deciding factor in respondents whose household incomes were $75,000 - $90,000. Stroller space was only a deciding factor for a few groups and had a markedly low coefficient for most other groups. One reason for this might be because those traveling with children young enough to be in strollers will need a car seat to be shuttled around and that option was not offered. It could also be that people who are apprehensive about taking an autonomous vehicle around with their children.

Finally, the option bundles included some extras. Survey respondents could choose free wi-fi, power outlets, or none (baseline). Free wi-fi was among the most important features for respondents aged 18 - 24 (coef. = 0.24) and 55 - 64 (coef. = 0.30). To a lesser extent, free wi-fi was a deciding factor for respondents with household incomes less than $25,000 (coef. = 0.17) and $100,000+ (coef. = 0.19). Free wi-fi was also among the most important features for those who find the ABC Ramps inconvenient because they are too far away (coef. = 0.21) and because it's hard to find parking (coef. = 0.17). Power outlets were a much less important extra feature than free wi-fi as it had a lower coefficient for nearly every group that was studied. Nevertheless, power outlets had a somewhat significant influence on deciding on option bundles for respondents age 18 - 24 (coef. = 0.15) and 55 - 64 (coef. = 0.16) -- both groups that highly valued free wi-fi. Power outlets were also a deciding factor for respondents who think the ABC Ramps are inconvenient because they are too far away (coef. = 0.19).

Because survey respondents weighted security features so heavily, they should be the top priority during implementation. A camera will likely bring in users who are already comfortable with autonomous vehicles. More security measures such as a human attendant would be necessary for recruiting those who are more hesitant. Our study showed that survey respondents see the service more as an enhanced shuttle service rather than a ride-share so comfort features such as seat configuration and leg room will be less important to consider.

5.6 DISUCSSION

The COVID-19 pandemic dramatically reduced the number of users of the ABC Ramps and the users who were still using the ramps tended to be those who drive alone to work. This is likely the reason why the survey respondent pool was majority white and wealthy. A future study of the ABC Ramp users under more [normal] circumstances would likely yield different results. Particularly, future studies could gather data from minority groups that were not well represented in this study: non-white people, those who take transit, and those who do not have regular access to a vehicle.

The study found that safety features are by far the most important to potential users and so future studies should investigate this further. In addition to the camera and human attendant, studies can determine comfort level with other safety features such as a panic button or having all users be registered into a database. Future study on perceptions of safety related to AVs could explore other factors that affect perceptions of safety other than features of the vehicle (time of day, destination location, number of people in the car, etc).

CHAPTER 6: STATED PREFERENCE SURVEY—THE MINNESOTA STATE FAIR SAMPLE

6.1 BACKGROUND

On September 2nd, 2021, we participated in the University of Minnesota's Driven to Discover (D2D) program at the Minnesota State Fair. Specifically, we administered a simplified, shorter version of the Stated Preference Survey. The State Fair is held annually (with the exception of 2020 because of the COVID-19 pandemic) at the State Fairgrounds in Falcon Heights, Minnesota, a first ring suburb of St. Paul. We had two goals for conducting research at the state fair:

1. Survey a group of people from suburban, exurban, and rural areas. The State Fair draws attendees from around the state of Minnesota and often from neighboring states as well. SAV technology may serve different purposes for those living away from major urban centers.
2. Understand the preferences of older people toward shared automated vehicles. Elderly populations were underrepresented in our Twin Cities and Downtown Samples, likely because of our reliance on social media to virtually administer the surveys. Further, elderly populations may exhibit specific dependency on on-demand transportation options due to accessibility issues with traditional options. September 2nd 2021 – the day we opted to conduct our research at the Fair – was a Senior Day, where senior citizens received discount entry.

The D2D booth at the Fair (shown in Figure 14) featured between 5 and 6 other participatory-research throughout the day. We recruited participants by asking people who walked by or stopped to look at the booth if they were interested in "a 2-to-5 minute survey about how Minnesotans feel about driverless vehicles" with their pick of a University of Minnesota branded drawstring or tote bag as a prize. If interested, we would show them to our station inside the booth (Figure 15), where other team members were waiting with several IPads with Qualtrics surveys pre-loaded. If participants had questions, we guided them through the survey and clarified specific terminology.

Figure 14: D2D Booth at 2021 Minnesota State Fair

Figure 15: D2D SAVs Survey Participants

The version of the survey used at the Fair including the opening video used in earlier versions of the survey, followed by the same series of demographic questions with an additional question about participant disability status. Instead of locating home addresses on a map, participants instead were asked to enter their zip code. Then, participants completed five rounds of conjoint survey analysis, using the same exact setup as the two virtual surveys.

6.2 SUMMARY STATISTICS

Figure 16 shows a map of participant home zip codes, excluding the 16 located outside of Minnesota. Out of the 16 non-Minnesota zip codes, 6 lived in neighboring Wisconsin, 1 in neighboring Iowa, and the remaining 9 in states that do not border Minnesota, all west of the Mississippi river. Of the Minnesota residents who participated, most (201 out of 277) lived in the Twin Cities metro area. However, compared to the first survey, more participants lived in second and third ring suburbs. Specifically, some zip codes in the Anoka County suburbs featured over 5 participants.

Further, several participants lived in greater Minnesota, especially in Central and Southeast Minnesota. Specifically, there were about 10 participants who lived in the Brainerd area, a few others from the Mankato and a few from smaller cities in Southeast Minnesota like Rochester and Red Wing.

Table 18 shows demographic summary statistics for the State Fair sample. Our state fair sample was wealthier than the Twin Cities sample and Downtown samples, also enjoying more frequent auto access. Additionally, this sample was the most female sample out of the three. Surprisingly, despite their older average age (approximately 48) than our other two samples, respondents at the State Fair demonstrated higher baseline comfort with SAV technology, along with both current and pre-COVID vehicle-sharing. Additionally, the State Fair was substantially whiter than the other two samples, with about 82% of the sample (241 participants) identifying as White Nonhispanic. Most respondents reported living with spouses.

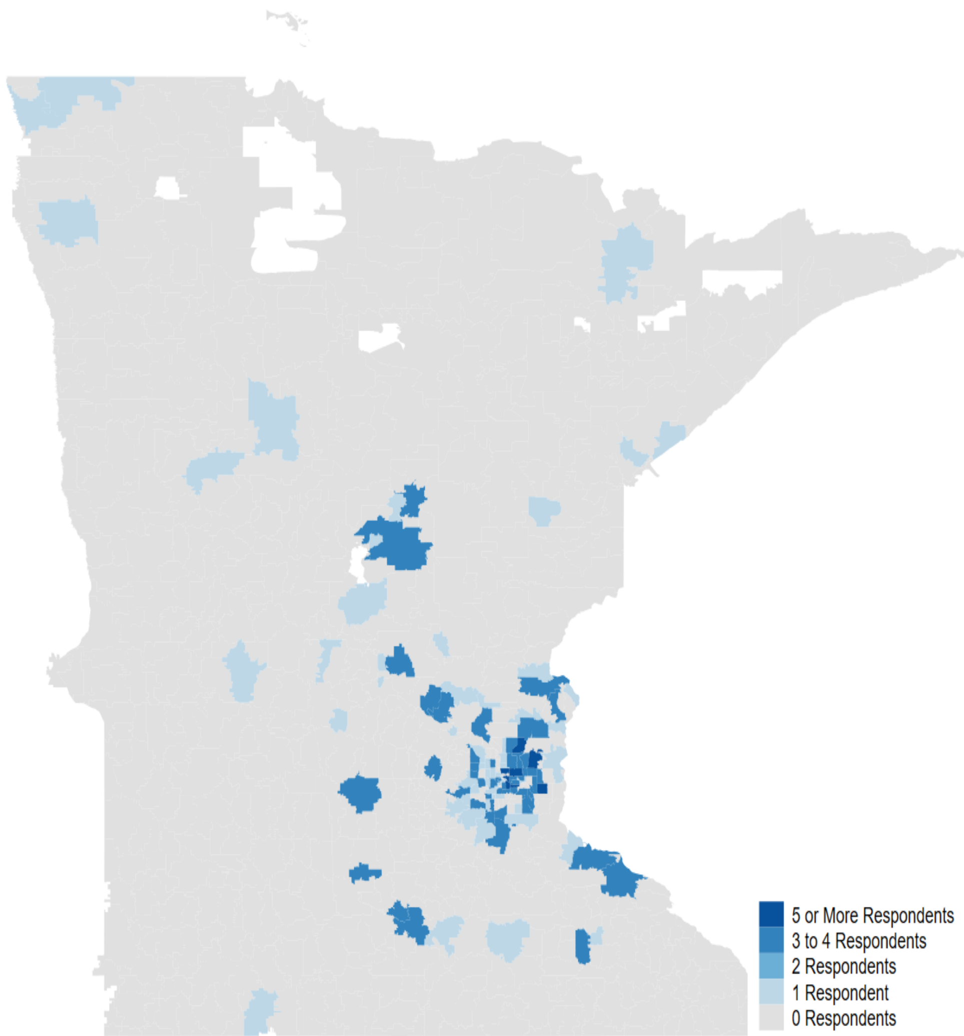

Figure 16: Map of State Fair Participants' Home Zip Codes

Table 18: Summary Statistics for State Fair Sample

Variable	Obs	Mean	N (Cat. Var)	St. D.	Min	Max
Income						
Less than $10,000	290	0.052	15	0.222	0	1
$10,000 - $24,999	290	0.086	25	0.281	0	1
$25,000 - $49,999	290	0.148	43	0.355	0	1
$50,000 - $75,999	290	0.179	52	0.384	0	1
$75,000 - $99,999	290	0.155	45	0.362	0	1
$100,000 or more	290	0.379	110	0.485	0	1
Health						
Poor	290	0.000	0	0.000	0	0
Fair	290	0.062	18	0.241	0	1
Good	290	0.376	109	0.484	0	1
Very good	290	0.348	101	0.477	0	1
Excellent	290	0.214	62	0.410	0	1
Automobile Access						
Rarely	290	0.038	11	0.191	0	1
Sometimes	290	0.062	18	0.241	0	1
Always	290	0.900	261	0.300	0	1
Gender						
Female	290	0.655	190	0.475	0	1
Male	290	0.328	95	0.469	0	1
Non-binary	290	0.003	1	0.059	0	1
Prefer not to say	290	0.014	4	0.117	0	1
SAV Comfort						
Very Uncomfortable	290	0.069	20	0.253	0	1
Somewhat Uncomfortable	290	0.152	44	0.359	0	1
Neutral	290	0.079	23	0.270	0	1
Somewhat Comfortable	290	0.424	123	0.494	0	1
Very Comfortable	290	0.276	80	0.447	0	1
Comfort with Vehicle Sharing (Now)						
Very Uncomfortable	290	0.093	27	0.291	0	1
Somewhat Uncomfortable	290	0.214	62	0.410	0	1
Neutral	290	0.169	49	0.375	0	1
Somewhat Comfortable	290	0.355	103	0.479	0	1
Very Comfortable	290	0.169	49	0.375	0	1
Comfort with Vehicle Sharing (Pre-COVID)						
Very Uncomfortable	290	0.041	12	0.199	0	1

Somewhat Uncomfortable	290	0.124	36	0.330	0	1
Neutral	290	0.138	40	0.345	0	1
Somewhat Comfortable	290	0.362	105	0.481	0	1
Very Comfortable	290	0.334	97	0.472	0	1
Table 18 (cont.)						
Race						
Black	293	0.017	5	0.130	0	1
Mixed Race/Other	293	0.041	12	0.198	0	1
Asian Pacific Islander	293	0.089	26	0.284	0	1
Hispanic	293	0.020	6	0.142	0	1
White-Nonhispanic	293	0.823	241	0.382	0	1
Prefer not to say	293	0.010	3	0.101	0	1
Cohabitation						
Live With Child	293	0.249	73	0.433	0	1
Live With No One	293	0.171	50	0.376	0	1
Live With Roommate/Other	293	0.157	46	0.364	0	1
Live With Spouse	293	0.423	124	0.494	0	1
Misc.						
Twin Cities Resident	293	0.689	202	0.463	0	1
Driver License	290	0.948	275.5	0.222	0	1
Age	267	47.933	---	17.595	18	80

6.3 ANALYSIS ON COMFORT USING SAV

First, we examine determinants of comfort using AV technology. Table 19 presents odds ratio estimates from a logit regression of the probability that some reports either feeling very or somewhat comfortable with riding the vehicle technology shown in the video. Participants with missing information were excluded from the sample for this regression, so the overall sample size is 249.

Overall, few coefficients were statistically significant. Specifically, women demonstrated 50% less comfort with SAV technology than men. People who lived with children under age 17 were over twice as likely to report comfort with SAV tech than those living just with a spouse or partner. Both findings were statistically significant at 90% confidence.

Additionally, general comfort with vehicle sharing was a highly significant predictor of comfort with SAV technology. Notably, those who reported comfort with sharing vehicles before the COVID-19 pandemic were about 3 times as likely to report comfort with riding SAV technology than those who were uncomfortable with general vehicle sharing prior to the pandemic. Current attitudes toward vehicle sharing also matter, with people currently comfortable sharing vehicles about 2.5 times as likely to report comfort with SAV technology than others.

Table 19: Determinants of SAV Comfort: State Fair Sample

Variable	Odds Ratio	Std. Err.	P>z
Gender			
Female	0.503*	0.182	0.058
Race			
Mixed Race / Other	0.747	0.657	0.740
Asian Pacific Islander	1.544	1.131	0.553
Hispanic	0.337	0.388	0.344
Income			
Mid ($50,000-99,999)	0.704	0.304	0.417
High ($100,000+)	1.086	0.474	0.850
Auto Access			
Sometimes	1.571	1.844	0.700
Always	0.306	0.429	0.398
Age Decade			
30s	0.462	0.312	0.254
40s	0.891	0.695	0.882
50s	0.441	0.311	0.245
60s	0.481	0.303	0.246
70s & 80s	0.315	0.247	0.140
Cohabitation			
Child Under 17	2.349*	0.190	0.056
No One	1.547	0.722	0.350
Roommate or Other	1.206	0.742	0.761
Misc.			
Driver License	4.850	6.790	0.259
Vehicle Sharing Comfort Now	2.466**	0.913	0.015
Vehicle Sharing Comfort Pre-COVID	3.088***	1.167	0.003
Foreign Born	0.946	0.582	0.928
Good Health	1.376	0.471	0.351
Twin Cities Metro	0.581	0.238	0.186
N		249	
Pseudo-R^2		0.183	

Notes: Odds ratios displayed. An asterisk is added if statistically significant at 90% confidence, two asterisks are added for coefficients that are significant at 95% confidence, and three asterisks for 99% confidence.

6.4 CONJOINT ANALYSIS ON PREFERENCES OF SAV FEATURES

Table 20 presents results of conjoint survey analysis, estimated using the same specification from Chapter 4. Overall, results reflect the results from conjoint survey analysis regressions included in both previous chapters. In the full sample, participants preferred more flexible payment and booking, and bag or bike storage space to no storage option. Strollers were preferred as well, but only by about 22% and at 90% confidence. Both security cameras and attendants were preferred to no security features, with an attendant being driving selection choices just slightly more than the camera option. As for seating, participants preferred ample seating and seating that faces forward, similar to previous survey samples. One slight difference with this sample is that power outlets were preferred only at 90% confidence, although there was still significant preference for free wi-fi.

Regarding preference heterogeneity by race, results here generally mirror those from the Twin Cities sample, as shown in Table 20. However, there are some differences. Black and Hispanic participants demonstrated higher preference for flexible payment than others, yet substantively lower preference for flexible booking. Further, they, along with other people of color, demonstrated higher preference for bike storage space than White Nonhispanic participants. While people of color generally exhibited slightly lower preference for security features than their white counterparts, Black and Hispanic participants specifically demonstrated higher preference.

In Columns 5 and 6 of Table 20, we compare preferences by gender. Because there was only one respondent who identified as nonbinary, we specifically compare male and female respondents. Men demonstrated higher preference for flexible payment, but not for flexible booking, compared to women. Additionally, men were about 2.24 times more likely to choose a collection when bike storage was present, while he odds ratio for women was only about 1.5. As with other samples, women care more about security features than men. However, men prefer ample sitting room more than women, and both equally prefer forward-facing sitting. Likely because of smaller sample sizes, fewer coefficients on extra features are significant when partitioning by gender, compared to the full sample.

Table 21 further splits up the sample by health status, income, and disability. Overall, this sample demonstrates less heterogeneity by these factors than the sample in Chapter 4. However, unhealthy participants prefer security attendants at slightly higher margins than others. Further, high income participants demonstrated higher preferences for bike space than others. Because disabled participants had a low sample size, not many coefficients were statistically significant. However, they did prefer flexible booking systems and security attendants substantially more than able-bodied participants.

Table 20: Conjoint Analysis of State Fair Survey - Demographics

VARIABLES	(1) Full Sample	(2) White	(3) People of Color	(4) Black and Hispanic	(5) Male	(6) Female
Payment Syst/O						
App/Onboard	1.589***	1.638***	1.415*	2.550**	1.814***	1.481***
	(0.127)	(0.146)	(0.283)	(1.183)	(0.268)	(0.143)
Booking Syst/O						
App/Onboard	1.265***	1.337***	0.975	0.515*	0.969	1.450***
	(0.100)	(0.115)	(0.200)	(0.201)	(0.138)	(0.137)
Storage Space						
Bags	1.407***	1.355**	1.672*	1.576	1.528**	1.378**
	(0.165)	(0.177)	(0.445)	(0.722)	(0.312)	(0.201)
Bikes	1.750***	1.595***	2.879***	4.084***	2.244***	1.491***
	(0.206)	(0.208)	(0.797)	(2.070)	(0.505)	(0.212)
Strollers	1.224*	1.143	1.710**	1.586	1.395*	1.149
	(0.136)	(0.143)	(0.396)	(0.827)	(0.244)	(0.169)
Security Measures						
Camera	2.358***	2.439***	2.106***	3.199**	1.886***	2.712***
	(0.220)	(0.255)	(0.433)	(1.451)	(0.343)	(0.298)
Attendant	2.792***	2.991***	2.069***	4.763***	2.662***	2.992***
	(0.293)	(0.336)	(0.572)	(2.796)	(0.514)	(0.374)
Sitting Room						
Ample	1.625***	1.612***	1.782***	1.498	2.059***	1.475***
	(0.132)	(0.141)	(0.396)	(0.569)	(0.274)	(0.153)
Seating						
Face Each Other	0.592***	0.601***	0.551***	0.687	0.554***	0.586***
	(0.0500)	(0.0570)	(0.104)	(0.301)	(0.0846)	(0.0622)
Extras						
Power Outlets	1.204*	1.173	1.318	1.142	1.305	1.183
	(0.119)	(0.130)	(0.285)	(0.653)	(0.222)	(0.148)
Wifi	1.385***	1.342**	1.485	0.989	1.216	1.509***
	(0.150)	(0.161)	(0.370)	(0.456)	(0.223)	(0.208)
Constant	0.243***	0.238***	0.256***	0.221***	0.243***	0.236***
	(0.0337)	(0.0366)	(0.0853)	(0.112)	(0.0560)	(0.0412)
Observations	2,900	2,410	490	110	950	1,900
Pseudo-R2	0.0714	0.0737	0.0750	0.139	0.0861	0.0737

Standard errors clustered at participant level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 21: Conjoint Analysis of State Fair Survey – Health, Income, and Disability

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	Unhealthy	Healthy	Low Income	Mid Income	High Income	No Disability	Disability
Payment System							
App/Onboard	1.598***	1.588***	1.631***	1.576***	1.584***	1.594***	1.469
	(0.192)	(0.172)	(0.251)	(0.202)	(0.223)	(0.135)	(0.408)
Booking System							
App/Onboard	1.349**	1.204*	1.741***	1.034	1.211	1.227**	2.182**
	(0.164)	(0.127)	(0.260)	(0.148)	(0.152)	(0.0988)	(0.713)
Storage Space							
Bags	1.469**	1.363**	0.805	1.918***	1.692**	1.419***	1.222
	(0.270)	(0.209)	(0.158)	(0.396)	(0.349)	(0.173)	(0.571)
Bikes	1.525**	1.957***	1.068	1.993***	2.281***	1.772***	1.358
	(0.288)	(0.292)	(0.229)	(0.405)	(0.445)	(0.218)	(0.539)
Strollers	1.309*	1.173	0.803	1.515**	1.440**	1.244*	0.862
	(0.214)	(0.177)	(0.169)	(0.296)	(0.261)	(0.142)	(0.373)
Security Measures							
Camera	2.296***	2.415***	2.390***	2.728***	2.158***	2.404***	1.962**
	(0.338)	(0.292)	(0.402)	(0.483)	(0.323)	(0.236)	(0.644)
Attendant	3.140***	2.543***	2.243***	3.827***	2.712***	2.774***	3.773***
	(0.482)	(0.363)	(0.435)	(0.766)	(0.451)	(0.299)	(1.646)
Sitting Room							
Ample	1.581***	1.683***	1.518**	1.404**	1.955***	1.664***	1.169
	(0.191)	(0.188)	(0.247)	(0.200)	(0.241)	(0.143)	(0.304)
Seating							
Face Each Other	0.635***	0.562***	0.657***	0.518***	0.625***	0.575***	0.893
	(0.0808)	(0.0631)	(0.0973)	(0.0819)	(0.0863)	(0.0512)	(0.240)
Extras							
Power Outlets	1.008	1.381**	0.989	1.440**	1.192	1.234**	0.881
	(0.157)	(0.177)	(0.192)	(0.228)	(0.197)	(0.127)	(0.310)
Wifi	1.163	1.573***	1.288	1.341*	1.487**	1.422***	0.872
	(0.188)	(0.231)	(0.254)	(0.239)	(0.282)	(0.160)	(0.368)
Constant	0.249***	0.236***	0.339***	0.209***	0.196***	0.240***	0.284**
	(0.0521)	(0.0442)	(0.0919)	(0.0505)	(0.0454)	(0.0347)	(0.152)
Observations	1,270	1,630	830	970	1,100	2,690	210
Pseudo-R2	0.0708	0.0763	0.0659	0.0906	0.0811	0.0733	0.0780

Standard errors clustered at participant level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

6.5 DISCUSSION

Participants in the state fair sample were more comfortable with SAV technology in general, but also more comfortable with baseline vehicle sharing. Gender gaps in overall comfort with SAV comfort and in conjoint preferences were still present.

Notably, the sample here may differ for another reason besides geography. Because the 2021 Minnesota State Fair occurred in the midst of the COVID-19 pandemic and was a large public gathering, people in the State Fair sample may have been less COVID-risk-averse than participants in the first two surveys, which were administered remotely and away from large crowds. This could also explain the overall higher rate of comfort with sharing vehicles, including SAVs. It could also explain some of the differences in conjoint preferences, if overall vehicle sharing comfort is correlated with specific feature priorities.

CHAPTER 7: CONCLUSIONS AND DISCUSSION

As a whole, this study provides detailed information on how SAV systems could provide transportation equity solutions, emphasizing the connection between equity concerns and an eventual public rollout. By using the Twin Cities metro area as a primary study area and expanding our scope by conducting research at the Minnesota State Fair, we were able to obtain rich qualitative data from local transportation policy entities, while gathering quantitative data on public attitudes and preferences from three originally designed survey instruments.

There are a few weaknesses to the overall study. First, because the three stated preference surveys were finalized and administered at different times, they slightly differ. For example, for the Twin Cities and Downtown surveys, we did not ask about respondent disability status, instead operating under the assumption that hypothetical SAV system technology would receive public funding and thus would need to comply with the Americans with Disabilities Act. However, upon further consideration, we opted to include a question about participant disability status to the final survey we administered on the State Fair sample. Specifically, we wanted to see how conjoint survey preferences may have differed by disability status, something the absence of a disability question in the first two surveys forced us to omit from prior analysis.

Another shortcoming of this report is its inability to obtain rich quantitative data on concerns about worker displacement and workforce changes voiced by practitioners at Metro Transit. Our stated preference surveys intended to supplement the qualitative data sourced from practitioners with detailed quantitative data on consumer attitudes and preferences, and as a result were not intended nor equipped to discuss workforce shifts due to automation. However, this topic is still important and could change the lives of a particular group of people: current transit operators and other employees who work in the public transportation sector. This is one opening for future research. What concerns do transit workers have regarding the possibility of SAV technology gaining prominence?

Notably, the entire data-gathering process took place during the COVID-19 pandemic. Peoples' self-reported travel behavior in the first two surveys may differ from their pre-COVID transportation practices. However, we attempted to account for this explicitly in the survey, asking about vehicle sharing comfort both in the status quo and prior to the pandemic. As such, our findings may not necessarily be generalizable to a future in which COVID-19 is eradicated. However, as the pandemic approaches endemicity, these findings may have lasting validity (at least for the Twin Cities metro area).

Despite these weaknesses, the study provides rich information into how people of different backgrounds and socioeconomic status view Shared Automated Vehicle technology, as well as how practitioners envision its integration into existing transit systems and networks. There are a few important takeaways.

First, we identified the currently existing transportation issues that an SAV system could ameliorate in the Twin Cities. The Twin Cities Stated Preference Survey and the Downtown Stated Preference Survey asked participants about transportation barriers or “hassles” that SAV could help resolve. Notably, people who experienced more transportation hassles demonstrated higher willingness to pay for an SAV ride as well as slightly higher comfort with SAV technology. This finding implies that SAVs could serve as a primary transportation mode, supplanting other modes when trips are particularly difficult. There are racial and economic equity components to these findings as well. Black and Hispanic participants were more likely to report trip hassles yet also exhibited stronger willingness to use SAV technology. For people using the ABC Ramps, parking availability and cost were cited as factors that led people to make fewer trips to and from the ramp. This finding suggests the additional utility of an SAV shuttle service that focuses on first-and-last-mile solutions, connecting people to mobility hubs such as the ABC Ramps.

Second, we identified possible design-based features of SAV systems that could affect ultimate public adoption of a service. The novel use of conjoint survey analysis in all three stated preference surveys can help provide practitioners with guidance on how to roll out and ensure public support and use of SAV systems. All three surveys emphasized the importance of security services onboard the shared vehicles. The importance of security options differed by gender, race, and socioeconomic status. Further, we learned that SAV systems must have some degree of payment and booking flexibility that ensures people without smartphone access can use the system, a concern of the City of Minneapolis. These priorities also exist for populations outside of the core urban area, an additional consideration for policymakers examining how SAVs might be adopted statewide.

Finally, our findings provide new detailed insight into an increasingly discussed aspect of SAV equity: gender. All three of our stated preference survey instruments found notable and statistically significant gaps in self-reported comfort riding SAVs between men and women. Although gender considerations were not mentioned by any of the public agencies we interviewed, they clearly should shape the policy details of an SAV system rollout and the specific features offered in such a system. Women overall are less comfortable with SAV technology and prefer more flexibility in booking and payment systems as well as stronger security features. This recalls evidence that women’s safety risks on public transportation affects transportation behavior and implies that SAVs will only contribute to this same problem unless public agencies take further steps to ensure safety and flexibility.

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