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Advancing Equity and Congestion Relief: An Investigation of On-Demand Shared Rides for Underserved Populations

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16. Abstract

Transportation network companies (TNCs) and microtransit are changing the way people travel by providing dynamic, on-demand mobility that can supplement public transit and personal vehicle use. However, heavy use of such motorized vehicles among all sociodemographic populations could contribute to increased vehicle miles traveled, congestion, and/or greenhouse gas emissions. To balance the objectives of increasing mobility and access for underserved communities while simultaneously mitigating the potential adverse impacts of increased motor vehicle use, well-designed policy strategies, such as pooling and first-mile/last-mile linkages, are needed. In this study, we applied a mixed-method approach to examine on-demand transportation services for underserved populations with a focus on shared-ride services. We conducted a series of interviews and a literature review, identifying individual narratives and lived experiences that put flesh into the quantitative analysis. Specifically, we administered a national online mobility survey and conducted analyses to uncover current shared mobility user patterns and possible relationships to transportation equity. The results of this study aim to provide a better understanding of the likelihood of certain sociodemographic populations using on-demand transportation services (particularly shared mobilities), the factors contributing to user behavior, and the potential strategies maximizing equitable access and mobility offered through these services while mitigating potential adverse impacts.

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Executive Summary

Emerging mobility options are causing major disruptions in transportation, with the popularity of on-demand transportation services such as transportation network companies (TNCs) and microtransit skyrocketing during the last several years. These services can be flexible and convenient for users, but if they are to have any future in a sustainable world, consumers must abandon single-occupancy vehicle use in favor of shared rides. While these services do offer increased access to vehicles, particularly for marginalized groups without personal vehicle ownership, equal access is not universal, with racial and gender minorities, low-income households, and individuals with disabilities, among others, at risk of being left behind. Since these services are not equally available to everyone, they may exacerbate rather than alleviate, as initially hoped, much of the current inequity in the transportation system of the United States.

This report is part of a larger study focused on on-demand transportation, with a particular emphasis on shared-ride services. The first phase of the study centered on improving pooling rates across all on-demand services in order to mitigate some of the environmental, economic, and traffic concerns related to those services. This phase of the study was concerned with identifying differences in usage of on-demand and shared-ride mobility options across different sociodemographic groups, classifying populations as possibly marginalized or underserved, pinpointing the causes of these differences, and establishing a framework to address these differences through policies aimed at reducing inequity.

A two-pronged approach was employed to address these questions, beginning with shared mobility interviews. A total of 35 semi-structured, individual interviews were conducted to gather long-form, holistic, and in-depth descriptions of the transportation experiences of individuals. Most interviewees were low-income, had a disability, and tended to be from older age brackets, with the average age being 52; women and ethnic minorities were also overrepresented. These were all potentially marginalized groups, so focusing on their stories provided valuable insight to this study. Surprisingly, minority respondents universally indicated their identity was not a factor in their behavior regarding on-demand and shared-ride services, with most of the interesting results related to affordability and accessibility. Lack of car ownership proved to be a large source of burden for participants, with disabilities and low-income being linked with lower rates of ownership. Rural residents reported lacking low-cost transportation modes that were feasible for their needs, such as transit, biking, and walking, and were often reliant on rides from friends and family. Those with low income or disabilities were unlikely to be frequent TNC users, citing cost and accessibility as issues, particularly for those who needed wheelchair-accessible vehicles. Many interviewees with disabilities who did use TNCs, however, did report satisfaction.

The preliminary results from the interviews guided the formation of the shared mobility survey that served as the second prong of our analysis. An online survey, similar to that used in Phase 1 of this study but enriched and expanded to a national scale, was administered between February and April 2023. Quotas were established to ensure sufficient sample sizes for potentially underserved groups (gender and racial minorities, older adults, people with low incomes, and people with disabilities) were oversampled. A final, usable sample of 2,950 participants was used in this study.

The findings provided various insights. Younger respondents were much more likely to have access to new mobility services compared to older participants, owing to the certain degree of tech savviness

required to use many of them. Likewise, those in the highest income brackets had greater access to these modes, while cost may present a possible barrier for people with low income. There were no significant or consistent differences in access across gender or race, and people with disabilities were more likely to indicate access to on-demand transit (such as microtransit) usually because they were much more aware of alternative transportation modes. Affordability factors were not nearly as large a concern as access factors, and there were no statistically significant differences in participants saying the cost was too high for any of the variables of interest. With respect to safety, perception, and use behavior, women and younger users expressed a higher inclination to avoid interacting with strangers. Females and people with disabilities were also much more aware of and concerned by safety issues associated with pooled services. Race was the personal identity that caused the most concern for respondents, with Native American and, to a lesser extent, Asian and Black participants saying they were worried about hostility from drivers or other passengers.

The primary concerns about pooled services were related to convenience and access rather than affordability. Unreliable travel times, unsafe drop-off locations, and inadequate infrastructure were major sources of complaint. Efforts to curb these effects, such as guaranteed time windows, were popular across the board. Those with disabilities wanted designated boarding zones and options to request help from drivers and fellow passengers. Asians consistently showed more favorable responses to cost-reducing policies; however, they were also the population groups that indicated having the most access, which raises questions about the efficacy of cost-related policies in reducing overall inequity. Service providers should focus on effectively communicating the viability of their services to low-income and marginalized travelers, while also assessing the unique barriers for different groups and exploring alternative strategies to encourage greater adoption among these populations. Females consistently were more likely to agree with policies to improve safety, such as video surveillance, preferences for selecting the gender of other passengers, and pooling from a known network of friends, family, coworkers, and so on.

The car-centric transportation system in the United States has contributed to transportation inequity, often resulting in adverse economic, health, and social outcomes for the most vulnerable members of society. New shared mobility options provide an opportunity to fix some of that inequity, but only through careful policy consideration and planning. Left unregulated, these industries may only worsen the existing problems. By making laws with equity in mind, we can ensure that all can equally share in the benefits of new technologies.

Chapter 1. Introduction

Shared mobility offers an exciting vision for an efficient, car-lite future, which many cities are beginning to incorporate into their sustainable transportation initiatives. As shared mobility options proliferate and gain popularity, the need to assess their use among all members of a local population grows.

Background

To harness the potential of shared mobility for reducing single-occupancy vehicles, services must be accessible, affordable, and perceived as safe by the public. Access, affordability, and perceived safety are essential traits for widespread adoption, but the criteria for fulfillment vary according to physical ability and socioeconomic and geographic factors. Therefore, these traits were used in this study to assess the ability of shared mobility solutions to adequately serve transportation-disadvantaged populations and improve transportation equity.

In New York City, transportation network companies (TNCs) have added an estimated 600 million miles of vehicular travel from 2014 to 2017, adding 51 million new vehicular passengers (Schaller, 2017). In this densest U.S. city, pooled rides still accounted for only 20 percent of Uber and 40 percent of Lyft rides. Nationally, only 14 cities have pooled TNC rides available, meaning most of the country has access to only private rides (Shaheen & Cohen, 2019). The composition of TNC ridership is up for debate, but consensus exists that lower age levels, higher education levels, higher income levels, and dense urban area residencies are all associated with higher TNC use (Dias et al., 2017; Hyun et al., 2021; Sabouri et al., 2017). However, mixed results persist regarding the association between race or ethnicity and trip use (Hyun et al., 2021; Lazarus et al., 2021).

The high cost of a single ride is the main barrier for low-income and transit-dependent users, while profit incentives may mean uneven and unequal distribution of rides throughout a city (Phun & Chalermpong, 2019), potentially favoring wealthier and Whiter areas (Jiao & Wang, 2021; Yang et al., 2021). Rider-to-rider discrimination (Moody et al., 2019) and driver-to-rider discrimination have both been established (Ge et al., 2016), highlighting the possibility of interpersonally mediated discrimination. The willingness to share a ride is higher in densely populated neighborhoods (Brown, 2019) and among low-income travelers (Fulton, 2020). This latter increased willingness may be explained by the lack of transportation options, geographic isolation from economic and transportation hubs, and/or depressed economic mobility (Shaheen et al., 2017). One in twenty U.S. households is unbanked (Shaheen et al., 2017), which needs to be accommodated by new mobility services.

The impact of a person's disability on TNC use varies depending on the type and level of debility. Disability is also systemically linked with poverty; more than half of working-age adults living in long-term poverty are disabled (National Council on Disability, 2017). Although disability paratransit services are available in most urban areas, their use policies include strict eligibility and documentation requirements. The limited access to these services—based on geography or use policy—means that people with disabilities can experience extremely restricted mobility, especially in rural areas (Rodier et al., 2022). Connecting poorer, older, disabled rural areas with shared mobility could increase options and improve economic opportunity (Rodier & Podolsky, 2017).

The Current Study in Context

This study defined transportation equity as the ability for all people to travel easily throughout their region, without undue time, cost, physical, or other burdens. Those who cannot travel easily for their daily needs (shopping, work, school, etc.) without any of the aforementioned burdens were considered to be underserved or transportation-disadvantaged populations. This investigation focused on local travel rather than long-distance travel. Intraurban spatial dynamics are affected by geographic, economic, and historical factors. These complex factors make disaggregated assessments key to understanding whether shared mobility services serve and improve transportation for underserved populations. This study aims to contribute to this growing need through an assessment of current transportation challenges experienced by underserved populations, responsive shared mobility solutions, and necessary modifications to these solutions to meet travel needs.

This study is part of a larger project focused on consumer attitudes and behaviors regarding on-demand services, with a particular focus on pooled options. This phase of the study (Phase 2) built on the Phase 1 study (Sener et al., 2023a; 2023b) results by combining qualitative and quantitative methods. Specifically, Phase 2 includes a literature review of shared mobility and equity, a series of individual interviews, and a national survey investigating the use and attitude patterns of on-demand and shared mobility. An understanding of shared mobility decision-making remains inconclusive, partly due to a lack of context for large dataset findings. Qualitative data from interviews were used, along with the Phase 1 findings (Sener et al., 2023a; 2023b), to inform the Phase 2 survey design and priorities, with the goal of holistically capturing transportation considerations.

Shared mobility solutions explored in this study primarily included microtransit and pooled TNC rides. Shared mobility using automated vehicles (AVs) was also considered to capture differences in perception and readiness to adopt AVs. Our populations of interest included individuals or groups who experienced established transportation inequity and who fell within protected categories based on age, gender, race, income, or disability.

We acknowledge that the study groups are overlapping and nonexclusive and that people belonging to multiple marginalized groups experience intersecting forms of inequities. In a transportation context, systematic challenges and disadvantages compound, creating inequitable transportation. In addition, we used the legal definition of disability that categorizes deafness, compromised hearing, and autism as disabilities, although many people with these diagnoses do not consider themselves disabled. The study otherwise segmented the disability category to fully reflect the wide range of sometimes conflicting needs and challenges for people with travel-related disabilities.

The remainder of this report includes three additional chapters. Chapter 2 focuses on exploring the shared mobility interviews through the lens of equity. It offers a concise overview of the methods employed for conducting these interviews and sheds light on the discussion of the findings derived from the interview process. Chapter 3 centers around the shared mobility survey, which was implemented online and encompassed a nationwide scope with a particular emphasis on transportation equity. The chapter delves into the design and execution of the survey, highlighting how the equity lens was integrated into its formulation. It further presents and analyzes the key findings obtained from the survey, offering valuable insights into shared mobility from a more inclusive and equitable perspective. Finally, Chapter 4 provides a summary followed by concluding remarks on the overall study and its contribution to advancing the understanding of equitable shared mobility practices.

Chapter 2. Shared Mobility Interviews through an Equity Lens

In this chapter, we provide a concise overview of our methodology, key findings, and a discussion of shared mobility interview results, focusing on transportation equity.

❖ A detailed description of the interview methodology and further discussion of the findings is forthcoming and will be available in the research paper titled '*Necessary and Prohibitive: A Qualitative Study on Shared Mobility and Transportation Equity*', by Cabay and Sener (2024).

Interview Methods and Data

A series of semi-structured, individual interviews were conducted to shed light on the lived experiences and practical considerations related to transportation, particularly given the sharp rise in gas prices in 2022 and the matured pandemic environment without government distancing guidelines. The qualitative interview methodology was chosen for its strengths in gathering in-context information, allowing for long-form, holistic descriptions of transportation experiences and shedding light on individual experiences.

The interviews were also conducted with the intention of informing the Phase 2 survey design and priorities, as described in Chapter 3. Approval from the Institutional Review Board (IRB) of the Texas A&M University Human Subjects Protection Program was received prior to any data collection.

The interview methodology employed is an extension of the preceding online survey, building upon the voluntary engagement of individuals who expressed interest in participating in follow-up interviews during the second phase of the study. The research team initiated contact with these "willing" participants, confirming their consent to participate in the interviews and subsequently scheduling interviews for those eligible for the study. Our efforts in participant selection were geared toward populations affected by established transportation disadvantages, with a primary focus on seniors, individuals with low income, people with disabilities, and individuals from diverse racial and ethnic backgrounds. We also worked on geographical representation and sought out interviewees from different regions on the urban-rural spectrum.

A total of 35 interviews were conducted. Most interviewees had at least one legally defined disability (65 percent) and were living at or below the federal poverty level (60 percent). Participant ages ranged from 20 to 88 with an average age of 52. In addition, around 40 percent of interviewees were from minority ethnic groups including Asian, Black or African American, and Hispanic, and around 60 percent identified as women. Interviews were conducted by either video or phone calls, lasted 35 to 60 minutes, and followed a semi-structured format. After conducting the interviews, a data-driven thematic analysis was performed to uncover the most common themes and explore findings.

Interview Findings and Discussion

Interviews were conducted to explore the individual experiences and intentions regarding the use of private and pooled TNC rides, as well as microtransit, among people with low incomes, minority races or ethnicities, and people with disabilities. Surprisingly, interviews with minority participants universally

indicated that their identity had not influenced their decisions to use pooled or private TNC rides. As a result, the discussion below will particularly focus on individuals with low incomes and people with disabilities.

Although most participants cited transportation challenges, those who were most inhibited and burdened by transportation typically did not drive or own a car. While some drivers experienced financial burdens related to car ownership, the majority reported few routine challenges. Notably, these findings were not independent of disability and income status. People with disabilities and individuals with low incomes were less likely to drive or own a car, and even among drivers in these groups, the cost of car ownership often imposed significant financial burdens, limiting their mobility due to maintenance, insurance, or gas costs.

People with disabilities residing in rural areas experienced the most restrictive transportation challenges. Low- or no-cost transportation modes, such as transit, biking, and walking, were unavailable. As a result, if individuals did not drive or could not afford a car, their primary means of transportation relied on rides from friends and family. The intersections of marginalization compound the burdens on these individuals, as rural areas and their residents, along with low-income and high racial and ethnic minority neighborhoods in urban areas, often face limited transportation options.

Interview results indicated that while TNC users were generally satisfied with the services, their overall willingness to use pooled TNCs was low. Low-income riders were most willing to use pooled TNCs unless they were at higher risk of COVID-19 infection as a senior or disabled person.

People with low incomes or disabilities were unlikely to be frequent TNC users due to significant cost or ability barriers. Many interviewees in these categories reported experiencing pronounced isolation due to a lack of transportation options. Microtransit offers a low-emission, affordable, and accessible transportation alternative for people with disabilities. Professionals and working people are time-conscious, while people with disabilities are cautious of their health and seek avenues for independence.

Interviewees with disabilities who did use TNC rides reported enjoying the rides and finding them useful and reliable. However, for wheelchair and power chair users, the unavailability of wheelchair-accessible vehicles (WAVs) made the service unreliable. They were the only group to express concerns about the reliability of TNC rides. Currently, some TNC companies offer WAVs, but the service is limited to specific geographies and available for only a few hours a day, while other companies do not offer WAV services at all.

Existing research on shared mobility has provided insufficient or inconclusive information on the willingness of marginalized populations to use pooled TNCs and microtransit. Study samples often represent higher income and Whiter samples than their study area (Brown et al., 2021; Rayle et al., 2016; Xing et al., 2022). TNC users can be divided into two groups; one group uses TNCs predominantly by choice for leisure and travel, while the other group relies on them for commuting or medical transit when public transportation is inaccessible, unavailable, or unreliable. During the COVID-19 pandemic, transit agencies were under duress, experiencing slashed ridership, lowered budgets, and increased operating costs. These agency challenges left the second group of riders more transportation-insecure than before.

Policy efforts to improve the accessibility, comfort, and reliability of public transportation will ensure that large segments of the population have access to reliable transportation, and current transportation-burdened households may be able to reduce their costs by leaving their car at home (Degood & Schwartz, 2016). With the passing of the Inflation Reduction Act in 2022 (GovTrack.us, 2023) and big policy changes in several states across the nation, electrification of the nation's vehicle fleet will likely occur in the next decades. However, providing alternatives to personal vehicle ownership is more sustainable and less expensive for households and consumers. Car ownership is too often the necessary key to unlocking economic opportunity, especially in highly segregated cities and rural areas. Car dependency reduces independent mobility for people with disabilities. It would be important to support and fund cleaner, shared transportation options.

An electrified fleet of shared transportation—both TNCs and microtransit services—is a potential bridge to sustainable and accessible transportation. During the development of such a fleet, policies to change disparities and inequities in the transportation landscape are required. Racial and ethnic minorities, particularly Black and Indigenous communities, have been historically distanced from the centers of economic prosperity. Reducing minority and disabled poverty rests, in part, on access to economic opportunities and healthcare, as well as friends, places of worship, and leisure.

Chapter 3. Shared Mobility Survey through an Equity Lens

Combining the qualitative data from shared mobility equity interviews and the Phase 1 findings, we designed and administered a nationwide shared mobility survey as part of this Phase 2 study. In this chapter, we provide a concise overview of our methodology, key, context-relevant findings, and the discussion of shared mobility survey results, focusing on transportation equity. For a comprehensive description of the data collection methods, please see Sener et al. (2023a; 2023b). Additional details relating to the Phase 2 survey results and discussions encompassing various perspectives on on-demand transportation and shared mobility will also be made available in separate manuscripts by the authors.

Survey Design and Administration

The Phase 2 survey was an expanded version of the survey administered previously by Sener et al. (2023a; 2023b). The most recent survey included the entire United States, while the previous survey was limited to 10 Texas cities where on-demand services (TNCs, taxis, and microtransit) were in use. A soft launch of the survey was initiated in February 2023. Following a review of the survey data from the soft launch, a full launch was initiated in late February 2023, with data collection ending in mid-April 2023.

Quotas were established to ensure that the sample contained enough members of marginalized communities. In Phase 1 of this project, small sample sizes for select groups precluded the valid use of some data analysis methods. Phase 2 focused on obtaining quality information regarding the attitudes, use, and preferences of select underserved populations with respect to transportation. Thus, we oversampled minorities of interest to guarantee sufficient sample sizes for analysis.

Table 1 compares the percentages in the survey sample, target survey quota, and U.S. population for each of the demographic variables considered during sampling. Data from the 2020 U.S. Census served as a benchmark for comparison.

Oversampling populations of interest is a key part of complex survey design. Researchers in the health and social sciences are increasingly using complex survey data instead of more straightforward data due to the advantages of measuring expensive variables or reaching hard-to-reach members of the population who might be left out of simple random surveys (Lumley, 2010). While the sampling methods used in this study led to a sample that was quite different from the U.S. population across certain variables, these methods are not new or unusual. The U.S. National Center for Health Statistics (NCHS) uses similar methods in its National Health and Nutrition Examination Survey (NHANES) and National Health Interview Survey (NHIS). The desire to address the needs of marginalized groups—a core goal of this research—required the use of oversampling techniques.

Table 1. Comparison of the Survey Sample, Target Survey Quota, and U.S. Population

Demographic Variables Used for Survey Quotas		Analytical Sample (N=2,950)	Target Survey Quota	U.S. Population
Age	18–34	27.5%	25.0%	29.2%
	35–54	33.7%	22.0%	24.6%
	55–64	14.5%	23.0%	24.7%
	65 or over	24.3%	30.0%	21.6%
Gender	Male	47.9%	47.5%	49.5%
	Female	51.5%	47.5%	50.5%
	Nonbinary/third gender	0.5%	5.0%	N/A
	Prefer not to say	0.2%	N/A	N/A
Race	Asian	13.8%	12.0%	6.2%
	Black or African American	26.7%	24.0%	12.4%
	Indigenous American or Alaska Native	6.1%	5.0%	1.1%
	Other (Mixed Race, Native Hawaiian, Other)	25.4%	37.0%	18.7%
	White	28.1%	22.0%	61.6%
Ethnicity	Hispanic, Latin, or Spanish Origin	36.5%	37.0%	18.7%
	Not Hispanic, Latin, or Spanish Origin	63.5%	63.0%	81.3%
Living Type	Rural	17.0%	20.0%	14.0%
	Suburban	41.8%	40.0%	55.0%
	Urban	38.7%	40.0%	31.0%
	Not Sure	2.5%	N/A	N/A
Disability	Some sort of disability	41.9%	30.0%	12.0%
	No disabilities	58.1%	70.0%	88.0%
Specific Disability	Hearing (Deaf or hard of hearing)	10.4%	4.0%	3.5%
	Vision (Blind or serious difficulty seeing, need to travel with a service animal, a disability affecting the ability to get driver's license)	17.1%	6.0%	2.4%
	Ambulatory (Serious difficulty walking or climbing stairs, limited number of active hours due to pain)	29.2%	12.0%	6.3%
	Cognitive (disability that affects ability to travel alone, serious difficulty communicating with strangers or navigating unfamiliar environments)	19.7%	10.5%	5.1%
Household Income	Less than $25,000	24.7%	30.0%	17.4%
	$25,000 to $49,999	25.9%	25.0%	18.7%
	$50,000 to $99,999	26.2%	25.0%	28.1%
	$100,000 or more	20.3%	20.0%	35.8%
	Prefer not to answer	2.9%	N/A	N/A

Demographic Variables Used for Survey Quotas		Analytical Sample (N=2,950)	Target Survey Quota	U.S. Population
Region	West (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming)	23.8%	24.0%	23.7%
	Midwest (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin)	18.6%	21.0%	20.8%
	South (Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia)	40.1%	38.0%	38.0%
	Northeast (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont)	17.5%	17.0%	17.4%

The oldest and youngest age groups were slightly overrepresented and underrepresented, respectively, compared to the U.S. population. The largest discrepancies, however, were among members of the middle two age groups (35–54 and 55–64). Individuals aged 65 or over were oversampled by a factor of 1.5. Senior citizens tend to have higher accessibility needs, different travel patterns, and lower incomes than their younger counterparts. They face unique transportation challenges that should be addressed. Additionally, many of the emerging on-demand transportation services require the use of technology such as smartphone apps; older users may see technology as a barrier to transportation in contrast to younger users (Bayne et al., 2021).

Female participants were slightly overrepresented compared to male participants. While the U.S. Census Bureau does not include any data on nonbinary or other third-gender Americans, a study from the Williams Institute at the University of California–Los Angeles (UCLA) School of Law (Wilson & Meyer, 2021) found that there were 1.2 million nonbinary adult Americans, representing 0.3 percent of the U.S. population. Despite a target goal of 5 percent, only 14 nonbinary adults, representing 0.5 percent of the sample, were included. This small sample size proved to be an issue during the data analysis; many methods were inapplicable.

Whites and non-Hispanics were heavily undersampled in favor of racial minorities and Hispanic ethnicities. The quota for the Hispanic ethnicity group was nearly met, and the quotas for all racial minority groups were met with one exception. While the Asian, Black or African American, and Indigenous/Native American Indian minority groups exceeded their targets, the Other (Mixed Race, Native Hawaiians, Other) minority group did not meet the intended target. Native Hawaiians had a sample size of 41, or 1.4 percent of the total. This sample size was large enough for most analyses that included all respondents, but a more granular analysis that divided the sample into further subcategories would have required a larger number of Native Hawaiians than was in the study. In the analysis summary tables in this report, this analysis limitation is denoted using *N/A*.

People with disabilities were heavily oversampled, with every single disability type exceeding the target quotas. Many people with disabilities require additional facilities or assistance that a typical traveler

would not and therefore face unique transportation challenges. If these challenges are not overcome, people with disabilities may be unable to utilize the new transportation systems, exacerbating existing inequities.

With respect to income levels, the lowest two income groups were overrepresented, while the highest two income groups were underrepresented, particularly for the group earning $100,000 or more annually. Because the poor tend to be among the most vulnerable members of society, they are at a higher risk of not having their transportation needs met.

The sample was generally representative of the four U.S. regions, although the Midwest group was slightly underrepresented and the South group was slightly overrepresented. It should be noted, however, that unlike the Phase 1 analysis, which was limited to 10 Texas cities where on-demand services were known to be in effect, this survey did not control for the availability of on-demand services (i.e., not every survey participant may have been living in an area where all services of interest were available at the launch of the survey). However, it was assumed that there were no systematic differences in access between regions, and thus quotas were meant to be as representative of the overall population as possible.

Participants living in suburban residential areas were undersampled in favor of participants in urban and rural areas. Previous studies have shown that urban residents tend to use TNCs more frequently (Circella et al., 2018; Vinayak et al., 2018); including more urban residents was thought to be more representative of TNC users. Conversely, rural areas are least likely to be serviced by these companies; including more rural residents was intended to provide more insight into their needs.

Survey Analysis

Bivariate and univariate descriptive statistics were conducted along with statistical inferential methods[1] to explore the data. The differences between groups were tested to examine whether there were statistically significant differences in proportions. Pearson's chi-squared test was used, with the null hypothesis being that proportions were identical across all populations and the alternative hypothesis being that at least one of the proportions was different from the others. In the event of only 1 degree of freedom (i.e., only two populations were considered), Yates' continuity correction was applied to account for any errors in the chi-squared approximation. This test requires each comparison group to have a sufficiently large sample size for the approximation to be valid; as a result, nonbinary/third-gender individuals needed to be excluded from nearly all analyses, and Native Hawaiians were excluded from any granular analysis that required dividing the sample into further subgroups.

Several questions in the survey included a 5-point Likert scale as responses, from *strongly disagree* to *strongly agree* or *extremely negative* to *extremely positive*. To determine any differences across populations for these questions, the qualitative responses were converted to numerical values, with *extremely positive* being assigned 2, *somewhat positive* being assigned 1, and so on. The mean response score was calculated for each population and then the Kruskal-Wallis test was conducted, with the null

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[1] Statistical models of sharing behavior were developed for this study, but their detailed discussion is excluded in this report to maintain focus on presenting the main survey findings related to the equity component. A comprehensive analysis of these models can be found in separate manuscripts as noted at the beginning of Chapter 3.

hypothesis being the means were all identical and the alternative hypothesis being at least one mean was different than the others.

Survey Sample Characteristics

Nearly all surveys were completed in English (92 percent in English versus 8 percent in Spanish). The mean and median times for survey completion were 27 and 19 minutes, respectively. After filtering out any responses thought to be suspect, such as surveys completed in an unusually fast time with nonsensical or contradictory responses, a final sample of 2,950 usable surveys from unique individuals was used to form the dataset. Tables 2 and 3 summarize the individual and household characteristics in the sample, respectively.

Table 2. Individual Characteristics in the Sample

Variable	Category	Number	Percent
Age	18–24	364	12.3
	25–34	447	15.2
	35–44	548	18.6
	45–54	446	15.1
	55–64	428	14.5
	65 or over	717	24.3
Gender	Male	1412	47.9
	Female	1519	51.5
	Nonbinary/third gender	14	0.5
	Prefer not to say	5	0.2
Race	Native American Indian or Alaska Native	180	6.1
	Asian	406	13.8
	Black or African American	788	26.7
	Native Hawaiian or Other Pacific Islander	41	1.4
	White or Caucasian	828	28.1
	Mixed Race	384	13.0
	Other or prefer to self-describe	323	10.9
Hispanic, Latin, or Spanish Origin	Yes	1078	36.5
	No	1872	63.5
Disability	No disability	1715	58.1
	Have one or more disability	1235	41.9
Disability Type (Among Individuals with a Disability)	Deaf or serious difficulty hearing	308	24.9
	Blind or serious difficulty seeing	303	24.5
	Need to travel with a service animal	163	13.2
	Serious difficulty walking or climbing stairs	564	45.7
	Limited number of active hours due to pain	686	55.5
	Difficulty communicating with strangers or navigating unfamiliar environments	433	35.1

Variable	Category	Number	Percent
	Disability that affects the ability to get a driver's license	226	18.3
	Disability that affects the ability to travel alone for transportation, such as going to school or shopping	306	24.8
Education	Less than high school, high school graduate, or General Educational Development (GED)	648	22.0
	Technical or trade certificate	181	6.1
	Some college	680	23.1
	Associate degree	375	12.7
	Bachelor's degree	684	23.2
	Master's degree or more	382	12.9
Employment	Employed full time	1162	39.4
	Employed part time	431	14.6
	Retired	749	25.4
	Student	85	2.9
	Unemployed—looking for work	346	11.7
	Unemployed—not looking for work	223	7.6
Work Location (Among Employed Individuals)	Working from home	394	24.9
	Working outside the home	818	51.7
	Both (home and outside the home)	371	23.4
Own or Have Access to a Personal Vehicle	Yes—vehicle is in working condition	2400	81.4
	Yes—vehicle is not in working condition	112	3.8
	No	438	14.8
Have a Valid Driver's License	Yes	2499	84.7
	No	451	15.3
Own or Have Access to a Smartphone Used Regularly	Yes—with reliable high-speed access to the internet	2742	92.9
	Yes—with no reliable high-speed access to the internet	81	2.7
	No	127	4.3
Technology Adoption	I am among the first of my friends and family to adopt new technology	1023	34.7
	I wait awhile and eventually adopt new technology	1383	46.9
	I am among the last of my friends and family to adopt new technology, if I adopt at all	544	18.4

Table 3. Household Characteristics in the Sample

Variable	Category	Number	Percent
Household Income	Less than $25,000	728	24.7
	$25,000 to $49,999	765	25.9
	$50,000 to $74,999	494	16.7
	$75,000 to $99,999	280	9.5
	$100,000 to $149,999	369	12.5
	$150,000 or more	229	7.8
	Prefer not to answer	85	2.9
Household Type	Single, no children or dependents	967	32.8
	Single, with children or dependents	425	14.4
	Married or domestic partner, no children or dependents	716	24.3
	Married or domestic partner, with children or dependents	751	25.5
	Other	91	3.1
Age of Children in Household (Among Households with Children)	0–6 years	472	40.1
	7–12 years	416	35.4
	13–15 years	258	21.9
	16–17 years	401	34.1
Household Living Situation	Renting a house or apartment	1157	39.2
	Living with parents—rented house or apartment	142	4.8
	Living with parents—owned house or apartment	182	6.2
	Own a house or apartment	1348	46.4
	Other	101	3.4
Household Residential Area Type	Urban	1141	38.7
	Suburban	1232	41.8
	Rural	502	17.0
	Not sure	75	2.5
Language Spoken at Home	English only	1853	62.8
	English mostly	290	9.8
	English and another language equally	572	19.4
	Another language mostly	157	5.3
	Another language only	78	2.6

Survey Findings and Discussion

The results of the shared mobility survey related to the access to and affordability of shared-ride services, as well as the perceptions and use of these services among the different population groups, are presented in this section.

Access to Shared-Ride Services

For people to share or pool their rides, on-demand services must exist in their local areas. Addressing inequity starts by assessing access. Access to shared-ride services includes the physical availability and accessibility of service, as well as the technological accessibility of service. As part of this study, we considered differences in access by population group; potential operational, employer-based, and governmental improvements to access; and access to shared-ride services in AVs.

Access by Group

Participants who reported not using on-demand services (TNCs, taxis, microtransit) were asked if these services were available in their local area. We used Pearson's chi-squared test to confirm any statistically significant differences in availability for different groups. Accessibility features for people with disabilities and seniors were also investigated.

Participants in the oldest two age groups reported the least access to TNCs and on-demand transit. The higher technology use requirements of these modes (compared to taxis) could partly explain the older respondents' avoidance. Conversely, older participants reported having much higher access to taxis than participants in the 18–24 age group. Younger generations have become accustomed to using on-demand services via the internet and no longer see a need to physically chase taxis. They likely do not consider taxis to be a viable transportation option and thus do not know how to access one if needed.

Males reported having more access to taxis than females but not to any other service. While there were statistically significant differences in access across races, no group reported having consistently higher or lower access across all three services, highlighting the need for more nuanced future analyses to determine the effects of race on ridesharing policy. Participants in the higher-income groups consistently reported having more access to TNCs and taxis than participants in lower-income groups, largely owing to their greater disposable income. The only significant difference in access between participants with and without disabilities was for on-demand transit. Participants with disabilities were surer of their access to on-demand transit; 26 percent of participants with disabilities reported being unsure of their access compared to 30 percent of nondisabled participants. People with disabilities have different and often neglected accessibility needs. As such, they may be more aware of service offerings and transportation developments.

Participants were given a list of factors to choose from and asked which, if any, caused them to be dissatisfied with a shared-ride service. Four of these factors were related to accessibility: (1) unreliable travel times, (2) pickup/drop-off point being too far of a walk, (3) pickup/drop-off point being in an unsafe area, and (4) pickup/drop-off point not having good sidewalks or crossings.

Among all shared-ride service users, the most common complaint was related to unreliable travel times, with 34.3 percent of dissatisfied and 19.2 percent of satisfied users citing it as an issue. Companies must determine how to add more riders to a vehicle without inconveniencing the other passengers. Adding passengers will likely and unavoidably increase total travel time; all customers will consider the tradeoff between time and cost when deciding to use the pooled option. Companies that can balance these two factors—time and cost—will profit the most.

Younger shared-ride service users were typically less concerned about travel time than older participants, although this trend was not monotonic. Comparatively, older participants were typically less concerned about pickup and drop-off locations than younger participants. This result may appear counterintuitive at first sight. Older people tend to have more physical ailments and health issues, suggesting that they would want their pickup/drop-off location to be a quick walk away and in a safe area with easily accessible sidewalks. One explanation could be that older users are accustomed to using traditional transit that follows fixed routes; they are already used to traveling to and from a bus stop or train station. Younger users, who have grown accustomed to on-demand services taking them to their exact destination, would presumably be more upset if sharing a ride requires them to walk for some distance.

Participants with disabilities were more likely to indicate that their pickup/drop-off point being too far of a walk or in an unsafe area was an issue when ridesharing. The consequences of having to walk farther or being dropped off in an inaccessible area as a result of sharing a ride with a stranger are more serious for a disabled person than for a nondisabled person.

Participants were next given a list of shared-ride service attributes and asked to select the attributes that they personally found appealing. Among all shared-ride service users, 21.5, 31.1, and 23.4 percent reported satisfaction with the shared trip due to the reliable travel time; speed (relative to transit, walking, or biking); and safety (relative to transit, walking, or biking). Compared to this study's previous results, more participants reported being dissatisfied with shared-ride service travel times than satisfied, indicating a major barrier that service providers must overcome to achieve mass-market appeal.

As the most significant difference across groups, people with disabilities were much more likely to indicate that shared or pooled rides were safer than walking, biking, or taking public transit. Despite the added risks associated with shared rides for people with disabilities that were discussed previously, this mode remains safer for them than walking, biking, or taking transit. These results are consistent with this study's findings related to use; people with disabilities were found to be much more likely to report currently using on-demand services.

Operational Access Improvements

All survey participants were given a list of potential operational improvements for shared-ride services and asked which, if any, would make them personally more likely to use these services. These improvements can be directly implemented by companies and transportation providers, allowing them to better control their users' experiences.

Participants with disabilities were significantly more likely to select designated boarding zones at busy intersections and curbside areas. Recall that participants with disabilities were much more likely to indicate that their pickup and drop-off points were too far from a walk or were in unsafe areas.

Widespread implementation of designated boarding zones would substantially address those concerns. Designated boarding zones could have signs clearly demarcating where to wait and board, bright lights for visibility, and security cameras, making it much easier for people with disabilities to use shared-ride services.

Ensuring a guaranteed time window for drop-off was the most selected operational access improvement for shared-ride services, further confirming that unreliable travel times are a significant issue that discourages people from pooling rides. While this operational change was the most selected across all participant groups, only Asian participants and participants aged 45–64 were significantly more likely to favor this change.

Male participants were more likely than female participants to request that people be dropped off in order of boarding. Participants with a disability were more than twice as likely to select the option of requesting assistance from the driver or other passengers during a shared ride. One potential barrier to sharing rides for people with disabilities relates to the challenge of entering and exiting a vehicle with mobility devices, service animals, and so on. If they can receive help from others in the vehicle, this barrier would be greatly reduced.

Employer-Based Access Improvements

Employers can also have a large impact on shared-ride service use among their employees by implementing transportation-related programs at the workplace. Employees spend a significant portion of their lives at work, and traveling to and from work is one of the most common trips an individual makes in a typical week. Employer-enacted programs can affect not just the workers of the company, but possibly their customers as well, depending on the nature of the company and the programs/policies implemented. As was the case for operational access improvements, all survey participants were given a list of potential employer-based access improvements for shared-ride services and asked which, if any, would make them personally more likely to use these services.

Participants in the oldest age group were consistently least likely to select any of the potential employer-based access improvements to encourage ridesharing. The easiest explanation may also be the most plausible. Participants aged 65 and older were typically retired; any programs implemented by employers that primarily benefit workers likely do not apply to them.

Interestingly, no statistically significant difference was confirmed between male and female participants who selected either flexible working hours or flexible work-from-home schedules. This result is surprising; previous polls have found that females prioritized flexible working hours and locations more than males (Comoglio & Benditt, 2021) because of their increased share of household responsibilities (Brenan, 2020) and caregiving duties (Botek, 2022). Participants who reported earning $100,000 to $149,999 annually were most likely to select flexible work-from-home schedules, while participants who reported earning $25,000 to $49,999 were the least likely to select this option. Participants in the higher income group are likely white-collar workers who can more easily perform their jobs from home. Conversely, participants in the lower-income group are likely blue-collar and service workers whose jobs require them to be in person at a site other than their home.

Participants who reported earning less than $50,000 were more likely to select a guaranteed ride home program (as a backup when shared-ride services are unavailable) than participants who reported

earning $100,000 or more. This finding may be symptomatic of the lower favorability toward these services expressed by lower-income participants.

Governmental Access Improvements

Governments at local, state, and federal levels have a tremendous impact on their citizens' transportation behaviors through policies related to taxation, construction projects, zoning, vehicle standards, and so on. While on-demand services have been in place for several years, the use of these services still lags many other forms of transportation, such as driving a personal vehicle. Government assistance may be helpful, and in some cases necessary, to encourage the popularity of shared-ride services among the public. All survey participants were again given a list of potential governmental access improvements for shared-ride services and asked which, if any, would make them personally more likely to use these services.

Statistically significant differences were confirmed between various age groups. Participants in the oldest age group were least likely to select additional high-occupancy lanes or priority lanes for pooled vehicles and traffic signal priority for pooled vehicles. Work commutes are time-sensitive and typically occur during rush hour. Hence, improvements such as priority lanes and priority traffic signals would greatly benefit workers trying to get to their jobs on time but would provide less benefit to people making less time-sensitive trips. More surprisingly, participants in the oldest age group were also least likely to select improved sidewalks, intersections, and Americans with Disabilities Act (ADA) compliance. Because senior citizens are more likely to have health issues that make travel difficult, more accommodation for people with disabilities should disproportionately help older adults. Participants with disabilities were more likely to select this improvement than participants without disabilities, but this level of support did not translate into support from older respondents.

Access to Shared-Ride Services in Automated Vehicles

Unlike conventional shared-ride services, shared-ride services that use self-driving vehicles or automated vehicles (AVs) are not widely available. Because AVs are a new technology that has yet to be widely implemented, we first measured the survey participants' familiarity and attitudes toward self-driving vehicles before considering the effects of AVs in the context of on-demand transportation and shared rides. Figure 1 is a heatmap of the participants' familiarity and attitude toward self-driving vehicles; the green shading represents a lower proportion of participants and the red shading represents a higher proportion of participants.

In general, negative attitudes tend to decrease while positive attitudes tend to increase as people become more familiar with self-driving vehicles. Among participants who said they were not familiar with AVs at all, less than 10 percent had a positive view of them, while 49 and 42 percent had a negative and neutral view, respectively. Manufacturers and transportation providers must overcome this barrier to mainstream this technology; individuals who are least informed about the technology tend to have the most negative views. Only 35 percent of participants said they were either moderately or extremely familiar with AVs. However, three-quarters of the participants extremely familiar with AVs had a positive view of them, which bodes well for the budding industry. If companies do a better job of marketing the product to the public and informing them of the potential benefits, consumers will respond favorably.
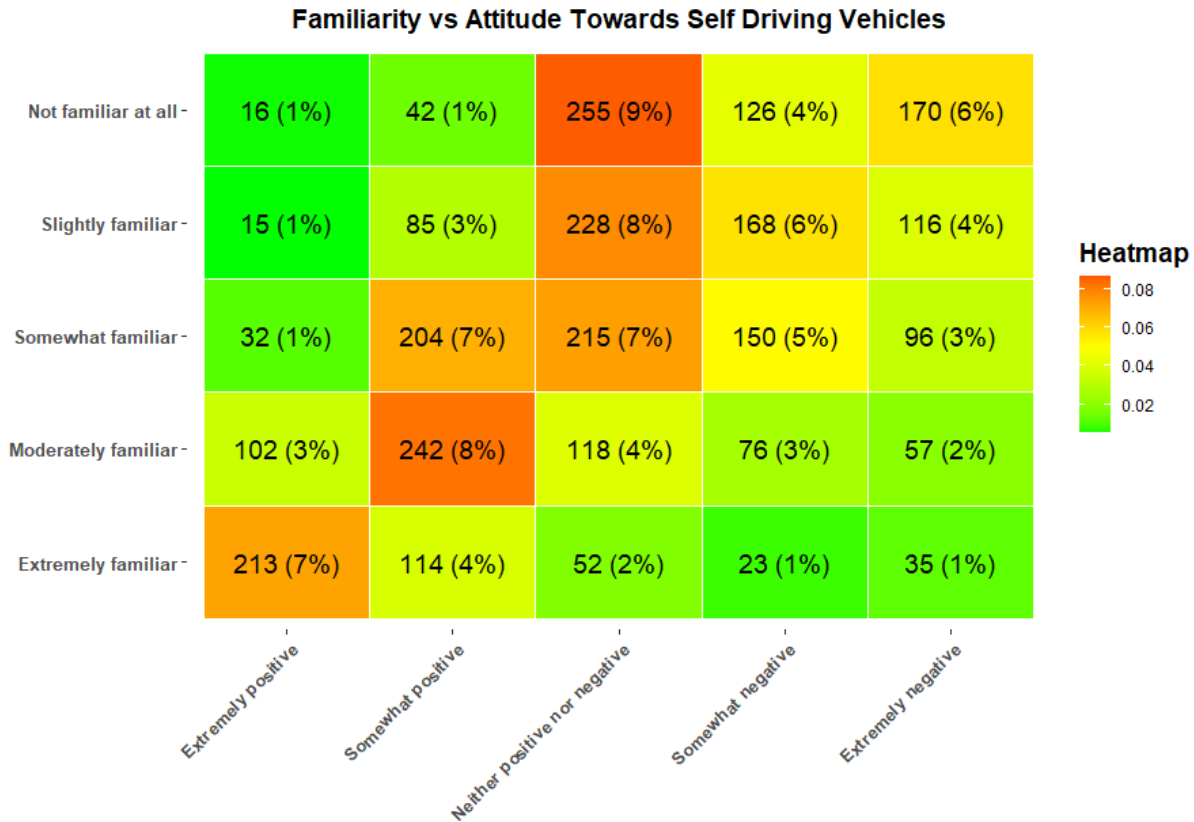
Familiarity vs Attitude Towards Self Driving Vehicles

	Extremely positive	Somewhat positive	Neither positive nor negative	Somewhat negative	Extremely negative
Not familiar at all	16 (1%)	42 (1%)	255 (9%)	126 (4%)	170 (6%)
Slightly familiar	15 (1%)	85 (3%)	228 (8%)	168 (6%)	116 (4%)
Somewhat familiar	32 (1%)	204 (7%)	215 (7%)	150 (5%)	96 (3%)
Moderately familiar	102 (3%)	242 (8%)	118 (4%)	76 (3%)	57 (2%)
Extremely familiar	213 (7%)	114 (4%)	52 (2%)	23 (1%)	35 (1%)

Heatmap
- 0.08
- 0.06
- 0.04
- 0.02

Figure 1. Familiarity versus attitude toward self-driving vehicles

All survey participants were then given a list of shared AV attributes and asked which, if any, they found personally appealing.

A significantly higher proportion of female participants reported being unable to drive currently and thus found the independence provided by a driverless on-demand service appealing. In 15 percent of American households, the number of adults exceeds the number of available vehicles, resulting in a *car deficit* (Ruggles et al., 2017). In these households, adults often compete for vehicle access. In such instances, one study found that women were more likely to primarily use the car. The person who used the car most often was whoever *needed* the car more; women bear disproportionate responsibilities for housework, errands, childcare, and so on, and were thus more often the ones monopolizing car use (Blumenberg et al., 2022). In households where the car must be shared, women must either wait until the car becomes available again or must use other modes of travel such as walking, biking, or transit to fulfill their needs. Another study found that households headed by a female were significantly less likely to own a car (Nolan, 2010). Based on these previous findings, females would benefit more from the independence provided by shared AVs.

Although participants aged 65 or over were also limited in their ability to drive due to health or legal reasons, participants in this age group were the least likely to find the independence provided by a driverless on-demand service appealing. This finding is likely due to the skepticism of older respondents regarding this type of service and technology in general. Ironically, participants aged 65 or over did not even find AVs as a mobility enabler for older users appealing, signifying a deep level of hesitation and/or

distrust. Participants with disabilities were significantly more responsive to shared AV accessibility attributes than nondisabled participants, specifically citing the increased independence and enabled mobility for older adults and individuals with difficulty driving as appealing attributes.

Consistent with previous results, participants with disabilities were significantly more likely to cite drop-off points not having good sidewalks or crosswalks and mobility devices/service animals requiring additional room as barriers to sharing rides in an AV. Younger participants cited drop-off points with good sidewalks or crossings as an important attribute for shared AV use; the absence of this infrastructure would dissuade them from ridesharing in driverless vehicles. As discussed previously, younger generations have become accustomed to using on-demand services that take them from their exact origin to their exact destination. If sharing a ride means deviating from their optimal route and/or being forced to walk through an area with low-quality pedestrian infrastructure, younger users are likely to discontinue their use of these services.

Affordability of Shared-Ride Services

In addition to access, we also considered the affordability of shared-ride services. Specifically, we considered differences in affordability by population group; potential operational, employer-based, and governmental improvements to affordability; and the affordability of shared-ride services in AVs.

Affordability by Group

Only 16 percent of participants who reported having shared a ride indicated that the cost of sharing a ride was not worth it compared to solo rides. This relatively small percentage is likely attributable to the targeted sample subset of only rideshare users—if rideshare users thought the cost of using the service was too high or not worth the additional inconvenience, they would likely have never tried it. While this percentage is not trivial, affordability factors were not as concerning for participants as access factors, with travel time reliability and speed/safety of the service cited by more than 30 percent of participants as a concern. No statistically significant differences were confirmed in the proportions of participants indicating that the cost was too high across any of the variables, implying that costs were not a factor driving the inequity in shared-ride services between different sociodemographic groups. According to the survey results, while efforts to reduce costs may lead to an increase in the total number of users, these efforts may not adequately address the underlying disparities in shared-ride services. It might be important to note here that interviewees with low income and disabilities emphasized the value of on-demand transportation services, including shared-ride services, but they expressed that the costs were prohibitive, even for the few rides they chose to take monthly. Combining this insight with the data from the larger survey sample, it becomes evident that the pricing model of ridesharing in traditional TNCs may not be conducive to widespread affordability. Other factors besides cost may be at play in the inequities observed.

All survey participants were given a list of cost-related factors affecting shared-ride service use and asked which, if any, would make them change their travel choices and consider more frequent shared rides. Table 4 summarizes these results. Approximately 39 percent of participants indicated that they would consider more shared rides if the cost of driving their own vehicle became more expensive. Similarly, approximately 34 percent of participants indicated that they would consider more shared rides if the cost to share a ride was cheaper. It was previously noted that driving in a personal car was by far the most popular mode of transport. People would prefer to drive alone over sharing a ride, even if the

cost of sharing a ride decreased. However, if the cost of driving alone became prohibitively high, especially when compared to sharing a ride, more Americans may be open to shared-ride services. Approximately 27 percent of the participants indicated that they would not change their mode of travel, regardless of these cost-related factors. These participants may have broader considerations regarding their mode choice that extend beyond cost, possibly pertaining to the access-related factors as discussed earlier.

Table 4. Cost-Related Factors That May Increase Shared-Ride Service Use

Factor	Percent
Cost of gasoline or driving travel was more expensive	38.6
Cost to share a ride was cheaper	33.6
Parking was not reliably available or more expensive where I needed to travel	26.9
Cost to ride alone in an on-demand service was more expensive	25.0
Congestion on roadways for my trips increased	20.0
Something else	1.7
None of these would change my decision on sharing trips	26.8

Operational Affordability Improvements

All survey participants were given a list of potential operational improvements related to the affordability of shared-ride services and asked which, if any, would make them personally more likely to use these services. One option included some sort of financial reimbursement if a trip takes too long beyond the estimated trip time. Statistically significant differences were confirmed across racial groups for this option; nearly one-third of Asian participants—a much higher proportion than the proportions for other racial groups—indicated that such a policy would make them personally more likely to use shared-ride services. No other statistically significant differences that had any meaningful interpretation were confirmed, further demonstrating that any differences in shared-ride service use are a function of various factors that likely do not include cost.

Employer-Based Affordability Improvements

Three potential employer-based improvements related to the affordability of shared-ride services— rewards programs, direct subsidies, and parking cash-out programs for workers taking shared trips— were presented to all survey participants, who were then asked which, if any, would make them personally more likely to use these services. Participants aged 65 or over were significantly less likely to indicate that any of these improvements would make them personally more likely to use shared-ride services. This finding likely reflects the high composition of retirees in this age group. Asian participants were significantly more likely to favor direct subsidies to encourage their ridesharing. Interestingly, participants in the highest income groups were significantly more likely to indicate that rewards programs and direct subsidies would make them more likely to share rides. These proposed improvements are ostensibly intended to make shared-ride services more affordable, thus reducing inequity in access between high- and low-income workers. However, if higher-income workers are more likely to take advantage of reduced costs for shared rides, these improvements may be counterproductive.

Governmental Affordability Improvements

All survey participants were given a list of potential governmental improvements related to the affordability of shared-ride services and asked which, if any, would make them personally more likely to use these services. Statistically significant differences were confirmed across the racial groups when considering direct subsidies for shared trips and subsidies for shared-ride trips that connect to transit hubs. Asian participants were significantly more likely to favor these improvements. Favorability for creating tax advantages for employers with shared-ride programs increased as income levels increased. If the goal of policy makers is to increase the use of shared or pooled rides within the Asian community, providing financial incentives seems to be the most effective method. However, Asian participants reported having the most access to TNCs and taxis (relative to other races) and are unlikely to be the top priority for such targeting efforts. Improvements that reduce costs may not be the most cost-effective way to reduce inequity in shared-ride services, particularly if the populations who stand to benefit the most are Asians and higher-income travelers—users who already have the most access to these services. Service providers need to convey the viability of their services more effectively to low-income and other marginalized travelers and find other avenues to encourage uptake.

Affordability of Shared-Ride Services in Automated Vehicles

The dynamic interactions between shared AVs—that are simply not possible with human drivers—could decrease accidents on the road, leading to lower insurance costs for companies, on-demand users, and even other drivers. Automated vehicles could also communicate with each other in real time, allowing for optimized routing, reduced travel times and congestion, and additional monetary savings.

All survey participants were given a list of shared AV attributes related to affordability and asked which, if any, they found personally appealing. Only 16 percent of participants indicated that they found the lower insurance costs associated with shared Avs to be appealing. Participants in the oldest age group were least likely to find the lower insurance premiums appealing. As noted previously, older individuals are often hesitant to accept new technology; despite potential financial benefits, their skepticism toward the technology prevails. No other statistically significant differences were confirmed related to the lowered insurance costs.

A significantly higher proportion of male participants indicated that the cost of sharing a trip in an AV is too high (the benefit is not enough) when compared to riding alone. To encourage more males to use shared AVs, offering financial incentives may be a valid method.

Perceptions and Use Behaviors of Shared-Ride Services

As a final task in this Phase 2 study, we considered the perceptions and use behaviors of shared-ride services. Specifically, we considered differences in perceptions and use behaviors by population group; the media's role in shaping perceptions and use behaviors; potential operational, employer-based, and governmental improvements related to perceptions and use behaviors; and the perceptions and use behaviors of shared-ride services in AVs.

Perceptions and Use Behaviors by Group

Participants were given a list of factors to choose from and asked which, if any, caused them to be dissatisfied with a shared-ride service. For factors relating to safety, a much higher proportion of female participants than male participants indicated that they do not like talking to strangers. A National Bureau of Economic Research (NBER) study in Boston found that many female passengers felt that their drivers were being overly chatty and attempting to flirt with them (Ge et al., 2016). This issue is likely exacerbated with more strangers in the car. In fact, a prior study found that the more strangers there are in the car, the more likely women are to feel uncomfortable—the only exception being gender-dedicated systems with only women present in the car (Tang et al., 2021). Interview results corroborated this finding, with female gender often being the only mentioned risk factor for safety, and that women experience unwanted and excessive flirting. Younger participants were also much more likely than older participants to indicate that they dislike talking to strangers. According to a OnePoll survey of 2,000 young (18 or older) Americans, 65 percent of millennials do not feel confident in face-to-face social interactions (Hrustic, 2017). A dislike of talking to strangers may be exacerbated in a shared-ride situation where travelers are confined to a small, enclosed area; any faux pas or awkward conversation may make the rest of the trip very uncomfortable.

Statistically significant differences were confirmed between the disability groups for most of the safety-related factors—unsafe vehicle experience, not liking to talk with strangers, getting paired with unpleasant passengers, germs from contagious passengers, vehicle interior being too small or uncomfortable when sharing, and hostile passengers due to personal identity. Higher proportions of participants with disabilities identified these safety factors as a cause for dissatisfaction. People with disabilities may be immunocompromised due to their disability and thus more likely to be concerned about germs from contagious passengers. The vehicle interior being too small or uncomfortable when sharing was also identified as a concern by the participants with disabilities. Traveling with a service animal or mobility device already presents unique challenges regarding space; sharing the space with additional strangers only adds to these challenges.

Among all racial groups, Native American participants expressed the most concern about hostile passengers due to personal identity; White or Caucasian and Other participants expressed the least concern. Many Asian and Black or African American participants also expressed concern about hostile passengers due to personal identity. Figure 2 helps to clarify these findings.
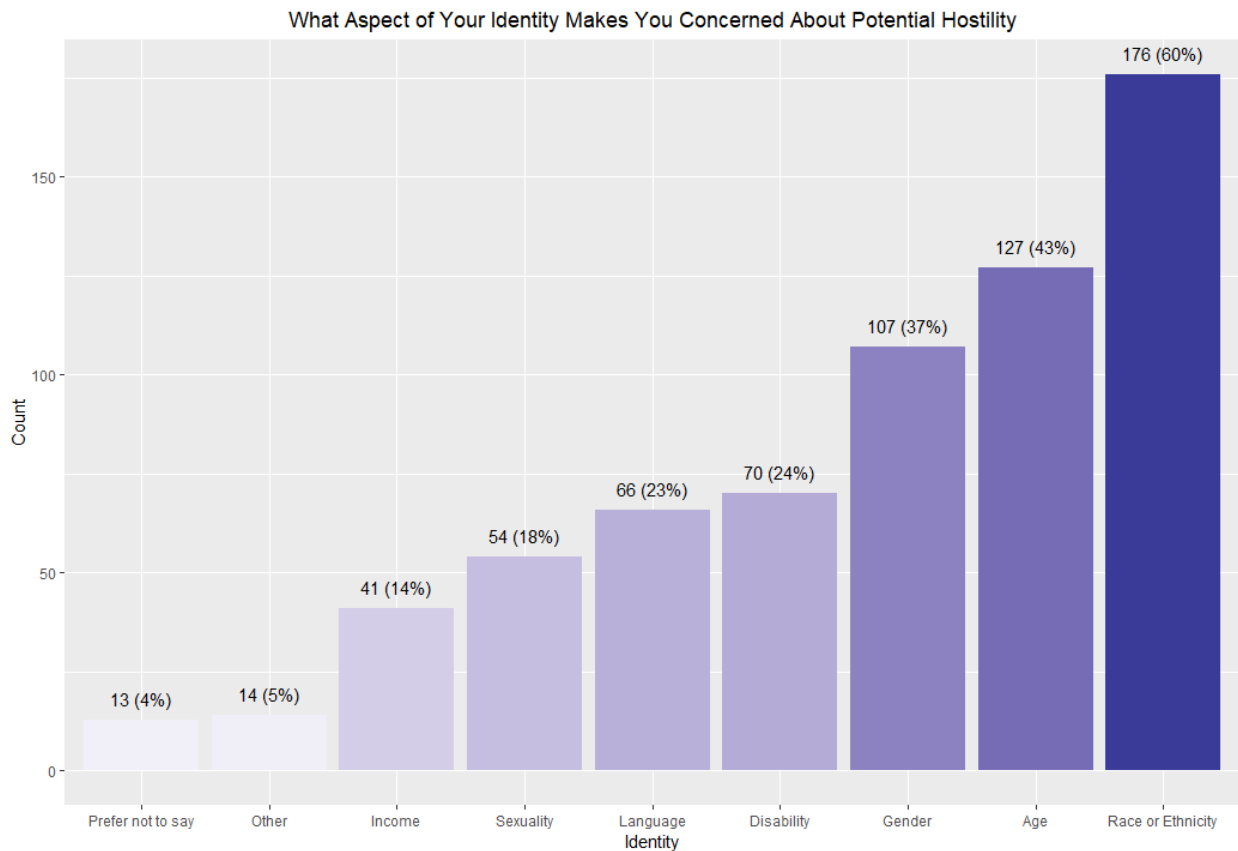
What Aspect of Your Identity Makes You Concerned About Potential Hostility

Figure 2. Aspect of identity causing concern for survey respondents

Among participants who expressed concerns about hostile passengers, the most common aspects of their identity that concerned participants were race and ethnicity; other aspects that ranked highly—but well behind race and ethnicity—were age and gender. These findings suggest that the fear of potential conflict with other passengers over their race or ethnicity is a significant impediment to initial or continued shared-ride service use by racial minorities. Recall that Native American participants—the racial group most likely to be concerned about hostile passengers—also reported the lowest current on-demand service use rates. Improvements intended to prevent racial abuse and discrimination within shared vehicles are important in convincing minorities to use shared-ride services and bridging any racial gaps.

Media Role in Shaping Perceptions and Use Behaviors

The media—through various mediums—can influence individual perceptions and guide public discourse and narratives surrounding a particular topic. Based on interview results, we added questions in the Phase 2 survey to explore patterns in the source, affect, and effect of on-demand transportation safety stories. Interviewees mentioned hearing stories of assault, harassment, and rape in shared-ride services. These stories were particularly frightening to non-users who lacked personal experience with shared-ride services. Interviewees who expressed higher levels of safety concern during rides and reported using many built-in safety features were more likely to mention the potential dangers of shared-ride services based on second-hand sources, rather than personal experience. Negative on-demand service stories have the potential to spread widely, especially online, and can potentially harm the service and

the company's reputation. Conversely, positive press could generate a lot of interest in a new service, helping it become more economically viable and stable. Table 5 summarizes the nature of safety-related information (i.e., positive, negative, or mixed/unsure) heard by participants for on-demand services by source. The last column indicates the percentage of participants who had not heard any information regarding on-demand service safety.

Table 5. Nature of Safety-Related Information for On-Demand Services by Source

Source	Positive	Negative	Mixed/Unsure	No Information
Family	67.5%	12.4%	20.1%	74.1%
Friends	59.4%	11.3%	29.2%	73.5%
News (TV or Newspaper)	26.9%	33.3%	39.8%	74.4%
Social Media or Online News Outlets	36.9%	23.9%	39.2%	76.0%
Other	29.4%	5.9%	41.2%	99.4%

When hearing about on-demand services from people known to the respondent, such as family and friends, most information was reportedly positive. A much larger share of negative and mixed information was available from the news and social media. Perhaps this finding is a testament to the quality of the services provided by on-demand companies; individuals who used the services and had a positive experience tell their friends and family, generating good word-of-mouth. As companies try to expand their share of the transportation market, marketing strategies that focus on these positive customer experiences would likely be more successful than marketing strategies that focus on traditional and social media outlets, which seem to have a bias toward negativity. Among all survey participants, 44.5 percent indicated that they had not heard information from anyone or anywhere, 52.0 percent indicated that the information had no effect on their use of on-demand services, and 23.5 and 24.5 percent indicated that they were more likely and less likely to use on-demand services because of information they heard, respectively. These results suggest that the effects of media on consumer behavior may be negligible.

Operational Perception and Use Behavior Improvements

All survey participants were given a list of potential operational improvements related to safety perceptions of and preferences for shared-ride services and asked which, if any, would make them personally more likely to use these services.

Statistically significant differences between gender groups were confirmed for the proposed operational improvements: (1) seeing the name, gender, and age of other passengers in the app; (2) being able to set a preference for the gender of other passengers; (3) broadcasting a current location to a trusted friend or family member; and (4) providing an on-call concierge number or helpline in case of safety issues. A higher proportion of female than male participants indicated that each of these improvements would make them more likely to share rides. These findings clearly indicate that females tend to prioritize safety more than males do; improvements that make users feel safer are thus much more likely to resonate with them. Consistent with this study's findings, Tang et al. (2021) found that women prefer gender-dedicated systems that allow only members of the same gender to be present in a vehicle over standard systems that randomly connect the nearest drivers to riders. Services that address the

safety concerns of women through operational changes would likely see an increase in their share of female passengers.

Statistically significant differences between age groups were also confirmed for many of the operational improvements. Older participants consistently indicated that they would not personally use the services more as a result of the operational improvements. The older participants indicated a lower willingness to use the services regardless of any changes. Increasing the share of older adults using shared-ride services will likely be difficult due to their strong opposition to new technology. One potential improvement that could make older adults more likely to share rides is the introduction of video surveillance onboard vehicles; participants in the older age groups responded much more favorably to this improvement than participants in the younger age groups.

Asian and Native American participants were significantly less likely than other racial groups to favor a program where passengers are matched together from trusted networks like schools, workplaces, or social groups. Native American and White or Caucasian participants were significantly less likely than other racial groups to favor seeing a picture of other passengers in the app. Because Native American participants expressed significant concerns about passenger hostility due to personal identity, they may not want others to see their photos in the app out of fear that they could be targeted for harassment. Both Native American participants and, to a lesser extent, Asian participants expressed concerns that their identities would cause conflict; however, both groups largely rejected a program where passengers are matched together from trusted networks like schools, workplaces, or social groups. Being paired together with known people from trusted networks would likely assuage some of their fears. These results reinforce the complex relationship between race and shared-ride service use. Effectively addressing any gaps in use across different races requires a tremendous amount of nuance. No definitive improvements were identified that could reduce any racial inequities.

Employer-Based Perception and Use Behavior Improvements

Similar to the operational improvements, all survey participants were given a list of potential employer-based improvements related to safety perceptions of and preferences for shared-ride services and asked which, if any, would make them personally more likely to use these services. Unsurprisingly, female participants were more likely than male participants to indicate that workplace programs in which rides could be shared with coworkers or known networks of people would make them more likely to share rides. This type of program would alleviate the discomfort of sharing a car with strangers. No other statistically significant differences of note were confirmed across any of the other variables.

Governmental Perception and Use Behavior Improvements

All survey participants were next given a list of potential governmental improvements related to safety perceptions of and preferences for shared-ride services and asked which, if any, would make them personally more likely to use these services.

Consistent with previous findings, female participants were much more likely to support additional surveillance and security at designated boarding zones. Male participants, on the other hand, indicated that they would like the government to regulate the sale or use of data generated from using the apps. This finding is interesting because it suggests that privacy laws would be more effective in enticing more males to use shared-ride services.

Older participants again consistently indicated that they would not personally use the services more as a result of the governmental improvements. Participants who reported earning $150,000 or more annually were significantly less likely to indicate that reducing local traffic speeds to improve pedestrian safety would make them more likely to share rides. These participants likely own their own car and would feel inconvenienced by lower traffic speeds. On the other hand, participants in the lowest income groups may be more likely to be pedestrians and would thus favor improvements that protect pedestrians.

Perceptions of Shared-Ride Services in Automated Vehicles

Finally, all survey participants were asked about their perceptions of AV safety as compared to the safety of conventional vehicles. Male participants were significantly more likely to indicate that AVs were safer than conventional vehicles. Conversely, participants aged 65 or over were least likely to indicate that AVs were safer than conventional vehicles, confirming their skepticism toward new technology. Asian participants were by far the most likely among all races to indicate that AVs were safer than conventional vehicles; Native American participants were the least likely to indicate that AVs were safer than conventional vehicles. No statistically significant differences in the safety perceptions of AVs were confirmed across income or disability variables.

Chapter 4. Conclusions

Transportation marginalized populations experience different barriers and have varying needs and preferences for shared mobility solutions. The Phase 2 study results were incremental—the Phase 1 study (Sener et al., 2023a; 2023b) highlighted differences between groups, identified potential sources of inequity, and served as a blueprint for the shared mobility survey. Findings from the shared mobility equity interviews informed the development of the national enriched shared mobility survey, which in turn expanded on ideas introduced by interviewees. Each set of results stressed the primacy of accessibility improvements from operators and the greater built environment for travelers with disabilities.

Some of the key results of the study include the following:

- Older respondents have less access to on-demand services than younger ones, with many citing unfamiliarity with or distrust of new technology as a factor.
- The most common complaints people have regarding shared services relate to unreliable travel times, and guaranteeing travel time windows was popular among all groups.
- Affordability factors were not as concerning as access factors, with no statistically significant differences in the proportion of any given group indicating that service costs were prohibitively high.
- Those with disabilities cite pickup/drop-off locations being too far or in unsafe areas and a variety of other safety concerns as barriers. Having designated boarding zones with the necessary infrastructure to accommodate their needs would positively impact the usage among disabled passengers.
- Females were very concerned about the possibility of uncomfortable interactions with strangers in vehicles. Improvements to safety, such as video surveillance, setting preferences for fellow passengers, and broadcasting location, were all much more likely to be selected by women than by men.
- No clear relationship between race and on-demand use was found, with inconsistent results across different services and policies.

Based on a larger sample size, the national shared mobility survey results confirmed the ambiguous relationship between race and shared mobility use and attitudes; racial and ethnic minorities are conflicted between using and enjoying a service's convenience and being apprehensive of hostility. No single racial group consistently had higher access to or more favorable attitudes toward on-demand and shared-ride services. Policies aiming to encourage minorities to use these services must consider a variety of interacting factors. Operators and governmental bodies can both play a role in increasing comfort, safety, and accessibility, especially for women, racial and ethnic minorities, and people with disabilities. People with low incomes are priced out of shared-ride services, while older adults are uninterested or nervous about them due to their inherent hesitance toward new technology and change that they deem radical.

Perceptions regarding these new mobility options, whether they be real or not, substantially impact consumer behavior, with a lack of awareness about the services contributing to their underuse. An effective policy would involve outreach to key populations of interest that showcase the benefits of these services while acknowledging that steps are being taken to improve them. A positive takeaway

from these factors is that effective marketing can have positive impacts on consumer behavior, with those who are highly familiar with these services typically having positive opinions of and experiences with them.

Determining how to prioritize efforts, how these efforts should be led, and who should be targeted is easier with a complete understanding of needs. As emphasized throughout this report, there is no one-size-fits-all solution to address the current inequity in on-demand and shared-ride services. Addressing inequity requires listening to and taking the concerns of users, particularly the disadvantaged, seriously while admitting that a combination of several factors is at play in consumer behavior. New technology does not always guarantee better results; public policy should avoid repeating past mistakes and ensure equitable benefits for all, not just the privileged few.

While this study is not intended to be a comprehensive or final statement on the topic, it holds significant value as a foundational study, paving the way for further research into the transportation needs of marginalized groups. The findings can help determine interactions among intersections of marginalization, identify equity priorities, and guide the deployment of new or existing shared-ride services.

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