How Older Adults Use Ride-hailing Booking Technology in California

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ABSTRACT

Ride-hailing services like Lyft and Uber have the potential to improve mobility for many older adults, especially those who cannot or prefer not to drive. We used survey data from 2,917 Californians 55 years and older to investigate (1) how older adults who currently ride-hail booked their trips, and (2) what personal characteristics, including attitudes towards technology, were correlated with booking trips online versus by phone or with help. We specified four binary probit models in which the outcome variables are the manner in which a respondent accessed ride-hailing services: self-booked by phone, self-booked by app, booked by a family/friend/caregiver but rode alone, or booked by others and rode with them. We controlled for two attitudinal constructs (confident and cautious about technology), residential location, general travel behavior, physical health, and standard socio-economic factors. We found that respondents who were more confident using technology booked via apps, while those who were more cautious about technology were less likely to book using apps. This latter group was more likely to book by phone or rely on others for help. Other characteristics associated with higher likelihood of booking via apps were: living in the suburbs, not relying on others for rides, having physical health issues, being college educated, and being non-Hispanic. Our findings provide a basis to think about expanding ride-hailing to other older adults, particularly those who are not comfortable with technology, through convenient access to ride-hailing booking.

Keywords: attitudes; factor analysis; older adults; probit; ride-hailing; technology adoption

Highlights

- Contrary to popular belief, many over 65 years ride-hail, often self-booking rides
- Older adults who are more comfortable with technology book via the app
- Those who are less comfortable with technology rely on others or use phone booking
- Those with health issues and disabilities are *more* likely to book trips using an app
- More seniors would likely use ride-hailing if the booking process is made easy for everyone

1. Unequal access to ride-hailing: An impact of attitude to technology?

The population is aging and many older Americans are aging in place (Peek et al. 2014; Warner et al. 2016). Alternative mobility solutions can contribute to quality of life in old age (Pangbourne et al. 2010). Among new forms of transportation services, ride-hailing is now ubiquitous in most urban areas (Alemi et al. 2018; Gehrke et al. 2019; Sikder 2019). Ride-hailing is attractive because it relaxes the schedule- and location-based constraints of traditional transit services and provides door-to-door travel for users. Ride-hailing services can also be a boon for the community-dwelling senior who has ceased driving, for whom driving has become risky due to medical conditions, or who simply would prefer alternatives to driving (Coughlin 2009; Dobbs 2012). Ride-hailing is widespread in California throughout urban and suburban counties, and even available to some extent in most rural communities (Brown 2019; Gehrke 2020). However, is it a feasible option for older adults? Some studies have concluded that many older adults do not want to, or are not able to, use the service (Shirgaokar 2018; Vivoda et al., 2018). This inability or unwillingness may be due to discomfort with smartphone technology and online financial tools. Though some ride-hailing companies and third-party service providers, such as GoGoGrandparent, facilitate connecting older adults to ride-hailing without using apps, many older adults do not have access to such support services.

Our research specifically tested technology barriers explored in earlier studies (Mitra et al., 2019; Shirgaokar 2018; Vivoda et al. 2018). These studies did not incorporate the attitudinal basis for behavior (Ajzen 1991). In this paper, we advanced these earlier efforts by including attitudinal constructs that we hypothesized would encourage technology acceptance (Davis et al. 1989; Venkatesh and Davis 2000). Peek et al. (2014) performed a systematic review of the research literature investigating factors that influenced the intention to use and the actual use of electronic technology for aging in place. They found that pre-adoption studies abound but post-adoption studies were rare, and most studies did not rely on quantitative methods. Our contribution is to investigate post-adoption views on ride-hailing using quantitative methods.

Shirgaokar (2018) and Vivoda et al. (2018) relied on convenience sampling which limited the generalizability of the results. We used quota sampling to match the California population of adults 55 and over based on age, gender, race, ethnicity, income, education, and community type. Because our sample represents the California population, the findings are generalizable to all adults 55 and older. For this research, we defined older adults (or seniors) as those who were 65 years of age or older. The literature has consistently shown that age is an important variable. Higher age and female gender are correlated with worse outcomes for mobility (Luiu et al. 2017; Rosenbloom 2004). In this paper, we took a different approach and were interested in learning what Californians in the *younger* ten-year cohort (55-64 years) thought about ride-hailing, because this group likely constitutes a large portion of the future market for ride-hailing services.

In this paper, we investigated how older adults respond to one aspect of ride-hailing technology, i.e., the process of booking trips. More specifically, we posed the following research questions:

1. How do older adults who ride-hail access the service? Do they book trips themselves by phone, book ride-hailing trips themselves by app, take rides (on their own) that were booked by a third party such staff at a medical office, or ride with another person who booked the trip?

2. Does owning connected devices (smartphones, computers, tablets), or comfort using online tools and financial services, correlate with attitudes towards technology? Do these attitudes in turn affect choices about how a ride-hailing trip is booked?
3. What socio-demographic and travel behavior characteristics correlate with any of these choices about how a trip is booked?

We answered these questions by studying weighted distributions, and running four binary probit models, one for each type of ride-hailing booking interaction. To understand attitudes towards technology adoption, we relied on confirmatory factor analysis to extract two attitudes, confident and cautious towards technology.

2. Ride-hailing, comfort with technology, and acceptance of technology: A literature review

2.1 The ride-hailing market with a focus on older adults

A number of researchers have written about the need for expanding technology-based travel options for older adults (Hubers and Lyons 2013; Pangbourne et al. 2010; Peek et al. 2014; Peek et al. 2016). Few have studied the specific link between travel options such as ride-hailing and its potential for older adults' mobility. Researchers have asked about who rides in Uber/Lyft-like services (Alemi et al. 2018; Alemi et al. 2019; Brown 2019; Conway et al. 2018; Grahn et al. 2019; Sikder 2019; Tirachini 2019). We know that ride-hailing services are particularly attractive to the young, educated, employed, and urban segments of the population; older adults more rarely ride-hail (Mitra et al. 2019; Shirgaokar 2018; Vivoda et al. 2018).

Some researchers have addressed questions such as differences between ride-hailing and taxi markets (Conway et al., 2018), which is an important consideration since some older adults rely on taxi services for their transportation (Habib 2019; Schmöcker et al. 2008). However, the taxi industry has shrunk due to the success of ride-hailing, creating issues for the travel of older adults with/out disabilities. Researchers (Cochran 2020; Deakin et al. 2020) show that public agencies could effectively partner with ride-hailing companies to expand mobility for this group. Researchers have also studied the nature of the shared ride-hailing market (Gehrke et al. 2019; Middleton and Zhao 2019), since shared rides are more cost effective and may be attractive to older adults with limited income. Leistner and Steiner (2017) investigated a case in Gainesville, FL of a transit agency's partnership with a ride-hailing service aimed at providing travel options for older adults. They learned that older women found ride-hailing attractive and kept using it for the length of the program, especially for social, shopping, and medical trips. Shirgaokar et al. (2021) found that older adults from suburbs and small towns were more likely to ride-hail compared to those from cities. Some characteristics of ride-hailing patrons, namely, use by individuals from households with fewer cars than drivers, the disabled, and occasional riders (Brown 2019; Tirachini 2019) suggest that this service is also likely to be useful for older adults.

2.2 Comfort with technology

Those who are comfortable with technology, for example millennials and generation Xers, are also likely to be users of technology-enabled services (Alemi et al. 2019; LaMondia et al. 2018). Being *un*comfortable with using technology can become a critical barrier to exploring new options including transportation (Kim et al. 2016; Pangbourne 2018). Though it is popular opinion that older adults today are not comfortable with technology, researchers have shown this is not always the case (Agrawal et al. 2020; Anderson 2017; Faber and van Lierop 2020). In

contrast, some researchers have found that old age is related to a lack of comfort with technology (Heart and Kalderon 2013; Pangbourne et al. 2010). Yet, Peek et al. (2016) learned that comfort and acceptance of technology in older adults is context-dependent. For example, older women were more accepting of ride-hailing compared to older men in a demonstration project for using Uber instead of transit for trips (Leistner and Steiner 2017). Vivoda et al. (2018), however, observed that older men have more e-hail knowledge compared to older women, demonstrating higher comfort with technology.

Researchers have also shown that older adults are willing to learn and adopt new tools but may not be comfortable with the ways in which they have to teach themselves to use technology (Abraham et al. 2017). This is especially important because the ecosystems (i.e., rules, objects, motives, and community) of smartphone-based transportation technology vary (Ettema 2017; Pangbourne et al. 2010). Other socio-economic barriers remain in addition to acceptance and comfort with technology. Researchers have shown that low-income individuals and persons of color might face far more barriers with access to the smart-technology ecosystem (Golub et al. 2019; Groth 2019). Further concerns, such as privacy, might remove potential users of new technology from the market (Groth 2019).

2.3 Acceptance of technology models

Ajzen presented the theory of planned behavior (TPB). He proposed that the attitudes towards a behavior (e.g., positive feelings about ride-hailing), subjective norms (e.g., other friends ride-hail so it is acceptable), and perceived behavior control (e.g., ease of booking the service) nudged intentions leading to behaviors (e.g., actual booking) (Ajzen 1991, pg. 182). Within the technology acceptance models (TAM), Davis et al. (1989. Pg. 985) and Venkatesh and Davis (2000, pg. 188) offered a related but different view with a particular link to perceived behavior control from TPB. They proposed that the intention to use a system (e.g., book ride-hailing) was determined by attitudes that included two constructs, namely, perceived ease of use (how easy it is to book a ride-hailing trip) and perceived usefulness (how useful is ride-hailing). Given how older adults view technology such as ride-hailing (Mitra et al., 2019; Shirgaokar 2018; Vivoda et al. 2018), these two constructs are particularly salient to our work. Our research includes insights from both TPB (Ajzen 1991) and TAM (Davis et al. 1989; Venkatesh and Davis 2000). For the curious reader, Taherdoost (2018) offers a comprehensive review of the various proposed models.

Researchers have used TPB (Ajzen 1991) to understand the psychology of travel behavior. For example, Dill et al. (2014) used TPB to study bicycling. The technology acceptance model (TAM) (Davis et al. 1989) has been the lens to study older adults' use of social networking sites (Braun 2013), electric vehicle acceptance (Globisch et al. 2018), and ICT use (Macedo 2017). Some studies, like ours, used constructs form both TPB and TAM to investigate technology acceptance (Buckley et al. 2018; Heart and Kalderon 2013). More generally, researchers have studied the role of attitudes in travel behavior for some time including examination of acceptance of technology along with attitudes. For example, Alemi et al. (2018) included attitudes in their analysis of ride-hailing acceptance among millennials and genXers.

Overall, this literature review showed that a smaller percentage of older adults ride-hail but their travel needs point to a suppressed market for such services. Research on comfort with technology indicates that older adults may use technology more widely than is commonly

assumed; yet using technology comfortably remains a challenge for this demographic. Mobility options that rely heavily on technology need to come to terms with concerns around access for older adults who may be on limited incomes or identify as persons of color. The challenge of using technology can be investigated using models such as the theory of planned behavior and the technology acceptance model. In this paper, we addressed the gap in the literature by showing how attitudes towards technology were linked to technology use for booking ride-hailing trips in older adults.

3. Data collection and sample characteristics

Our study examined data from California, which has a large and growing population of adults 55 years and over. Projections indicate that the population over 55 will grow from 11.1 million in 2020 to 14.6 million in two decades (California Dept. of Finance, 2021). We collected data on Californians 55 years and older using an online survey platform, an increasingly common method for surveys of the general population (e.g., Alemi et al., 2019; Middleton and Zhao 2019).

While an online survey would have excluded a large fraction of older adults a decade ago, today a majority of Californians 55 and older do use online technologies. American Community Survey microdata show that, based on 5-year estimates from 2018, 73% of adults 55 and over in California had smartphones and 86% had internet access through at least one device. Among adults 65 and over in California, 65% had smartphones, while 82% had internet access. Just a year later in 2019, the year of the survey, even these very high rates of smartphone and internet use are likely underestimates, given the continuing growth in the proportion of adults who are online (Anderson 2017). Assuming this trend continues, even more *future* older adults are likely to be comfortable with online technology.

An important consideration with respect to an online survey is that the method can exclude adults who are, on average, most likely to be older, lower income, less educated, and living in rural communities (Perrin and Atske 2021). We compensated for this limitation by using quota sampling. The sampling quotas were set up to be comparable to the population in terms of basic socio-demographics. Specifically, with respect to gender, race and ethnicity, employment status, annual household income, and age as reported in 2017 American Community Survey (5-year estimates), the sample is similar to the California population 55 years and older. Yet, even with quota sampling, there remains the possibility that our study oversampled in a group of Californians 55 and over who are comfortable with technology use, thus biasing our results. In future work, we hope to use in-person/phone-based survey and interview techniques to specifically explore how those with low levels of access and comfort to technology think of ride-hailing services. Likewise, in future analyses with the current data, we hope to incorporate finer measures such as age as a continuous variable as well as explore spatial aspects of ride-hailing behaviors among older adults.

The survey questionnaire was designed to measure the extent to which respondents were using ride-hailing, how they accessed the services, and their opinions about ride-hailing. In addition, we collected information on factors that we hypothesized might influence ride-hailing use and opinions: communication access; comfort with use of technology; frequency of use of ride-hailing services; valuing features of ride-hailing; comfort with using ride-hailing, credit cards, etc.; benefits of ride-hailing; and the standard socio-economic factors of age, gender, race, ethnicity, employment status, and household income.

Qualtrics fielded the survey from June 19 to September 9, 2019, using their online survey applications and with a panel they recruited. Agrawal et al. (2020) discuss further details about the survey methodology and the survey instrument is presented in the **Appendix**. We received completed records for 2,917 respondents. For weighted statistics of variables used in the models for this paper, see **Table 1**.

Table 1 Weighted summary statistics for full sample (users and non-users)

	N	Mean/ Propor -tion	Std. Dev.	Median	Min.	Max
Outcome Variables						
Booked a ride-hailing trip myself over the telephone with a live agent	2,824	9%			0	1
Booked a ride-hailing trip myself using an app	2,871	29%			0	1
Taken a ride-hailing trip that was booked for me	2,838	24%			0	1
Ridden along on a ride-hailing trip with a family member/friend/caregiver who booked the trip	2,861	31%			0	1
Explanatory Variables						
Urban	2,910	28%			0	1
Suburban	2,910	50%			0	1
Rural	2,910	22%			0	1
Number of days commuting per week	1,014	3.98	1.45	5	1	5
Can drive alone	2,903	83%			0	1
Gets a ride from family	2,895	65%			0	1
Gets a ride from friends/neighbors	2,880	38%			0	1
Has disability	2,905	16%			0	1
Has physical health issues	2,908	9%			0	1
Female	2,903	61%			0	1
Senior (65 years and over)	2,917	44%			0	1
White	2,917	53%			0	1
Hispanic	2,917	32%			0	1
College educated	2,910	24%			0	1
Household income ($)	2,917	69,869	66,487	37,500	2,500	250,000

Note: These statistics are weighted to represent the population of California 55 years and older.

Figure 1 presents weighted distributions of the manner in which Californians 55 and older interact with ride-hailing booking (see Q. 13 in **Appendix**). As expected, more respondents in the 55-64 year cohort used various methods to access ride-hailing compared to the 65 and older group.

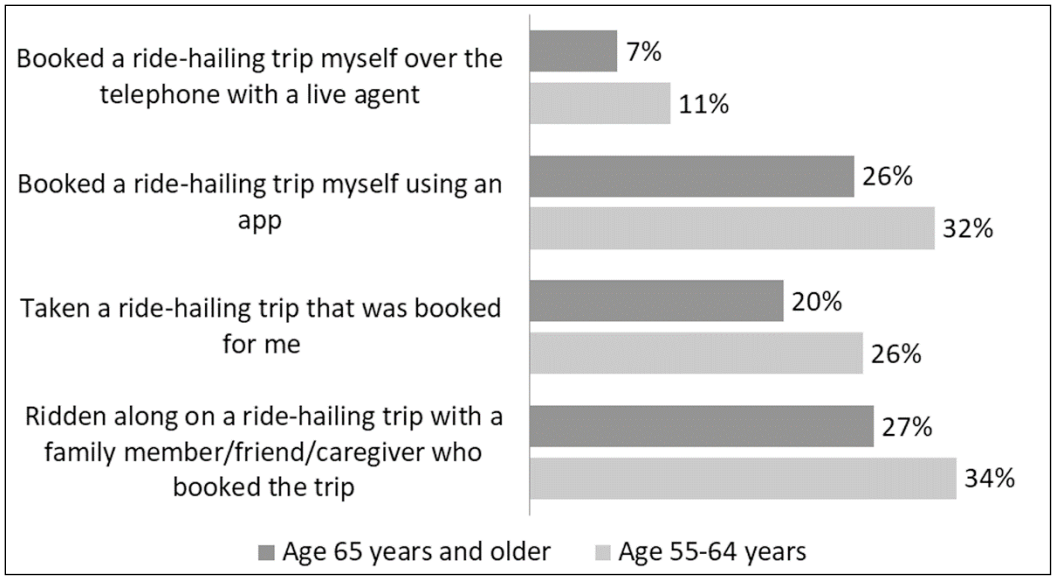

Figure 1 Interactions with Ride-hailing among Californians 55 years and older

We estimate that 48% of the 55-64 year cohort and 44% of the 65 years and older group have experienced ride-hailing in at least one of the four ways listed in **Figure 1**. Further, 34% of the 55-64 year cohort and 27% of the 65 years and older group have booked a trip themselves using the app or over the phone.

4. Analytical Approach

For this analysis, we used the following survey question: "Have you used ride-hailing in any of the following ways?" Respondents had four options to choose from for this question (trip booked by themselves using app; or over phone; trip booked by others for them; and trip booked by others that was taken with them), and for each option, they could either answer yes or no. We used binary discrete choice models to relate their choices with their attitudes and socio-demographic attributes. For explanatory variables that can capture attitudes of comfort with technology adoption, we used factor analysis to identify items within the survey that can be used as surrogates for these attitudes.

4.1 Confirmatory factor analysis

Analysts use factor analysis to identify patterned variation among some or all the observed variables and group them into relevant meaningful factors, thus reducing multi-collinearity and dimensionality within the data (Rummel 1988; Thurstone 1947). Factor analysis is built upon the understanding that variability within the data can be decomposed into a few main components. A part that is common among the variables i.e., the trend or pattern in variation, also known as communality among the variables, and another part that is distinctive to any variable, also known as uniqueness of any variable. The unique part of the variation can again be decomposed into random and explained parts.

The role of factor analysis is to uncover the communalities among variables such that variables sharing high communalities, and having a meaningful explanation of doing so, can be grouped together into a factor. Factor analysis can be exploratory or confirmatory. As the name

suggests, exploratory factor analysis is used to identify relations between seemingly unrelated variables, while confirmatory factor analysis is used to justify a previously decided upon hypothesis or correlation among variables. While factor analysis is a popular method of dimensionality reduction and latent trend identification, there has been significant criticism about factor analysis being used in post-hoc data analyses to force data into some relational structure (Fabrigar et al. 1999, Fabrigar and Wegner 2012).

In the travel behavior literature, researchers have used factor analysis widely to extract latent constructs from responses to survey questions (e.g., Shirgaokar and Habib 2018). We used confirmatory factor analysis in our research, since we were cognizant of the criticisms of exploratory factor analysis. We designed the survey questions based on the conjecture that participants owning and using newer technology such as smartphones were likely to be similar in preference to those who used internet-based services like e-payment systems, booked ride-hailing trips over apps, or used ride-hailing services overall. Our factor analysis was, therefore, a confirmatory factor analysis to test our assumptions, using the data collected. Specifically, the confirmatory factor analysis focused on the following:

1. Communication access (5 items – landline phone, simple cell phone (no internet browsing), smartphone connected to the internet with apps, computer with internet access, tablet with internet access).
2. Comfort with use of technology (8 items – using an app on a smartphone or tablet, sending and receiving text messages, making a video call, searching for information online, paying bills online, buying something at a store with a credit card, buying something online with a credit card, checking a bank balance online).
3. Frequency of use of ride-hailing services (3 items – frequency of use in hometown, frequency of use when out of town, use at night). We use frequency here as a surrogate measure of familiarity with ride-hailing services. In particular, difference in use when in hometown, out of town, and at night gives us a more nuanced idea of level of confidence with using ride-hailing services. On the one hand, respondents who do not use ride-hailing frequently in their hometown (low score on the item frequency of use in hometown) but do so out of town (high score on the item frequency of use when out of town) are likely individuals who have access to own cars at home but feel confident using ride-hailing services as they use the service elsewhere. On the other hand, respondents who score low on both these items are people who may not feel confident using ride-hailing services. Thus, including these items in the factor analysis provides us a surrogate to measure confidence of using ride-hailing services.
4. Valuing features of ride-hailing (6 items – vehicle is accessible, driver is trained to help older passengers, driver gives a paper bill that can be paid at a local store, can book trip over the phone with a live agent, can pay with a pre-loaded card, company helpline to call).
5. Comfort with using ride-hailing, using credit card, etc. (4 items – riding with unknown driver, sharing credit-card with ride-hailing company, using ride-hailing after dark, or sharing trip with other unknown passengers).
6. Benefits of ride-hailing (4 items – can go out without relying on family/friends, can go out at night without the need to drive, do not worry about getting lost when driving, help with carrying bags to my door).

Overall, 30 items from the survey were used in the factor analysis. A scree plot (**Figure 2**) based on principal component analysis (PCA) is used to initially determine the approximate

number of factors for representing the 30 variables. **Table 2** shows the results of our confirmatory factor analysis.

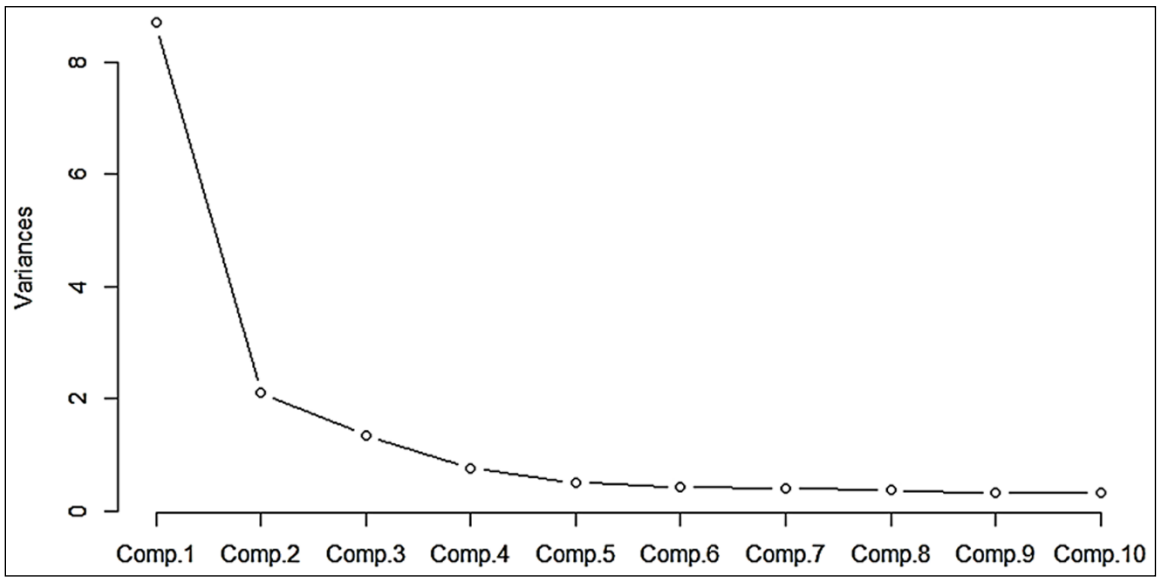

Figure 2 Scree plot for factor analysis

As seen from the scree plot, either a two-factor or a three-factor solution could capture most of the variation in the data, and accordingly, we performed factor analysis using three and two factor solutions. The three-factor solution captured 32% of the variation while a two-factor solution captured 26% of the variation in the factor variables. However, the two-factor solution appeared to be more logically consistent in identifying distinct group characteristics, hence, we relied on the two-factor solution for this paper. We carried out the factor analysis using VARIMAX rotation in R using the function *factanal*.

Table 2 presents the factor loadings on each of the thirty responses. Any variable with a score of 0.4 and higher on a factor is used to indicate significant loading on that factor and is used to define the factor. Similar to most studies utilizing the factor analysis method, this threshold is determined by the analyst based on previous experience and thresholds used in similar studies. For an excellent meta-analysis on acceptable factor loadings used in research historically see Peterson (2000), where the author points out that factor loadings of +/- 0.3 is considered minimum while +/- 0.4 is considered "more important". Variables with scores lower that 0.4 are not considered important in defining that factor; hence, are not presented. However, we have included the negative loadings in **Table 2** even when they are below the 0.4 threshold. Our aim is to understand which individual features can negatively impact respondents' perception and use of ride-hailing services, although they may not be significant when presented in combination with other features.

Table 2 Factor Loadings on Items

Items	Factor 1 (Confident)	Factor 2 (Cautious)
Has landline		
Has simple cellphone	**-0.400**	
Has a smartphone with app	**0.418**	
Has a PC with internet		-0.172
Has a tablet with internet		

Comfortable in using an app	**0.672**	
Comfortable in sending and receiving text	**0.487**	
Comfortable in making a video call	**0.527**	
Comfortable in searching the internet	**0.505**	
Comfortable in paying bills over the internet	**0.590**	-0.105
Comfortable in using card payment in stores	0.398	-0.147
Comfortable in using cards for purchase online	**0.540**	-0.132
Comfortable in checking bank balance online	**0.544**	-0.129
Use ride-hailing services at night	**0.430**	
Frequency of use of ride-hailing services when in hometown		0.359
Frequency of use of ride-hailing services when out of town	**0.444**	
Values accessible vehicle feature		**0.662**
Values ability to book with a trained agent over phone	-0.295	**0.614**
Values driver being trained in elder care	-0.100	**0.753**
Values having a hotline to book a trip		**0.640**
Values having a paper bill at the end of the trip	-0.135	**0.482**
Values having a prepaid card for the service		**0.602**
Comfortable in using ride-hailing at night	**0.535**	
Comfortable sharing credit card with ride-hailing company	**0.539**	
Comfortable sharing ride with other unknown passengers		
Comfortable riding with an unknown driver	**0.511**	
Ride-hailing can help to not rely on others		**0.567**
Ride-hailing can help in getting help with carrying bags		**0.576**
Ride-hailing can help with travel at night		**0.442**
Ride-hailing can help in not getting lost		**0.525**
	Factor 1 (Confident)	**Factor 2 (Cautious)**
SS loadings	4.253	3.789
Proportion Var	0.137	0.122
Cumulative Var	0.137	0.259

Notes: Test of the hypothesis that two factors are sufficient: The chi-square statistic is 6029.49 on 404 degrees of freedom. The p-value is 0.000.

As seen in **Table 2**, responses to these items can be grouped into two categories. One group is comprised of elements indicating comfort with the latest technologies and ride-hailing services, which indicate a high-tech, pro-technology adoption attitude. We dubbed this attitude as "confident". The other group of variables indicates a lack of comfort using technologies in financial transactions and a greater valuing of additional features of ride-hailing services such as paper bills and booking with agents, thus indicating low-tech, pro ride-hailing attitude. We dubbed this attitude "cautious".

4.2 Which socio-demographic characteristics are associated with the two attitudes?

The next step was to investigate whether there are statistically significant relationships between various socio-demographic characteristics and the attitudinal factors. Does being in any particular socio-demographic group increase or decrease the likelihood of being comfortable using online technologies? Our hypothesis was that seniors (i.e., those 65 and older) and female respondents were likely to be less comfortable with technology adoption and use than their male counterparts, while higher education and income would increase the likelihood of being comfortable with technology adoption and use.

Table 3 shows the results of two models relating the two types of attitudes with socio-demographic attributes of the respondents. Since factor scores are continuous, we introduced two

proxy binary variables—"confident" and "cautious"—for classifying each respondent. We used the same cut-off as the factor analysis for group assignment, i.e., if the respondent had a factor score greater than 0.3 for a particular factor, the respondent is considered being in that attitude group. In other words, if a respondent scores 0.3 or greater for factor 1, the variable confident is coded as 1 while if the score is 0.3 or less, the same variable is coded as 0. The binary variables "confident" and "cautious" are then each separately modeled using discrete probit choice models. A detailed explanation of discrete choice models, of which probit models are a subclass, is provided in **Section 5**.

Table 3 Binary Probit Models Relating Attitudes to Socio-demographics

	Confident			*Cautious*		
	Estimate	**Std. Err.**	**Sig**	**Estimate**	**Std. Err.**	**Sig**
(Intercept)	-0.494	0.138	***	0.637	0.140	***
Living at an Urban Location	0.093	0.116		0.008	0.116	
Living at a Suburban Location	0.144	0.109		-0.360	0.109	***
Being Female	-0.268	0.069	***	0.132	0.071	.
Being Senior	-0.344	0.072	***	-0.188	0.073	**
Being White	0.179	0.073	*	-0.216	0.074	**
Being College Educated	0.086	0.077		-0.261	0.077	***
Household Income($10K)	0.036	0.005	***	-0.036	0.005	***
Being Hispanic	0.208	0.098	*	-0.012	0.099	
McFadden's Rho-sq	0.07			0.10		
	Null deviance: 2,027.7 on 1,467 degrees of freedom			Null deviance: 1,964.8 on 1,467 degrees of freedom		
	Residual deviance: 1,891.6 on 1,459 degrees of freedom			Residual deviance: 1,778.4 on 1,459 degrees of freedom		
	AIC: 1,909.6			AIC: 1,796.4		

Notes: Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '^' 0.1 ' ' 1

Following our hypothesis, as compared to male, being female is negatively related to having a confident attitude but positively related to exhibiting a cautious attitude towards technology adoption. In contrast, exhibiting confident attitude increases positively with higher income while being negatively related to exhibiting a cautious attitude. Being college educated is negatively related to the cautious attitude as is being White. Contrary to our hypothesis, older adults, relative to those in the 55-64 year group, are less likely to be in either attitudinal group, possibly indicating the general disinclination to use ride-hailing services among the 65 years or older group. Thus, these models indicate that females are more likely to be cautious adopters of technology, while higher income, White and Hispanic individuals, and those who are college educated are more likely to be confident adopters and users of technology.

5. How Attitudes are linked to Ride-hailing Booking Behavior

In the final stage of this analysis, we used causal models to study how these attitudes towards technology influenced trip-booking behavior. The dependent variable was the following survey question: "Have you used ride-hailing in any of the following ways?" Respondents had four binary choices: (i) booked a ride-hailing trip myself over the telephone with a live agent, (ii) booked a ride-hailing trip myself using an app, (iii) taken a ride-hailing trip that was booked for me, and (iv) ridden along on a ride-hailing trip with a family member/friend/caregiver who

booked the trip. Each booking option was offered as a binary choice where the respondent could answer yes or no (**Figure 1** and **Appendix** Q. 13).

We used discrete choice models in our analysis. Discrete choice models are econometric decision models based on utility maximization theory of consumer behavior. The underlying concept of utility maximization theory is that when faced with competing alternatives, consumers choose the alternative that gives them maximum utility or satisfaction (Ben-Akiva and Lerman 1985; Koppelman and Bhat 2006; McFadden 1974; Train, 2009). Utility is defined as a function of attributes of the alternatives and of the decision maker. Here U_{ij} is the utility that consumer j derives from alternative i, which is given as $U_{ij} = f(x_i, z_j)$, where x_i is the vector of attributes of the alternative i and z_j is the vector of characteristics of consumer j. Since it is not possible for the analyst to know all the factors that go into the decision making process of the consumer, random utility models (RUM) are proposed which split the utility U_{ij} into two components, the deterministic, observed part of the utility V_{ij} and the stochastic, unobserved part of the utility e_{ij}. Following RUM then U_{ij} becomes

$$U_{ij} = V_{ij} + e_{ij},$$

where e_{ij} may include unobserved heterogeneity due to alternatives and consumer characteristics. Based on the distribution of difference between e_{ij}, RUM models are classified into different families of models, one of which is the probit model where the e_{ij} are normally distributed as is the difference between e_{ij} (Ben-Akiva and Lerman 1985).

The advantage of using probit models instead of the more commonly used logit model is that probit models allow for the unobserved characteristics among alternatives to be correlated. This is more appropriate for our dataset. For example, spatial effects (neighborhood cohorts) or living situation effects (single family versus senior living community) may influence decision and attitude of individuals towards ride-hailing services but these variables are not part of our explanatory variables. These characteristics then become one of the elements of the unobserved part e_{ij} in the utility equation for each individual, introducing correlation among e_{ij} across different individuals. Probit specifications allow us to explicitly model correlated unobserved characteristics among individuals and, hence, are adopted for this analysis.

Table 4 shows the four probit models for the ride-hailing booking choices made by the respondents. The factor variables of attitude towards technology (confident and cautious) were included in the model, as were variables related to location (urban/suburban/rural), general travel behavior (number of weekly commute days, drives alone, relies on family/friends for a ride), and health condition (including disability). Finally, all socio-demographic variables that were used to weight the data for representativeness were included in the model as control variables. To ensure that multicollinearity issues do not affect the model results, we performed Variation Inflation Factor (VIF) tests on each of the models. VIFs values for all variables were below 3, indicating no significant multicollinearity issues in the models.

To develop the model, variables were added one at each step and model fit improvements were checked to ensure balance between model fit and interpretability. The model fits of the final models with desired set of explanatory variables are high, ranging from 0.60 to 0.71. Variables that were not significant in any model but had consistent expected signs, and were supported by theory, were kept in the final set of models because they provide insights for future of ride-hailing and policy decisions.

Our models show that, having more of the confident attitude towards technology increases the odds of self-booking ride-hailing trips, using an app by 2.4 times, while increasing

the odds of using phone to book the ride by 1.1 times but decreasing the odds of having the ride booked by someone else. Having more of the cautious attitude towards technology, however, increases the odds of booking ride-hailing trips using an app by 1.2 times but that of booking over phone by 1.5 times, and that of getting the ride booked by someone else by 1.4 times. These findings are in agreement with the technology adoption model (TAM) proposed by Davis et al. (1989) and Venkatesh and Davis (2000). In our case, respondents who are more confident using other technologies are likely to find it easy to adopt new technologies. These individuals have likely come to realize the usefulness of technologies in daily life and are more likely, therefore, to use ride-hailing apps. Respondents in our study who are more cautious about using technologies in general are also less likely to book using ride-hailing apps and more likely to use phone-based booking.

The models also show that various personal characteristics increase the odds of self-booking ride-hailing trips. Individuals from urban areas are more likely to book trips by themselves, either using an app or over the phone. We suspect this trend to be a result of prevalence of ride-hailing services in urban areas as compared to suburban or rural areas (Alemi et al. 2018), and the resulting familiarity with related booking technologies among urban peers. This is an example of context dependent acceptance of technology among urban older adults (Peek et al. 2016; Shirgaokar et al. 2021). Respondents who get a ride from friends and family are likely to have trips booked by others and take trips with others, as expected. Individuals having health issues and physical disabilities are *more* likely to book trips using an app or by getting the trip booked by others. While this result is contrary to what we originally expected, it likely points towards people's need for autonomy and acceptance of a technology that can help them achieve that autonomy in some aspects of life (Cochran 2020). College educated individuals are also more likely to take trips with others that have been booked by others, as are female and Hispanic respondents. Hispanic respondents are significantly less likely to book a trip using an app. Even after controlling for attitudes, being White increases the odds of booking trips over phone while being college educated increases the odds of booking trips using an app, both by 1.3 times. The results for the college educated respondents validate earlier research by Alemi et al. (2018) that shows greater adoption of ride-hailing technology among the young and more educated populace. That adoption trend may naturally extend to adoption of ride-hailing apps and their use among the college educated. Women taking trips with others is a traditional gendered trip making behavior, where women are mostly found to take trips with family members, catering to family needs (Luiu et al. 2017; Rosenbloom 2004). However, since our respondents are older adults, the lower app use by women might also be an indicator of older women being less comfortable in using ride-hailing and its related technologies by themselves; hence, making trips with others, which is somewhat in contradiction with the findings from the Gainesville, FL case study by Leistner and Steiner (2017). Studies by other researchers (Golub et al. 2019; Groth 2019) have shown that people of color and low income individuals have more barriers to accessing technologies than others. We suspect that our finding that Hispanic individuals use the ride-hailing app less than non-Hispanic persons is a confirmation of these findings.

Table 4 Binary Probit Models for Trip Booking Behavior

	Booked by Self Over Phone				**Booked by Self Using App**				**Booked by Others**				**Booked by Others with Whom Ride Taken**			
	Coef.	*Sig.*	*Std. Err.*	*Odds Ratio*	*Coef.*	*Sig.*	*Std. Err.*	*Odds Ratio*	*Coef.*	*Sig.*	*Std. Err.*	*Odds Ratio*	*Coef.*	*Sig.*	*Std. Err.*	*Odds Ratio*
Intercept	-1.31	**	0.407	0.27	0.53		0.397	1.70	-0.76	*	0.345	0.47	-0.41		0.353	0.66
"Confident" attitude towards technology	0.10		0.082	1.11	**0.86**	***	0.085	**2.36**	0.00		0.068	1.00	0.01		0.068	1.01
"Cautious" attitude towards technology	**0.42**	***	0.077	**1.51**	**0.16**	*	0.075	**1.18**	**0.36**	***	0.065	**1.43**	0.04		0.066	1.04
Urban *(Rural ref.)*	0.15		0.245	1.16	0.26		0.218	1.30	-0.02		0.198	0.98	-0.34		0.216	0.71
Suburban *(Rural ref.)*	0.24		0.234	1.27	**0.45**	*	0.207	**1.56**	0.11		0.188	1.12	-0.31		0.207	0.73
Number of days commuting per week	0.04		0.044	1.04	-0.07		0.043	0.94	0.03		0.037	1.03	0.02		0.037	1.02
Can drive alone	0.00		0.217	1.00	-0.02		0.226	0.98	0.02		0.199	1.02	0.30		0.197	1.34
Gets a ride from family	-0.22		0.179	0.80	-0.02		0.181	0.98	0.23		0.154	1.26	**0.33**	*	0.150	**1.39**
Gets a ride from friends/neighbors	-0.23		0.165	0.79	**-0.31**	^	0.166	**0.73**	**0.36**	*	0.142	**1.43**	**0.68**	***	0.143	**1.97**
Has disability	0.06		0.264	1.06	0.18		0.277	1.20	0.35		0.252	1.41	-0.17		0.251	0.84
Has physical health issues	0.05		0.296	1.06	**0.62**	^	0.364	**1.86**	0.09		0.286	1.09	-0.32		0.280	0.73
Female	0.12		0.132	1.12	-0.13		0.129	0.88	0.07		0.112	1.07	**0.34**	**	0.117	**1.40**
65 years and over *(55-64 years ref.)*	-0.09		0.148	0.91	-0.12		0.142	0.88	0.08		0.126	1.09	-0.09		0.129	0.91
White	**0.29**	*	0.139	**1.34**	-0.11		0.135	0.90	**0.23**	*	0.119	**1.26**	0.00		0.122	1.00
Hispanic	0.05		0.170	1.05	**-0.30**	^	0.170	**0.74**	0.16		0.151	1.18	**0.30**	^	0.160	**1.34**
College educated	-0.01		0.149	0.99	**0.29**	^	0.143	**1.34**	0.06		0.130	1.06	**0.23**	^	0.132	**1.26**
Household income ($10,000)	0.00		0.010	1.00	0.01		0.009	1.01	0.00		0.008	1.00	0.01		0.009	1.01
Number of observations	583				599				579				592			
LL(0)	-639.3				-924.1				-985.3				-924.2			
LL(ρ)	-256.8				-270.4				-371.0				-343.1			
Mcfadden's ρ2	0.60				0.71				0.62				0.63			

Notes: Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '^' 0.1 ' ' 1

6. Discussion and Policy Implications

Ride-hailing services can provide accessible mobility to older adults, especially to seniors who have ceased driving an automobile. Our survey found that older adults in California interacted with ride-hailing services in various ways. We investigated four ways of trip booking: self-booking on phone, self-booking via app, riding alone in a trip booked by someone else, and riding along with family/friend/caregiver who booked a trip. Our findings showed that, contrary to the popular belief that those 65 and older do not ride-hail, 44% have experience being on a ride-hail trip and 27% have booked a ride themselves using the app or over the phone. Note that the access methods for three out of four older adults were non-app based, which suggested that the ride-hail app has a limited role in expanding ride-hailing as a means of mobility.

We constructed two latent attitudinal variables using factor analysis, namely, confident with technology, and cautious with technology. Each individual has both attitudes in some measure. Our use of probit models acknowledged that unobserved heterogeneity in ride-hailing booking behavior is likely to be correlated, especially among respondents sharing similar travel behavior and/or living arrangements. The probit models (**Table 4**) showed that attitudes towards technology were significantly related to booking behavior of the respondents. Those who were more confident about technology were more likely to book via the app, while those who tended to be cautious about technology were likely to use all means of accessing ride-hailing including phone booking and relying on others to book a trip for them.

On the one hand, respondents who used ride-hailing services but were not confident adopters of technology indicated discomfort in online or mobile financial transactions, and valued having a prepaid card or a paper receipt at the end of the trip. They also valued having additional features in ride-hailing services such as drivers trained in the care of older adults or having an accessible vehicle, help with carrying bags, and the ability to book rides over phone with a live agent. On the other hand, the confident technology adopters viewed paper bills and booking over phone with an agent as possible negative attributes of the service, and were comfortable sharing financial information online. On trip booking behavior, corroborating Alemi et al. (2018), our findings also indicated that the younger 55-64 year group, and higher income and college educated individuals, were likely to use ride-hailing apps to book trips by themselves.

The study results suggested that changes to certain service features would expand the number of adults 55 years of age and older who use ride-hailing services. Ride-hailing companies can expand the pool of older adults willing to use the services by adding more accessible options for booking trips such as having the ability to book a trip over phone or having a prepaid card. These features could help users feel safe and in greater control since many older adults are uncomfortable with sharing financial information online or through apps. Similarly, value-added features such as accessible vehicles and drivers trained in elder care can go a long way in helping older adults trust and rely on ride-hailing service for their mobility needs. Our work suggests that non-app mechanisms to access ride-hailing such as phone booking are critical and can expand this service to those who do not have internet access and smartphones. In California, based on 2018 American Community Survey 5-year estimates, about 52,000 older adults do not have internet access and 1 million do not have a smartphone.

Ride-hailing companies could partner with public sector agencies (Deakin et al. 2020; Shirgaokar 2018) to expand this service including explore cost-sharing, contracting of specialized vehicles/drivers, phone-based support, and training courses for older adults who wish

to learn how to use these services. The emerging literature in this area and our work (**Table 4**) shows that women (Leistner and Steiner 2017; Luiu et al. 2017) and those with health conditions/experiencing disabilities (Cochran 2020) particularly need support in learning to use ride-hailing services. In conclusion, our study corroborates many findings from the literature on older adults, and suggests that there is a large current and future market for ride-hailing among older adults *if* individuals could find it easy to book a ride.

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References

1. Abraham, H., Lee, C., Brady, S., Fitzgerald, C., Mehler, B., Reimer, B., & Coughlin, J. (2017, January 1). *Autonomous Vehicles and Alternatives to Driving: Trust, Preferences, and Effects of Age*. Annual meeting of the Transportation Research Board, Washington D.C.
2. Agrawal, A., Shirgaokar, M., Misra, A., Wachs, M., & Dobbs, B. (2020). *Will ride-hailing enhance mobility for older adults? A California survey* (No. 20–30; p. 79). Mineta Transportation Institute. https://doi.org/10.31979/mti.2020.1815
3. Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T
4. Alemi, F., Circella, G., Handy, S., & Mokhtarian, P. (2018). What influences travelers to use Uber? Exploring the factors affecting the adoption of on-demand ride services in California. *Travel Behaviour and Society*, *13*, 88–104. https://doi.org/10.1016/j.tbs.2018.06.002
5. Alemi, F., Circella, G., Mokhtarian, P., & Handy, S. (2019). What drives the use of ridehailing in California? Ordered probit models of the usage frequency of Uber and Lyft. *Transportation Research Part C: Emerging Technologies*, *102*, 233–248. https://doi.org/10.1016/j.trc.2018.12.016
6. Anderson, G. (2017). *Technology Use and Attitudes among Mid-Life and Older Americans* (p. 29). AARP. https://www.aarp.org/content/dam/aarp/research/surveys_statistics/technology/info-2018/atom-nov-2017-tech-module.doi.10.26419%252Fres.00210.001.pdf (Accessed August 31, 2021)
7. Ben-Akiva, M., & Lerman, S. (1985). *Discrete choice analysis: Theory and application to travel demand*. MIT Press.

8. Braun, M. (2013). Obstacles to social networking website use among older adults. *Computers in Human Behavior*, *29*(3), 673–680. https://doi.org/10.1016/j.chb.2012.12.004
9. Brown, A. (2019). Redefining Car Access: Ride-Hail Travel and Use in Los Angeles. *Journal of the American Planning Association*, *0*(0), 1–13. https://doi.org/10.1080/01944363.2019.1603761
10. Buckley, L., Kaye, S, & Pradhan, A. (2018). Psychosocial factors associated with intended use of automated vehicles: A simulated driving study. *Accident Analysis & Prevention*, *115*, 202–208. https://doi.org/10.1016/j.aap.2018.03.021
11. California Dept. of Finance. (2021). *Demographic Projections (Total Estimated and Projected Population for California: July 1, 2010 to July 1, 2060 in 1-year Increments)*. http://www.dof.ca.gov/Forecasting/Demographics/Projections/ (Accessed August 31, 2021)
12. Cochran, A. (2020). Understanding the role of transportation-related social interaction in travel behavior and health: A qualitative study of adults with disabilities. *Journal of Transport & Health*, *19*, 100948. https://doi.org/10.1016/j.jth.2020.100948
13. Conway, M., Salon, D., & King, D. (2018). Trends in Taxi Use and the Advent of Ridehailing, 1995–2017: Evidence from the US National Household Travel Survey. *Urban Science*, *2*(3), 79. https://doi.org/10.3390/urbansci2030079
14. Coughlin, J. (2009). Longevity, Lifestyle, and Anticipating the New Demands of Aging on the Transportation System. *Public Works Management & Policy*, *13*(4), 301–311. https://doi.org/10.1177/1087724X09335609
15. Davis, F., Bagozzi, R., & Warshaw, P. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science*, *35*(8), 982–1003. https://doi.org/10.1287/mnsc.35.8.982
16. Deakin, E., Halpern, J., & Parker, M. (2020). *Examining the Potential for Uber and Lyft to be Included in Subsidized Mobility Programs Targeted to Seniors, Low Income Adults, and People with Disabilities*. https://doi.org/10.7922/G2NK3C9S
17. Dill, J., Mohr, C., & Ma, L. (2014). How Can Psychological Theory Help Cities Increase Walking and Bicycling? *Journal of the American Planning Association*, *80*(1), 36–51. https://doi.org/10.1080/01944363.2014.934651
18. Dobbs, B. (2012). The New Older Driver in the United States and Canada: Changes and Challenges. In *Aging America and Transportation: Personal Choices and Public Policy* (pp. 130–146). Springer Publishing Company.
19. Ettema, D. (2017). Apps, activities and travel: An conceptual exploration based on activity theory. *Transportation*, 1–18. https://doi.org/10.1007/s11116-017-9844-5
20. Faber, K., & van Lierop, D. (2020). How will older adults use automated vehicles? Assessing the role of AVs in overcoming perceived mobility barriers. *Transportation Research Part A: Policy and Practice*, *133*, 353–363. https://doi.org/10.1016/j.tra.2020.01.022
21. Fabrigar, L., & Wegener, D. (2012). *Exploratory Factor Analysis*. Oxford University Press.
22. Fabrigar, L., Wegener, D., MacCallum, R., & Strahan, E. (1999). Evaluating the use of exploratory factor analysis in psychological research. *Psychological Methods*, *4*(3), 272–299. https://doi.org/10.1037/1082-989X.4.3.272
23. Gehrke, S. (2020). Uber service area expansion in three major American cities. *Journal of Transport Geography*, *86*, 102752. https://doi.org/10.1016/j.jtrangeo.2020.102752
24. Gehrke, S., Felix, A., & Reardon, T. (2019). Substitution of Ride-Hailing Services for More Sustainable Travel Options in the Greater Boston Region. *Transportation Research Record*, 0361198118821903. https://doi.org/10.1177/0361198118821903

25. Globisch, J., Dütschke, E., & Schleich, J. (2018). Acceptance of electric passenger cars in commercial fleets. *Transportation Research Part A: Policy and Practice*, *116*, 122–129. https://doi.org/10.1016/j.tra.2018.06.004
26. Golub, A., Satterfield, V., Serritella, M., Singh, J., & Phillips, S. (2019). Assessing the barriers to equity in smart mobility systems: A case study of Portland, Oregon. *Case Studies on Transport Policy*, *7*(4), 689–697. https://doi.org/10.1016/j.cstp.2019.10.002
27. Grahn, R., Harper, C., Hendrickson, C., Qian, Z., & Matthews, H. (2019). Socioeconomic and usage characteristics of transportation network company (TNC) riders. *Transportation*. https://doi.org/10.1007/s11116-019-09989-3
28. Groth, S. (2019). Multimodal divide: Reproduction of transport poverty in smart mobility trends. *Transportation Research Part A: Policy and Practice*, *125*, 56–71. https://doi.org/10.1016/j.tra.2019.04.018
29. Habib, K. (2019). Mode choice modelling for hailable rides: An investigation of the competition of Uber with other modes by using an integrated non-compensatory choice model with probabilistic choice set formation. *Transportation Research Part A: Policy and Practice*, *129*, 205–216. https://doi.org/10.1016/j.tra.2019.08.014
30. Heart, T., & Kalderon, E. (2013). Older adults: Are they ready to adopt health-related ICT? *International Journal of Medical Informatics*, *82*(11), e209–e231. https://doi.org/10.1016/j.ijmedinf.2011.03.002
31. Hubers, C., & Lyons, G. (2013). New technologies for the old: Potential implications of living in later life for travel demand. *Transport Policy*, *30*, 220–228. https://doi.org/10.1016/j.tranpol.2013.08.005
32. Kim, S., Gajos, K., Muller, M., & Grosz, B. (2016). Acceptance of Mobile Technology by Older Adults: A Preliminary Study. *Proceedings of the 18th International Conference on Human-Computer Interaction with Mobile Devices and Services*, 147–157. https://doi.org/10.1145/2935334.2935380
33. Koppelman, F., & Bhat, C. (2006). *A self-instructing course in mode choice modeling: Multinomial and nested logit models*. U.S. Department of Transportation. http://www.caee.utexas.edu/prof/bhat/courses/lm_draft_060131final-060630.pdf (Accessed August 31, 2021)
34. LaMondia, J., Gajkowski, T., & Ramirez, V. (2018). Are Small- and Medium-Sized Community Paratransit Riders Ready to Adopt Real-Time Information (RTI) Technology? *Transportation Research Record*, 0361198118796019. https://doi.org/10.1177/0361198118796019
35. Leistner, D., & Steiner, R. (2017). Uber for Seniors?: Exploring Transportation Options for the Future. *Transportation Research Record*, *2660*, 22–29. https://doi.org/10.3141/2660-04
36. Luiu, C., Tight, M., & Burrow, M. (2017). The unmet travel needs of the older population: A review of the literature. *Transport Reviews*, *37*(4), 488–506. https://doi.org/10.1080/01441647.2016.1252447
37. Macedo, I. (2017). Predicting the acceptance and use of information and communication technology by older adults: An empirical examination of the revised UTAUT2. *Computers in Human Behavior*, *75*(Supplement C), 935–948. https://doi.org/10.1016/j.chb.2017.06.013
38. McFadden, D. (1974). The measurement of urban travel demand. *Journal of Public Economics*, *3*(4), 303–328. https://doi.org/10.1016/0047-2727(74)90003-6
39. Middleton, S., & Zhao, J. (2019). Discriminatory attitudes between ridesharing passengers. *Transportation*. https://doi.org/10.1007/s11116-019-10020-y

40. Mitra, S., Bae, Y., & Ritchie, S. (2019). Use of Ride-Hailing Services among Older Adults in the United States. *Transportation Research Record*, *2673*(3), 700–710. https://doi.org/10.1177/0361198119835511
41. Pangbourne, K. (2018). Mobility and Ageing: A Review of Interactions between Transport and Technology from the Perspective of Older People. In *Geographies of Transport and Ageing* (pp. 51–71). Springer International Publishing. https://doi.org/10.1007/978-3-319-76360-6_3
42. Pangbourne, K., Aditjandra, P., & Nelson, J. (2010). New technology and quality of life for older people: Exploring health and transport dimensions in the UK context. *IET Intelligent Transport Systems*, *4*(4), 318–327. https://doi.org/10.1049/iet-its.2009.0106
43. Peek, S., Luijkx, K., Rijnaard, M., Nieboer, M., Voort, C., Aarts, S., Hoof, J., Vrijhoef, H., & Wouters, E. (2016). Older Adults' Reasons for Using Technology while Aging in Place. *Gerontology*, *62*(2), 226–237. https://doi.org/10.1159/000430949
44. Peek, S., Wouters, E., van Hoof, J., Luijkx, K., Boeije, H., & Vrijhoef, H. (2014). Factors influencing acceptance of technology for aging in place: A systematic review. *International Journal of Medical Informatics*, *83*(4), 235–248. https://doi.org/10.1016/j.ijmedinf.2014.01.004
45. Perrin, R., Atske, S., *7% of Americans don't use the internet. Who are they?* Pew Research Center. https://www.pewresearch.org/fact-tank/2021/04/02/7-of-americans-dont-use-the-internet-who-are-they/ (Accessed August 31, 2021)
46. Peterson, R. (2000). A Meta-Analysis of Variance Accounted for and Factor Loadings in Exploratory Factor Analysis. *Marketing Letters*, *11*(3), 261–275. https://doi.org/10.1023/A:1008191211004
47. Rosenbloom, S. (2004). Mobility of the Elderly: Good News and Bad News. In *Transportation in an Aging Society: A Decade of Experience, technical papers and reports from a conference, November 7-9, 1999, Bethesda, Maryland* (pp. 3–21). Transportation Research Board of the National Academies. http://trb.org/publications/conf/reports/cp%5F27.pdf (Accessed August 31, 2021)
48. Rummel, R. (1988). *Applied Factor Analysis* (1 edition). Northwestern University Press.
49. Schmöcker, J., Quddus, M., Noland, R., & Bell, M. (2008). Mode choice of older and disabled people: A case study of shopping trips in London. *Journal of Transport Geography*, *16*(4), 257–267. https://doi.org/10.1016/j.jtrangeo.2007.07.002
50. Shirgaokar, M. (2018). Expanding seniors' Mobility through Phone Apps: Potential Responses from the Private and Public Sectors. *Journal of Planning Education and Research*, *40*(4), 405–415. https://doi.org/10.1177/0739456X18769133
51. Shirgaokar, M., & Habib, K. (2018). How does the inclination to bicycle sway the decision to ride in warm and winter seasons? *International Journal of Sustainable Transportation*, *12*(6), 397–406. https://doi.org/10.1080/15568318.2017.1378779
52. Shirgaokar, M., Misra, A., Agrawal, A., Wachs, M., & Dobbs, B. (2021). Differences in ride-hailing adoption by older Californians among types of locations. *Journal of Transport and Land Use*, *14*(1), 367–387. https://doi.org/10.5198/jtlu.2021.1827
53. Sikder, S. (2019). Who Uses Ride-Hailing Services in the United States? *Transportation Research Record*, 0361198119859302. https://doi.org/10.1177/0361198119859302
54. Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories. *Procedia Manufacturing*, *22*, 960–967. https://doi.org/10.1016/j.promfg.2018.03.137
55. Thurstone, L. (1947). *Multiple factor analysis*. University of Chicago Press.

56. Tirachini, A. (2019). Ride-hailing, travel behaviour and sustainable mobility: An international review. *Transportation*. https://doi.org/10.1007/s11116-019-10070-2
57. Train, K. (2009). *Discrete Choice Methods with Simulation* (2nd edition). Cambridge University Press.
58. Venkatesh, V., & Davis, F. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science*, *46*(2), 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926
59. Vivoda, J., Harmon, A., Babulal, G., & Zikmund-Fisher, B. (2018). E-hail (rideshare) knowledge, use, reliance, and future expectations among older adults. *Transportation Research Part F: Traffic Psychology and Behaviour*, *55*, 426–434. https://doi.org/10.1016/j.trf.2018.03.020
60. Warner, M., Homsy, G., & Morken, L. (2016). Planning for Aging in Place Stimulating a Market and Government Response. *Journal of Planning Education and Research*, 0739456X16642824. https://doi.org/10.1177/0739456X16642824

Appendix: Survey Instrument

[Group 1: Screening questions for sampling quotas]

1. What is your gender?
☐$_1$ Male
☐$_2$ Female
☐$_3$ Other

2. What is your current age? _____

3. Which of the following describes your race or ethnicity? (Check all that apply)
☐$_1$ White
☐$_2$ Black or African American
☐$_3$ Asian or Asian American
☐$_4$ American Indian or Alaska Native
☐$_5$ Hispanic, Latino/a, or of Spanish origin
☐$_6$ Native Hawaiian or Other Pacific Islander
☐$_7$ Other_____

4. What was your total annual household income in 2018 from all sources, before taxes?
☐$_1$ $0 to $4,999
☐$_2$ $5,000 - $9,999
☐$_3$ $10,000 - $24,999
☐$_4$ $25,000 - $49,999
☐$_5$ $50,000 - $74,999
☐$_6$ $75,000 - $99,999
☐$_7$ $100,000 - $149,999
☐$_8$ $150,000 - $199,999
☐$_9$ $200,000 or more

5. What is your current employment status?
☐$_1$ Working for pay
☐$_2$ Unemployed, but looking for work
☐$_3$ Not working for pay, by choice (retired, etc.)

[Group 2: Technology adoption]

6. Which of the following do you have and use? (Check all that apply)
☐$_1$ Landline phone
☐$_2$ Simple cell phone (no internet browsing)
☐$_3$ Smartphone connected to the internet with “apps” (like Google Maps)

☐$_4$ Computer with internet access
☐$_5$ Tablet with internet access (like an iPad)

7. How comfortable are you using smart phones/computers to do the following? [Randomize order]

	Very comfortable	Somewhat comfortable	Not at all comfortable
Using an "app" on a smartphone or tablet	☐$_1$	☐$_{11}$	☐$_{21}$
Sending and receiving text messages	☐$_2$	☐$_{12}$	☐$_{22}$
Making a video call (such as Skype or FaceTime)	☐$_3$	☐$_{13}$	☐$_{23}$
Searching for information online (such as bus schedules)	☐$_4$	☐$_{14}$	☐$_{24}$

8. How comfortable are you doing the following? [Randomize order]

	Very comfortable	Somewhat comfortable	Not at all comfortable
Paying bills online	☐$_1$	☐$_{11}$	☐$_{21}$
Buying something at a store with a credit card	☐$_2$	☐$_{12}$	☐$_{22}$
Buying something online with a credit card	☐$_3$	☐$_{13}$	☐$_{23}$
Checking a bank balance online	☐$_4$	☐$_{14}$	☐$_{24}$

9. Can you get help using a smartphone, from someone you know? (For example, a friend or relative)

☐$_1$ Yes, whenever I need help
☐$_2$ Sometimes
☐$_3$ No
☐$_4$ I don't need help using a smartphone or the internet

[Group 3: Ride-hailing use/familiarity]

Ride-hailing services such as Lyft and Uber connect passengers with drivers who offer rides in their own vehicles for a fee.

10. Have you heard of ride-hailing services?

☐$_1$ Yes
☐$_2$ No

11. As far as you know, are ride-hailing services available in your community?

☐$_1$ Yes

☐$_2$ No

12. Do you have an online account with any ride-hailing services? (Check all that apply.)
☐$_1$ Lyft
☐$_2$ Uber
☐$_3$ GoGo Grandparent
☐$_4$ Other_____

13. Have you used ride-hailing in any of the following ways? [Randomize order]

	Yes	No
Booked a ride-hailing trip myself over the telephone with a live agent (such as Lyft Concierge)	☐$_1$	☐$_2$
Booked a ride-hailing trip myself using an app	☐$_1$	☐$_2$
Taken a ride-hailing trip that was booked for me	☐$_1$	☐$_2$
Ridden along on a ride-hailing trip with a family member/friend/caregiver who booked the trip	☐$_1$	☐$_2$

14. When you are at home, how many days a month do you typically use ride-hailing? (Exclude trips made when you are out-of-town)
Days per month:_____

15. When you are out of town, how often do you use ride-hailing?
☐$_1$ Never
☐$_2$ Sometimes
☐$_3$ Frequently

[Group 4: Ride-hailing trip scenarios]
(Note to reader: This section is the execution of the stated preference design; logic transitions are *not* shown here. For questions 16-24, each survey taker was randomly presented with three of the nine prompts.)

The following questions present simple scenarios. These situations may or may not apply to your daily life. Please imagine being in the scenarios described and select the best answer.

16. Imagine you are making a trip today **to visit friends or family, or go to the movies**. Would you consider using ride-hailing services like Lyft/Uber if the one-way cost of the trip is $30?
☐$_1$ Yes
☐$_2$ No
☐$_3$ Maybe

17. Imagine you are making a trip today **to visit friends or family, or go to the movies**. Would you consider using ride-hailing services like Lyft/Uber if the one-way cost of the trip is $20?

☐$_1$ Yes
☐$_2$ No
☐$_3$ Maybe

18. Imagine you are making a trip today **to visit friends or family, or go to the movies**. Would you consider using ride-hailing services like Lyft/Uber if the one-way cost of the trip is $10?

☐$_1$ Yes
☐$_2$ No
☐$_3$ Maybe

19. Imagine you are making a trip today **for a pre-scheduled doctor's appointment**. Would you consider using ride-hailing services like Lyft/Uber if the one-way cost of the trip is $30?

☐$_1$ Yes
☐$_2$ No
☐$_3$ Maybe

20. Imagine you are making a trip today **for a pre-scheduled doctor's appointment**. Would you consider using ride-hailing services like Lyft/Uber if the one-way cost of the trip is $20?

☐$_1$ Yes
☐$_2$ No
☐$_3$ Maybe

21. Imagine you are making a trip today **for a pre-scheduled doctor's appointment**. Would you consider using ride-hailing services like Lyft/Uber if the one-way cost of the trip is $10?

☐$_1$ Yes
☐$_2$ No
☐$_3$ Maybe

22. Imagine you are making a trip today **to the grocery store or the pharmacy**. Would you consider using ride-hailing services like Lyft/Uber if the one-way cost of the trip is $30?

☐$_1$ Yes
☐$_2$ No
☐$_3$ Maybe

23. Imagine you are making a trip today **to the grocery store or the pharmacy**. Would you consider using ride-hailing services like Lyft/Uber if the one-way cost of the trip is $20?

☐$_1$ Yes
☐$_2$ No
☐$_3$ Maybe

24. Imagine you are making a trip today **to the grocery store or the pharmacy**. Would you consider using ride-hailing services like Lyft/Uber if the one-way cost of the trip is $10?

☐$_1$ Yes
☐$_2$ No
☐$_3$ Maybe

25. Which of the following service features might be important for you on the same trip? (Check all that apply) [If answer is "Yes" or "Maybe" for Q. 16-24]

☐$_1$ The vehicle is accessible (i.e., can store a wheelchair)
☐$_2$ The driver is trained to help older passengers
☐$_3$ The driver gives me a paper bill and I pay at a local store
☐$_4$ I can book the trip over the phone with a live agent (I don't have to use the app)
☐$_5$ None of the above
☐$_6$ Other _____

26. Which of the following service features might make you more likely to consider ride-hailing for the same trip? (Check all that apply) [If answer is "No" for Q. 16-24]

☐$_1$ The vehicle is accessible (i.e., can store a wheelchair)
☐$_2$ The driver is trained to help older passengers
☐$_3$ The driver gives me a paper bill and I pay at a local store
☐$_4$ I can book the trip over the phone with a live agent (I don't have to use the app)
☐$_5$ None of the above
☐$_6$ Other _____

27. Which of these is the single most important service feature for you?

☐$_1$ The vehicle is accessible (i.e., can store a wheelchair)
☐$_2$ The driver is trained to help older passengers
☐$_3$ The driver gives me a paper bill and I pay at a local store
☐$_4$ I can book the trip over the phone with a live agent (I don't have to use the app)
☐$_5$ The feature I suggested

28. Would you be willing to pay for this one important service feature you selected?

☐$_1$ Yes
☐$_2$ No

29. How much would you be willing to pay for this one feature? [If answer is "Yes" for Q. 28]

☐$_1$ $2.01-$4.00
☐$_2$ $4.01-$6.00
☐$_3$ $6.01-$8.00
☐$_4$ $8.01-$10.00
☐$_5$ $10.01-$12.00

[Group 5: Your opinions]
Now think about all the trips you might be able to make using ride-hailing.

30. How much would you value these service features, given your current lifestyle? [Randomize order]

	A lot	Somewhat	Not at all
The vehicle is accessible (i.e., can store a wheelchair)	☐1	☐2	☐3
The driver is trained to help older passengers	☐1	☐2	☐3
The driver gives me a paper bill and I pay at a local store	☐1	☐2	☐3
I can book the trip over the phone with a live agent (I don't have to use the app)	☐1	☐2	☐3
I can pay with a pre-loaded ride-hailing card that is not linked to my bank account/credit card	☐1	☐2	☐3
There is a company helpline I can call	☐1	☐2	☐3

31. How comfortable are you with the following features of ride-hailing? [Randomize order]

	Very comfortable	Somewhat comfortable	Not at all comfortable
Riding with a driver I don't know	☐1	☐2	☐3
Sharing my credit card with the ride-hailing company	☐1	☐2	☐3
Using ride-hailing after dark	☐1	☐2	☐3
Taking a shared ride-hailing trip with other passengers I don't know	☐1	☐2	☐3

32. Now think about all the trips you might be able to make using ride-hailing. Do these statements describe reasons you might want to use ride-hailing, given your current lifestyle? [Randomize order]

	Yes	Maybe	No
I can go out without having to ask family/friends for rides	☐1	☐2	☐3
I can go out at night without having to drive myself	☐1	☐2	☐3
I don't have to worry about getting lost driving myself	☐1	☐2	☐3
I have help carrying heavy bags to my door	☐1	☐2	☐3

[Group 6: Transportation use]

33. During a typical week, how many days do you commute to work? [If answer is "Working for pay" in Q. 5]

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5+

34. Do you volunteer outside your home?

☐$_1$ Yes

☐$_2$ No

35. During a typical week, how many days do you commute for volunteering? [If answer is "Yes" in Q. 34]

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5+

36. What is the <u>most recent time</u> you used each type of travel to get somewhere?

	Last 7 days	Last 30 days	Not used
Drove myself (in a car, truck, motorcycle, etc.)	☐$_1$	☐$_2$	☐$_3$
Rode as a passenger in a personal vehicle (exclude trips in taxis, ride-hailing services like Lyft or Uber, etc.)	☐$_4$	☐$_5$	☐$_6$
Public transit (bus, train, ferry, etc.)	☐$_7$	☐$_8$	☐$_9$
Paratransit	☐$_{10}$	☐$_{11}$	☐$_{12}$
Taxi	☐$_{13}$	☐$_{14}$	☐$_{15}$
Ride-hailing services like Lyft or Uber	☐$_{16}$	☐$_{17}$	☐$_{18}$
Other _____	☐$_{19}$	☐$_{20}$	☐$_{21}$

37. What is the most recent time you have gotten a ride from…

	Last 7 days	Last 30 days	Not used
Family	☐$_1$	☐$_2$	☐$_3$
Friends or neighbors	☐$_4$	☐$_5$	☐$_6$
Paid caregiver	☐$_7$	☐$_8$	☐$_9$

Volunteer driver from a program that helps older adults	☐10	☐11	☐12
Other _____	☐13	☐14	☐15

[Group 7: Health]

38. Do you have any disabilities or illnesses that interfere with your ability to travel outside your home? (Physical, mental, sensory, psychiatric, learning, etc.)
    ☐1 Yes
    ☐2 No

39. Does your current physical health interfere with your ability to carry out everyday activities like shopping, dressing, and preparing meals?
    ☐1 Yes
    ☐2 No

40. How often do you use the following mobility aids?

	Regularly	Occasionally	Never
Walking cane	☐1	☐2	☐3
Walker	☐4	☐5	☐6
Non-motorized wheelchair	☐7	☐8	☐9
Motorized scooter or motorized wheelchair	☐10	☐11	☐12
Other _____	☐13	☐14	☐15

[Group 8: Other]

41. What is the highest level of education that you have completed?
☐1 Grade school
☐2 High school or GED
☐3 Two-year degree or vocational school
☐4 Completed some college (less than 4 years)
☐5 Graduated from college
☐6 Post-graduate degree (MA, MBA, PhD, MD, etc.)

42. How would you describe the area where you live?

☐$_1$ Urban part of a city/region
☐$_2$ Suburban part of a city/region
☐$_3$ Small town
☐$_4$ Rural area

43. Do you live in a community for older adults? (For example, a retirement community or assisted-living facility.)
☐$_1$ Yes
☐$_2$ No

44. Your home is…
☐$_1$ A single-family house
☐$_2$ A condo or apartment
☐$_3$ Other _____

45. Are you living with anyone?
☐$_1$ A spouse or partner
☐$_2$ Extended family
☐$_3$ Other _____
☐$_4$ No one - I am living alone

46. Is there anything you would like to tell us about ride-hailing services?
_____