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The Impact of COVID-19 on User Perceptions of Public Transit, Shared Mobility/Micro-Mobility Services, and Emerging Vehicle Types

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PURDUE UNIVERSITY®

CENTER FOR CONNECTED AND AUTOMATED TRANSPORTATION

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16. Abstract

The objective of this project is to investigate the impact of COVID-19 on public perceptions of public transit, shared mobility services, and micro-freight delivery services. As transportation systems were at the forefront of the COVID-19 pandemic, it is critical to examine the changes in habits and overall travel behavior of users of shared modes and/or emerging services to best plan for transportation policies in the long run. Three surveys were conducted in select communities with different levels of transit and smart mobility usage [Indianapolis (low), Minneapolis (medium), and Chicago(heavy)] to assess public perceptions for public transit, emerging technologies such as ride-hailing, micro-mobility, and micro-freight delivery services in the COVID era. This study evaluates the relationship between certain demographics and travel preferences during the pandemic. The study also draws a comparison between the three urban settings with regards to travel habits and intentions. The research results can help transportation agencies enhance their plans and policies towards any future pandemics. Overall, the study contributes to the ongoing national dialogue on transportation, accessibility, and mobility in the post-COVID-19 era.

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1 INTRODUCTION

The pandemic has had a major impact on the transportation system and has brought significant reductions in mobility (Warren and Skillman, 2020), accounting for more than 60% decrease in traffic in some areas (Graber, 2020). However, this reduction has not occurred uniformly, as COVID-19 had a more significant impact on the usage and perception of emerging shared mobility services compared to private vehicles. For instance, public transportation, a traditional shared-mobility service, has been found to have suffered significantly due to COVID-19 both in the US and internationally. Nationwide, subway use fell in New York City by 90%, mostly from trip reductions and increased bike-sharing (Teixeira and Lopes, 2020). Additionally, a survey study from Chicago found that transit is the highest risky mode of transportation in residents' view (Shamshiripour et al., 2020). Reductions in public transit have also been observed in various shared modes across different locations. The service suffered cutbacks of up to 80% as people reduced travel as well as shifting modes to walking, cycling, and private vehicles in Brazil (Fumagalli et al., 2021), and Australia (Munawar et al., 2021). An international study by Dingil and Esztergár-Kiss (2021) found that the probability of changing transit modes was 31.5 times greater for transit users than car users due to fears about infection on public transit. Bus service in Trieste, Italy fell sharply to be replaced by walking, cars, and cycling (Scorrano & Danielis, 2021). Light and heavy rail use also dropped significantly, especially for users that live further from stations, and was replaced mostly by cars, walking, and cycling (Hu & Chen, 2021; Tan & Ma, 2021).

While public transit usage declined during the pandemic, many forms of individual and active travel grew, especially as restrictions loosened. Bike-sharing stands out as the shared mobility service that has grown the most during the pandemic. Patterns of bike use have changed as they begin to be used more for leisure than for commuting. Chai et al. (2020) found that in Beijing there had been a sharp decline in bike-share use for productive purposes, especially near subway stations where they are often used for first and last mile service. Teixeira and Lopes (2020) report similar findings in the first weeks of the pandemic in New York City, where bike-sharing use fell more inside the subway catchment than outside it. On the other hand, it is found that other use of bike-sharing in New York City has grown significantly (Wang & Noland, 2021). This is coupled with an increase of bike sharing usage for casual users as well as an increase in trip length suggesting replacement for other commuting modes. Li et al. found that bikes are directly replacing other forms of public transportation that are considered riskier in Zurich, and that this has caused trip lengths to increase (Li et al., 2021). Similarly, Lock finds that reduced traffic in Sydney has also provided an additional incentive for cyclists and more people are reporting interests in improving the city's infrastructure (Lock, 2020). Additionally, another emerging shared mobility option that was affected by COVID-19 is ride-hailing. In this regard, the service has had a less uniform decline, often being viewed as riskier than private vehicles but less risky than traditional public transit options (Ozbilen et al., 2021). In April 2020, Lyft, a prominent ride-

hailing company, reported a 75% drop in the number of trips compared to the same month a year before, (Lekach, 2020). On the other hand, Dzisi et al. (2021) found that the mode share of ride-hailing rose from 30% to 59% in Ghana during the pandemic as part of a larger shift towards ride-hailing.

Overall, mobility has been greatly affected by COVID-19. The pandemic's effect on transportation modes has not been uniform. Private vehicles and active modes have been the biggest gainers whereas overall shared mobility services have endured losses. This is mainly due to induced risk perception from using travel options that involve sharing, such as shared mobility. Previous efforts have been made to understand travelers' risk perceptions of using shared mobility during COVID-19 (Rahimi, et al., 2021). The study finds that the built environment setting, and demographic attributes are key determinants of risk perception in the context of shared mobility usage. Additionally, three years after the pandemic has come about, the perceived risk associated with COVID-19 may have diminished, but it is evident that several lifestyle changes are likely to persist for the foreseeable future. Among the activities that boomed during COVID-19 are the increased adoption of online shopping and widespread teleworking. Online shopping has become ingrained in consumer behavior, as individuals have grown accustomed to the convenience, broader product selection, and contactless nature of digital retail. A Release by the Annual Retail Trade Survey (ARTS) showed an increase of 43% in e-commerce sales in 2020 due to online shopping (U.S. Census Bureau, 2020). This has largely contributed to the emergence of micro-freight delivery services as companies sought to bring goods to customers' doorsteps in an efficient and reliable manner. Similarly, teleworking has transformed work dynamics, enabling employees to perform their tasks remotely and reducing the need for daily commutes. Survey data by the U.S. Bureau of Labor Statistics (Dalton & Groen, 2022) found that one-third of establishments increased telework for some or all employees during the COVID-19 pandemic. Overall, these emerging activities experienced significant surges during the pandemic and have since further contributed to the change in the transportation system. As society adapts to the evolving landscape, it is crucial to further explore the perceptions of travelers regarding these changes.

In this context, it is imperative to investigate the public's intentions to use shared modes and emerging options, as transportation systems continue to be impacted by the overarching effects of COVID-19 pandemic. In this regard, there is limited to non-existent literature on the usage intentions of shared mobility after COVID-19 is no longer perceived to be a threat. Investigating usage intentions is imperative to help overcome this barrier and promote adoption. The existing literature has widely investigated the mobility patterns of the services during COVID-19 using ridership data and spatiotemporal methods (Bi et al., 2022; Chai et al., 2020; Dean and Zuniga-Garcia, 2022), and less prominently using survey data (Rahimi et al., 2021). Several studies investigated the intentions to travel during COVID-19 (Sánchez-Cañizares et al., 2021), to use ride-hailing in the future (Nguyen-Phoc et al., 2022), and work from home in the post COVID-19 era (Jain et al., 2022). However, no studies have explored the intentions to use shared bike-sharing and e-scooter sharing in a post COVID-19 scenario. Additionally, as online shopping and

other activities emerged during COVID-19, they had a profound influence transportation patterns. Therefore, understanding the factors influencing transportation behavior is crucial for policymakers to develop effective transportation policies in the long term. Specifically, findings can help policymakers to better understand the complex interplay between individual attitudes, social norms, and broader societal trends driving people's choices regarding shared mobility. It would eventually inform the development of policies and programs aimed at promoting sustainable and efficient transportation systems in a post COVID-19 era, while also addressing public health concerns.

In view of the above, the project is designed to achieve three objectives: (i) assess the sustaining change and generated travel behavior caused by the pandemic, (ii) investigate the public's usage intentions of shared mobility in a post COVID-19 era, (iii) compare COVID-19's overarching impact among three select cities. To achieve the study objectives, a stated-preference survey was designed and distributed in three midwestern cities (Chicago, Indianapolis, and Minneapolis). A total of 4,816 individuals began the survey, with 1,534 participants (311 from Indianapolis, 613 from Minneapolis, and 610 from Chicago) meeting the final sample criteria after several data quality checks, including screening questions and attention checks, were conducted (Section 2.3).

This project is in line with CCAT's mission to understand future transportation needs and challenges. More specifically, this project enhances our existing knowledge of the determinants influencing user perceptions of shared and connected mobility in the context of COVID-19. The report is organized as follows: Section 2 discusses the data including study area, survey design, and data collection. Section 3 presents the study findings. Section 4 discusses the implications and conclusions of this study. Section 5 outlines the plans for future work.

2 DATA DESCRIPTION

2.1 Study Area

The selection of Indianapolis, Minneapolis, and Chicago for this study is due to multiple factors. The deployment of shared mobility services is primarily concentrated in densely populated areas, such as urban centers due to high demand. The three areas considered in this study are all urban centers, but vary in population size, with Chicago, Minneapolis, and Indianapolis having populations of 9.6 million, 3.6 million, and 2 million, respectively, according to the United States Census Bureau (2022). The dynamics between shared mobility services and transportation system components is a subject of ongoing research, with contradictory evidence emerging from various studies. Martin and Shaheen (2014) shows that while some studies suggest that ride-hailing and bike-sharing complement public transit in certain areas, other ones indicate that they may compete with and replace transit in other areas. This can be attributed to the varying characteristics of shared mobility services in different cities or regions, which lead to diverse effects on the transportation system. Hence, it is crucial to explore how these services interact with transportation systems of different sizes and settings. Additionally, the three cities are major urban centers in the Midwest region of the U.S. Private vehicles still dominate transportation in all three cities, with Indianapolis having the highest percentage of private vehicle usage for commuting (96.09%), followed by Minneapolis (92.33%) and Chicago (84.83%). All cities enjoy a range of alternative transportation options including public transit, ride-hailing, bike-sharing, e-scooter sharing services, and other forms of shared mobility. However, each city has a unique aspect to it when it comes to usage of alternative transportation options, especially shared mobility. The distinctive feature of Chicago is its high-speed rail system, with a daily ridership of over 330,000 riders. The National Household Travel Survey (NHTS) indicates that 21.84% of Chicago residents use the train at least a few times a month. Indianapolis, on the other hand, has a minimal ridership percentage of 2.63% for the bus (Federal Highway Administration, 2017). Turning to Minneapolis, the city leads in promoting bicycle culture, with the new cycle plan aimed at constructing 230 miles of bike lanes, 144 of which to be protected. The city ranks fourth among the best cycling cities in the US (bicycle magazine, 2018) and has the third-highest five-year average of bicycle commuting for large US cities (Census, 2022). The NHTS survey demonstrates that 13% of Minneapolis residents have used a bike at least once in the last 30 days compared to 7.4% in Indianapolis.

Despite their differences, the Midwest region presents its unique transportation challenges and opportunities. Investigating shared mobility in this area could provide insights into any underlying factors that influence the usage and perception of shared mobility in this part of the country. Hence, the different populations are likely to have a diverse array of preferences and experiences pertaining to shared mobility that would offer valuable insights for the surveys. Additionally, the three cities have different demographic compositions due to their different sizes and locations such as race, income, age, and education. This could help identify potential

disparities in the perception of shared mobility across different demographic groups and allow comparison between the cities in this regard.

2.2 Survey Design

The primary data source for this study was a stated preference survey. The survey includes twelve sections and features a variety of question formats, as shown in Figure 1.

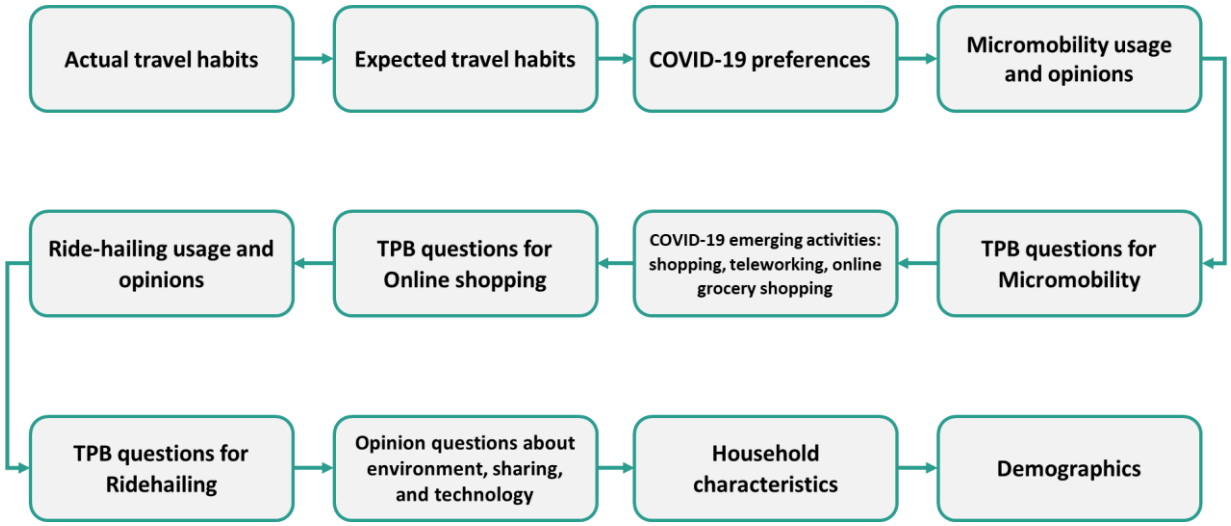


Figure 1. Survey flow

Each section was designed to capture a certain travel behavior in the population. The first section is titled "Actual Travel Habits" and includes questions on usage frequency of different transportation modes, trip frequency to several destinations, most frequently used transportation mode for each trip frequency, and the effect of COVID-19 on travel to different destinations. The second section is titled "expected travel habits" and focuses on the expected change in the behaviors that are asked about in the first section due to COVID-19. The third section includes questions about "COVID-19 preferences". It specifically asks about travelers' opinion on how long it will take us to recover from COVID-19, COVID-19 concern statements, and asks about travelers' opinion on the probability of contracting COVID-19 while using shared modes. The fourth section, "Micro-mobility usage and opinions," focuses on the usage of micro-mobility before, during, and after COVID-19. Moreover, the fifth section is titled "Theory of planned behavior questions for Micro-mobility." It involves asking opinion questions on Micro-mobility that follow the theory of planned behavior (Ajzen, 1991). Section six is titled "COVID-19 emerging activities: shopping, teleworking, online grocery shopping." It includes questions about the frequency of certain activities during stay-at-home COVID-19 order and the number of times doing these activities (shopping, eating out, working from home, etc.). Sections seven and nine,

titled “TPB questions for Online shopping” and “TPB questions for ride-hailing,” ask similar questions to section fix but in the context of online shopping and ride-hailing, respectively. Section eight follows the same question wording as section four but in the context of ride-hailing and is titled “Ride-hailing usage and opinions.” Additionally, section ten, titled “Opinion questions about environment, sharing, and technology,” features opinion questions on the environment, sharing, and technology. Section eleven is titled “Household characteristics” and focuses on the number of cars, electric cars, scooters, bikes in a certain household, vehicle ownership change due to COVID-19, and membership in any shared mobility services. Lastly, section twelve includes questions on socio-demographics.

Matrix tables were frequently employed, particularly for opinion questions. A matrix question is one of the most common question types since it is simple to create from the creator's perspective and simple for responders to read (and so answer) because the answer possibilities and scales remain consistent across all table entries. The quantity of these tables, however, was carefully managed to ensure that it was not misused, as answering several tables can easily lead to respondents' fatigue and bad survey results. Throughout the poll, multiple choice and five-point Likert scales were also employed, particularly for opinion questions. Several questions were repeated throughout the survey to accommodate for pre and post COVID-19 circumstances. Moreover, concise wording was used throughout the survey instrument to reduce ambiguity and ensure effective survey-taking behavior. In this regard, several surveys were consulted for relevant questions such as a survey on the future of COVID-19 designed by Mobis group, University of Texas in Austin, New York University, and more (Salon et al., 2022). Additionally, the U.S. Census and the National Household Travel Survey (NHTS) were used to ensure that the structure of socio-demographic questions adhered to the current norm. Ultimately, this helped expand on specific topics in our questionnaire.

2.3 Data collection

The survey was administered in Indianapolis, Minneapolis, and Chicago, to obtain information on various shared micro-mobility services that have been operational in these cities over the past few years. The Institutional Review Board (IRB Protocol #2022595) evaluated and approved the final questionnaire before the distribution. Adult residents of the Metropolitan Statistical Areas associated with each city were specifically targeted. The survey was disseminated in the three cities between September 23rd and November 7th, 2022, and stratified sampling was employed to ensure that the preferences of different types of travelers were represented. Participants were sampled based on strata of varying age and gender, with the size of each stratum calculated using the ACS (U.S. Census Bureau, 2022) table named "Age and Sex." A total of 4,816 individuals began the survey, with 1,534 participants (311 from Indianapolis, 613 from Minneapolis, and 610 from Chicago) meeting the final sample criteria after several data quality checks, including screening questions and attention checks, were conducted.

The dataset was weighted in order to ensure it is representative of the population. Prior research has demonstrated that the adoption of shared mobility services is often associated with certain

demographic factors, specifically age, gender, and income (Elmashhara et al., 2022). As such, weights were calculated and applied, by employing a corresponding ACS table from each city to the sampled observations based on the three aforementioned demographic variables. The weighting method was accomplished following the methodology outlined in the work of Biemer and Christ (2008). Table 1 denotes the demographics of each city after weighting. Occupation information from the census is not grouped in a similar manner as our survey. Hence, it is not included in the table.

Table 1. Distribution of demographical attributes in the census compared to the sample

Demographic	Value	Chicago %		Minneapolis %		Indianapolis %	
		Census	Sample	Census	Sample	Census	Sample
Gender	**Female**	52.6%	52.7%	51.1%	50.4%	53.0%	53.4%
	Male	47.4%	47.3%	48.9%	49.6%	47.0%	46.6%
Age	**18-24**	10.7%	10.8%	13.0%	13.0%	11.0%	11.2%
	25-34	24.8%	25.2%	25.0%	26.3%	21.7%	22.3%
	35-44	18.3%	18.3%	18.6%	18.5%	17.6%	17.3%
	45-54	15.1%	14.8%	13.8%	13.5%	15.6%	14.8%
	55-64	14.5%	14.4%	14.3%	13.9%	16.7%	16.9%
	65 and over	16.6%	16.5%	15.4%	14.9%	17.4%	17.4%
Education	**Some high school or less**	13.3%	1.2%	10.2%	1.9%	12.7%	1.7%
	High school diploma or GED	22.0%	17.9%	17.3%	19.6%	28.1%	22.4%
	Some college, but no degree	18.3%	20.2%	19.1%	18.9%	20.2%	23.5%
	Associates or technical degree	5.6%	10.3%	7.8%	13.4%	7.4%	14.3%
	Bachelor's degree	24.3%	29.9%	28.2%	30.3%	20.7%	27.3%
	Graduate or professional degree (MA, MS, MBA, PhD, JD, MD, DDS etc.)	16.4%	20.5%	17.5%	16.0%	10.8%	10.7%
Income	**Less than $25,000**	17.2%	16.8%	13.4%	13.1%	16.7%	17.0%
	$25,000-$49,999	18.0%	17.9%	17.9%	17.8%	22.3%	23.9%
	$50,000-$74,999	15.6%	16.1%	17.2%	17.6%	20.1%	19.9%
	$75,000-$99,999	12.2%	12.7%	13.0%	13.2%	13.8%	12.7%
	$100,000-$149,999	16.6%	16.8%	18.7%	19.0%	15.9%	17.0%
	$150,000 or more	20.5%	19.7%	19.8%	19.3%	11.1%	9.5%

Table 2. (continued)

Demographic	Value	Chicago %		Minneapolis %		Indianapolis %	
		Census	Sample	Census	Sample	Census	Sample
Gender	**Female**	52.6%	52.7%	51.1%	50.4%	53.0%	53.4%
Pers/ household	**One**	21.2%	21.7%	21.7%	20.9%	21.0%	18.2%
	Two	31.1%	28.3%	32.9%	35.3%	35.3%	32.4%
	Three	17.0%	19.9%	15.7%	17.5%	17.1%	21.5%
	Four	14.5%	18.6%	13.7%	14.9%	13.6%	17.9%
	Five or more	16.2%	11.4%	16.0%	11.4%	13.0%	10.0%
Children	**None**	75.2%	61.3%	73.1%	65.6%	73.3%	64.7%
	One	11.9%	16.3%	10.4%	14.8%	11.2%	15.3%
	Two	8.5%	17.0%	9.3%	13.7%	9.6%	15.4%
	Three	3.1%	3.8%	4.2%	5.2%	4.1%	2.3%
	Four or more	1.3%	1.5%	3.0%	0.8%	1.9%	2.4%
Occupation	**Work full time**	NA	49.6%	NA	54.8%	NA	49.3%
	Work part time	NA	13.1%	NA	10.7%	NA	8.9%
	Student	NA	4.4%	NA	5.1%	NA	3.9%
	Homemaker	NA	4.9%	NA	5.0%	NA	7.6%
	Currently Unemployed	NA	7.7%	NA	7.5%	NA	10.0%
	Retired	NA	15.7%	NA	15.2%	NA	16.2%
	Other	NA	4.6%	NA	1.7%	NA	4.1%

The sample demographic distribution matches the census in terms of age, gender, and income because it was weighted according to these metrics. However, some demographic features in the sample were different, such as having less respondents with low educational attainment and no children in their household. Despite these differences, we believe that our sample is representative of the general population.

Additionally, the survey includes questions pertaining to household characteristics such as the number of cars, electric cars, scooters, bikes in a certain household, and vehicle ownership change due to COVID-19. Figure 2 presents a distribution of the number of available travel options in a household.

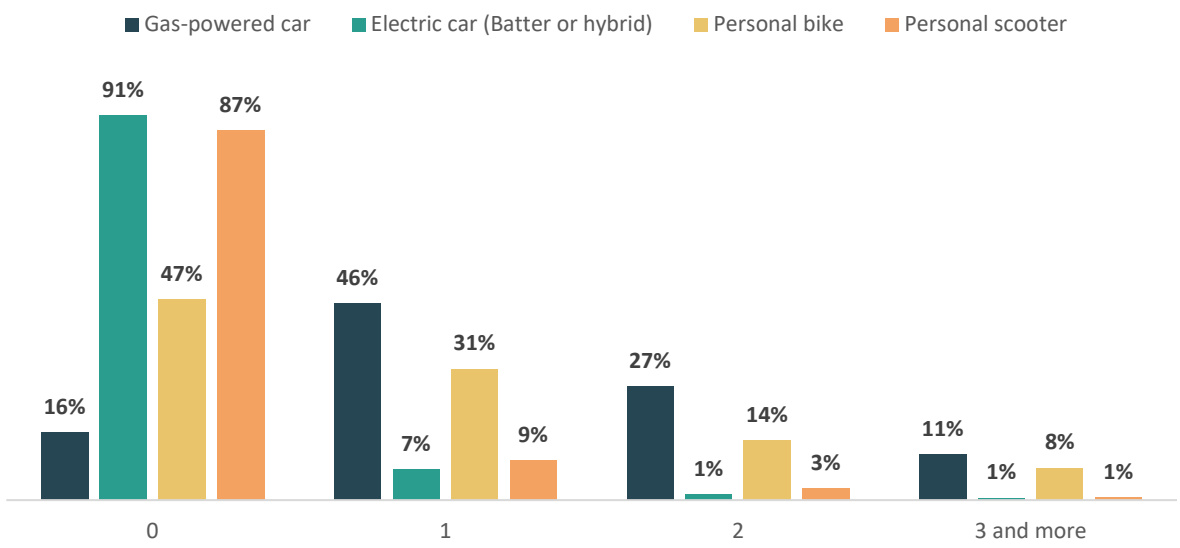


Figure 2. Number of available travel options in a household

The majority of households have at least one gas-powered car (84%) while only a small percentage own or have access to an electric car (9%). Personal bikes are the most commonly owned non-motorized vehicle (47%), followed by personal scooters (26%). The ownership of multiple gas-powered cars (27%) is more common than owning multiple personal bikes (14%) or personal scooters (3%). Owning an electric car or a personal scooter is not as common as owning a car or a personal bike. The results validate the dependency on cars.
Additionally, respondents were asked about any change in vehicle ownership during COVID-19 (shown in Figure 3).

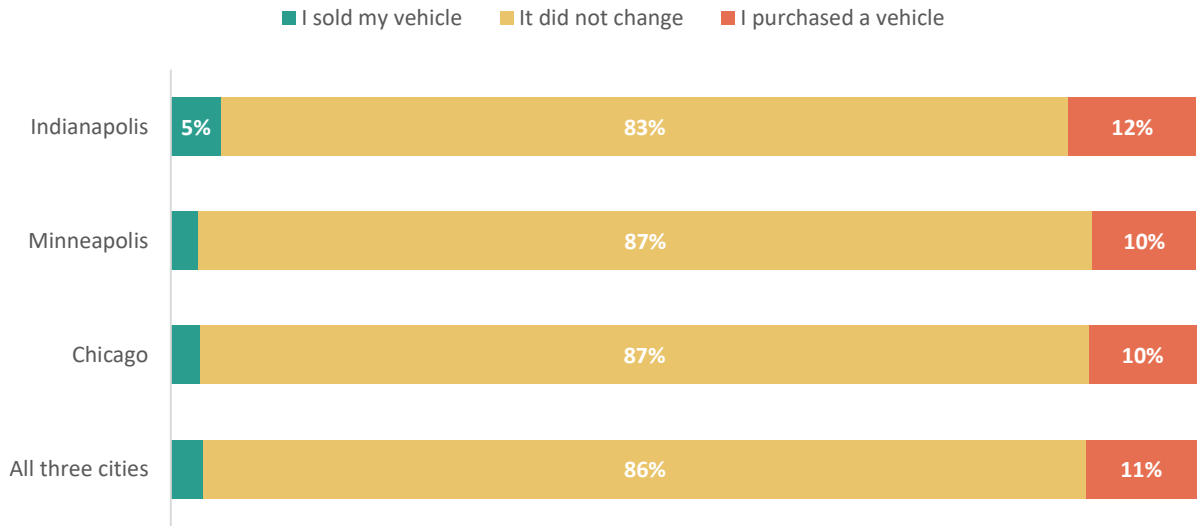


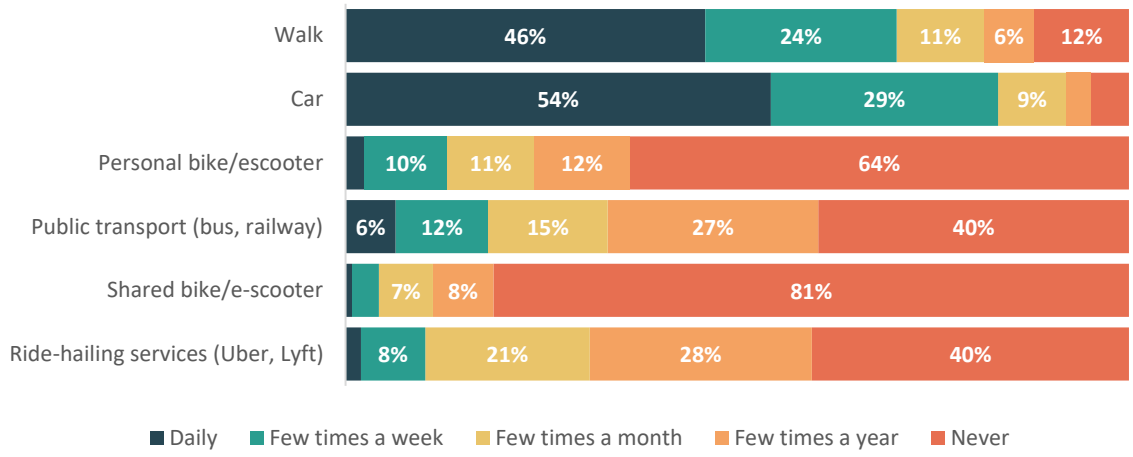
Figure 3. Change in vehicle ownership during COVID-19

In all three cities, the majority of respondents reported that their vehicle ownership did not change during COVID-19, with 86% overall. However, 11% of respondents, overall, report purchasing a vehicle during the pandemic, with a slightly higher percentage in Indianapolis at 12%. Only a small percentage of respondents report selling their vehicle, ranging from 3% to 5% across the cities. Overall, a higher percentage of respondents indicate purchasing a vehicle comparing to selling it which suggests that the number of cars might have increased during the pandemic.

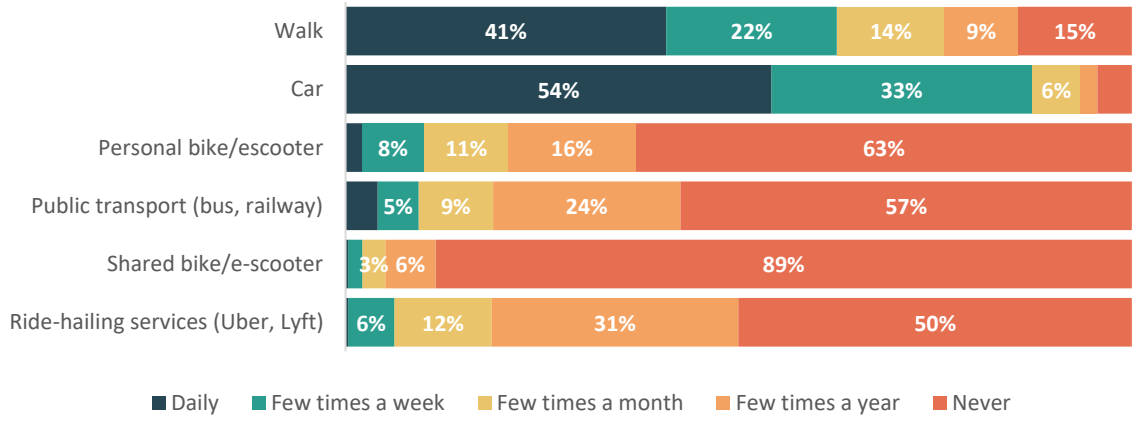
3 FINDINGS

3.1 Actual Travel Habits

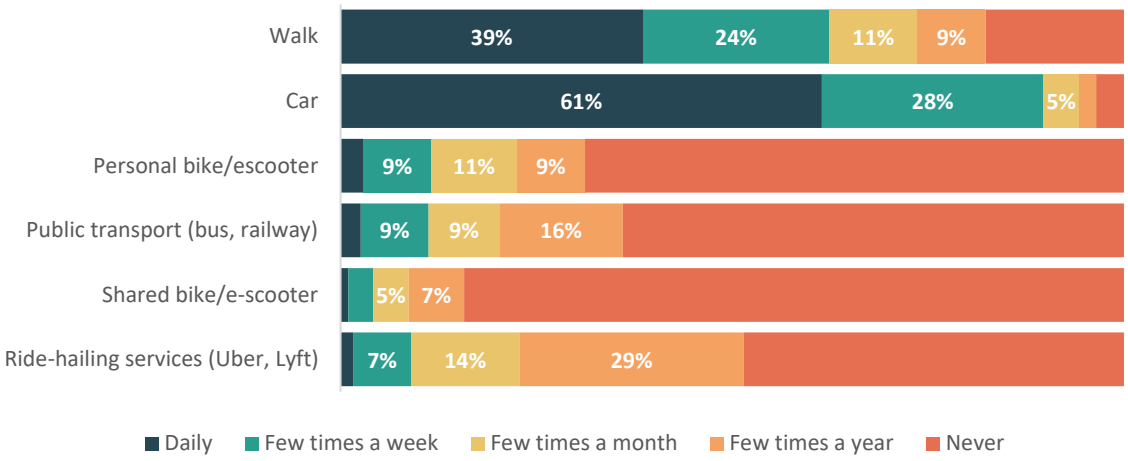
This section investigates usage frequency of different transportation modes, trip frequency to several destinations, most frequently used transportation mode for each trip frequency, and the effect of COVID-19 on travel to different destinations. Figure 4 presents the frequency of usage of different modes of transportation across three distinct cities: Chicago, Minneapolis, and Indianapolis. Overall, it is shown that walking and cars are the most commonly used modes of transportation in all three cities. The usage of personal bikes and bike-sharing/e-scooters is relatively low in comparison to other modes of transportation. In Chicago, 46% of people walk daily, while 54% use a car for their daily trips.



(a) Chicago



(b)Minneapolis

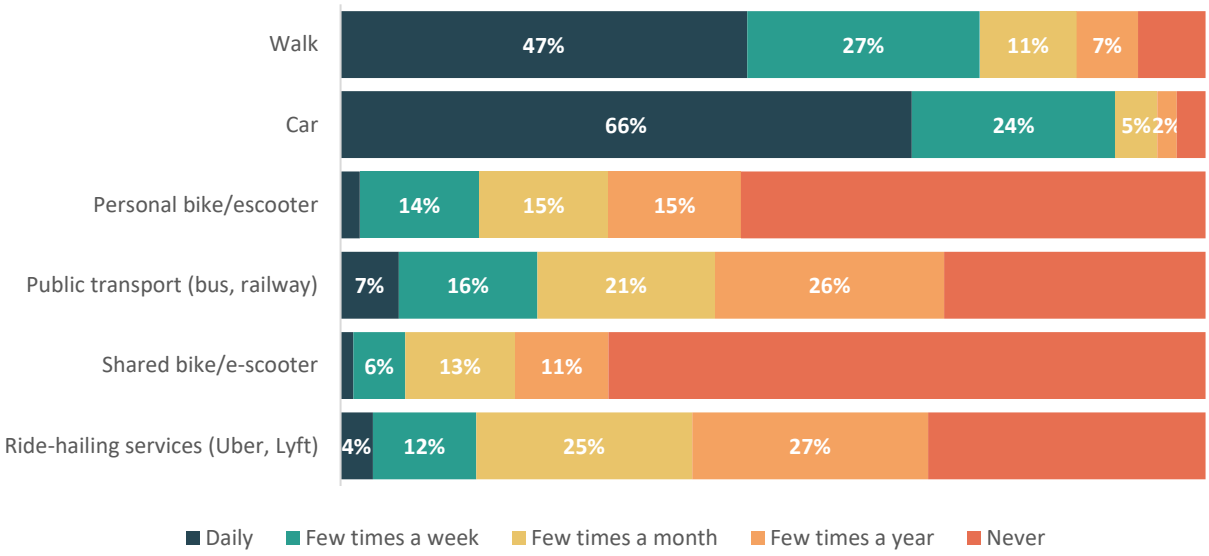


(c) Indianapolis

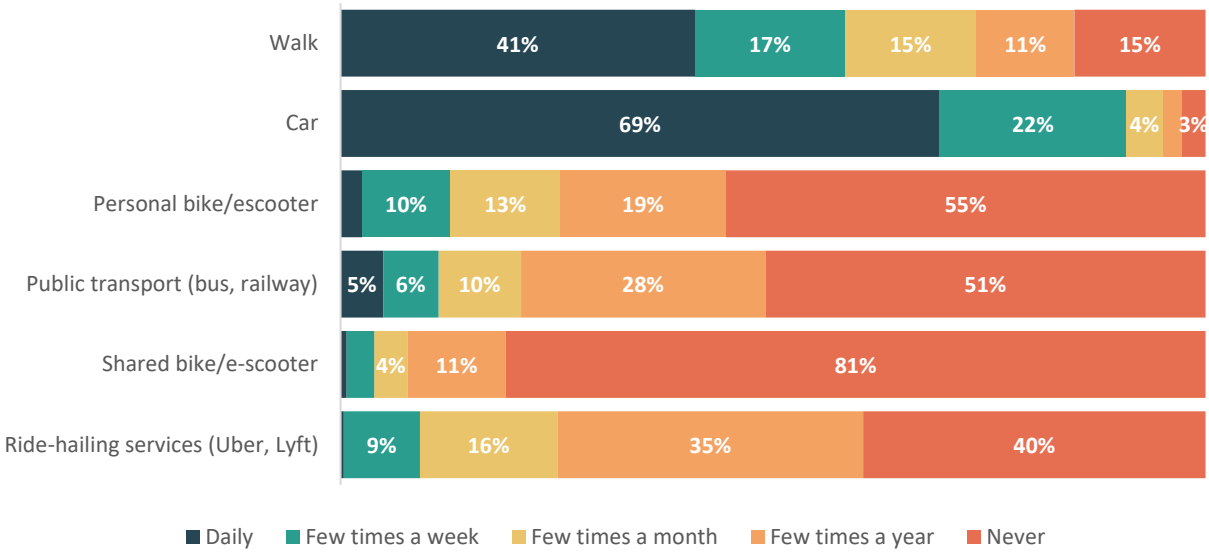
Figure 4. frequency of usage of different modes of transportation in (a) Chicago, (b) Minneapolis, and (c) Indianapolis.

In Minneapolis and Indianapolis, the percentage of people walking daily is slightly lower, while car usage in Indianapolis is higher. Additionally, public transport (bus and railway) is used more frequently in Chicago compared to Minneapolis and Indianapolis. Ride-hailing is used occasionally more than the rest of transportation modes are. Overall, it is evident that people in these three cities primarily rely on cars and walking for transportation. To further assess the difference among the three cities, a Chi-squared test is conducted to determine any difference in the distribution of frequency of each mode. The results suggest that there is a significant difference in the usage frequency of public transit ($p = 0.00$), shared bike/scooters ($p = 0.02$), and ride-hailing services ($p = 0.00$). Car usage is the least significant ($p = 0.12$) indicating similar usage frequency among the three cities, followed by walking ($p = 0.08$) and personal bikes/ scooters ($p = 0.09$).

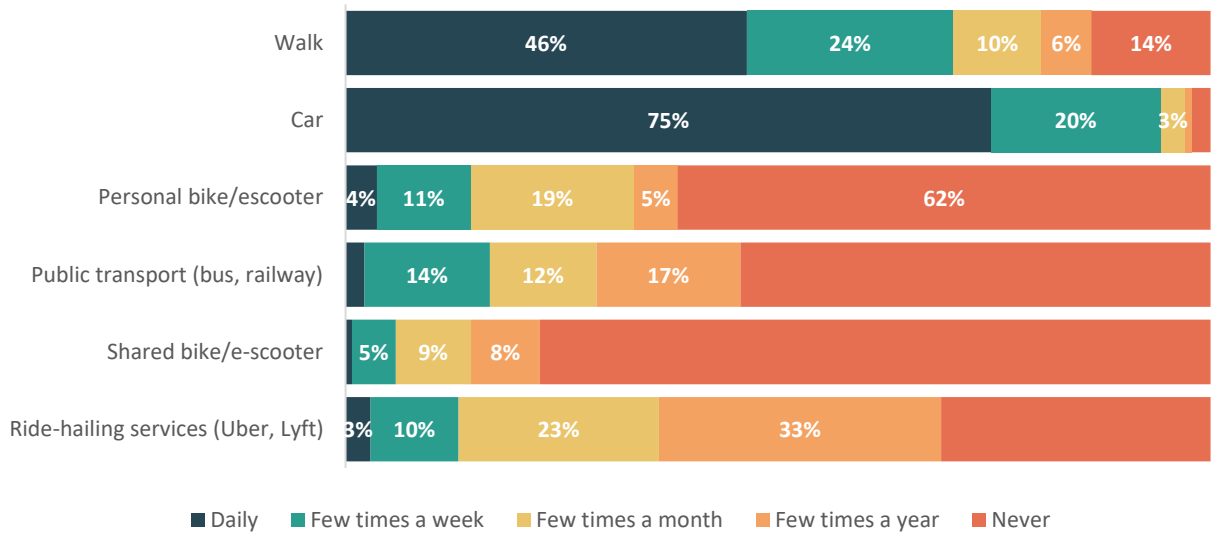
Additionally, travel trends of full-time workers are shown in Figures 5 to explore whether they differ from the general population among the three cities. Overall, full-time workers tend to use all travel modes more frequently than the general population, given that they are more mobile. Walking, cars, and public transportation are more frequently used compared to the general population.



(a) Chicago



(b) Minneapolis



(c) Indianapolis

Figure 5. Travel frequency with different modes for full-time workers in (a) Chicago, (b) Minneapolis, and (c) Indianapolis.

In Chicago, full-time workers tend to walk and use public transportation more frequently compared to the other two cities, with 47% of them walking daily and 7% using public transportation daily. In contrast, full-time workers in Indianapolis rely heavily on cars, with 75% of them using cars daily, which is higher than the general population's 61%. Similar to the general population, full time workers rarely use shared bike/e-scooter, with only 1% of them using it daily. Furthermore, a series of Chi-square tests indicate that the usage frequency of all modes, except for private vehicles ($p = 0.84$), is statistically different among the cities suggesting different travel trends.

Furthermore, the usage certain transportation modes on a daily basis is investigated for all the occupations that are represented in the data. Figure 6 explores walking for several occupations. We can see that students (64.29%) are the group that walks the most daily, followed by those who work part-time (44.72%), those who work full-time (44.41%), and homemakers (38.82%). Those who are retired (32.12%) and others (41.67%) also walk daily, but to a lesser extent.

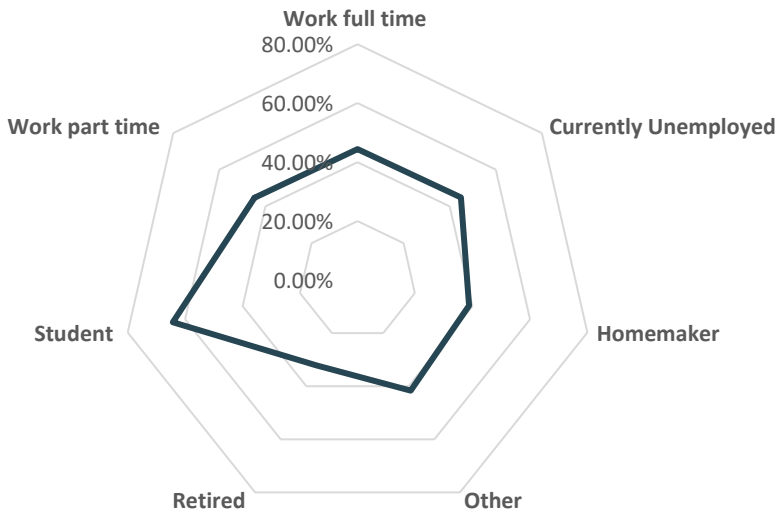


Figure 6. Amount of daily walking for different occupations in all cities

The usage of cars is also investigated in Figure 7. It is shown that full-time workers (69.09%) and those who work part-time (58.79%) are the groups that use their private vehicles the most daily. Homemakers (52.94%) also use their private vehicles daily, but to a lesser extent. Those who are retired (37.09%), students (42.86%), and currently unemployed (37.50%) use their private vehicles less frequently.

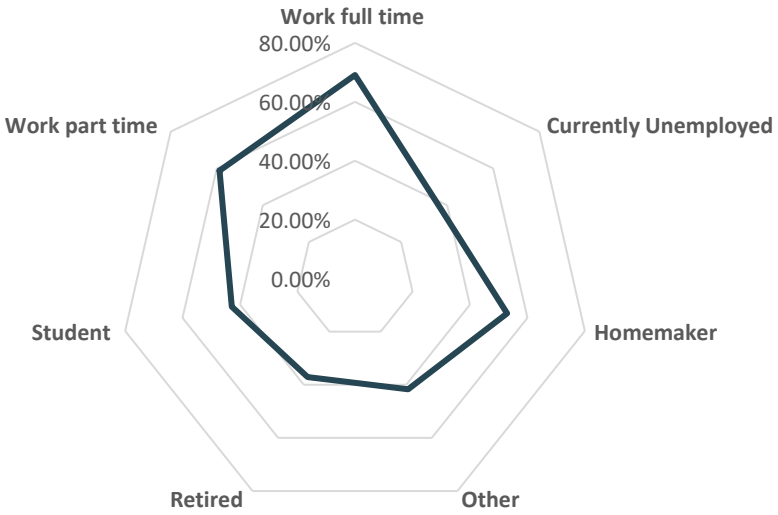


Figure 7. Amount of daily usage of cars for different occupations in all cities

Figure 8 sheds light on public transit usage. It is shown that students (16.07%) are the group that uses public transport the most daily, followed by those who work part-time (6.53%), those who work full-time (5.08%), those who are currently unemployed (5.15%), and homemakers (3.53%). On the other hand, it shown that those who are retired (1.32%) do not frequently use public transport daily.

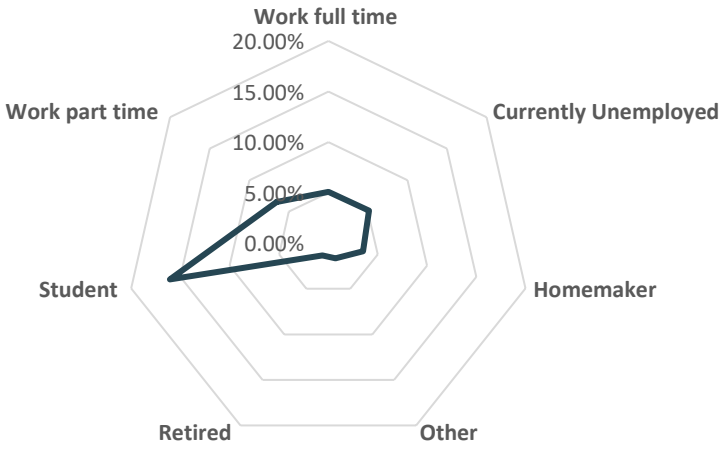


Figure 8. Amount of daily transit usage for different occupations in all cities

Furthermore, respondents were asked to indicate their most frequently used mode of travel for different trip purposes (Figure 9). The four trip purposes included are work, shopping, personal, and social.

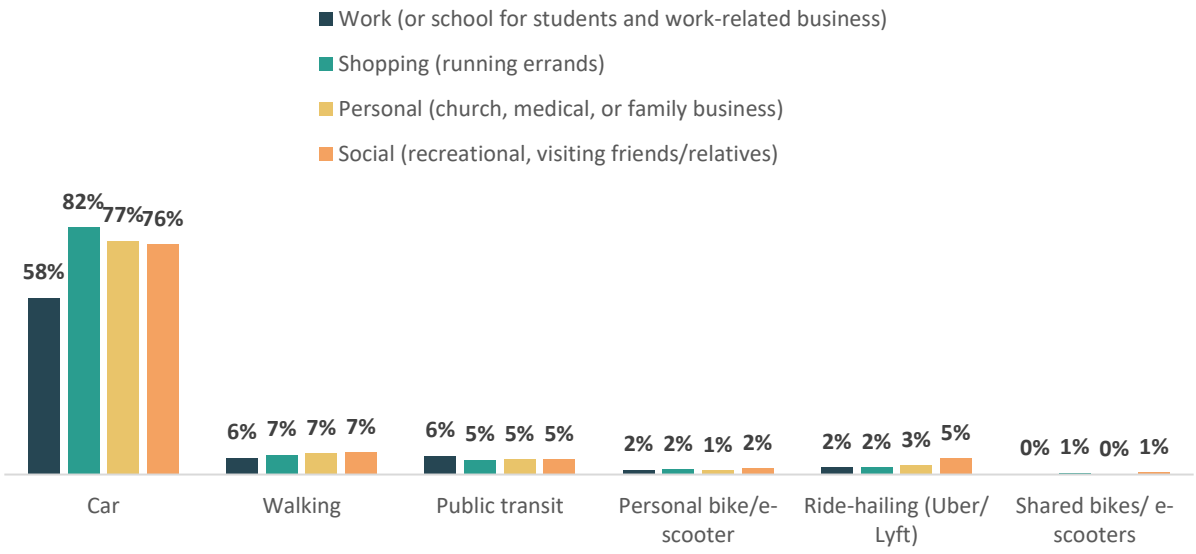


Figure 9. Most frequently used mode of travel for each trip purpose

It is evident that cars are the most commonly used mode of transportation for all trip purposes (73%), with walking and public transit following at 6% each. For shopping, an overwhelming 82% of respondents report using a car, while for personal trips such as medical or family business, 77% depend on this transportation mode. In contrast, public transit is used by only a small percentage of respondents for each of the four trip purposes ranging from 5% to 6%, but mostly for work trips. Additionally, ride-hailing services are used by only a small percentage of respondents as well, ranging from 2% to 5%, but mostly for social trips. These results suggest that cars continue to dominate as the most frequently used mode of transportation for a variety of trip purposes, while other modes, such as public transit and ride-hailing services have yet to make a breakthrough.

Additionally, respondents were asked to rate the extent to which their travel to certain activities has been affected by COVID-19. Figure 10 illustrates their perception of the effect of COVID-19 on travel. Findings suggest that the pandemic has had a varying degree of impact on different types of travel.

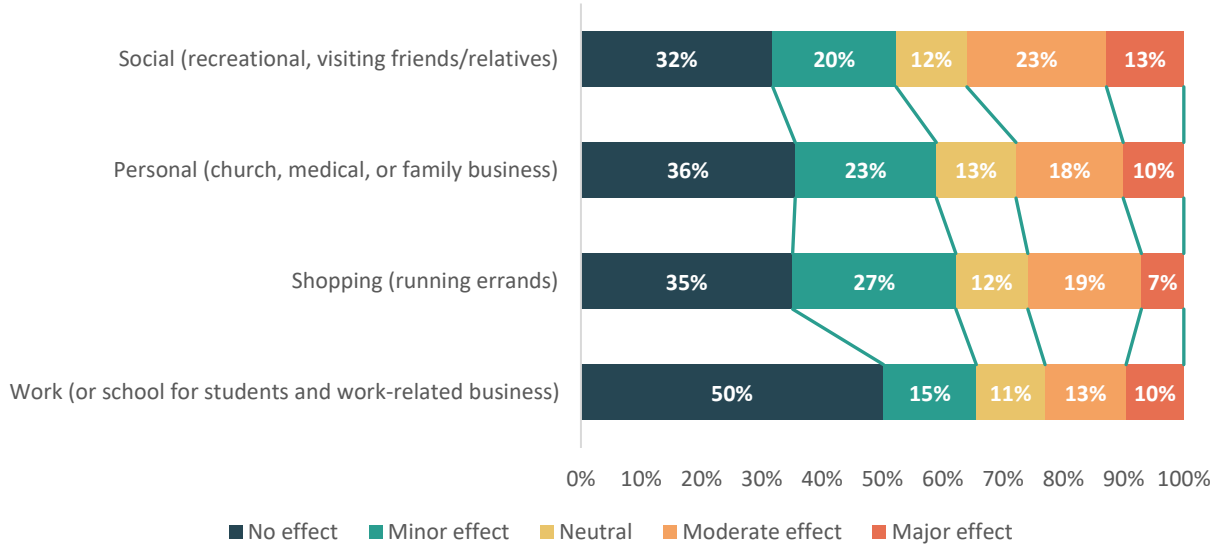


Figure 10. Perception of the effect of COVID-19 on travel

For work-related travel, half of the respondents report no effect, while only 10% reported a major effect. Shopping trips are more likely to be unaffected, with only 35% reporting no effect, while 27% report a minor effect. Personal trips, such as visiting family or attending medical appointments, also have a similar pattern, with 36% reporting no effect and 23% reporting a minor effect. Social trips, such as recreational or visiting friends, are the most affected, with only 32% reporting no effect and 23% reporting a moderate effect, and 13% reporting major effect.

Given that COVID-19 had unequal impacts depending on age, its effect is explored on work and social activities in Figures 11 for different age groups.

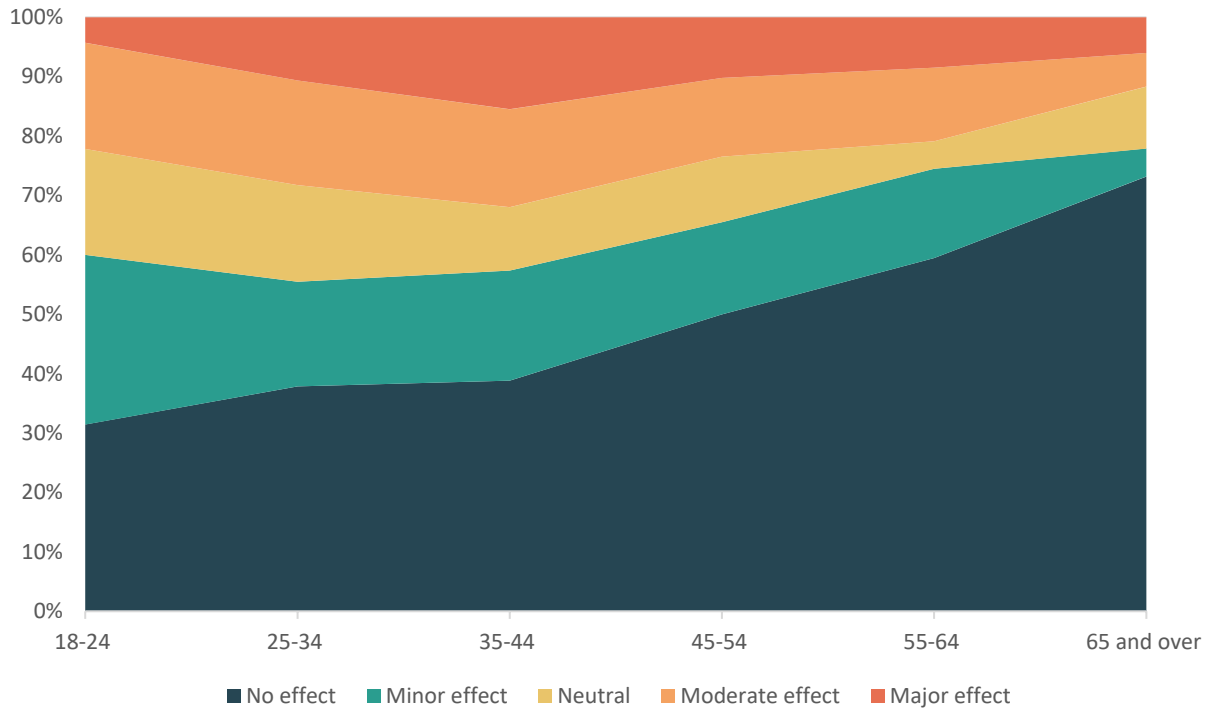


Figure 11. The effect of COVID-19 on work trips with respect to age.

Findings show that the percentage of respondents reporting no effect of COVID-19 on their travel to work increases with age, with the highest percentage in the 65 and over age group (73%). In contrast, the percentage of respondents reporting a major effect of COVID-19 on their travel to work is reported by mid-aged participants rather than older and younger ones. The results suggest that the impact of COVID-19 on travel to work varies by age group, with older adults being less affected than younger adults, which is unexpected due to the higher risk of COVID-19 impacts on older people.

Figure 12, one the other hand, investigates the impact of COVID-19 on social trips for different age groups. It is shown that the trends are not as pronounced compared to work activities.

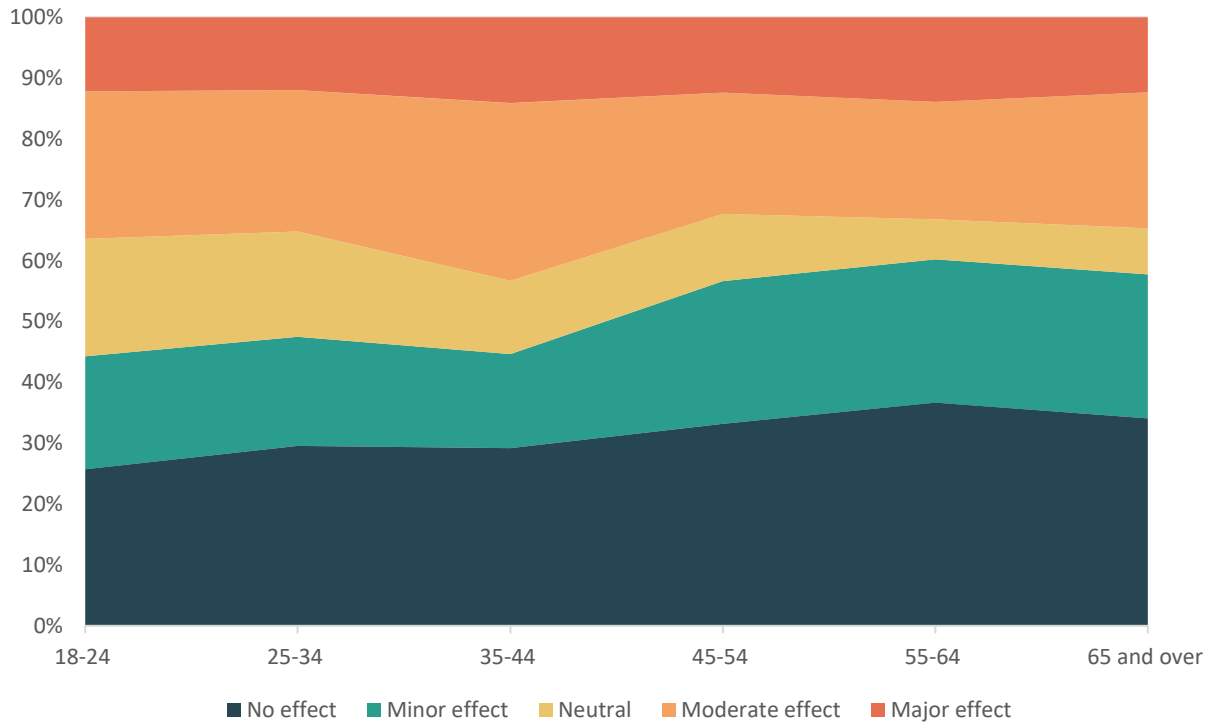


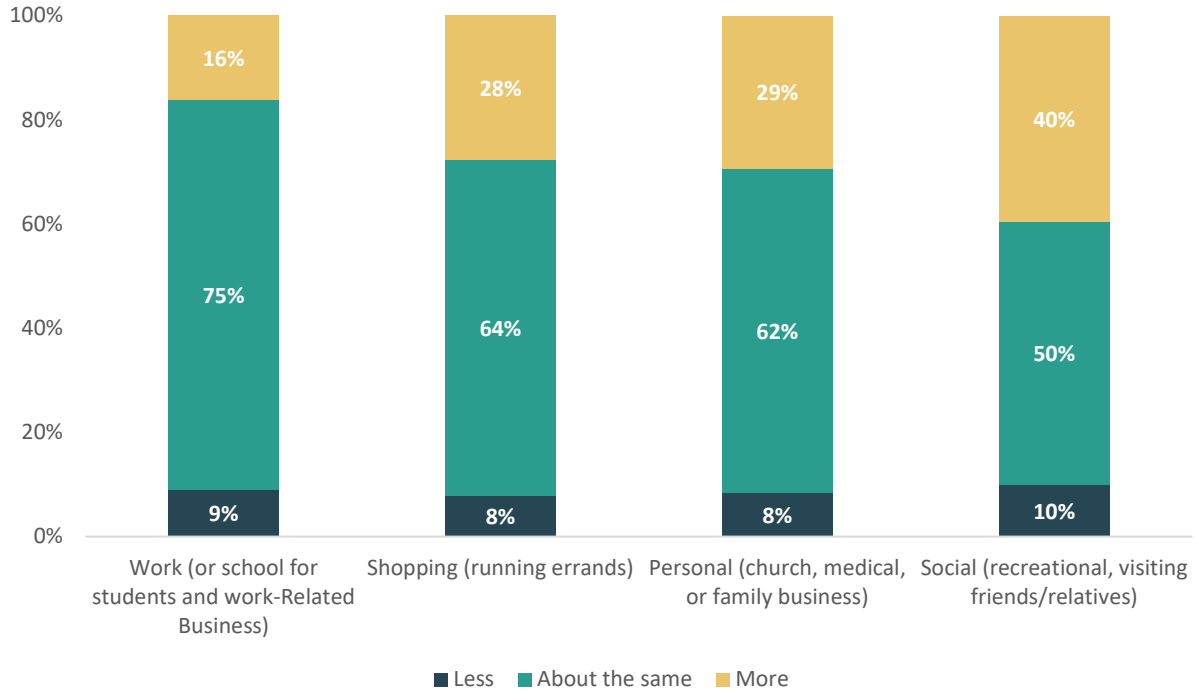
Figure 12. The effect of COVID-19 on social trips with respect to age

However, it is shown that there is a small difference across age groups. The age groups with the highest percentage of no effect are 55-64 (37%) and 65 and over (34%), while the age groups with the lowest percentage are 18-24 (26%) and 25-34 (30%). For those reporting moderate effects, 35-44 (29%) and 18-24 (24%) are the age groups with the highest percentage whereas 55-64 (19%) and 65 and over (22%) are the lowest. The percentage of people reporting a major effect on social travel is similar across all age groups, ranging from 12% to 14%, which is higher than the percentage of major effect on work. Overall, its suggested that COVID-19 has affected social travel differently across age groups, with younger age groups being more affected compared to older age groups, but more significantly than for work trips.

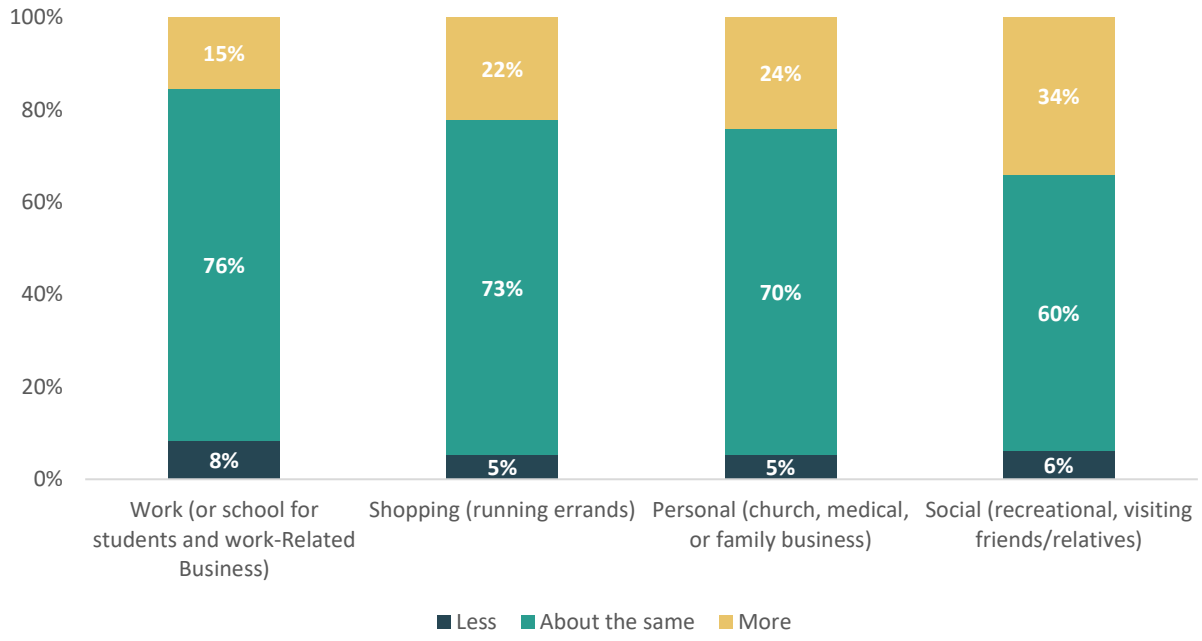
3.2 Expected Travel Habits

This section focuses on the expected change in the behaviors that are asked about in the first section due to COVID-19. Specifically, Figure 13 investigates the intentions to travel across the three cities to certain activities once COVID-19 is no longer a threat. Chi-square tests indicate that the distribution of expected travel frequency is significantly different among the three cities for shopping ($p = 0.03$), Personal ($p = 0.00$), and social ($p = 0.01$) activities expect for work-related ones ($p = 0.15$). Findings show that for work-related activities, the majority of people in all three cities (Chicago, Minneapolis, and Indianapolis) expect to travel about the same amount as they

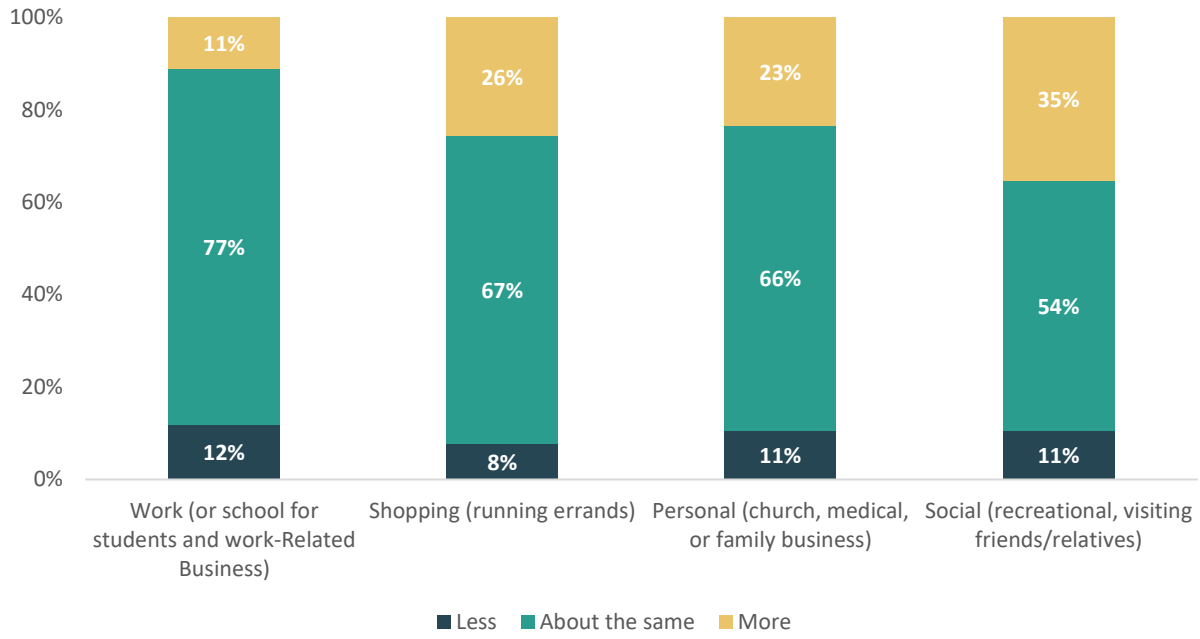
currently do, with slight variations ranging from 75% to 77%. However, a small percentage of people in Chicago and Indianapolis (9% and 12%, respectively) expect to travel less.



(a) Chicago



(b) Minneapolis



(c) Indianapolis

Figure 13. The intentions to travel to certain activities once COVID-19 is no longer a threat in (a) Chicago, (b) Minneapolis, and (c) Indianapolis.

For shopping and running errands, the majority of people in all three cities also expect to travel about the same amount as they currently do, with variations ranging from 64% to 73%. However, a slightly higher percentage of people in Chicago and Indianapolis (28% and 26%, respectively) expect to travel more for shopping after the pandemic is no longer a threat, which is double the percentage of people anticipating going to work more. For social activities, there are some differences between the cities. In Chicago, a higher percentage of people (40%) anticipate traveling more for social activities post COVID-19, compared to Minneapolis and Indianapolis where only 34% and 35% of people, respectively, expect to travel more. Additionally, a higher percentage of people expect to travel more for social activities post-COVID-19 compared to other trip purposes, which shows that social trips are the most affected by the pandemic. Overall, people in all three cities have different expectations for work-related activities. They expect to travel about the same amount for different trip purposes, with some slight variations. However, a higher percentage of people from Minneapolis anticipate the travel the same amount for all trip purposes.

Additionally, another question asked about the intentions to use different transportation modes. The figure 14 shows the expectations of those who expect to travel more using those modes. Chi-

squared tests indicate that the expected usage of all travel modes is significantly different among the three cities ($p < 0.05$).

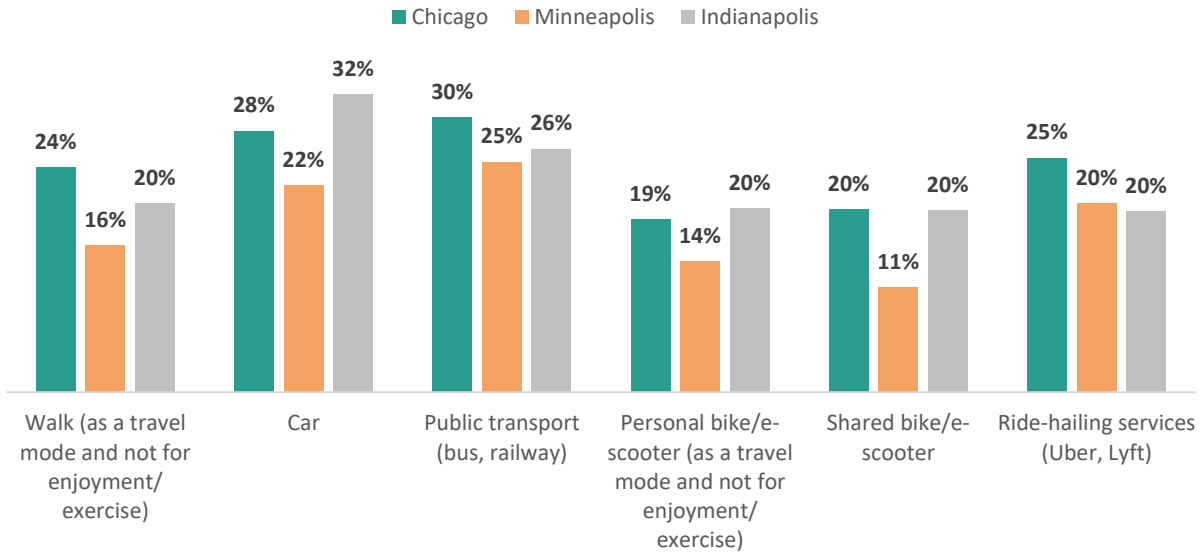
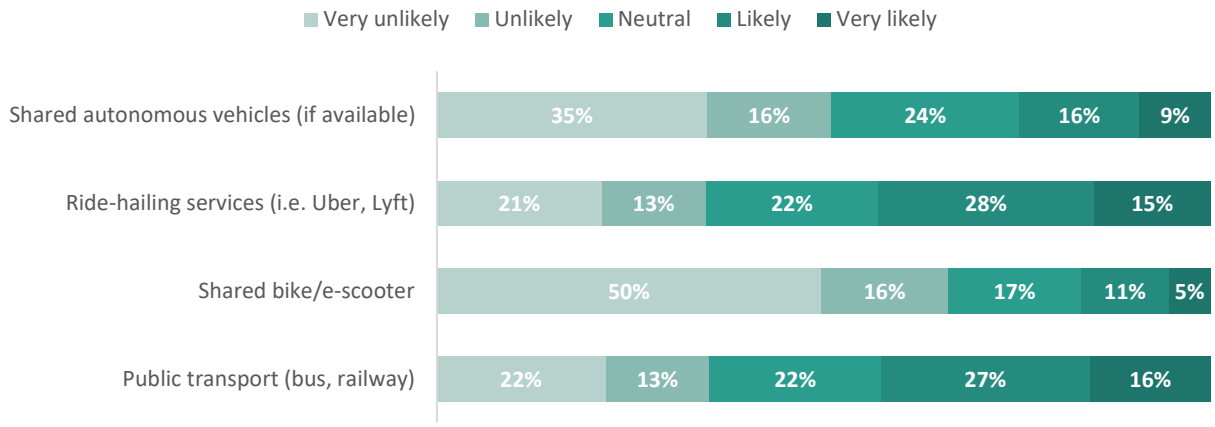


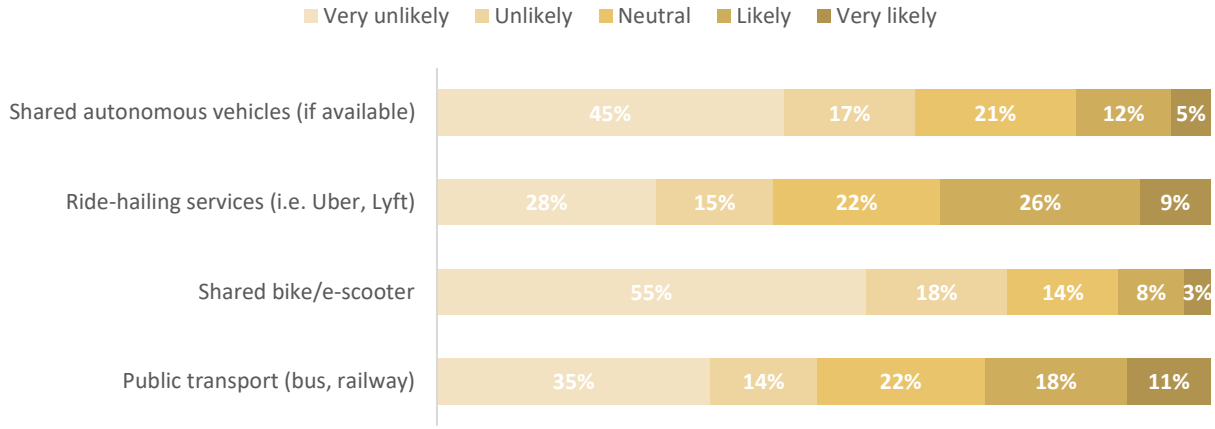
Figure 14. The anticipation to use travel modes for those who expect to travel more after COVID-19

The figure shows that the majority of people across the three cities expect to use public transit the most after the pandemic. Additionally, Chicago has the highest percentage of people (24%) who expect to walk more post-COVID-19. Minneapolis and Indianapolis have lower percentages, with 16% and 20% respectively. In contrast, the highest percentage of people (32%) who expect to use cars more post-COVID-19 is in Indianapolis, followed by Chicago (28%) and Minneapolis (22%). Turning to shared bikes/e-scooters, there is a similar percentage of people in Chicago and Indianapolis (20%) who expect to use them more post-COVID-19 compared to now, with the lowest percentage (11%) in Minneapolis. Finally, the highest percentage of people (25%) who expect to use ride-hailing more post-COVID-19 is in Chicago, followed by Minneapolis and Indianapolis with 20%.

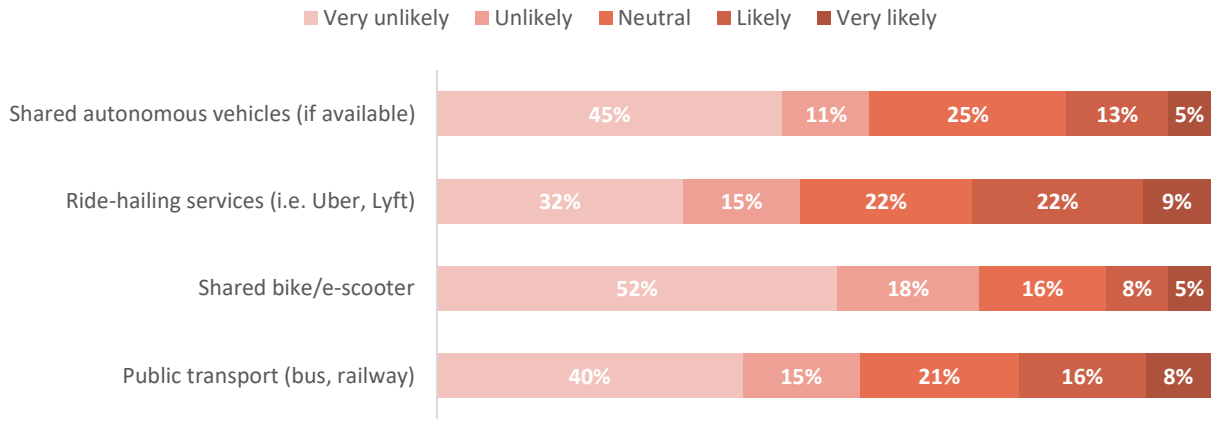
Another question asked about the likelihood of using a set of shared transportation modes given that their usage decrease specifically during COVID-19 due to increased risk perception. Figure 15 presents the results across the three cities in an effort to detect any differences. The Chi-squared tests indicate that the intention of travelers to use shared modes significantly changes among cities especially for public transit ($p = 0.00$), ride-hailing ($p = 0.00$), and shared autonomous vehicles ($p = 0.00$). On the other hand, the expectation to use shared bikes/e-scooters after COVID-19 is not significantly different among the three cities ($p = 0.2$) indicating similar anticipation for the services.



(a) Chicago



(b) Minneapolis



(d) Indianapolis

Figure 15. Anticipation to use shared modes of transportation after COVID-19 is no longer a threat in (a) Chicago, (b) Minneapolis, and (c) Indianapolis.

Results show that people expressed a higher likelihood to use public transit after the pandemic, with 27% of respondents indicating they are likely to use it. Ride-hailing services such as Uber and Lyft are also popular, with 28% of respondents indicating that they are likely to use them. In contrast, shared bike/e-scooter and shared autonomous vehicles are the least likely means of transportation that people would use, with 35% and 50% of respondents indicating that they are very unlikely to use them, respectively.

Compared to Chicago, Minneapolis and Indianapolis have a lower percentage of people who are likely or very likely to use public transportation (bus, railway) after COVID-19, with 18% and 16% respectively. On the other hand, both Minneapolis and Indianapolis have a higher percentage of people who are very unlikely to use public transportation (bus, railway), with 35% and 40% respectively. In terms of shared bike/e-scooter usage, there is a high percentage of people in all three cities who are very unlikely to use them after COVID-19, with Minneapolis having the highest percentage at 55%. Regarding shared autonomous vehicles, a high percentage also indicates the unlikelihood to use them in the future across the three cities.

In addition, the relationship between several demographic factors, including age, gender, and income, and the likelihood of future shared mobility adoption was examined. Results show that younger participants (aged 18-34 years) expressed higher expectations towards using public transit, shared micro-mobility, and ride-hailing services in the future across all three cities. In terms of gender, it is found that males have a greater likelihood of anticipating future use of ride-hailing services (60%), while no significant trend is observed for the other services. With respect to income, individuals with higher incomes are more likely to anticipate using ride-hailing and shared micro-mobility services, while the opposite is true for future public transit usage expectations.

3.3 COVID-19 preferences

This section specifically asks about travelers' opinion on how long they expect it will take them to recover from COVID-19. It also includes COVID-19 concern statements and asks about travelers' opinion on the probability of catching COVID-19 while using shared modes. Figure 16 sheds light on respondents' expectations of the time it will take to recover from COVID-19 across the three cities, which are statistically different ($p = 0.001$).

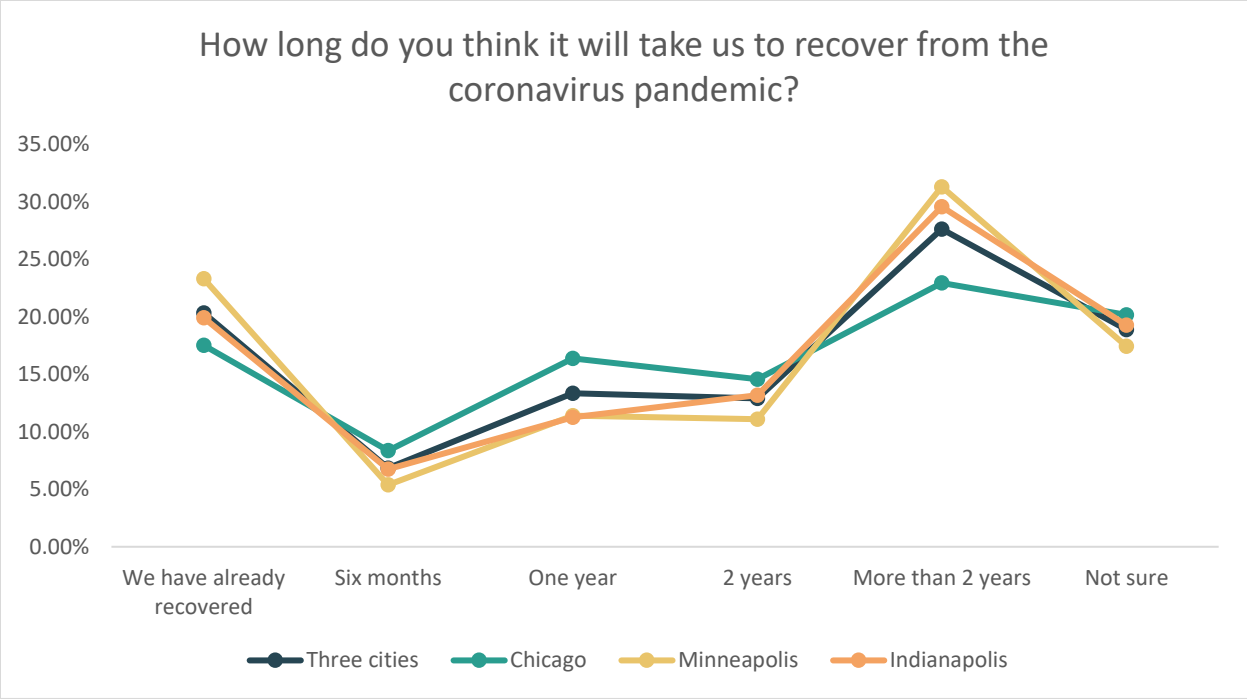
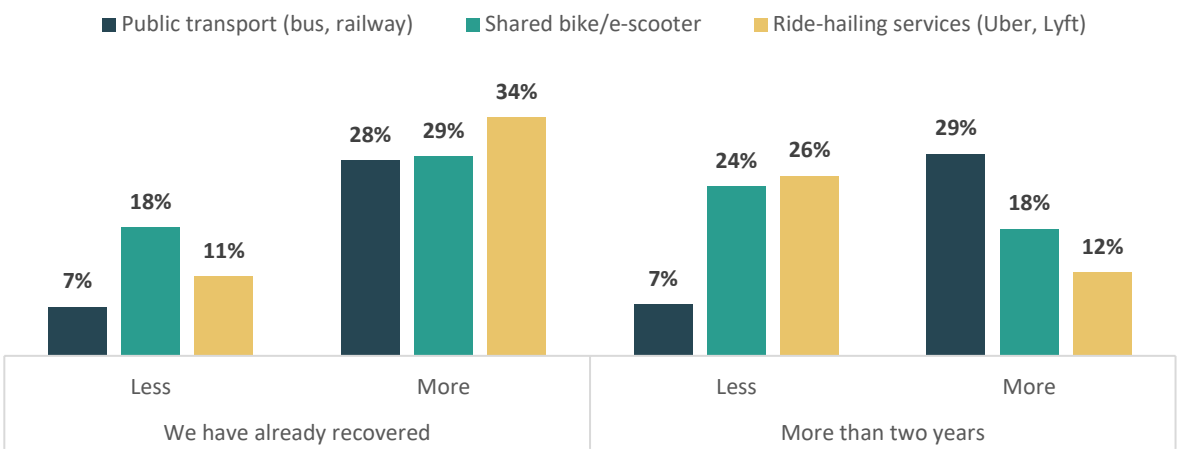


Figure 16. Expectations of how long it would take to recover from COVID-19

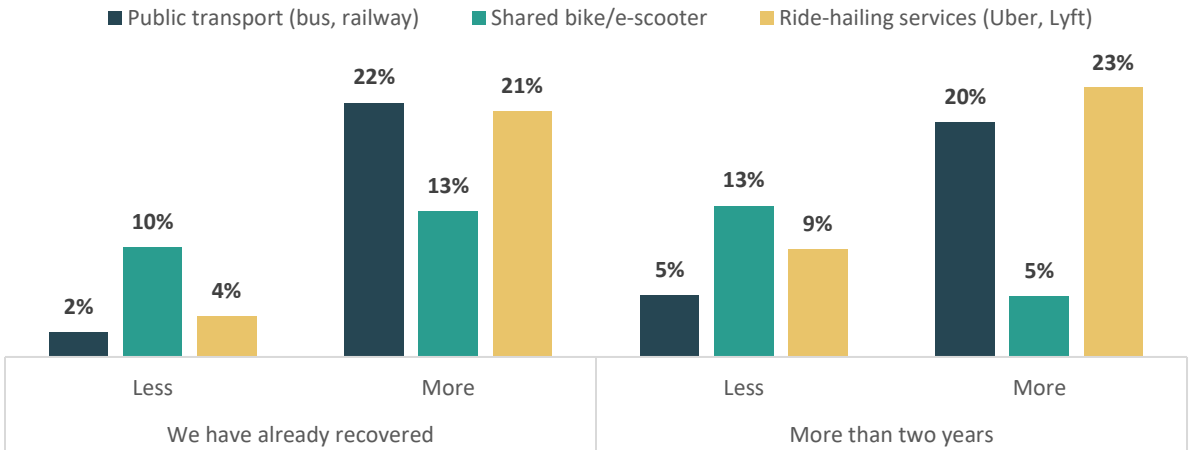
More than half of the respondents believe that it will take more than two years for society to recover from the pandemic, with Minneapolis having the highest percentage at 31.32%. Meanwhile, a significant proportion of respondents from all cities are unsure about the duration of the recovery. Minneapolis also has the highest percentage of respondents who believe that we have already recovered. The figure shows that respondents from Minneapolis have more extreme opinions compared to Chicago and Minneapolis.

In an effort to understand the nexus between recovery opinions and the expectation to travel, the intention to use shared travel options was investigated for respondents who believe that we have already recovered as well as those who think we still have two more years to recover. Figure 17 shows varying expectations among each city for future use of shared travel options for those who believe that recovery from the pandemic has already occurred and those who believe we still have two years left.

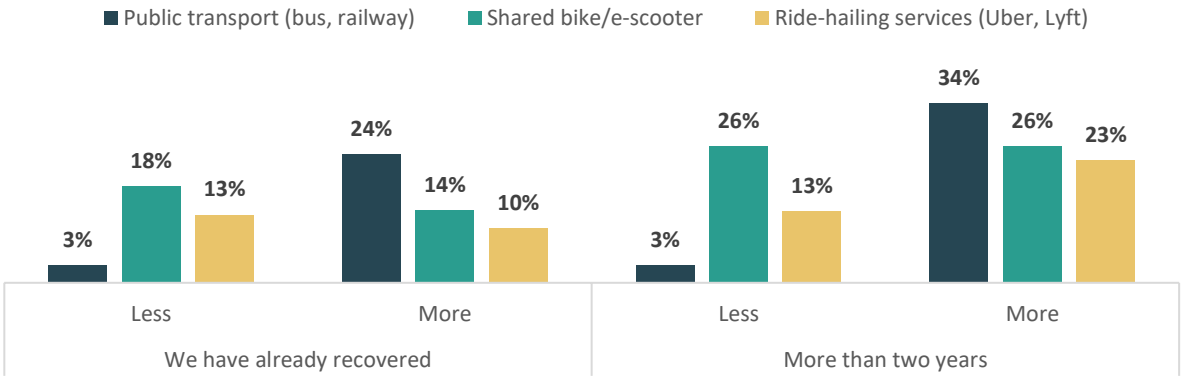
Results show that among all respondents, those who believe we have already recovered are more likely to expect to use shared mobility in the future. On the other hand, findings show that respondents who believe we still have more than two years to recover are overall the least likely to expect using shared mobility in the future.



(a) Chicago



(b) Minneapolis



(c) Indianapolis

Figure 17. Expectation to use shared mobility in the future in (a) Chicago, (b) Minneapolis, and

In Chicago, those who believe we have already recovered are more likely to anticipate using shared modes more in the future. On the other hand, those expecting two more years of the pandemic, are more likely to anticipate using shared mobility less except for public transit. As for Minneapolis, the anticipation to use shared mobility more is higher for both public transportation and ride-hailing services regardless of the belief regarding recovery time.

Comparing the three cities, Chicago shows higher expectations for increased use of shared travel options compared to the two other cities. A relatively higher proportion of respondents expect to use public transport (bus, railway) more in the future in Chicago (28%), compared to 22% in Minneapolis and 24% in Indianapolis. Additionally, more respondents in Chicago (29%) expect to use shared bike/e-scooter more in the future, compared to 13% in Minneapolis and 14% in Indianapolis. Similarly, a significant proportion of individuals in Chicago (34%) anticipate using ride-hailing services (Uber, Lyft) more in the future, which is higher than the percentages in Minneapolis (21%) and Indianapolis (10%).

In Chicago, a higher proportion expects to use shared travel less among those who believe we still have two years. Additionally, in Minneapolis, a lower number of respondents expects to use shared micro-mobility more, compared to those expecting to use it less. When comparing the three cities, Indianapolis shows the highest expectations for increased use of public transport, shared micro-mobility and ride-hailing services. Specifically, more respondents in Indianapolis expect to use ride-hailing services (23%) and shared micro-mobility (26%) more, compared to 12% and 18% in Chicago and 23% and 5% in Minneapolis, respectively.

Another set of questions solicited the participants' opinions regarding COVID-19 statements using a 5-point Likert scale Strongly disagree-Strongly agree. The results are shown in Figure 18.

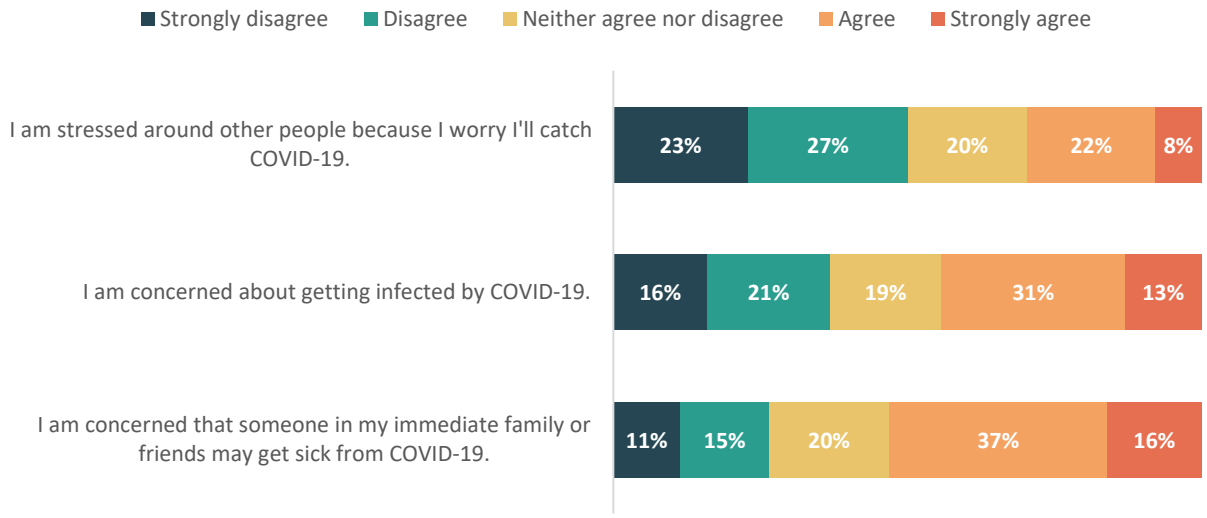


Figure 18. Opinions regarding COVID-19 statements

53% and 44% of respondents are either concerned about someone in their family or friends getting sick from COVID-19 or concerned about getting infected themselves, respectively. Additionally, 30% of respondents agree or strongly agree that they are stressed around other people because they worry about catching COVID-19. In terms of differences between the statements, the statement about concern for friends or family members has the highest level of agreement, with 53% of respondents agreeing or strongly agreeing. The second statement about concern for getting infected personally has slightly lower agreement, with 44% of respondents agreeing or strongly agreeing. The third statement about stress around others due to COVID-19 has the lowest level of agreement, with only 30% of respondents agreeing or strongly agreeing.

In an effort to understand the impact of being stressed due to COVID-19 on the intentions of travelers to use shared micro-mobility services in the future, figure 19 is plotted showing the percentages of those who answered "Yes" to the question "Do you intend to use these shared micro-mobility services in the future?" versus their level of agreement with the statement "I am stressed around other people because I worry I'll catch COVID-19."

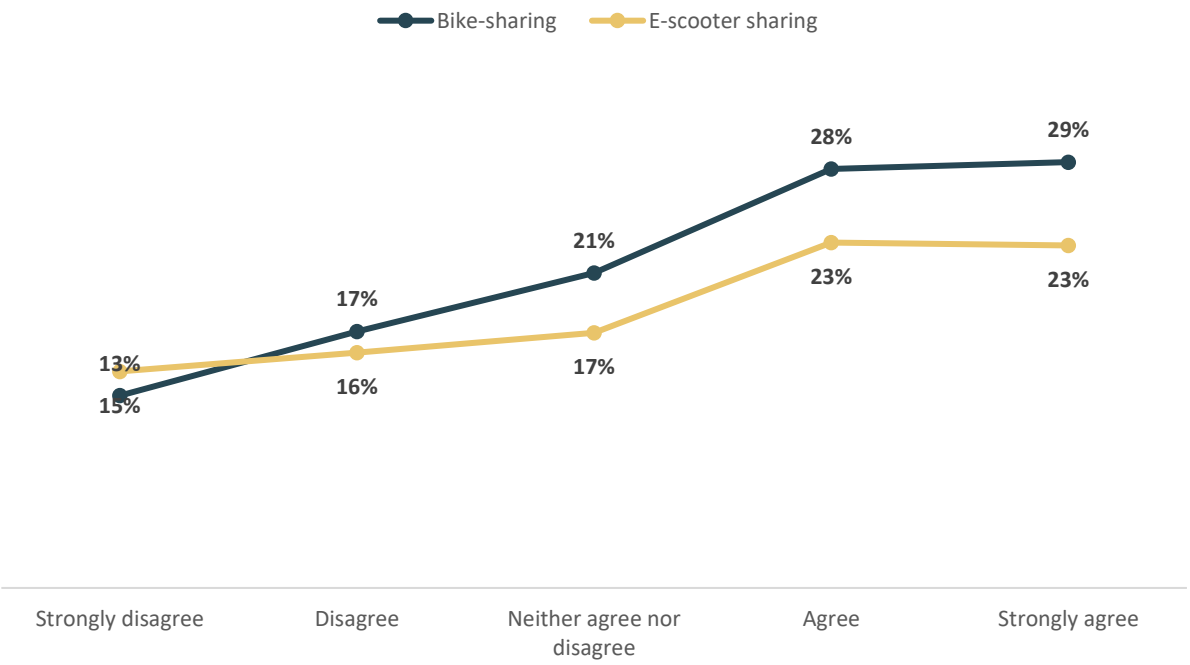


Figure 19. Intention to use micro-mobility in the future of participants who worry they will catch COVID-19 around other people

The figure shows that the percentages of intentions to use these services are increasing with the increasing level of agreement with the statement. These results suggest that individuals who are more stressed around others due to the risk of contracting COVID-19 are more likely to perceive bike-sharing and e-scooter sharing as safe transportation options. Therefore, shared micro-mobility services might be a preferred transportation option for these individuals.

In the context of online shopping, the figure 20 presents the percentage of individuals who shop online for grocery at least a few times a month given their agreement level to the statement "I am concerned about getting infected by COVID-19."

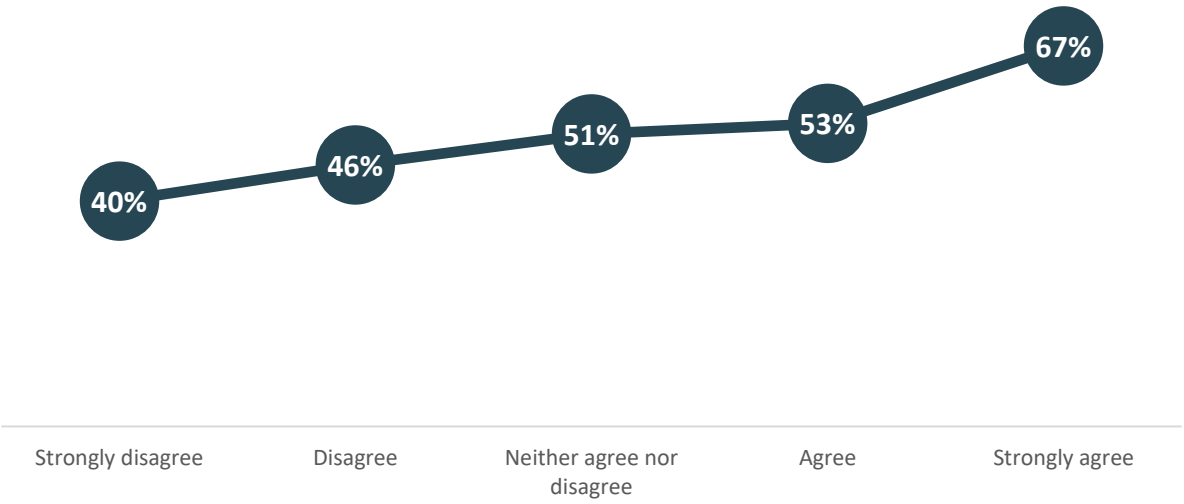


Figure 20. Frequency of online shopping: More than a few times a month versus the level of concern with COVID-19.

Findings suggest that those who frequently shop for groceries online are more concerned about getting infected by COVID-19. The percentage of agreement increases as the frequency of online grocery shopping increases, indicating that the more concerned people are about getting infected by COVID-19, the more often they shop online for groceries.

Furthermore, one question seeks to explore the risk perception of contracting COVID-19 from using shared transportation options. Figure 21 illustrates the results.

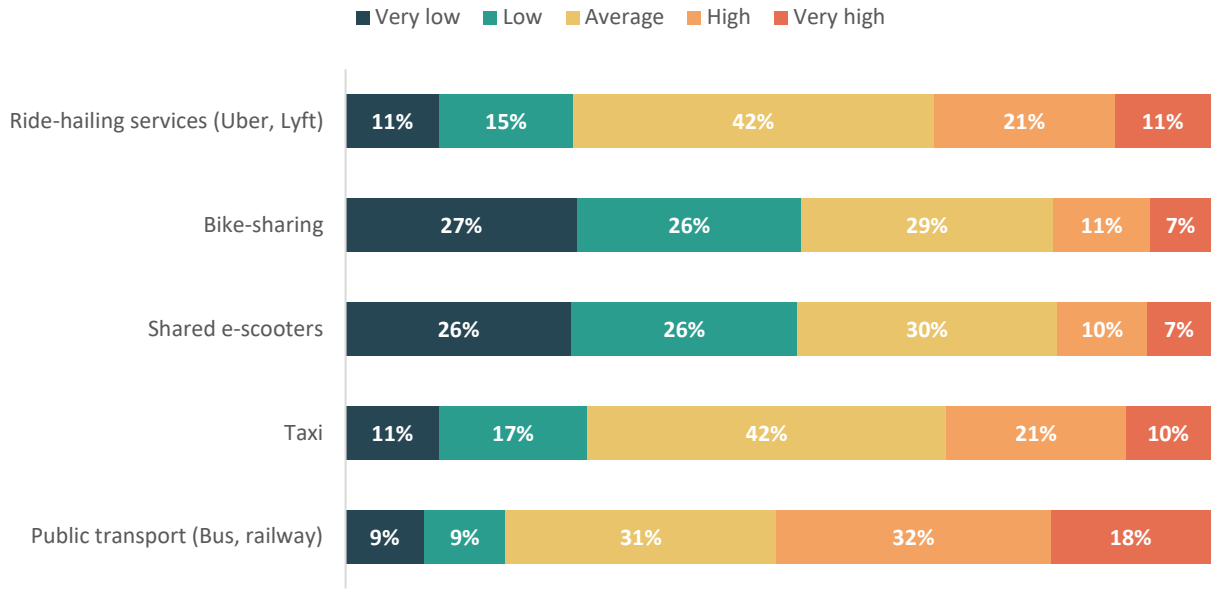
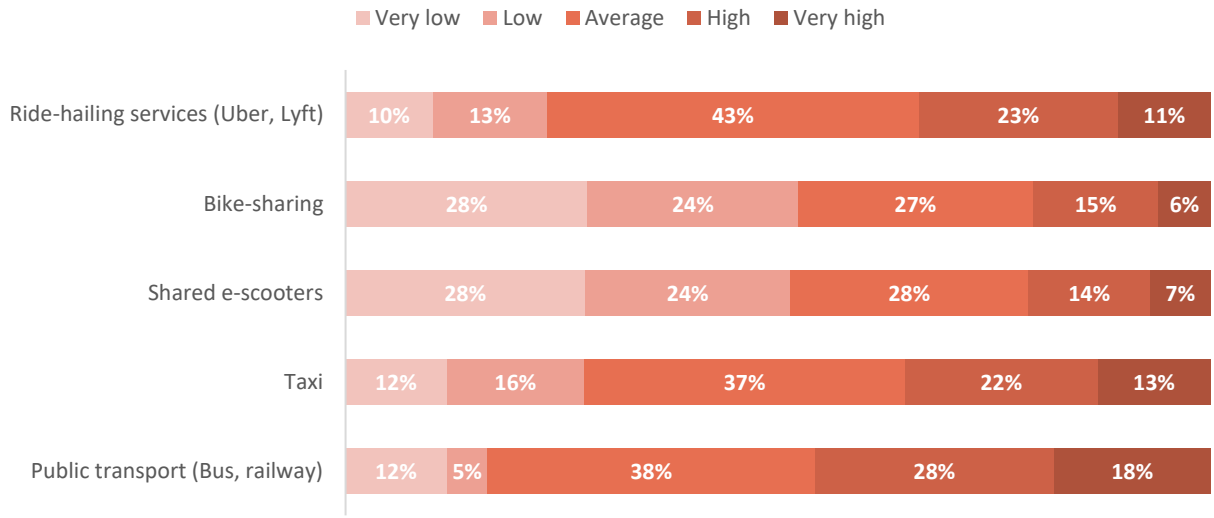


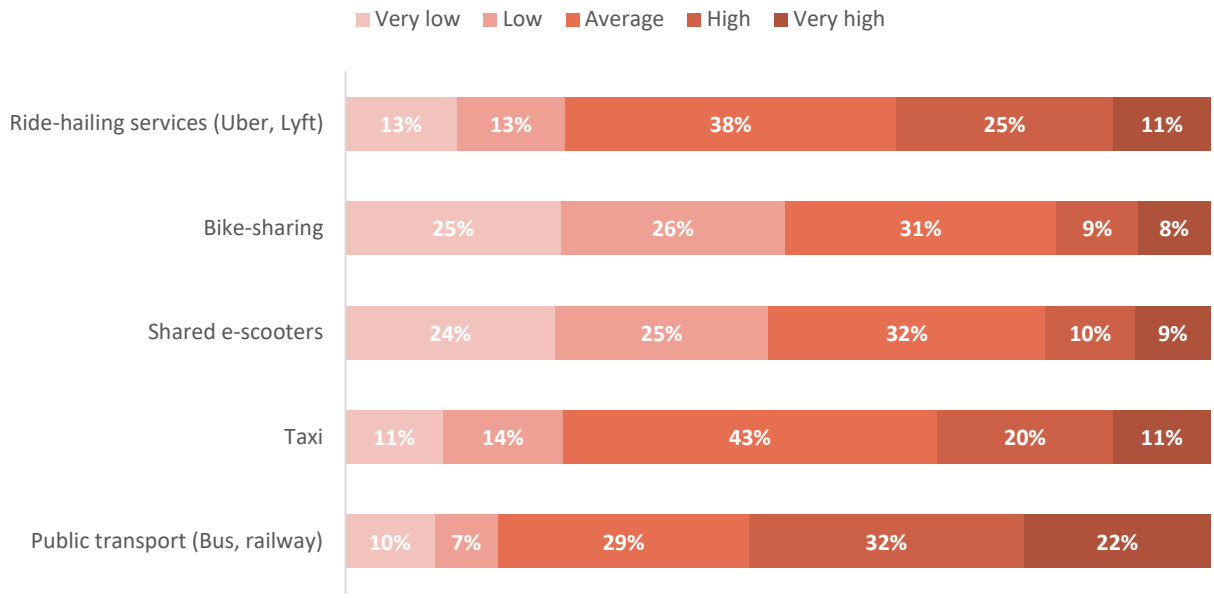
Figure 21. Risk perception of contracting COVID-19 from using shared transportation options

The majority of respondents perceive the risk of contracting COVID-19 to be either average or high while using public transport, taxi, and ride-hailing services. In contrast, shared e-scooters and bike-sharing are perceived to have a lower risk of contracting COVID-19.

A previous study in Indianapolis, conducted in 2021, asked a similar question (Luo et al., 2022). The figures 22 correspond to the results from the city two years apart. They represent the distribution of COVID-19 risk perception for shared travel modes among respondents in the city for two consecutive years, 2021 and 2022.



(a) 2021



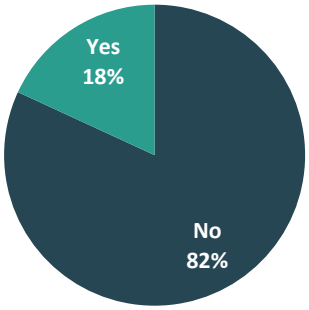
(b) 2022

Figure 22. Perception of the probability of contracting COVID-19 while using the shared modes in (a) 2021 and (b) 2022

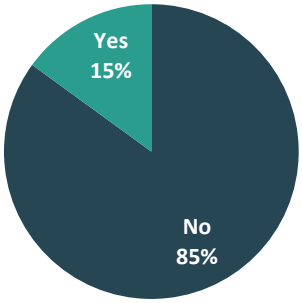
The figures show that the distributions for most modes of travel do not change much from 2021 to 2022. However, the distribution for public transport (bus, railway) changes slightly from 2021 to 2022, with a slight increase in the number of respondents reporting high and very high concerns from using the service. The Chi-square value corresponding for public transit ($p=0.065 < 0.1$) indicates that this change is marginally significant. On the other hand, the change in distribution for all other modes is not significant indicating that the perception of danger from shared modes remains relatively stable between the two years.

3.4 Micro-mobility Usage and Opinions

The section focuses on the usage of micro-mobility before, during, and after COVID-19. Results across the three cities were at first compared and it is found that they share similar trends. As such, findings are presented for all the sample. Figure 23 shows the percentage of people who indicated having used micro-mobility before COVID-19.



(a) Bike-sharing

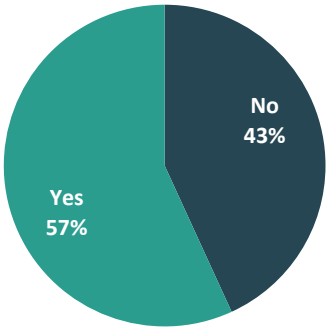


(b) E-scooter sharing

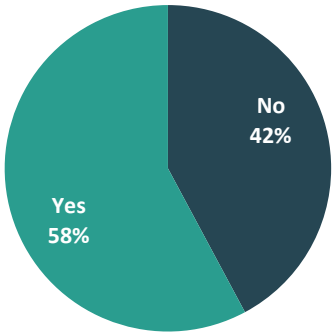
Figure 23. Usage of (a) bike-sharing and (b) e-scooter sharing before COVID-19

The pie charts show that a majority of the respondents (82%) had not used bike-sharing before COVID-19, while only 18% had used it. Similarly, 85% of respondents had not used e-scooter-sharing, while only 15% had used it before COVID-19, which is slightly less than bike-sharing.

Furthermore, Figure 24 presents two pie charts investigating whether before-COVID-19 users have used the services during COVID-19. This allows for exploring the continuance to usage of the services.



(a) Bike-sharing



(b) E-scooter sharing

Figure 24. Usage of (a) bike-sharing and (b) e-scooter sharing during COVID-19

The majority of those who had used bike-sharing before COVID-19 (57%) have continued to use it during the pandemic, while 43% have not. For e-scooter-sharing, 58% of those who had used it before COVID-19 have continued to use it during the pandemic. These results suggest that the services lost many users but also a significant proportion of users of both bike-sharing and e-scooter-sharing services have continued to use them during the pandemic, despite the risks associated with shared mobility services.

Additionally, the intention to use micro-mobility in the future, in a post-COVID-19 era. Figure 25 specifically illustrates the intentions of non-users to gain insight regarding prospective users.

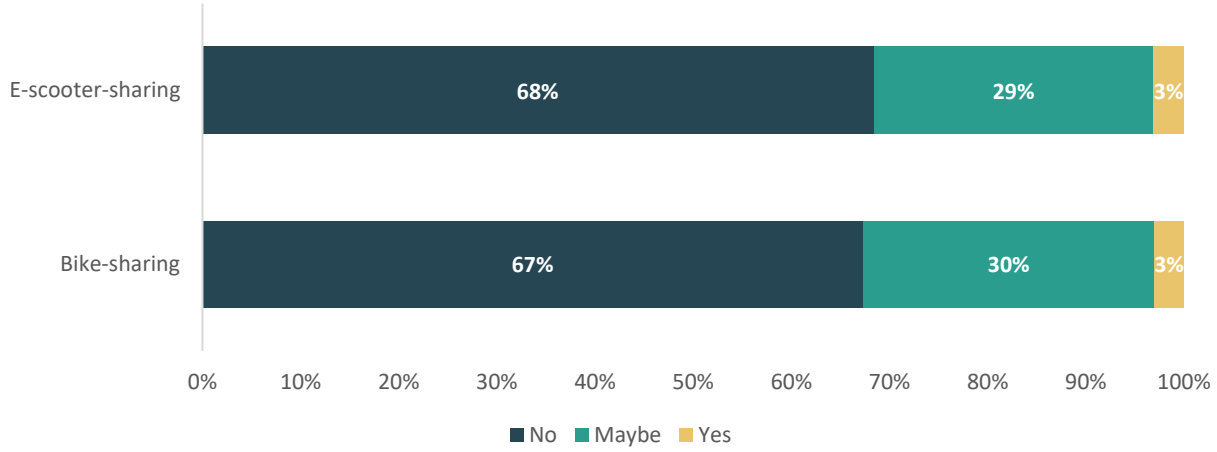


Figure 25. Intention to use in the future post COVID-19 for those who have never used it before

The majority of respondents who had never used bike-sharing or e-scooter-sharing services before, do not intend to use them in the future, with 67% and 68% responding "No," respectively. However, a significant portion of respondents for both services indicated that they were unsure by responding "Maybe" (30% for bike-sharing and 29% for e-scooter-sharing), while only 3% responded "Yes." This shows that non-users do not intent to start using the services.

Respondents in this section were finally asked about what they think micro-mobility services are mostly used for in general. Figure 26 illustrates their ranking of several purposes by different demographical groups that we thought would be relevant such as age, gender, and income.

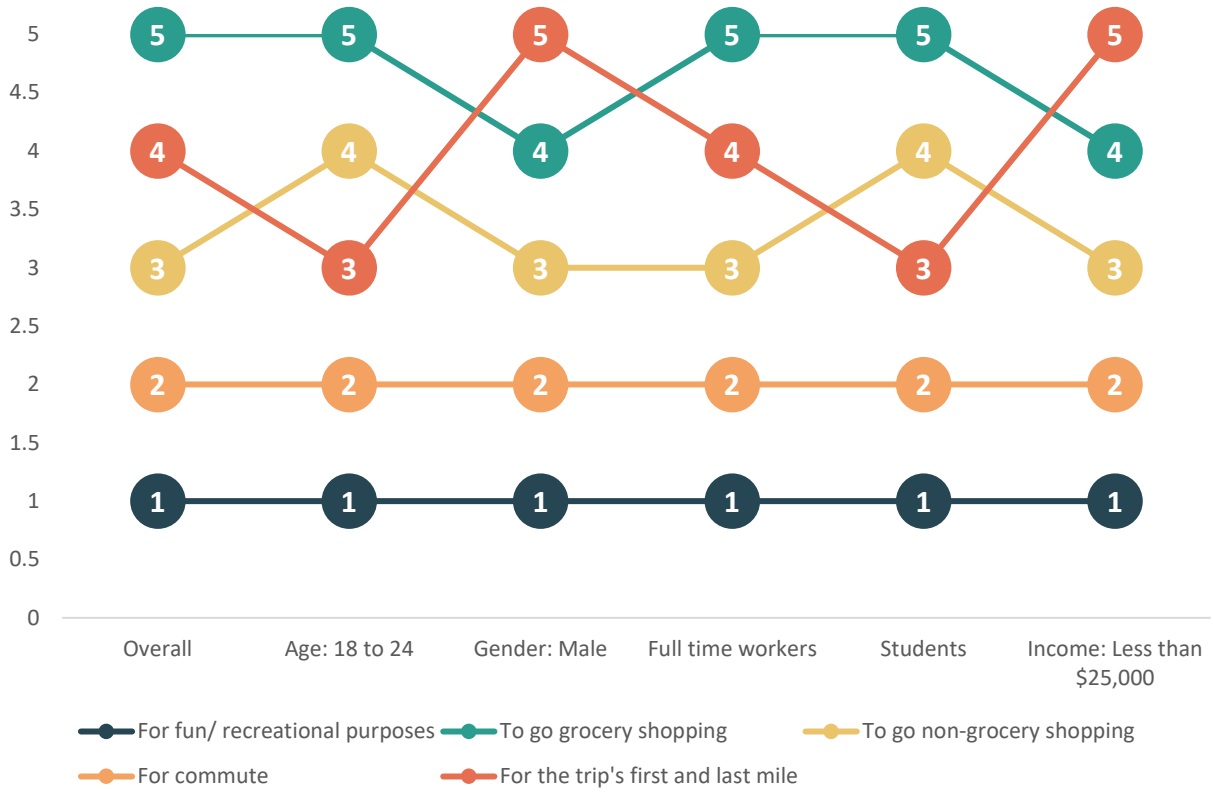


Figure 26. ranking of several purposes of micro-mobility usage by different demographical groups

Consistently, “For fun/recreational purposes” is ranked as the most common use for bike-sharing and e-scooter sharing systems, followed by “For commute” across all demographical groups. Among respondents aged 18 to 24 and students, “For the trip’s first and last mile” is seen as the third most common use. Respondents with an income of less than $25,000 per year join males and full time workers in ranking “To go non-grocery shopping” as the third most common use instead of “For the trip’s first and last mile” as ranked by the overall respondents. This can be explained by the fact that younger generations are more likely to perceive a benefit from Micro-mobility in the context of first/ last mile.

3.5 COVID-19 Emerging Activities: Shopping, Teleworking, And Online Grocery Shopping

This section discusses questions about the frequency of certain activities during stay-at-home COVID-19 order and the number of times doing these activities (shopping, eating out, working from home, etc.). Respondents are asked about the frequency of certain activities that flourished during COVID-19 (Figure 27).

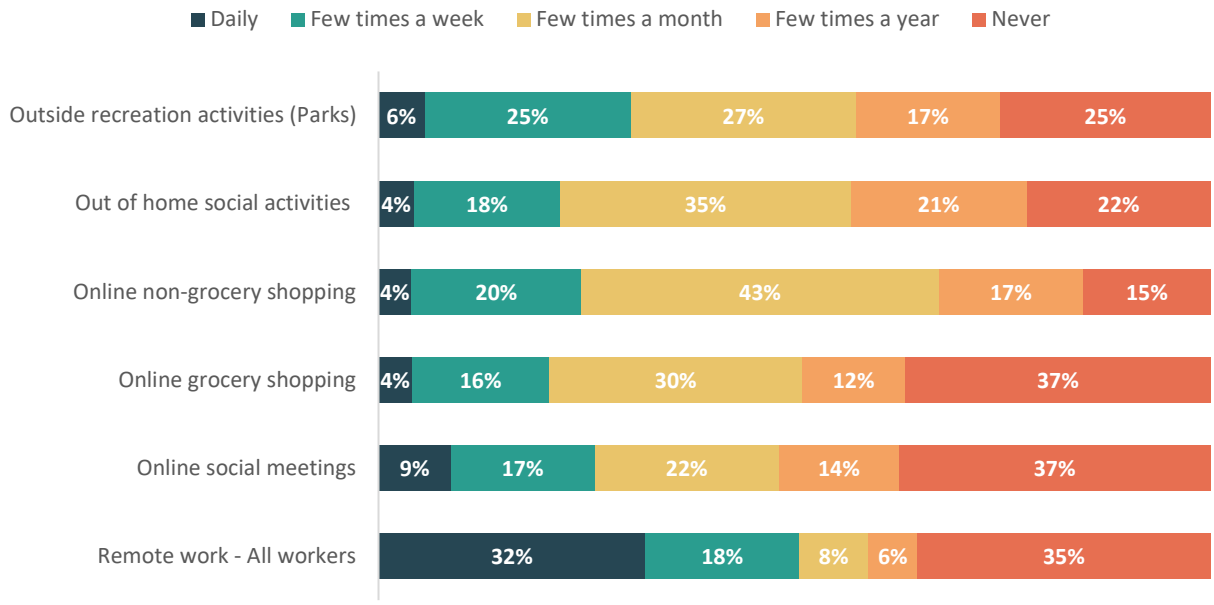


Figure 27. Frequency of certain activities during COVID-19

Remote work is still a common activity for many workers, with 32% reporting working remotely daily and 18% doing it a few times a week. Online social meetings have become more common, with 17% of respondents participating a few times a week and 22% a few times a month. Online grocery shopping has also become more frequent, with 16% reporting doing it a few times a week and 30% a few times a month. In contrast, out-of-home social activities like meeting with friends and family have decreased, with only 4% of respondents doing it daily and 18% doing it a few times a week. Outdoor recreation activities like going to parks have remained steady, with 25% of respondents doing it a few times a week and 27% doing it a few times a month.

Additionally, the frequency of remote work is compared between full-time and part-time workers as shown in Figure 28.

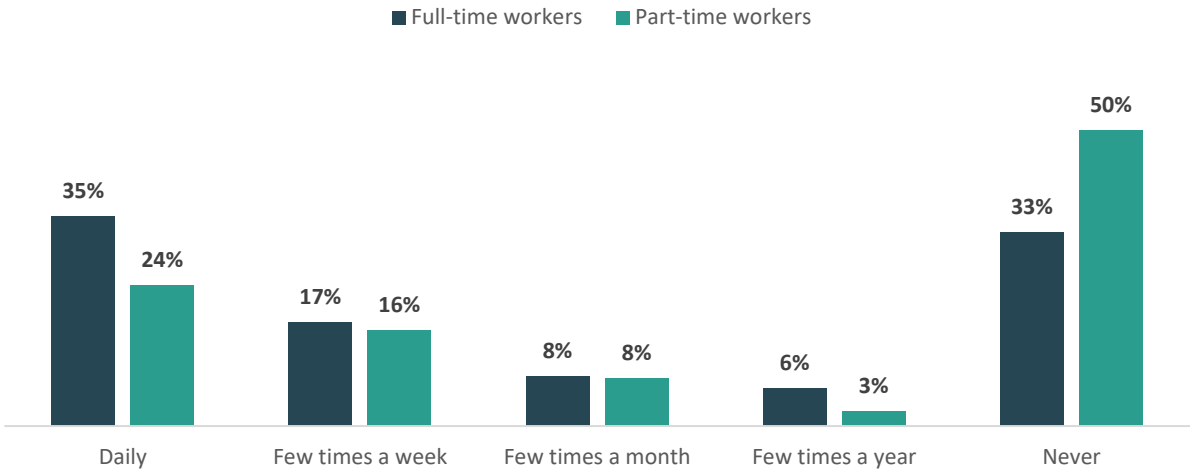


Figure 28. Frequency of remote work (including Online work meetings)

Full-time workers perform remote work daily at a rate of 35%, compared to only 24% of the time for part-time workers. Full-time workers perform remote work slightly more frequently than part-time workers a few times a week (17% for full-time vs. 16% for part-time), and similarly few times a month (8% for full-time vs. 8% for part-time). Part-time workers are more likely to level work remotely (50%) compared to full-time workers (33%). This comparison shows that full-time workers tend to work remotely more often than part-time workers.

Moreover, in an effort to investigate the frequency of in-person trips, respondents were asked about their travel to grocery and non-grocery stores, as well as going out to eat dinner. Figure 29 presents the number of weekly of trips involving the aforementioned activities.

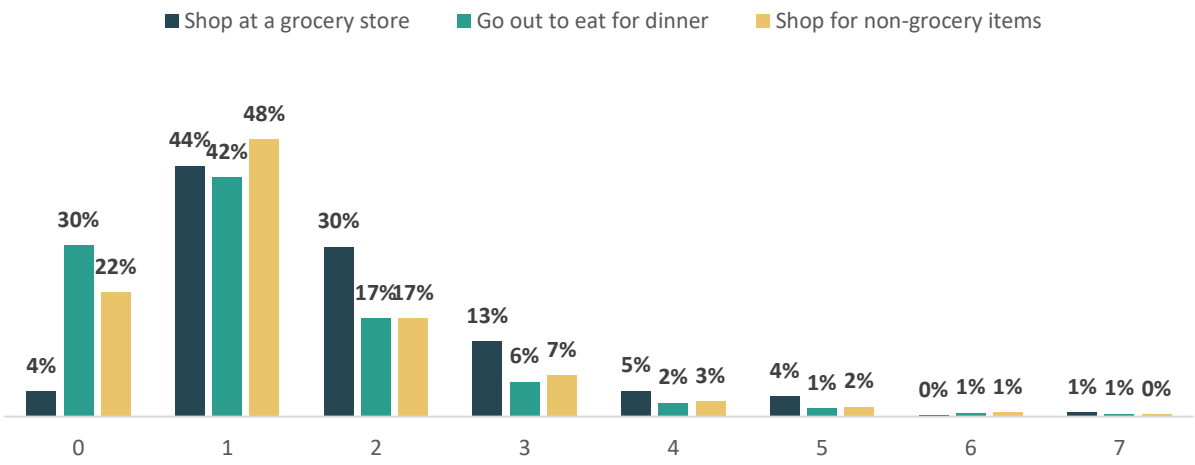


Figure 29. Number of weekly in-person trips to certain activities

The majority of respondents engage in these activities one time per week. However, there is a noticeable difference in the frequency of going out to eat for dinner compared to shopping for groceries or non-grocery items. While 42% of respondents go out to eat for dinner once per week, 30% of respondents do so less often. Additionally, findings show that people shop at a grocery store more frequently than going out to eat for dinner or shopping for non-grocery items. Most respondents go grocery shopping once or twice a week, whereas they go out to eat for dinner or shop for non-grocery items once a week on average or even less. Only 4% do not do grocery shopping weekly, while 22% respondents indicate not shopping for non-grocery items weekly. This shows that grocery shopping is the most frequently undertaken in-person activity among the three options presented whereas going out to eat for dinner is least one.

3.6 Ride-hailing Usage and Opinions

This section explores questions that follow the same wording as the ones discussed in section 3.4 but in the context of ride-hailing. Results across the three cities are found to be slightly different for some questions. As such, some findings are presented and compared across the three cities and others are shown for all the sample. Figure 30 shows the percentage of people who indicated having used ride-haling before COVID-19 for the entire sample.

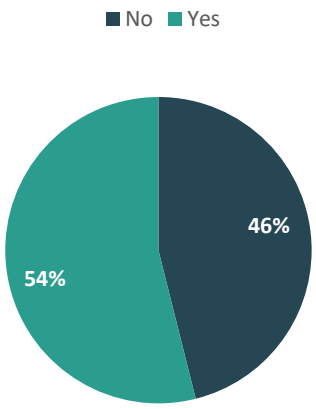


Figure 30. Usage of ride-hailing before COVID-19

The pie chart indicates that 54% of the respondents had used ride-hailing services at least once, while 46% had not before COVID-19. Additionally, Figure 31 shows the continuance of usage of ride-hailing during COVID-19 by those who had used it before the pandemic.

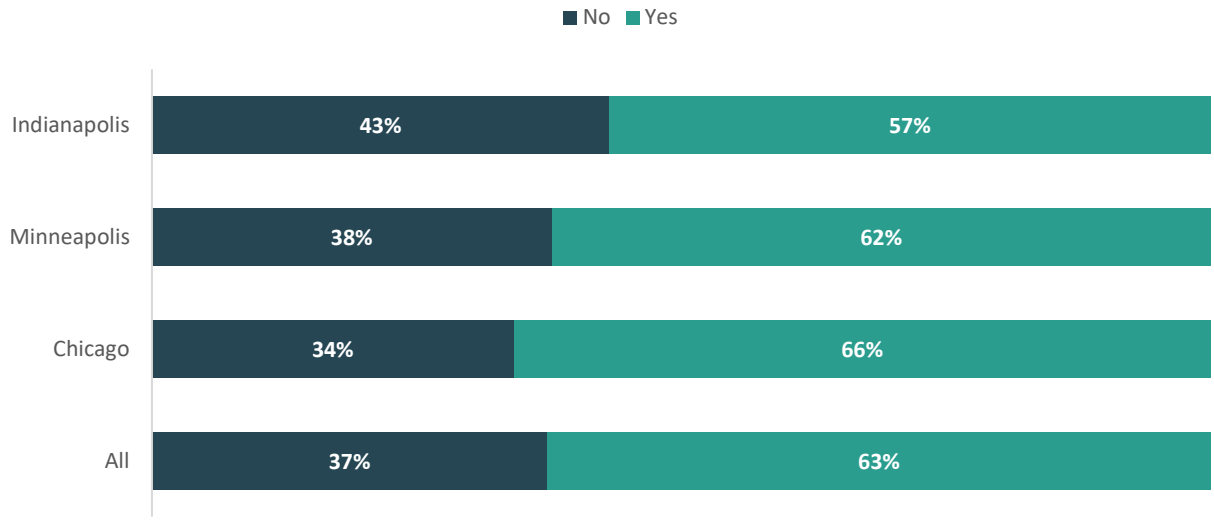


Figure 31. Usage of ride-hailing during COVID-19 by previous users

The figure shows that the majority of respondents continued using ride-hailing during COVID-19. However, Chicago had the highest percentage of respondents who continued using ride-hailing (66%) compared to 62% and 57% in Minneapolis and Indianapolis, respectively. However, a Chi-square test indicates that the difference is not statistically different among the three cities ($p = 0.146$). This shows that, consistently across the three cities, a high number of people did not stop using this service despite the associated high-risk perception.

4 CONCLUSIONS AND RECOMMENDATIONS

This study investigates the impact of the pandemic on mobility and the public's perception of various transportation modes. Specifically, it involves three objectives, namely, i) assessing changes in travel behavior caused by the pandemic; ii) investigating the public's intention to use shared mobility post-COVID-19; and iii) comparing the pandemic's overall impact among three midwestern cities: Chicago, Indianapolis, and Minneapolis. A stated-preference survey was designed and disseminated in adult residents of the three cities in 2022.

Looking at household characteristics, the results show that the majority of households own at least one gas-powered car whereas other types of vehicles are significantly less popular. Vehicle ownership is not shown to change during COVID-19. However, it is indicated that it might have slightly increased instead suggesting a high dependency on cars during the pandemic. Findings offered insights into the impact of COVID-19 on mobility and perceptions. It is shown that cars and walking are the most commonly used modes of transportation in all three cities, with personal bikes and bike-sharing/e-scooters being less frequently used. Cars are the most commonly used mode of transportation for all trip purposes, followed by walking. Additionally, the pandemic has had a varying degree of impact on different travel activities, with social trips being the most affected. The study also finds that the majority of people in all three cities expect to travel about the same amount for different trip purposes, with a higher percentage of people in Chicago and Indianapolis anticipating traveling more often for social activities post COVID-19. Turning to concerns related to COVID-19, the results indicate that more than half of the respondents stated that "it would take at least one year for society to recover from the pandemic". Respondents who stated "we have already recovered" are more likely to expect to use shared mobility in the future. Those who stated "we still have more than two years to recover from COVID-19" are overall the least likely to expect to use shared mobility in the future. Additionally, a significant proportion of respondents from all cities were concerned about someone in their family or friends getting sick from COVID-19 or concerned about getting infected themselves.

4.1 Public transit

There are significant differences in the frequency of public transit usage across the three cities. Most of the participants stated that the risk of contracting COVID-19 is high when using public transport. The research also indicates that younger respondents (between 18 to 34 years) are more likely to anticipate using public transit in the future.

It is recommended that public transit authorities implement measures to address the concerns around COVID-19 transmission. This could include the implementation of contactless payment, increased cleaning and sanitization of vehicles and stations, as well as coupling their effort with transparent information to help reassure passengers. It is also recommended that authorities in each city tailor their strategies to address the specific needs and challenges faced in their

respective regions. This could include improving the frequency and reliability of service to target this change and attract more passenger. Additionally, given that younger respondents expressed higher expectations towards using public transit in the future, authorities could focus on targeting this demographic with outreach efforts such as promotional discounts and partnering with universities and schools to provide discounted or free passes to students.

4.2 Shared micro-mobility

It is found that the usage frequency of shared micro-mobility is different among the cities. Respondents were also asked about what they believe micro-mobility services are used for, and the most common usage purpose across all groups is for fun/recreational purposes, followed by commuting. In terms of COVID-19, shared e-scooters and bike-sharing is perceived to have a lower risk of contracting COVID-19. Additionally, respondents who are stressed around others due to the risk of contracting COVID-19 are more likely to perceive bike-sharing and e-scooter sharing as safe transportation options. Younger participants (aged 18-34 years) expressed higher expectations towards using shared micro-mobility in the future across all three cities. With respect to income, individuals with higher incomes are more likely to anticipate shared micro-mobility services.

Based on the finding that shared micro-mobility services are perceived to have a lower risk of contracting COVID-19, transportation providers should communicate this to potential users to increase adoption of these services. Providers can also offer additional safety measures, such as disinfection protocols and contactless payment options, to further address concerns about COVID-19. Given that younger participants expressed higher expectations towards using shared micro-mobility in the future, transportation providers should target this demographic with marketing campaigns and promotions that highlight the benefits of these services, such as affordability and environmental sustainability. Additionally, to encourage adoption of shared micro-mobility among individuals with lower incomes, transportation providers can explore pricing strategies such as discounts, subsidies, or flat rates.

However, findings also show that a majority of respondents had not used bike-sharing or e-scooter-sharing before COVID-19 and a bigger percentage does use ride-hailing. However, among users, a significant portion continued to use all three services during the pandemic. Non-users mostly do not intend to use micro-mobility services in the future. To increase usage of bike-sharing and e-scooter-sharing services, transportation providers can invest in infrastructure such as bike lanes and parking areas to make these services more accessible and convenient. Transportation providers can also collaborate with local governments and other stakeholders to promote the benefits of micro-mobility services, such as reducing traffic congestion and improving air quality. Moreover, to encourage adoption among non-users, transportation providers can free trials to incentivize individuals to try these services. Providers can also address common barriers to adoption, such as safety concerns and the perception that these services are not suitable for all trip purposes.

4.3 Ride-haling

The majority of respondents had perceptions of high risk of contracting COVID-19 from ride-hailing usage. A large percentage use ride-hailing and a significant portion of users continued to use the service during pandemic. In terms of usage expectation, males have a greater likelihood of anticipating future use of ride-hailing services (60%). Similar to shared micro-mobility, younger adults expressed higher expectations towards using ride-hailing services in the future across all three cities. Individuals with higher incomes were more likely to anticipate using ride-hailing in the future.

Findings suggest that ride-hailing companies should prioritize safety measures to address customers' perception of high COVID-19 transmission risk. These measures could include mandatory mask-wearing, hand sanitizer provisions, and increased cleaning protocols. Additionally, companies should be transparent about their safety measures to build trust with customers. Additionally, marketing strategies for ride-hailing companies should target demographics with a higher likelihood of future use, such as males and younger adults. Tailored advertising and promotions could be effective. Given the higher anticipated future use of ride-hailing services among individuals with higher incomes, companies could offer discounts to appeal to low-income users.

4.4 Online shopping

Around 50% of participants specify doing online grocery shopping at least few times a month. The percentage of those who frequently shop for groceries online increases with the increase in the level of concern about getting infected.

To meet the growing demand for online grocery shopping, retailers should invest in improving their online platforms and delivery services to provide a better shopping experience for customers. Offering incentives like discounts or free delivery could encourage more frequent use of these services. Additional safety measures, such as contactless delivery, providing personal protective equipment for employees, and using sanitization protocols to clean products and delivery vehicles, could also help reassure customers who are worried about getting infected.

4.5 Limitations

Although the study paves the way to further analyses on shared mobility perceptions regarding COVID-19, the findings of this study should be interpreted in light of certain limitations. The data was collected using a stated-preference survey, which may not always accurately reflect actual behavior. Survey data may hold some bias. Secondly, the study is based on stated preferences and lacks actual ridership data (revealed preferences) to confirm and solidify the findings and link them to reality. Finally, the study only focuses on midwestern cities, limiting the generalizability of the findings to other regions. Further research that includes more diverse samples and actual ridership data is necessary to better understand the impact of the pandemic on mobility and public perception of shared mobility services.

5 SYNOPSIS OF PERFORMANCE INDICATORS

5.1 Part I

The research from this advanced research project was disseminated to over 180 people from industry, government, and academia. The research was presented at several conferences, including the 2022 ASCE ICTD, and both the 2022 and 2023 Annual CCAT Global Symposiums. This project supported 1 graduate student (doctoral).

During the study period: (a) 1 undergraduate course was offered by the PI (b) 2 undergraduate students and 1 graduate student participated in this research project and were funded by this grant during the study period.

5.2 Part II

Research performance Indicators: This project resulted in 2 conference posters and 1 presentation, but did not produce any new technologies, procedures/policies, or standards/design practices.

Leadership Development Performance Indicators: The research project resulted in 3 media engagements, 3 academic engagements, and 2 industry engagements. The principal investigator (PI) held positions in 2 professional societies that examine issues related to this research project, and the graduate student, who worked on this project, held student leadership positions.

Technology Transfer Performance Indicators: Two media stories that referred to the research or other associated activities were identified in relation to this CCAT research project, which included a tweet with several hits and a LinkedIn post that reached about 5,000 impressions.

Collaboration Performance Indicators: There was collaboration with other agencies as 1 agency contributed funds to an associated project.

6 OUTPUTS, OUTCOMES, AND IMPACTS

6.1 Outputs

i. The results of this work have been presented at various conferences as reported below:

ii. Chahine, R., Cai, H., Gkritza, K. Understanding Travel Behavior with regards to shared mobility services in Indianapolis during COVID-19. The 2022 CCAT Global Symposium on Connected and Automated Vehicles and Infrastructure, April 13th, 2022. Ann Arbor, MI. Also available on Youtube, at: https://lnkd.in/gjAvS3vv.

iii. Chahine, R., Qian, X., Gkritza, K. Understanding travel behavior with regards to shared mobility services in Indianapolis during COVID-19. Presented at the ASCE International Conference on Transportation and Development, Seattle, WA, May 31–June 3, 2022.

iv. Chahine, R., Losada-Rojas, L. L., Gkritza, K. Are we ready to share again? Understanding the impact of COVID-19 on the intention of travelers to use shared-mobility. Presented at the 6th Annual CCAT Global Symposium, Ann Arbor, MI, April 07, 2023.

v. Chahine, R., Losada-Rojas, L. L., Gkritza, K. Are we ready to share again? Understanding the impact of COVID-19 on the intention of travelers to use shared-mobility. Presented at the Next-Generation Transport Systems Conference (NGTS-3), West Lafayette, IN, May 17, 2023.

vi. Chahine, R., Losada-Rojas, L. L., Gkritza, K. Are we ready to share again? Understanding the impact of COVID-19 on the intention of travelers to use shared-mobility. Presented at the Transportation Research Board's Conference on Innovations in Travel Analysis and Planning, Indianapolis, IN, June 6, 2023. **Winner of best poster award**.

vii. Chahine, R., Losada-Rojas, L. L., Gkritza, K. Are we ready to share again? Understanding the impact of COVID-19 on the intention of travelers to use shared-mobility. Presented at the ASCE International Conference on Transportation and Development, Austin, TX, June 14-17, 2023.

6.2 Outcomes

- A better understanding of the intentions of travelers to ride shared mobility through the literature review.
- Increased understanding of the methods that need to be utilized to study the intentions of travelers.
- A survey instrument that can be used in future research to expand on the current one.
- Data analysis with insights on:

    - The public's preferences regarding COVID-19 in three different cities.
    - Difference between actual and expected travel habits in the context of COVID-19.
    - Micro-mobility and ride-hailing regarding usage and opinions during COVID-19.
- Micro freight delivery preferences in the context of COVID-19

6.3 Impacts

The findings from the data analysis and insights gained from this research project are expected to contribute to the body of knowledge in the field of transportation, particularly in understanding the public's preferences and travel habits in the context of COVID-19. The impacts of this research are expected to extend beyond the immediate project timeline and contribute to the ongoing discourse on transportation and mobility in the post-COVID-19 era.

6.4 Technology Transfer

Not Applicable.

6.5 Challenges

The timeline shifted slightly due to impacts of COVID-19 on human subjects' research as well as student recruiting.

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7 APPENDIX

Summary tables. They are done.

Question	Choices	Frequency
What is your age range?	18-24/ 25-34/ 35-44/ 45-54/ 55-64/ 65 and over	10/ 20/ 19/ 15/ 15/ 21
What gender do you identify with?	Male/ Female/ Other	42/ 57/ 1
Actual travel habits		
How often do you use the following modes of transportation? - Walk	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	46/ 24/ 11/ 6/ 12
How often do you use the following modes of transportation? - Car	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	54/ 29/ 9/ 3/ 5
How often do you use the following modes of transportation? - Personal bike/e-scooter	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	2/ 10/ 11/ 12/ 64
How often do you use the following modes of transportation? - Public transport (bus, railway)	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	6/ 12/ 15/ 27/ 40
How often do you use the following modes of transportation? - Shared bike/e-scooter	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	1/ 3/ 7/ 8/ 81
How often do you use the following modes of transportation? - Ride-hailing services (Uber, Lyft)	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	2/ 8/ 21/ 28/ 40
On average during this past year, how often did you travel for the activities listed below: - Work (or school for students and work-related business)	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	39/ 16/ 6/ 6/ 34
On average during this past year, how often did you travel for the activities listed below: - Shopping (running errands)	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	12/ 60/ 22/ 2/ 3
On average during this past year, how often did you travel for the activities listed below: - Personal (church, medical, or family business)	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	8/ 35/ 36/ 13/ 8
On average during this past year, how often did you travel for the activities listed below: - Social (recreational, visiting friends/relatives)	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	9/ 31/ 43/ 14/ 4
Which of the following is your most frequently used mode of travel for each trip purpose? (Please select only one mode for each trip purpose). - Work (or school for students and work-related business)	Walking/ Car/ Personal bike/e-scooter/ Public transit/ Shared bikes/ e-scooters/ Ride-hailing (Uber/ Lyft)/ Other/ N/A (I am not travelling for this purpose)	6/ 55/ 1/ 10/ 0/ 3/ 0/ 24
Which of the following is your most frequently used mode of travel for each trip purpose? (Please select only one mode for each trip purpose). - Shopping (running errands)	Walking/ Car/ Personal bike/e-scooter/ Public transit/ Shared bikes/ e-scooters/ Ride-hailing (Uber/ Lyft)/ Other/ N/A (I am not travelling for this purpose)	9/ 76/ 1/ 6/ 1/ 4/ 0/ 2
Which of the following is your most frequently used mode of travel for each trip purpose? (Please select only one mode for each trip purpose). - Personal (church, medical, or family business)	Walking/ Car/ Personal bike/e-scooter/ Public transit/ Shared bikes/ e-scooters/ Ride-hailing (Uber/ Lyft)/ Other/ N/A (I am not travelling for this purpose)	9/ 72/ 1/ 8/ 0/ 4/ 1/ 6

Which of the following is your most frequently used mode of travel for each trip purpose? (Please select only one mode for each trip purpose). - Social (recreational, visiting friends/relatives)	Walking/ Car/ Personal bike/e-scooter/ Public transit/ Shared bikes/ e-scooters/ Ride-hailing (Uber/ Lyft)/ Other/ N/A (I am not travelling for this purpose)	8/ 71/ 1/ 9/ 1/ 6/ 1/ 2
How much has COVID-19 affected your travel for the following trip purposes? - Work (or school for students and work-related business)	No effect/ Minor effect/ Neutral/ Moderate effect/ Major effect	46/ 17/ 13/ 15/ 10
How much has COVID-19 affected your travel for the following trip purposes? - Shopping (running errands)	No effect/ Minor effect/ Neutral/ Moderate effect/ Major effect	31/ 26/ 14/ 20/ 8
How much has COVID-19 affected your travel for the following trip purposes? - Personal (church, medical, or family business)	No effect/ Minor effect/ Neutral/ Moderate effect/ Major effect	32/ 22/ 16/ 19/ 11
How much has COVID-19 affected your travel for the following trip purposes? - Social (recreational, visiting friends/relatives)	No effect/ Minor effect/ Neutral/ Moderate effect/ Major effect	29/ 20/ 13/ 26/ 13
Expected travel habits		
After COVID-19 is no longer a threat (After COVID-19 is controlled and federal, state, and local sheltering-in-place orders are lifted), how often do you expect you will travel for the activities listed below compared to now? - Work (or school for students and work-Related Business)	Less/ About the same/ More	9/ 75/ 16
After COVID-19 is no longer a threat (After COVID-19 is controlled and federal, state, and local sheltering-in-place orders are lifted), how often do you expect you will travel for the activities listed below compared to now? - Shopping (running errands)	Less/ About the same/ More	8/ 64/ 28
After COVID-19 is no longer a threat (After COVID-19 is controlled and federal, state, and local sheltering-in-place orders are lifted), how often do you expect you will travel for the activities listed below compared to now? - Personal (church, medical, or family business)	Less/ About the same/ More	8/ 62/ 29
After COVID-19 is no longer a threat (After COVID-19 is controlled and federal, state, and local sheltering-in-place orders are lifted), how often do you expect you will travel for the activities listed below compared to now? - Social (recreational, visiting friends/relatives)	Less/ About the same/ More	10/ 50/ 40
After COVID19 is no longer a threat, how do you expect your use of the following means of transportation to change, compared to now? - Walk (as a travel mode and not for enjoyment/ exercise)	Less/ About the same/ More/ Not applicable	8/ 60/ 22/ 10

After COVID19 is no longer a threat, how do you expect your use of the following means of transportation to change, compared to now? - Personal bike/e-scooter (as a travel mode and not for enjoyment/ exercise)	Less/ About the same/ More/ Not applicable	8/ 38/ 11/ 43
After COVID19 is no longer a threat, how do you expect your use of the following means of transportation to change, compared to now? - Car	Less/ About the same/ More/ Not applicable	7/ 61/ 27/ 5
After COVID19 is no longer a threat, how do you expect your use of the following means of transportation to change, compared to now? - Public transport (bus, railway)	Less/ About the same/ More/ Not applicable	11/ 41/ 22/ 27
After COVID19 is no longer a threat, how do you expect your use of the following means of transportation to change, compared to now? - Shared bike/e-scooter	Less/ About the same/ More/ Not applicable	8/ 28/ 9/ 55
After COVID19 is no longer a threat, how do you expect your use of the following means of transportation to change, compared to now? - Ride-hailing services (Uber, Lyft)	Less/ About the same/ More/ Not applicable	10/ 43/ 18/ 28
After COVID-19 is no longer a threat, how likely would you use the following means of transportation? - Public transport (bus, railway)	Very unlikely/ Unlikely/ Neutral/ Likely/ Very likely	22/ 13/ 22/ 27/ 16
After COVID-19 is no longer a threat, how likely would you use the following means of transportation? - Shared bike/e-scooter	Very unlikely/ Unlikely/ Neutral/ Likely/ Very likely	50/ 16/ 17/ 11/ 5
After COVID-19 is no longer a threat, how likely would you use the following means of transportation? - Ride-hailing services (i.e. Uber, Lyft)	Very unlikely/ Unlikely/ Neutral/ Likely/ Very likely	21/ 13/ 22/ 28/ 15
After COVID-19 is no longer a threat, how likely would you use the following means of transportation? - Shared autonomous vehicles (if available)	Very unlikely/ Unlikely/ Neutral/ Likely/ Very likely	35/ 16/ 24/ 16/ 9
COVID-19 preferences		
How long do you think it will take us to recover from the coronavirus pandemic?	We have already recovered/ Six months/ One year/ 2 years/ More than 2 years/ Not sure	18/ 8/ 16/ 15/ 23/ 20
Please select your level of agreement with the following statements. - I am concerned that someone in my immediate family or friends may get sick from Covid-19.	Strongly disagree/ Disagree/ Neither agree nor disagree/ Agree/ Strongly agree	10/ 13/ 17/ 42/ 19
Please select your level of agreement with the following statements. - I am concerned about getting infected by COVID-19.	Strongly disagree/ Disagree/ Neither agree nor disagree/ Agree/ Strongly agree	13/ 18/ 19/ 36/ 15
Please select your level of agreement with the following statements. - I am stressed around other people because I worry Iâ€™ll catch COVID-19.	Strongly disagree/ Disagree/ Neither agree nor disagree/ Agree/ Strongly agree	21/ 21/ 22/ 27/ 9

How do you perceive the probability of contracting COVID-19 while using the shared modes listed below? Please answer even if you have not used the mode before. - Public transport (Bus, railway)	Very low/ Low/ Average/ High/ Very high	9/ 8/ 33/ 30/ 20
How do you perceive the probability of contracting COVID-19 while using the shared modes listed below? Please answer even if you have not used the mode before. - Taxi	Very low/ Low/ Average/ High/ Very high	10/ 16/ 42/ 21/ 11
How do you perceive the probability of contracting COVID-19 while using the shared modes listed below? Please answer even if you have not used the mode before. - Shared e-scooters	Very low/ Low/ Average/ High/ Very high	24/ 24/ 30/ 14/ 8
How do you perceive the probability of contracting COVID-19 while using the shared modes listed below? Please answer even if you have not used the mode before. - Bike-sharing	Very low/ Low/ Average/ High/ Very high	24/ 23/ 30/ 15/ 8
How do you perceive the probability of contracting COVID-19 while using the shared modes listed below? Please answer even if you have not used the mode before. - Ride-hailing services (Uber, Lyft)	Very low/ Low/ Average/ High/ Very high	10/ 14/ 45/ 19/ 13
Micro-mobility usage and opinions		
Please indicate whether you had ever used these shared micro-mobility services Before COVID-19. - Bike-sharing (Divvy bike)	Yes/ No	22/ 78
Please indicate whether you had ever used these shared micro-mobility services Before COVID-19. - E-scooter-sharing (Lime, Bird)	Yes/ No	15/ 85
Please indicate whether you have ever used these shared micro-mobility services during COVID-19. - Bike-sharing	Yes/ No	16/ 84
Please indicate whether you have ever used these shared micro-mobility services during COVID-19. - E-scooter-sharing	Yes/ No	12/ 88
Please indicate whether you intend to use these shared micro-mobility services in the future (After restrictions lifted and high vaccination rate) - Bike-sharing	Yes/ No/ Maybe	19/ 54/ 27
Please indicate whether you intend to use these shared micro-mobility services in the future (After restrictions lifted and high vaccination rate) - E-scooter-sharing	Yes/ No/ Maybe	14/ 60/ 26
Please rank the following options regarding what you think bike-sharing and E-Scooter sharing systems are mostly used for in general (Not what you use it for): - For fun/ recreational purposes	1/ 2/ 3/ 4/ 5	53/ 21/ 12/ 7/ 6

Please rank the following options regarding what you think bike-sharing and E-Scooter sharing systems are mostly used for in general (Not what you use it for): - To go grocery shopping	1/ 2/ 3/ 4/ 5	10/ 16/ 19/ 23/ 32
Please rank the following options regarding what you think bike-sharing and E-Scooter sharing systems are mostly used for in general (Not what you use it for): - To go non-grocery shopping	1/ 2/ 3/ 4/ 5	4/ 18/ 29/ 34/ 15
Please rank the following options regarding what you think bike-sharing and E-Scooter sharing systems are mostly used for in general (Not what you use it for): - For commute	1/ 2/ 3/ 4/ 5	20/ 25/ 19/ 21/ 16
Please rank the following options regarding what you think bike-sharing and E-Scooter sharing systems are mostly used for in general (Not what you use it for): - For the tripâ€™s first and last mile (distance a commuter needs to travel from a transit stop to their destination, and vice versa)	1/ 2/ 3/ 4/ 5	13/ 19/ 22/ 15/ 30
TPB questions for micro-mobility		
I intend to use micro-mobility post-COVID-19 (Or after COVID-19 is no longer a threat)	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	34/ 13/ 26/ 19/ 8
Please answer the following questions about micro-mobility (Or bike-sharing and e-scooter-sharing). - I find micro-mobility useful for my purposes.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	34/ 14/ 22/ 20/ 9
Please answer the following questions about micro-mobility (Or bike-sharing and e-scooter-sharing). - Using micro-mobility is suitable for my needs.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	33/ 18/ 20/ 20/ 9
Please answer the following questions about micro-mobility (Or bike-sharing and e-scooter-sharing). - Using micro-mobility has many advantages.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	12/ 7/ 28/ 38/ 14
Please answer the following questions about micro-mobility (Or bike-sharing and e-scooter-sharing). - Using micro-mobility is a great idea.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	9/ 7/ 28/ 37/ 18
Please answer the following questions about micro-mobility (Or bike-sharing and e-scooter-sharing). - Using micro-mobility sounds smart to me.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	12/ 10/ 28/ 33/ 17
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - I believe I have the necessary means and skills to use micro-mobility.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	15/ 10/ 21/ 34/ 21

Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - It is easy to access micro-mobility services near my house/ work.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	29/ 16/ 19/ 23/ 13
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - If I want, I can easily use micro-mobility services.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	26/ 15/ 21/ 22/ 16
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - I believe paying for micro mobility is not a burden for me.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	13/ 12/ 33/ 26/ 16
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - I would use micro-mobility if my friends and colleagues did the same.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	25/ 16/ 28/ 23/ 9
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - Micro-mobility will be the norm, in our society and our roads in the future.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	14/ 16/ 33/ 27/ 10
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - My family or friends think using micro-mobility is a good thing.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	14/ 10/ 44/ 21/ 11
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - People important to me will use micro-mobility more in the future.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	15/ 15/ 39/ 22/ 10
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - I might be exposed to the risk of COVID-19 when I use micro-mobility services.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	20/ 18/ 27/ 26/ 9
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - I might contract COVID-19 when I use micro-mobility services.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	20/ 18/ 27/ 27/ 8
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - I am concerned about using shared micro-mobility after other strangers have used it during COVID-19.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	21/ 17/ 22/ 27/ 13
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - I am concerned to share a bike/scooter with strangers during COVID-19.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	20/ 17/ 20/ 28/ 15
Please answer the following questions about micro-mobility, which includes	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	25/ 21/ 19/ 24/ 11

bike-sharing and e-scooter-sharing. - I would feel safe using micro-mobility in traffic.		
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - I believe that using a micro-mobility service is dangerous.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	9/ 20/ 29/ 31/ 11
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - Micro-mobility crash risk makes me nervous.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	8/ 14/ 23/ 34/ 21
Please answer the following questions about micro-mobility, which includes bike-sharing and e-scooter-sharing. - I am afraid of having a crash when using a micro-mobility service.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	11/ 13/ 22/ 32/ 20
COVID-19 emerging activities		
How often did you perform the following activities during COVID-19 (during the stay-at-home order)? - Remote work (including Online work meetings)	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	23/ 15/ 8/ 6/ 48
How often did you perform the following activities during COVID-19 (during the stay-at-home order)? - Online social meetings	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	9/ 19/ 25/ 14/ 32
How often did you perform the following activities during COVID-19 (during the stay-at-home order)? - Online grocery shopping	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	5/ 19/ 30/ 11/ 35
How often did you perform the following activities during COVID-19 (during the stay-at-home order)? - Online non-grocery shopping	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	4/ 21/ 44/ 18/ 13
How often did you perform the following activities during COVID-19 (during the stay-at-home order)? - Out of home social activities (Meet with friends and family)	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	5/ 19/ 34/ 20/ 22
How often did you perform the following activities during COVID-19 (during the stay-at-home order)? - Outside recreation activities (Parks)	Daily/ Few times a week/ Few times a month/ Few times a year/ Never	7/ 23/ 26/ 17/ 26
Lately, how many times per week (on average) have you undertaken the following in-person activities? - Shop at a grocery store - Number	0/ 1/ 2/ 3/ 4/ 5/ 6/ 7/ 8/ 9/ 10/ 100	5/ 39/ 29/ 17/ 5/ 4/ 0/ 1/ 0/ 0/ 0/ 0
Lately, how many times per week (on average) have you undertaken the following in-person activities? - Go out to eat for dinner - Number	0.0/ 1.0/ 2.0/ 3.0/ 4.0/ 5.0/ 6.0/ 7.0/ 8.0	30/ 41/ 17/ 7/ 3/ 1/ 0/ 0/ 0
Lately, how many times per week (on average) have you undertaken the following in-person activities? - Shop for non-grocery items (e.g., clothing) at store - Number	0.0/ 1.0/ 2.0/ 3.0/ 4.0/ 5.0/ 6.0/ 7.0/ 8.0/ 10.0	19/ 49/ 17/ 8/ 3/ 2/ 1/ 0/ 0/ 0

TPB questions for online shopping		
After COVID-19 is no longer a threat, I intend to do online grocery shopping more frequently than I did before COVID.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	29/ 18/ 22/ 19/ 12
Shopping groceries online more often than before COVID-19 would: - Help me save time.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	14/ 12/ 20/ 32/ 22
Shopping groceries online more often than before COVID-19 would: - Help me save money.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	19/ 20/ 26/ 21/ 14
Shopping groceries online more often than before COVID-19 would: - Give me flexibility.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	10/ 8/ 22/ 36/ 23
Shopping groceries online more often than before COVID-19 would: - Be safer for me.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	11/ 8/ 26/ 32/ 22
Shopping groceries online more often than before COVID-19 would: - Improve my daily habits (e.g., productivity).	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	12/ 15/ 29/ 27/ 17
People important to me think that I should do online grocery shopping more often than before COVID	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	27/ 12/ 33/ 18/ 10
My friends order online groceries more often than before-COVID.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	15/ 13/ 29/ 28/ 14
People important to me have recommended me online grocery shopping	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	22/ 17/ 23/ 24/ 13
Family and friends expect me to do online grocery shopping.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	31/ 17/ 22/ 18/ 11
The groceries that I buy are usually available online	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	6/ 9/ 29/ 34/ 22
Online grocery shopping is easier compared to shopping in-person	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	16/ 19/ 22/ 26/ 17
I feel comfortable using my electronic device and the online platform to order groceries online	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	8/ 9/ 20/ 31/ 32
For me, going in person to buy groceries is difficult and stressing	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	38/ 21/ 14/ 18/ 9
Ride-hailing usage and opinions		
Please indicate whether you had ever used ride-hailing Before COVID-19.	Yes/ No	56/ 44
Please indicate whether you had ever used ride-hailing During COVID-19.	Yes/ No	41/ 59
Please indicate whether you intend to use ride-hailing in the future (After restrictions lifted and COVID-19 is no longer a threat)	Yes/ No/ Maybe	43/ 28/ 30
TPB questions for ride-hailing		
I intend to use ride-hailing post-COVID-19 (Or after COVID-19 is no longer a threat)	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	17/ 9/ 26/ 25/ 23
Please answer the following attitude statements on ride-hailing. - I would find using ride-hailing useful for my purposes.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	18/ 11/ 21/ 30/ 19

Please answer the following attitude statements on ride-hailing. - Using ride-hailing would be suitable for my needs.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	18/ 11/ 21/ 31/ 19
Please answer the following attitude statements on ride-hailing. - I like the thought of using ride-hailing.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	18/ 12/ 25/ 27/ 18
Please answer the following attitude statements on ride-hailing. - Using ride-hailing is a good idea for me.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	19/ 14/ 21/ 28/ 19
Please answer the following attitude statements on ride-hailing. - Using ride-hailing has many advantages or benefits.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	11/ 9/ 23/ 38/ 20
Please answer the following attitude statements on ride-hailing. - Provided there is a ride-hailing service near me, I could use it if I wanted to.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	9/ 8/ 19/ 36/ 28
Please answer the following attitude statements on ride-hailing. - If I want, I can easily use ride-hailing services.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	8/ 8/ 19/ 37/ 28
Please answer the following attitude statements on ride-hailing. - I believe paying for ride-hailing is not a hassle for me.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	12/ 17/ 25/ 27/ 19
Please answer the following attitude statements on ride-hailing. - I believe ride-hailing would be easy to use to me.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	9/ 10/ 23/ 33/ 25
Please answer the following attitude statements on ride-hailing. - I feel confident that I could use ride-hailing.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	8/ 8/ 20/ 36/ 28
Please answer the following attitude statements on ride-hailing. - Most people who are important to me recommend that I use shared ride-hailing services.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	26/ 15/ 33/ 16/ 10
Please answer the following attitude statements on ride-hailing. - My relatives and friends often use ride-hailing services to travel.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	20/ 16/ 24/ 27/ 13
Please answer the following attitude statements on ride-hailing. - I would use ride-hailing if my friends and colleagues did the same.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	24/ 14/ 33/ 19/ 11
Please answer the following attitude statements on ride-hailing. - People important to me think that using ride-hailing is a good thing.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	13/ 12/ 32/ 31/ 11
Please answer the following attitude statements on ride-hailing. - In the near future people in the city will use ride-hailing more and more.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	7/ 5/ 30/ 40/ 17
Please answer the following statements on ride-hailing. - I might be exposed to the risk of COVID-19 when I use ride-hailing services.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	10/ 12/ 25/ 39/ 14
Please answer the following statements on ride-hailing. - I might contract COVID-19 when I use ride-hailing services.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	9/ 11/ 26/ 39/ 14

Please answer the following statements on ride-hailing. - I am concerned about using a car after other strangers have used it during COVID-19.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	13/ 16/ 22/ 33/ 15
Please answer the following statements on ride-hailing. - I am concerned to share a car with strangers by using Ride-hailing services during COVID-19.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	10/ 11/ 20/ 35/ 22
Opinion questions about environment, sharing, and technology		
Please answer the following statements about the environment: - I think it is very important to save natural resources and reduce carbon emissions.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	3/ 3/ 14/ 33/ 47
Please answer the following statements about the environment: - I always consider how my purchasing and transport choices affect the environment.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	9/ 17/ 27/ 31/ 16
Please answer the following statements about the environment: - I would like to reduce the consumption of energy and other resources while traveling.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	3/ 6/ 21/ 42/ 28
Please answer the following statements about the environment: - I would like to see and support more sustainable transport options.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	4/ 5/ 21/ 40/ 31
Please answer the following statements regarding your attitudes on sharing: - In general, sharing is a positive thing.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	2/ 5/ 17/ 42/ 34
Please answer the following statements regarding your attitudes on sharing: - I believe sharing saves money.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	1/ 4/ 23/ 42/ 30
Please answer the following statements regarding your attitudes on sharing: - Sharing is a fun thing to do.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	4/ 9/ 33/ 33/ 21
Please answer the following statements regarding your attitudes on sharing: - I think that sharing is a sustainable model of consumption.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	3/ 5/ 27/ 42/ 24
Please answer the following statements regarding your attitudes on new technology: - I'm excited about the possibilities offered by new technologies.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	3/ 6/ 20/ 42/ 29
Please answer the following statements regarding your attitudes on new technology: - I think technology advancements are generally a positive thing.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	1/ 4/ 19/ 45/ 31
Please answer the following statements regarding your attitudes on new technology: - If I heard about a new thing/technology, I would look for ways to experiment with it.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	7/ 12/ 27/ 35/ 18
Please answer the following statements regarding your attitudes on new technology: - Among my peers, I am	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	22/ 23/ 21/ 22/ 12

usually the first one to try new things/ technology.		
Please answer the following statements regarding your attitudes on new technology: - I like to experience new things/ technology.	Strongly disagree/ Somewhat disagree/ Neither agree nor disagree/ Somewhat agree/ Strongly agree	8/ 9/ 24/ 36/ 22
Household characteristics		
How many of the following vehicles do you own or are available in your household for use? - Gas-powered car - Number	0/ 1/ 2/ 3/ 4/ 5/ 10	19/ 49/ 23/ 6/ 1/ 1/ 0
How many of the following vehicles do you own or are available in your household for use? - Electric car (Batter or hybrid) - Number	0/ 1/ 2/ 3/ 4	90/ 7/ 2/ 1/ 0
How many of the following vehicles do you own or are available in your household for use? - Personal bike - Number	0/ 1/ 2/ 3/ 4/ 5/ 6/ 7	49/ 33/ 12/ 4/ 1/ 0/ 0/ 0
How many of the following vehicles do you own or are available in your household for use? - Personal scooter - Number	0/ 1/ 2/ 3/ 9	85/ 12/ 3/ 0/ 0
How did your vehicle ownership change during COVID-19? - Selected Choice	It did not change/ I sold my vehicle/ I purchased a vehicle/ Other	84/ 3/ 10/ 3
Demographics		
What is the gender that you identify with?	Male/ Female/ Other	42/ 57/ 1
What is your age range?	18-24/ 25-34/ 35-44/ 45-54/ 55-64/ 65 and over	10/ 20/ 19/ 16/ 15/ 21
What is the highest level of education you have completed?	Some high school or less/ High school diploma or GED/ Some college, but no degree/ Associates or technical degree/ Bachelorâ€™s degree/ Graduate or professional degree (MA, MS, MBA, PhD, JD, MD, DDS etc.)/ Prefer not to say	1/ 20/ 21/ 11/ 30/ 16/ 0
Choose one or more races that you consider yourself to be	White or Caucasian/ White or Caucasian,Black or African American/ White or Caucasian,Black or African American,Native Hawaiian or Other Pacific Islander/ White or Caucasian,American Indian/Native American or Alaska Native/ White or Caucasian,Asian,Native Hawaiian or Other Pacific Islander/ Black or African American/ Black or African American,American Indian/Native American or Alaska Native/ American Indian/Native American or Alaska Native/ Asian/ Native Hawaiian or Other Pacific Islander/ Other/ Prefer not to say	70/ 1/ 0/ 0/ 0/ 20/ 0/ 0/ 4/ 0/ 2/ 1
What describes best your employment situation? - Selected Choice	Work full time/ Work part time/ Currently Unemployed/ Student/ Retired/ Homemaker/ Other/ Prefer not to say	44/ 15/ 8/ 4/ 18/ 5/ 5/ 0
What describes best your employment situation? - Other - Text	Caregiver/ DISABLED (THAT'S WHY I COULD NOT USE THE BIKES NOR SCOOTERS)/ Disability/ Disable/ Disabled/ Disabled/ Disabled due to seizures and leg injury/ Freelancer/ Home mom son has a foot disability/ Self Employed/ Self employed/ Self employed/ Sick leave/ Sick leave/ Small business owner/ Sole proprietor/ Temp/ Unable to work disability/ Work 2 part time jobs/ Work fairly constantly but gigs/ disabled/ disabled	3/ 3/ 7/ 3/ 10/ 14/ 3/ 7/ 3/ 3/ 3/ 3/ 3/ 3/ 3/ 3/ 3/ 3/ 3/ 3/ 3/ 3/ 3

Do you have any flexibility to work from home?	My work type is from home/ I can decide either work from home or work at place/ My work does not allow me to work from home	28/ 26/ 46
How often do you typically work from home?	Less than 1 day per month/ 1-3 days per month/ 1-2 days per week/ 3-4 days per week/ 5 days per week	35/ 10/ 16/ 12/ 26
How often do you expect to work from home in the future after COVID-19 is no longer a threat?	Less than 1 day per month/ 1-3 days per month/ 1-2 days per week/ 3-4 days per week/ 5 days per week/ I do not expect to work from home	10/ 7/ 11/ 8/ 15/ 50
What was your total household income before taxes during the past 12 months?	Less than $25,000/ $25,000-$49,999/ $50,000-$74,999/ $75,000-$99,999/ $100,000-$149,999/ $150,000 or more/ Prefer not to say	16/ 22/ 21/ 17/ 13/ 7/ 3
Including yourself, how many persons are in your household?	One/ Two/ Three/ Four/ Five or more	24/ 32/ 18/ 16/ 10
Please indicate the number of children in your household under the age of 18.	None/ One/ Two/ Three/ Four or more	66/ 15/ 14/ 4/ 1
Do you have a US driver's license?	Yes/ No	91/ 9
Do you personally identify as having or living with disability (physical/mental)? - Selected Choice	Yes â€“ (optional: feel free to tell us more by describing your disability)./ No/ Prefer not to answer	14/ 83/ 3