SHARED MOBILITY OPTIONS FOR THE COMMUTE TRIP: OPPORTUNITIES FOR EMPLOYERS AND EMPLOYEES

FINAL PROJECT REPORT

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16. Abstract

This multi-institutional research project consisted of two components that were conducted, respectively, by University of Washington (UW) team members and University of Idaho (UI) team members. The UW component explored the commuting experience of essential workers during the COVID-19 pandemic, using the UW as a case study. The empirical work started with a quantitative analysis of data from the UW transportation needs assessment survey to depict and model the commute mode choices of essential workers before and during the pandemic. It found that most pre-pandemic public transit riders switched to other modes, especially driving alone, whereas almost all the essential workers who had driven alone, biked, or walked before the pandemic continued to do so. The shift to driving alone was most pronounced among essential workers with high incomes, whereas public transit remained a primary mode choice of lower-income groups. A qualitative analysis, which was based on a series of focus group discussions with UW employees, was then performed to gain deeper insights into essential workers' travel constraints and corresponding decision making. It revealed that most participants switched away from transit at the beginning of the pandemic because of safety concerns related to virus infection and issues with transit frequency, schedules, and reliability. It showed that incentives such as a fully subsidized transit pass and free carpool parking would encourage a reversed mode shift from driving alone to transit or carpooling post-pandemic. Together, results of the UW study suggest the need for timely adjustments in TDM policies in response to the evolution of the pandemic, as well as to expand the mobility options for employees, especially essential workers.

The UI component, which used the University of Idaho as a case study, investigated the travel behaviors of university students from rural and suburban communities and how their experience with non-automobile modes of transportation affected their mode choice. This research component was implemented through surveys, which were aimed at identifying any relationship between previous multi-modal experience and current travel behavior, and an experiment that took participants on a 90-minute tour of the community by bus, bike, and on foot and then evaluated the impact of the tour on the participants' travel behaviors. The results showed that students from rural communities who had frequently driven to high school and had had little experience with public and private transit were more likely to be driving currently and that participation in the experiment increased the students' bus and bike use and walking.

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LIST OF ABBREVIATIONS

COVID-19	Coronavirus disease 2019
ICT	Information and communications technologies
LCA	Latent class analysis
MMNL	Mixed multinomial logit model
MNL	Multinomial logit model
MNP	Multinomial probit model
NMT	Non-motorized transportation
PTS	Parking and Transportation Services (UI)
SOV	Single-occupancy vehicle
TDM	Travel demand management
UI	University of Idaho
UW	University of Washington
UWTS	UW Transportation Services
VIF	Variance inflation factor
VMT	Vehicle miles traveled
WFH	Work from home

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EXECUTIVE SUMMARY

This research project was a multi-institutional effort consisting of two main components: the University of Washington component, referred to hereafter as the UW component, and the University of Idaho component, referred to hereafter as the UI component. The UW component explored the commuting experience of essential workers during the pandemic, using the UW as a case study. This component consisted of two parts, a quantitative analysis of data from the UW transportation needs assessment survey (September to October 2020) and a qualitative analysis based on a series of focus group discussions with UW employees (June to July 2021). The UI component, which used the University of Idaho as a case study, investigated the travel behaviors of university students from rural and suburban communities and how their experience with non-automobile modes of transportation affected their mode choice.

The UW Component

Problem Statement

This study was an attempt to fill knowledge gaps about essential workers' commute patterns and needs by answering the following questions:

- How did COVID-19 impact transit riders’ perceptions of different commute modes? And how did that impact their commute mode choice?
- Under what conditions would essential workers shift their commute modes during a pandemic? Under what condition would they switch back to transit or carpool post-pandemic?
- What were the anticipated post-pandemic changes in commute mode choice and commute patterns?

- What could employers and transit agencies do to facilitate essential workers' commute using transit and carpool?

Methods

1) Quantitative analysis: This part consisted of a descriptive analysis and a commuting mode choice regression analysis for essential workers using data from the UW Transportation Needs Assessment Survey conducted by UW Transportation Services (UWTS) in autumn 2020. These data included 279 essential workers before and during the pandemic and their perspectives on commuting during the COVID-19 recovery period.
2) Qualitative analysis: This part consisted of a thematic analysis of four focus group discussions with UW employees who were mostly pre-pandemic transit riders. The discussion questions were designed to gain deep insights into essential workers' commuting mode choices and patterns during COVID-19 and to explore different approaches to plan for post-pandemic transportation services. The focus group discussions were conducted entirely online, using Zoom, and the transcriptions were analyzed by using NVivo 12 Pro, a computer-aided qualitative analysis software.

Results and Policy Implications

The quantitative analysis showed that over 60 percent of pre-pandemic public transit riders switched to other modes, especially driving alone. In contrast, almost all the essential workers who had driven alone, biked, or walked before the pandemic continued to do so during the pandemic. The shift to driving alone was most pronounced among essential workers with higher incomes, whereas public transit remained a primary mode choice of lower-income groups. As travel distance increased, the probability of choosing driving alone over public transit also increased, although the relationship was not linear. No consistent, significant associations between mode choice and other sociodemographic variables were found. The analysis also indicated that most essential workers anticipated returning to their pre-pandemic commute frequency and mode choice when the pandemic was under control.

The qualitative analysis showed that most participants switched from transit at the beginning of the pandemic to mostly driving alone to work because of safety concerns related to pandemic infection and issues with transit frequency, schedules, and reliability. However, once vaccines became widely available, travel cost, work schedule, and frequency of transit service became the primary factors in determining most essential workers' mode choice. In addition, participants indicated that incentives such as a fully subsidized transit pass, free carpool parking, and other financial incentives would encourage a reversed mode shift from driving alone to transit or carpooling. The pandemic also increased the need for safety measures in public transit and real-time updates on transit services, including bus tracking.

The two parts of this study each generated new insights into commuters' travel mode choice during a pandemic, which can serve as an empirical basis for planning for the future. Results from the quantitative analysis indicated clearly how commuters' mode shifted before and during the pandemic and how the patterns of travel behavior change were associated with not only their previous commute mode but also their socio-economic characteristics. This demonstrated the critical role of publicly provided mobility services in safeguarding transportation equity during major disruptions. In addition, the resiliency shown by biking and walking as commute options during the pandemic should serve as a reminder that non-motorized transportation is a fundamental component of the urban transportation system that needs to be carefully planned, designed, built, and adequately supported.

The findings from the qualitative study complemented the survey data analysis by providing a deeper understanding of essential workers' travel decision-making at the personal level, based on the available options and existing constraints. They showed the dynamic nature of commuters' perceptions and behaviors during a pandemic, which suggested the critical importance of making timely adjustments to policies to better address the evolution and recovery of a major disruption. Recovery planning and post-pandemic policies should encourage shared modes, such as the expansion of a fully subsidized transit pass and free or reduced-cost park-and-ride and carpool parking.

The UI Component

Problem Statement

This component aimed to assist the University of Idaho Parking and Transportation Services (PTS) administrators in increasing mode share for riding the bus, biking, and walking by answering the following research questions:

- Do university students from rural and suburban communities lack experience with non-automobile modes of transportation, i.e., bus, bike, walking, taxicab, Uber/Lyft, light rail, commuter rail, and bike/scooter share?
- Do university students who lack multi-modal experience tend to drive to campus and around town more than students who have experience with alternative transportation modes?
- Can providing exposure to riding the bus, walking, and biking motivate university students to use these modes more frequently?

Methods

This research component consisted of three surveys and an experiment. The first survey was sent to the whole student body to ascertain students' level of multi-modal experience in their rural, suburban, and urban hometowns. The survey also sought to identify any relationship between previous multi-modal experience and current travel behavior. Next, the experiment involved taking participants on a 90-minute tour of the community by bus, bike, and on foot. The tour participants were surveyed before the tour to determine how much they used these travel modes, and they were surveyed again six months later to investigate the impact of the tour on their travel behavior. Moreover, another group of students who did not participate in the tour were administered the same before and after surveys for comparison as a control group.

Results and Policy Implications

Nearly 800 students responded to the first survey and confirmed the hypothesis that rural students often lacked experience with multimodal travel. The results also supported the hypothesis that previous experience with multimodal travel is indicative of current travel behavior. The survey found that students from rural communities who had frequently driven to high school and had had little experience with public and private transit were more likely to be driving currently to campus and around town. Finally, the results from the experiment indicated that the treatment group increased their bus and bike use and walking, in terms of both their stated preference and revealed preference measures.

The results of the UI study showed in a convincing way that education about and exposure to alternative modes have a measurable effect on both behavior and attitudes. The policy implications are that transit operators and active travel staff must work with youth to increase their awareness of the available alternative transportation modes, and that colleges and employers should help create opportunities and provide support for college students and young workers to use environmentally more desirable commute options.

CHAPTER 1 INTRODUCTION

1.1 Project Background and Components

This PacTrans multi-institutional research project was originally proposed to investigate the opportunities created by new and dynamic forms of shared mobility, such as app-based carpooling and ride-hailing, for improving workers' commuting. However, because of the outbreak of the COVID-19 pandemic and the subsequent lockdowns, the original research plan became infeasible because two key collaborators—both providers of app-based shared mobility services—backed out of their commitments to support the proposed case studies as their businesses experienced the devastating impacts of the pandemic. Therefore, the project team had to substantially modify the research plan. The revised project, which is presented in this report, consisted of two studies that were conducted by University of Washington (UW) team members and University of Idaho (UI) team members.

The UW study was aimed at understanding the commuting experiences of essential workers during the COVID-19 pandemic and drawing useful lessons for future transportation planning. Essential workers were defined in this study as employees who play a critical role in maintaining the basic functioning of society during disruptive events and major crises and therefore must continue to make frequent commute trips. It is therefore vital for transportation planners and policymakers to ensure that adequate mobility services are provided to meet the travel needs of this group of workers. The study focused on faculty and staff members whose job responsibilities required them to commute to the University campus at least on some working days. In collaboration with professional planners working for UW's Transportation Services (UWTS), the researchers examined changes in commuting modal choice by faculty and staff members, especially those who were regular users of public transit or carpools, and then sought explanations for the observed changes.

This UW study was implemented in two complementary parts. The first part employed data from the UW Transportation Needs Assessment Survey, which was conducted by UWTS in autumn 2020, to depict and model the commute mode choices of essential workers before and during the COVID-19 pandemic. The second part conducted a series of focus group discussions with UW employees to gain deeper insights into essential workers' travel constraints and corresponding decision making. The project team believed that together these two parts would make the UW study a timely effort that not only would obtain a good understanding of employees' commuting hardships during the pandemic but also would inform the approaches that employers could take to help expand employees' mobility options both during and after the pandemic.

The UI component of this project investigated university student travel behaviors. The researchers were particularly interested in understanding whether a large percentage of university students from rural and suburban communities lacked experience with non-automobile modes of transportation and how such experience affected students' mode choice. Furthermore, the researchers wanted to find out whether providing exposure to riding the bus, walking, and biking would motivate university students to use these mobility options. The study was conducted in partnership with the University of Idaho's Parking and Transportation Services (PTS) and was aimed at understanding travel mode decisions made by UI students. The project team expected this case study to serve as a microcosm for people throughout the country who move to new mobility environments and to help planners, policy makers, business leaders, and university administrators better understand the travel behaviors of their constituents.

1.2 Project Report Organization

This report has five chapters. Chapter 2 provides a literature review of theoretical and empirical research on travel mode choice and its explanatory factors, which lays down a common foundation for the two studies of the project. Additional strings of relevant literature include research on teleworkers and essential workers and the impacts of COVID-19 on travel behavior and mode choice, which were directly related to the UW study. Chapter 3 presents the first part of the UW study, describing the research objectives, the survey data, research methods, and findings. The core of this chapter is multinomial logistic regression that was used to model the associations between essential workers' mode choices, home locations, and sociodemographic characteristics for pre- and during-pandemic periods. In Chapter 4, the process of organizing and conducting a series of focus group discussions with UW essential workers is described, the analysis of the transcript data is presented, and the rich insights into the participants' commuting mode choices are discussed. Finally, Chapter 5 reports the UI component of the research project, which examined the commute behaviors of university students by conducting a survey at UI and explored ways to encourage commuting by bike, walking, and public bus through an experiment for volunteer students.

CHAPTER 2 LITERATURE REVIEW

2.1 Explanatory Factors of Transportation Mode Choice

In the literature, determinants of transport mode choice are often divided into five main categories: individual and household characteristics, modal-specific attributes, the built environment-related factors, season and weather, and subjective variables, such as personality, attitudes toward trips by modes, and individual values (Vredin Johansson et al., 2006; Böcker et al., 2013; Paulssen et al., 2014; Ton et al., 2019). Note that determinants of mode choice and the extents of their influence by countries (Buehler, 2011). The same factor can have either a significant or insignificant effect on mode choice in the contexts of different countries. Thus, we need to be careful when applying the findings of other regions to our own study areas.

2.1.1 Individual and Household Characteristics

Individual characteristics consist of sociodemographic attributes, vehicle ownership or availability, and income level. Previous studies have claimed that age, gender, and education are associated with transport mode choice. Young people are more likely to choose public transit and non-motorized modes than the elderly, albeit this result is inconclusive (Mitra, 2013; Muñoz et al., 2016). Women have a higher likelihood of using public transport than cars (Harbering and Schlüter, 2020). Men have a higher frequency of cycling in countries with low cycling penetration (Broach and Dill, 2016; Fraser and Lock, 2011; Heinen et al., 2010), while women have been found to cycle more in countries with high cycling penetration (Fraser and Lock, 2011; Ton et al., 2019). Moreover, people with higher education levels are more likely to choose driving and less likely to choose biking (Heinen et al., 2010), even though it is not conclusive. Car availability is negatively associated with the probability of choosing to bike or walk (Mitra, 2013; Scheiner, 2010), while bicycle availability is positively correlated to the probability of choosing biking and public transport (Fraser and Lock, 2011; Handy et al., 2014; Harbering and Schlüter, 2020).

Household characteristics can include household income, composition, the number of children, and property items. An individual's transport mode choice could be affected by the other members in the household. Among these factors, members of households with fewer cars are less likely to choose driving (Buehler, 2011). The number of children has a negative association with the likelihood of choosing walking and biking (Hamre et al., 2014; Maley and Weinberger, 2011). Additionally, mixed results have been reported regarding the influence of household income levels (Handy et al., 2014; Mitra, 2013).

2.1.2 Modal-Specific Attributes

In terms of modal-specific factors, travel cost, measured by distance, time, and monetary expenses, is a key determinant of transport mode choice. Longer travel distance is strongly and positively associated with the probability of riding the metro rather than driving (Shen et al., 2016). In comparison to alternative modes, driving has a positive effect on utility but with a decreased marginal rate (Vredin Johansson et al., 2006; Whalen et al., 2013). Longer travel distance or time has been found to have a negative association with active modes (Heinen et al., 2010). However, Ton et al. (2009) found that travel cost can be positively associated with cycling, although this association is sensitive to other variables in the model. Additionally, commuters' attachment to the currently used modes has been found to be a barrier to switching to other modes (Wang, et al. 2020).

2.1.3 Built Environment-Related Factors

As for the effects of the factors related to the built environment, proximity to public transit services, higher population density, and greater mixed land use can decrease the probability of using cars (Buehler, 2011). The environment with mixed land use structure, higher density, and pedestrian-oriented designs can encourage the use of public transport and non-motorized modes (Cervero and Kockelman, 1997; Winters et al., 2017). Dense and continuous infrastructure and facilities for walking and biking, such as special bicycle lanes, off-street paths, pedestrian sidewalks, and bicycle parking, can promote the use of these two modes (Broach and Dill, 2016; Heinen et al., 2010; Mitra, 2013). The literature also states that the presence of parks, playgrounds, benches, and garbage bins is positively associated with the probability of choosing walking and biking (Fraser and Lock, 2011; Wang et al., 2016). Less flexible parking permits can decrease car usage and increase the probability of using non-motorized modes (Whalen et al., 2013).

2.1.4 Season and Weather

Biking and walking are affected by weather and season because these two activities are more exposed to outdoor conditions. People bike and walk more frequently during gentle summer and autumn, while they are less likely to travel by these two modes in rainy days and extreme weather or seasons (Böcker et al., 2013; Wang et al., 2016). However, a study found that weather characteristics were not relevant to active mode choice, which may have been caused by the mild climate with frequent rain and non-frequent extreme weather in the study area (Ton et al., 2019). Residents in the study area (Netherlands) were used to this weather, and therefore weather was not found to impact active mode choice. Moreover, the data captured only people’s travel behaviors in the short term, which meant that there were no significant variations in weather conditions. In addition, local weather conditions can also influence the public transit ridership of different populations during different time periods (i.e., peak hours vs. non-peak hours) (Wei, 2022). In comparison to other areas, city centers and university campuses are the locales that are most likely to have distinct weather responses.

2.1.5 Personality and Attitudinal Variables

People's personality traits and attitudes toward their experience of traveling by transport modes can reveal their mode preferences. These are often considered to be the latent variables in the hierarchy of determinants. Personality can be revealed by habits in daily life. For example, recycling paper or batteries can explain the environmental awareness of this person. There may exist a considerable discrepancy between attitudes and behaviors, and daily habits are reliable indicators of the latter. These two sets of factors jointly affect preference of transportation mode. Vredin Johansson et al. (2006) argued that attitudes toward flexibility, comfort, and environmental friendliness of travel modes significantly affect people's mode choices, along with travel time, travel cost, and some significant socioeconomic variables. However, their mode choice model did not show that safety preferences had a statistically significant effect, which may have been caused by the form of safety in diverse trip features (trip length, trip purpose, etc.) that could not be easily captured. Furthermore, Paulssen et al. (2014) claimed that values (power, hedonism and security), from which behaviors and attitudes originate, would fundamentally influence travel mode choice.

2.2 Modeling Transportation Mode Choice

Different models have been used to examine how these variables are associated with mode choice in terms of units of study (discrete models for individuals vs. aggregate models for population), types of mode (public transit, car, active transportation, emerging vehicle, etc.), and the study areas (e.g., central city vs. suburbs). The basic and most commonly applied statistical model is the multinomial logit model (MNL), which assumes that the error terms are independently and identically distributed with a Weibull, Gumbel Type I, or double exponential distribution (Harbering and Schlüter, 2020). An alternative is the multinomial probit model (MNP), which assumes that the error terms follow a normal and identical distribution (Vredin Johansson et al., 2006). Moreover, the fixed-effect model and mixed multinomial logit model (MMNL) can further capture taste heterogeneity between individuals and serial correlation in the error terms of one individual for cross-sectional and longitudinal panel datasets, and these have been frequently used in studies described in the literature (Deka and Carnegie, 2021; Ilahi et al., 2021; Ton et al., 2019; Wang et al., 2021). Latent modal captivity has also been considered in the modeling to explore how year-specific effects and generic effects on mode choice remain constant over time (Habib and Weiss, 2014). In addition, machine learning models, such as the random forest model and artificial neural network model, have been widely used to predict the travel modes of individuals (Omrani, 2015; Omrani et al., 2013; Zhao et al., 2020).

Latent class analysis (LCA) has become popular because of its ability to investigate invisible and underlying determinants of mode choice (Vij and Walker, 2016; Wang and Shen, 2022). Some scholars have argued that there exists a hierarchy of determinants of transportation mode choice in which unobservable preferences for transportation modes underly observable indicators that are directly associated with travel decisions. Using survey data from Swedish commuters and the discrete mode choice model, Vredin Johansson et al. (2006) showed that the performances of the models with latent variables were better than those of traditional mode choice models. Vij and Walker (2016) compared the performances of the integrated choice model, latent class model, and nested logit model with a simplified structure of explanatory variables by using synthetic datasets, which proved that the latent class model can improve prediction and reduce information loss. However, the hierarchical structure of explanatory variables in latent class models can cause difficulty in estimating error terms. It is hard to accurately estimate how the error term from a higher level transmits to the lower level and then to the results. Sometimes, the latent class model estimation cannot converge properly. Given these considerations, we tend to choose the MNL approach to generate the maximum likelihood estimate for the sake of easy interpretation of the model estimation.

2.3 Changing Commute in the Age of ICT-Enabled Shared Mobility

New transportation options enabled by information and communications technologies (ICTs) play important roles in shared economies. The characteristics of various shared mobility services have been extensively studied in the literature. Carsharing has been shown to be able to reduce car ownership, use of cars, and vehicle miles traveled (VMT) in different cities (Kent, 2014; Martin et al., 2010). It challenges the predominant role of automobiles as an alternative mode of commute (Kent and Dowling, 2013), while it is also mostly used for non-commuting and longer trips in less-densely populated areas (Rotaris and Danielis, 2018). The most frequent users of carsharing vary with urban environments and population density (Rotaris and Danielis, 2018; Sioui et al., 2013). Ridesharing (carpooling, vanpooling) can reduce commuter traffic during peak hours and facilitate the mobility of low-income groups and women (Chan and Shaheen, 2012; Lyons, 2018). App-based carpooling, a relatively new form of mobility option, has shown promise to lower VMT and travel costs for participating commuters because of its "deep sharing" nature (Shen et al., 2021).

Ridesourcing/ride-hailing has both complementary (providing access to/from the traditional mobility options) and substitute effects (replacing the options as an alternative) on public transport, traditional carpooling, and private car use (Brown, 2020; Jin et al., 2018; Meredith-Karam et al., 2021; Rayle et al., 2016; Wang et al., 2021). Individuals who are more familiar with the use of modern technologies are more likely to adopt on-demand ride services (Uber/Lyft), which can be enhanced by greater mixed land use, frequent long-distance traveling needs, and environmental awareness (Alemi et al., 2018; Mohamed et al., 2019). However, ridesourcing may also generate additional car trips and VMT, which can largely contribute to growing traffic congestion (Erhardt et al., 2019; Henao and Marshall, 2019; Jiao et al., 2020). Contradictory findings have been reported in other studies, which indicates that the impacts of ridesourcing on traffic congestion and VMT are unclear (Jin et al., 2018; Tirachini, 2020).

Bikesharing can increase cycling modal share and physical activities, as well as be a first mile/last mile option for public transportation and car trips, mainly for commuting purposes (Castro et al., 2019; Fyhri and Fearnley, 2015; Guidon et al., 2019; Jia and Fu, 2019). Bikesharing can provide convenience and contribute to travel cost reduction, which is especially important for low-income households (Fishman, 2016). However, bikesharing usually does not fully substitute for motorized modes.

2.4 Research on Teleworkers and Essential Workers

According to the literature, 25 percent to 37 percent of U.S. jobs can now be plausibly done from home (Baker, 2020; Dingel and Neiman, 2020). Among these jobs, computer and mathematical occupations compose the largest percentage, followed by education, legal, business, and financial occupations (Dingel and Neiman, 2020). The remaining jobs are challenging or impossible to do from home because of the nature of the jobs, including difficulties in adapting them to teleworking, reduced working hours and salaries, and the risk of being furloughed or laid-off. This overall high potential of teleworking in the U.S. but extremely uneven distribution among different occupations and income groups has been understood for more than two decades (Shen, 1998; Shen, 2000a; Shen, 2000b), even though the actual percentage of workers teleworking has remained relatively low because of a variety of constraints (Mohktarian, 1998).

The outbreak of COVID-19 and the subsequent lockdowns removed most constraints on teleworking and resulted in a high percentage of employees in the U.S. actually adopting work from home (WFH) or, more generally, working remotely. Brynjolfsson et al. (2020) gathered a sample from Google Consumer Survey in April and May 2020 and found that 37 percent of the workers were still commuting, 35 percent of those who used to commute were WFH, 15 percent had already been WFH, and 10 percent had been laid off. Bick et al. (2021) used the data from the Real-Time Population Survey (administered by the Federal Reserve Bank of Dallas) in May 2020 and found that 51.1 percent of workers still commuted to work every day, 13.7 percent commuted on some days, and the other 35.2 percent worked from home entirely. Interestingly, they also found that some workers in certain industries not normally suitable for remote work appeared to be forced to become teleworkers because of travel barriers. It is not surprising that commuters were more socioeconomically disadvantaged than teleworkers (Mongey et al., 2020; Shen, 1998).

Teleworking's positive effects, which can be on employees' productivity, work-life balance, and cost reductions to recruitment and retention, have been recognized by the U.S. federal government and some states. Since the Telework Enhancement Act of 2010 (Public Law 111-292) was enacted, all federal executive agencies have been required to develop a policy, create corresponding plans, and designate managers to authorize and oversee eligible employees' teleworking. The law also requires a written telework agreement between the employee and manager for participation in teleworking. Because of the COVID-19 pandemic, agencies throughout the nation increasingly used telework to decrease the disruption that the emergency imposed on accomplishing their regular missions. Georgia enacted a statewide telework policy to provide a framework for guiding an agency to operate a telework program (Georgia State Department of Administrative Services, 2020). It allows agencies to promote flexibility and productivity while reducing operational costs via specific definitions of employees' participation and responsibility. The California's statewide policy for teleworking also requires each department to establish a written policy specific to its business needs in accordance with this statewide policy (California State Department of General Services, 2021). The ways to utilize teleworking tools are still being explored, and they are facing some challenges, including human capital issues, economic benefits, mission suitability, and implementation difficulties. Even though the General Services Administration (GSA) provides guidance to improve space utilization, it has not been updated since 2006.

2.5 Impacts of COVID-19 on Travel Behaviors and Mode Choices

After the outbreak of the COVID-19 pandemic, people's travel behaviors, primary mode choices, and mode preferences changed drastically because of policies and regulations, as well as personal concerns about the pandemic. A common perception among the population was that active modes, motorcycles, and private cars were less risky than public transit during the pandemic (Dingil and Esztergár-Kiss, 2021). Attitudes toward traveling by public transportation became more negative during the pandemic, while attitudes toward driving alone in single-occupancy vehicles (SOV) became more positive (de Haas et al., 2020). People who primarily took public transit for commuting before the pandemic were more likely to switch to driving cars, especially for longer trips (Abdullah et al., 2021). During the pandemic, a significant modal shift from taking public transit to driving cars occurred, while it was not so significant from taking public transit to active transportation modes (Parker et al., 2021; Shakibaei et al., 2021).

In addition, travel behavior changes during the pandemic were prompted by both people's self-regulation and governmental restrictive measures (Shakibaei et al., 2021).

Some efforts were made to explore the determinants of mode choice during the pandemic. On the basis of an online questionnaire of various countries around the world, Abdullah et al. (2020) investigated the latent preferences on mode choice during the pandemic and found that people placed a higher priority on pandemic-related concerns (social distance, passengers wearing masks, infection, etc.) than on general concerns (comfort, travel time savings, travel costs). Gender, car ownership, employment status, travel distance, and primary travel purpose were also found to be significantly associated with mode choice during the pandemic, but they tended to have smaller effects than pandemic-related concerns. Moreover, different population groups showed different reactions to the pandemic. Low-income groups were found to be less able to reduce outdoor trips, whereas white people were more likely to choose non-motorized modes during the pandemic (Parker et al., 2021; Tao and Cao, 2021).

In addition, experience with ICT was found to facilitate teleworking and teleshopping and thus decrease the frequency of out-of-home activities during the pandemic (Irawan et al., 2021). The trade-off between telecommuting and commuting depends on the nature of the job, flexibility of the work schedule, and individual personalities (de Graaff and Rietveld, 2007). Some workers had to frequently commute to their workplaces during the pandemic (e.g., technicians and janitors), whereas others were confined to work from home by travel bans and were not able to make decisions about their commuting modes. The probability of WFH was positively associated with distance to workplaces, personal income, and occupation ranking (Hensher et al., 2022).

CHAPTER 3 EXAMINING COMMUTE MODE CHOICE OF ESSENTIAL WORKERS BEFORE AND DURING THE COVID-19 PANDEMIC USING TRAVEL SURVEY DATA

3.1 Research Background

People's commute behaviors dramatically changed in response to the outbreak of the COVID-19 pandemic. Remote working became much more common because of concerns about infection and safety. More than a third of U.S. households reported working from home more frequently than before the pandemic, and this ratio was higher among populations with higher income, more education, and better health (U.S. Census Bureau, 2021). However, the trade-off between teleworking and commuting also depended on the nature of the job, the flexibility of working time, and individual characteristics (de Graaff and Rietveld, 2007). Some workers were restricted to working from home by travel bans, whereas others had to commute frequently during the pandemic,. In this context, essential workers, defined here as those who played a critical role in maintaining the basic functioning of society, had to continue to make frequent commute trips. It was therefore vital to ensure that adequate mobility services were provided to meet the travel needs of this group of workers. Hence, this research aimed to gain a deeper understanding of the transportation challenges facing essential workers during the pandemic for the purposes of providing better commuting services to this group of workers, which is critical for the resilience of the entire society.

The work presented in this chapter used data collected from the University of Washington (UW) Transportation Needs Assessment Survey, conducted by the University's Transportation Services (UWTS) in autumn 2020, to examine the impact of COVID-19 on the commute mode choices of essential workers. The empirical research sought the answers to the following questions:

1) How did essential workers commute before and during the COVID-19 pandemic?

2) What were the key explanatory factors of essential workers' mode choices before and during COVID-19?
3) How can transportation planners and policymakers effectively support essential workers' commutes in the future?

We used descriptive analysis and multinomial logistic regression, which included sociodemographic and home location characteristics as explanatory variables, to model the mode choices of essential workers before and during the pandemic. We also investigated essential workers' attitudes toward mode choices before and during the pandemic, as well as the prospects of commuting in the recovery phase.

The next two sections of this chapter describe, respectively, the datasets and methods used to analyze the commute behaviors of essential workers. These are followed by three sections that present and interpret the results obtained from the statistical analysis and visualization. In the final section, several conclusions are drawn, along with a discussion of policy implications for travel demand management (TDM) during the recovery phase of the pandemic.

3.2 Data Collection and Processing

3.2.1 Survey Design

This study used data from the UW Needs Assessment Survey conducted by UWTS from September to October 2020 after the lockdown had ended. The survey was designed to gather information on the commute behaviors of UW students, faculty, and staff before and after the outbreak of COVID-19 to inform UWTS' commute program planning. Email invitations for the survey were randomly sent to 5,000 students, 2,534 faculty, and 2,245 staff. The survey yielded a sample of 1,208 respondents, a response rate of 12.35 percent. Of the respondents, 279 were considered to be essential workers based on our definition and were therefore selected as the analytic sample in this study. These essential workers were identified because their primary mode choices for commuting before and during the pandemic were not teleworking, which means that they had to work on site all the time. The information covered in the survey included respondents' department affiliation, demographics, and pre-, during-, and anticipated post-pandemic travel behaviors, as shown in table 3.1.

Table 3.1 The domains covered in the survey

No.	Domains	Categories	Covered questions
1	University affiliation	/	Status; Access to U-PASS; Full-time/ part-time registration or employment
2	Demographics	/	Age; Gender; Access to smartphone; Disability; Race; Annual household income; Home Zip code; Movement since March 2020
3	Pre-COVID travel behavior	Generic questions for all modes	Distance from residence to campus; Mode availability; Commute days and time; Primary mode choice; Mode use frequency; Factors contributed to mode decision; Satisfaction to mode
		Public transit	Type of services; Transfer times
		Drive alone/Carpool/Vanpool	Parking place; Pooling members; Use of ridesharing services
		Ride-hailing	Place of getting dropped off; Use of ride hail vehicle
		Biking/Walking	Type of bike; Parking place; Factors that influence parking; Challenges to choose walking
4	During COVID commute	Generic questions for all modes	Primary mode choice; Factors contributed to mode choice
		Teleworking	Frequency of teleworking; Perceived level of productivity; Interference of teleworking
5	Post COVID commute	/	Anticipated mode choice when operations return to normal; Commute frequency; Factors contributed to mode choice

3.2.2 Data Preprocessing

The essential workers' primary mode choices for commuting were categorized as follows: (1) public transit, (2) carpooling/vanpooling, (3) driving alone, (4) biking/walking. Notably, this classification did not include ride-hailing/ridesourcing because only two essential workers reported mainly using ride-hailing before COVID-19, while no one used ride-hailing as a primary commute mode during the pandemic. These two records were excluded from the analytic sample of 279 in total. Other transportation modes, such as motorcycle or scooter, were not included in the survey.

On the basis of the literature on travel mode choice and travel behavior change during the pandemic, as well as the data derived from the questionnaire (see Appendix A), this research selected a series of potential explanatory factors for essential workers' commute mode choices before and during the pandemic (table 3.2). These factors were age (55 or older; 35-54; 18-34), gender (female; male), race (white; all other races), household annual income (low; middle; high), car availability (yes; no), employment status (faculty; staff), distance from residence to campus (0-78 miles). The household annual income was divided into three levels: low-income (less than $50,000 per year), middle-income ($50,000 to $100,000 per year), and high-income (more than $100,000 per year).

Table 3.2 Potential explanatory factors for mode choice

No.	Variables	Values
1	Age	18-34; 35-54; 55 or older
2	Gender	Male; Female
3	Race	White; All other races
4	Household annual income	Low-income (less than $50,000 per year); Middle-income ($50,000~ $100,000 per year); High-income (larger than $100,000 per year)
5	Car availability	Yes; No
6	Employment status	Faculty; Staff
7	Distance to campus	0-78 mile

3.3 Methodology

3.3.1 Descriptive Analysis

This research used descriptive analysis to investigate the characteristics of the commute mode choices of the 279 essential workers before and during the pandemic and these workers' perspectives on commuting for the recovery phase. The essential workers were grouped by their sociodemographic attributes and mode choices before and during the pandemic. We also used the Sankey diagram to present their modal shift before and after the breakout of COVID-19. The characteristics of the essential workers' sociodemographic attributes and home locations are shown in table 3.3.

Table 3.3 Sociodemographic and location information of the essential worker respondents (N=279)

Items	Category	Count	Percentage
Age	55 or older	99	35.48
	35-54	126	45.16
	18-34	54	19.35
Gender	Female	154	55.20
	Male	125	44.80
Race	White	202	72.40
	All other races	77	27.60
Household income	Low	23	8.24
	Middle	81	29.03
	High	175	62.72
Car availability	Yes	245	87.81
	No	34	12.19
Employment status	Faculty	122	43.73
	Staff	157	56.27
Distance to main campus (mile)	[0, 1)	3	1.08
	[1, 2)	20	7.17
	[2, 5)	73	26.16
	[5, 10)	80	28.67
	[10, +∞)	103	36.92

3.3.2 Modeling Mode Choice Using Multinomial Logistic Regression

This research used multinomial logistic regression (MNL) models to investigate the key explanatory factors for essential workers' mode choices before and after the outbreak of the COVID-19 pandemic. To appropriately build the model, a distinction had to be made between the commute behaviors of riders with choice and captive riders. Some essential workers, to whom a car was unavailable, could not choose to drive alone for commuting. We fully recognized the endogeneity between car availability and mode choice. However, we did not use two-stage least squares (2SLS) models to cope with the endogeneity because the available data did not provide an adequate instrumental variable, which had to be a variable that was correlated with the endogenous variable (i.e., car availability) and had no correlation with the dependent variable (i.e., mode choice). Instead, we used two MNL models, one including and the other excluding the respondents without cars, to examine the effect of car availability on model estimates. Except for car availability, the other factors listed in table 3.1 were considered to be potential explanatory variables in the model, while the dependent variable was essential workers' commute mode choice. Because only 13 essential workers primarily chose carpooling or vanpooling before and during the pandemic, they were excluded from the modeling to avoid potential bias resulting from the small sample size of a certain category in the dependent variable. Distance to campus was standardized to a Z-score for the comparison of the effects with the other categorical/dummy variables. Multicollinearity was examined by fitting an ordinary least squares (OLS) model and calculating the variance inflation factor (VIF) between variables. The basic equations of the MNL model are shown below.

$$log(\frac{P(y_i=M_h)}{P(y_i=M_0)}) = \beta_0 + \sum_{k=1}^{q} \beta_k x_{ik} + \varepsilon_i \ (i = 1,2, \dots, n) \quad (1)$$

In equation (1), y_i is the mode choice of the ith respondent, M_h is the hth category of commuting modes before and during the pandemic, P(y_i=M_h) represents the probability of choosing M_h as the primary transportation mode for commuting, M_0 is a particular transportation mode that was chosen as reference. In addition, M_0 is driving alone. Then, x_{ik} is the kth covariate for the ith observation, β_k is the parameter of the kth covariate, q is the number of covariates, and ε_i is the error term of the ith observation.

3.4 Essential Workers' Commute Modal Shift After the Breakout of COVID-19

3.4.1 Modal Shift Before and During COVID-19

Figure 3.1 shows the characteristics of essential workers' modal shift from before the pandemic to during the pandemic, without including those who primarily teleworked or took ride-hailing. The left and right columns in the graph, respectively, show the number of essential workers that chose each transportation mode for commuting before and during the pandemic.

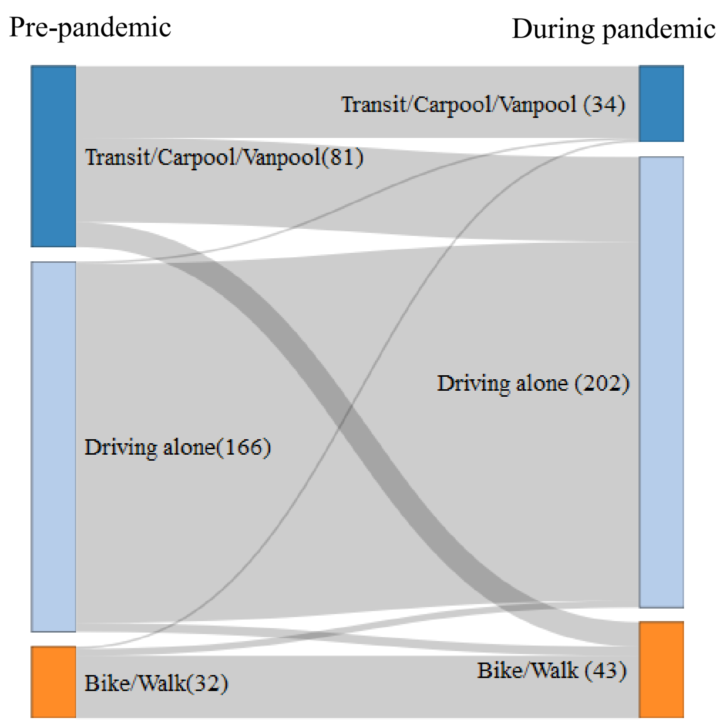


Figure 3.1 Modal shift of essential workers before and during COVID-19 (N= 279)

Among the 81 essential workers who primarily took public transit or a carpool/vanpool for commuting before the pandemic, 46.91 percent of them turned to driving alone during COVID-19, while 13.58 percent switched to biking or walking. In contrast, almost all the essential workers who primarily drove alone, biked, or walked before the pandemic continued to do so during the pandemic.

Table 3.4 shows the characteristics of pre-pandemic and during-pandemic mode choices for different sub-groups among the essential workers. The values in the table are the percentages of all workers in each sub-group or percentages of workers who chose a particular mode in each sub-group.

Table 3.4 Descriptive statistics grouped by commute mode choice before and during COVID-19 (N=279)

Variables	Category	Percentage of each category N = 279 (%)	Before COVID-19				During COVID-19			
			Public Transit N = 70 (%)	Carpool/Vanpool N = 11 (%)	Drive alone N = 166 (%)	Bike/Walk N = 32 (%)	Public Transit N = 24 (%)	Carpool/Vanpool N = 10 (%)	Drive alone N = 202 (%)	Bike/Walk N = 43 (%)
Age	55 or older	35.48	25.71	45.45	39.76	31.25	33.33	30.00	38.12	25.58
	35 - 54	45.16	38.57	36.36	50.00	37.50	29.17	50.00	48.02	39.53
	18 – 34	19.35	35.71	18.18	10.24	31.25	37.50	20.00	13.86	34.88
Gender	Female	55.20	55.71	54.55	54.82	56.25	50.00	60.00	54.46	60.47
	Male	44.80	44.29	45.45	45.18	43.75	50.00	40.00	45.54	39.53
Race	White	72.40	71.43	72.73	69.88	87.50	70.83	80.00	70.79	79.07
	All other races	27.60	28.57	27.27	30.12	12.50	29.17	20.00	29.21	20.93
Household annual income	Low	8.24	20.00	0.00	3.61	9.38	20.83	0.00	5.94	13.95
	Middle	29.03	40.00	72.73	22.89	21.88	54.17	90.00	23.76	25.58
	High	62.72	40.00	27.27	73.49	68.75	25.00	10.00	70.30	60.47
Car availability	Yes	87.81	75.71	72.73	99.40	59.38	58.33	70.00	98.51	58.14
	No	12.19	24.29	27.27	0.60	40.63	41.67	30.00	1.49	41.86
Employment status	Faculty	43.73	38.57	9.09	43.37	68.75	33.33	10.00	42.57	62.79
	Staff	56.27	61.43	90.91	56.63	31.25	66.67	90.00	57.43	37.21
Distance to main campus (mile)	[0, 1)	1.08	1.43	0.00	0.00	6.25	0.00	0.00	0.50	4.65
	[1, 2)	7.17	7.14	0.00	4.22	25.00	12.50	0.00	3.96	20.93
	[2, 5)	26.16	22.86	18.18	25.90	37.50	12.50	10.00	24.75	44.19
	[5, 10)	28.67	30.00	9.09	30.72	21.88	33.33	10.00	30.20	23.26
	[10, +∞)	36.92	38.57	72.73	39.16	9.38	41.67	80.00	40.59	6.98

As shown in table 3.4, drivers constituted the largest proportion of the essential workers (166 out of 279, or 58.87 percent, before and 202 out of 279, or 71.99 percent, during the pandemic) in comparison to other mode riders. Before the pandemic, transit riders tended to be younger than drivers and users of carpooling or vanpooling. No substantial difference was found between the mode choice of male and female workers. Most workers who primarily chose biking or walking were white. Low- and middle-income workers were more likely to choose public transit or carpool/vanpool, while higher-income workers were more likely to choose driving alone or non-motorized modes. Faculty members were more likely to ride bikes or walk to campus, whereas staff members tended to choose carpooling or vanpooling.

During the pandemic, older workers constituted a higher percentage of transit riders but lower percentages of the users of carpool/vanpool and non-motorized modes. In comparison to men, women were more likely to choose carpool/vanpool or non-motorized modes. White workers were more likely to choose carpooling or vanpooling. The percentages of middle-income workers among transit riders and users of carpool/vanpool were considerably higher. Staff members constituted higher percentages of transit riders, bikers, and walkers.

Table 3.5 highlights the characteristics of modal shift for pre-pandemic transit riders. The total number of workers in this group was 70.

Table 3.5 Modal shift for essential workers who took public transit before the pandemic (N=70)

Variables	Category	Modal shift from public transit			
		All pre-pandemic users of public transit N=70 (%)	Continued to take public transit N = 24 (%)	Switched to driving alone N = 35 (%)	Switched to biking or walking N = 11 (%)
Age	55 or older	25.71	33.33	28.57	0.00
	35 - 54	38.57	29.17	40.00	54.55
	18 – 34	35.71	37.50	31.43	45.45
Gender	Male	44.29	50.00	37.14	54.55
	Female	55.71	50.00	62.86	45.45
Race	White	71.43	70.83	77.14	54.55
	All other races	28.57	29.17	22.86	45.45
Household annual income	Low	20.00	20.83	17.14	27.27
	Middle	40.00	54.17	37.14	18.18
	High	40.00	25.00	45.71	54.55
Car availability	Yes	75.71	58.33	94.29	54.55
	No	24.29	41.67	5.71	45.45
Employment status	Faculty	38.57	33.33	40.00	45.45
	Staff	61.43	66.67	60.00	54.55
Distance to main campus (mile)	[0, 1)	1.43	0.00	0.00	9.09
	[1, 2)	7.14	12.50	0.00	18.18
	[2, 5)	22.86	12.50	25.71	36.36
	[5, 10)	30.00	33.33	28.57	27.27
	[10, +∞)	38.57	41.67	45.71	9.09

As shown in table 3.5, among the pre-pandemic transit riders, those who switched to driving alone during the pandemic accounted for the largest number (35 of 70), followed by those who continued to use transit. For comparison to men, more women switched to driving alone, while fewer switched to biking or walking. Transit riders with higher household incomes were more likely to shift to driving, biking, or walking. Faculty members tended to switch to biking or walking, whereas more staff members continued to take transit. In addition, in comparison to transit riders in other locations, transit riders who lived within 5 miles from campus were much more likely to switch to biking or walking. Among transit riders who lived farther than 10 miles from the campus, many continued to take public transit as their primary commute mode.

3.4.2 Reasons for Mode Choice Before and During the Pandemic

Travelers' attitudes toward transportation modes revealed their preferences for mode choice. The literature showed that attitudinal factors have significant effects on people's mode choice. In this research, we used descriptive statistics to analyze the reasons for essential workers' mode choice before and during the pandemic. Figure 3.2 and figure 3.3, respectively, show the likelihoods of different factors having an impact on mode choice before and during the pandemic, which were measured by the percentages of mode users who reported that the factors influenced their mode choice. The respondents were allowed to choose more than one reason for their mode choice.

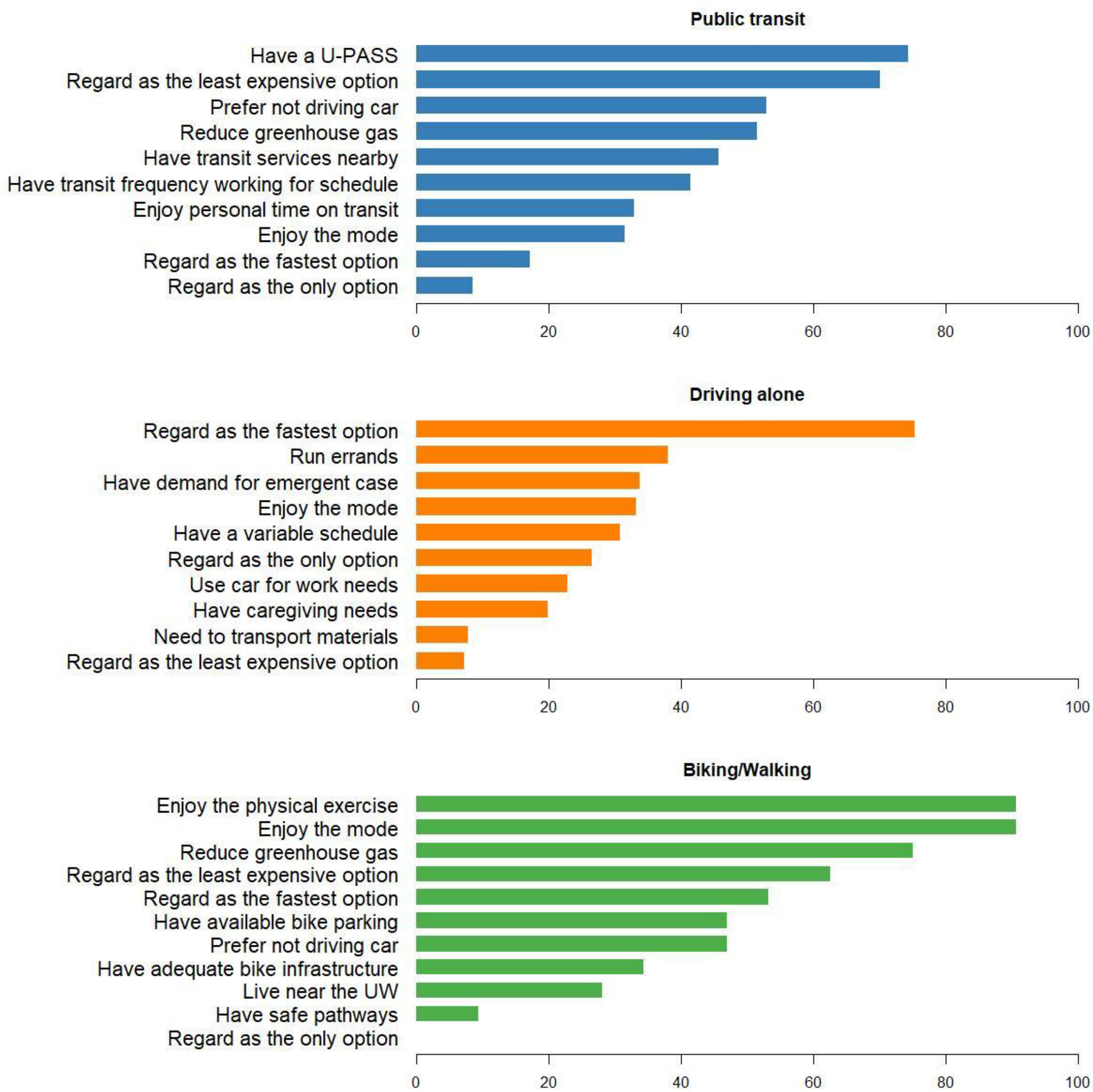


Figure 3.2 Percentage of the mode riders who reported that the factors influenced their mode choice (one could choose more than one factor)

Figure 3.2 shows that before the pandemic, having a U-PASS that subsidized transit trips contributed the most to transit riders' choice, followed by regarding public transit as the least expensive option. Moreover, environmentally responsible experience associated with taking public transit, preference for not driving a car, and available public transit services near the residence were also reasons that many essential workers chose public transit. Being fast was not a typical feature of public transit, since less than 25 percent of pre-pandemic transit riders indicated choosing this mode because it was fast. Besides, public transit was not the only option for most essential workers' commuting.

For the essential workers who primarily drove to the UW campus, they chose this mode mainly because driving was the fastest option for them. Meanwhile, special travel needs, such as driving in the event of an emergency or running errands before or after normal work time, also contributed a lot to the choice of this mode. It is worth mentioning that some workers said that they enjoyed driving cars, which was consistent with previous findings (Ton et al., 2019). It also intuitive that driving tends to be more expensive than other modes, and therefore only a few persons regarded it as the least expensive option. The need to transport materials or supplies to the workplace was not a relevant factor for the mode choice of most drivers.

Many essential workers chose to commute by bike or on foot because they really enjoyed these two non-motorized modes. Using either of these two modes can also facilitate physical exercise, which was reported as one of the most important reasons for choosing them. Meanwhile, people who lived nearby campus were more likely to commute by bike or on foot, whereas the situation was different for those who lived farther away. In addition, less than 40 percent of the users of non-motorized modes regarded adequate bike infrastructure and safe pathways as one of the reasons for their mode choice. No one regarded biking or walking as the only option for commuting, which indicated that non-motorized modes served as supplementary options for other modes.

Figure 3.3 shows the percentage of respondents who cited each reason for choosing a mode during the pandemic, indicating that essential workers had different attitudes toward mode choice during the pandemic. The statistics for public transit riders are not shown in the graph because none of the respondents identified any of these factors as the reason for taking public transit during the pandemic. In other words, the essential workers who rode public transit during the pandemic made the mode choice for reason not shown on the list.

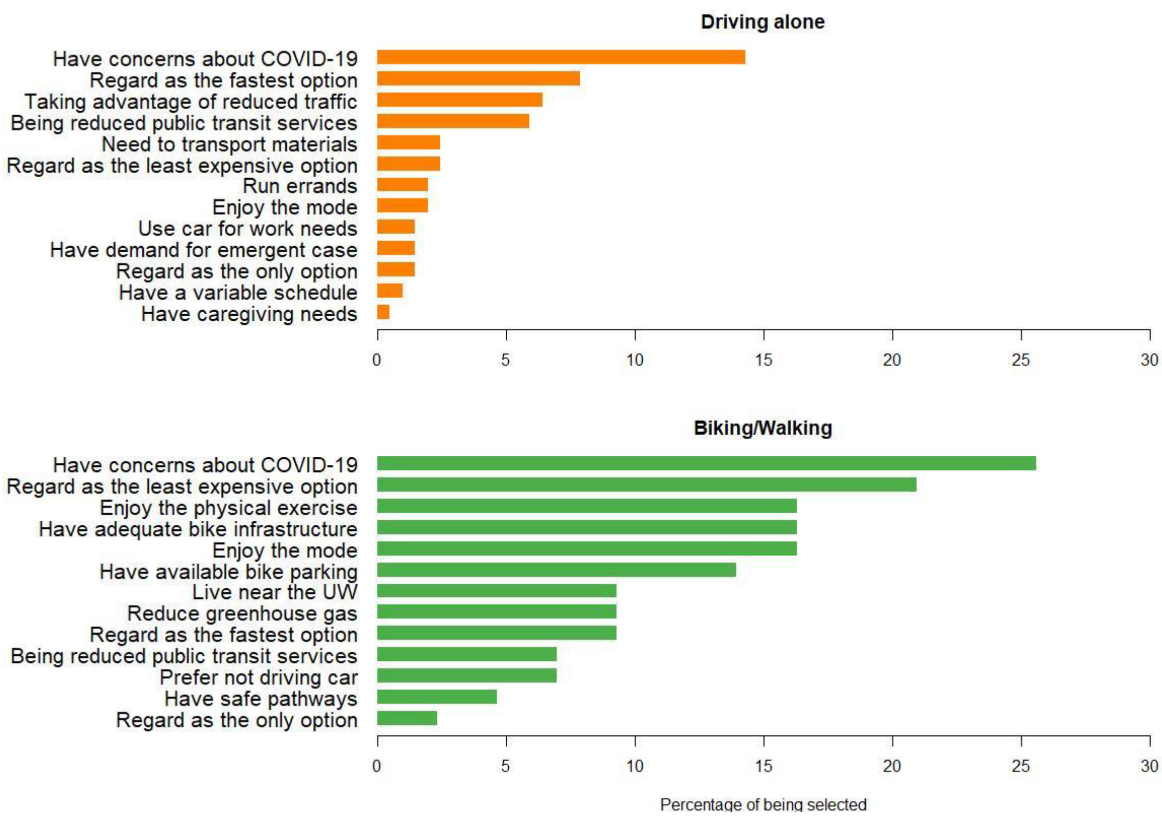


Figure 3.3 Percentage of the mode riders who reported that the factors influenced their mode choice (one could choose more than one factor)

For those who chose primarily to drive, concerns about COVID-19 contributed the most to their mode choice. Some workers considered driving alone as the fastest option, while some others viewed this option as taking advantage of reduced traffic during the pandemic. Special travel needs pertaining to driving alone also affected some essential workers' mode choice during the pandemic, including the needs for transporting materials and running errands. The needs for a car in an emergency or for caregiving became less pronounced among the drivers after the outbreak of COVID-19. In general, each of the reasons on the list was selected by a much lower percentage of respondents.

Moreover, concerns about COVID-19 also affected the choices of biking and walking during the pandemic. Among the workers who used primarily these active modes, they valued these less expensive options while enjoying the physical exercise, which could have been especially beneficial after having been restricted at home for a long time. In comparison to the pre-pandemic situation, adequate bike infrastructure contributed more to workers' choice of non-motorized modes, whereas concerns about environmental protection mattered less.

3.5 Key Explanatory Factors of Essential Workers' Commute Mode Choices Before and During COVID-19

3.5.1 Modeling Mode Choice Before COVID-19

Table 3.6 shows the parameter estimates of the models for essential workers' mode choices before the pandemic. One model included essential workers who did not have a car, while the other excluded them. The reference group of the dependent variable consisted of essential workers who primarily chose driving alone. For the reference category of each categorical variable, the coefficient value was zero by default. In each model, the variance inflation factor (VIF) was less than 5, indicating that the multicollinearity was moderate.

Table 3.6 Parameter estimates of the commute mode choice model, before COVID-19

Mode choice (ref category: driving alone[a])	Variable		Model including w/o car (N=266)			Model excluding w/o car (N=235)		
			Odds Ratio	95% Confidence Interval for Odds Ratio		Odds Ratio	95% Confidence Interval for Odds Ratio	
				Lower Bound	Upper Bound		Lower Bound	Upper Bound
Public transit	Intercept		0.30**	0.09	0.97	0.25**	0.07	0.88
	Age	55 or older	0.37**	0.15	0.92	0.45	0.17	1.21
		35-54	0.40**	0.17	0.92	0.43*	0.17	1.08
		18-34	0[b]					
	Gender	Female	1.18	0.62	2.24	1.30	0.65	2.60
		Male	0					
	Race	White	1.46	0.73	2.92	1.36	0.64	2.86
		All other races	0					
	Income	Low	8.39***	2.47	28.53	4.42**	1.13	17.27
		Middle	3.10***	1.50	6.41	2.75***	1.26	6.00
		High	0					
	Distance to campus		1.06	0.79	1.43	1.18	0.87	1.60
	Employment status	Faculty	1.45	0.72	2.94	1.28	0.60	2.73
		Staff	0					
Bike/ Walk	Intercept		0.05***	0.01	0.34	0.03***	0.00	0.50
	Age	55 or older	0.32*	0.09	1.11	0.34	0.08	1.54
		35-54	0.39	0.12	1.24	0.24*	0.05	1.13
		18-34	0					
	Gender	Female	1.06	0.44	2.57	1.10	0.37	3.31
		Male	0					
	Race	White	2.52	0.77	8.31	5.21	0.64	42.10
		All other races	0					
	Income	Low	2.85	0.41	19.65	0.99	0.07	14.50
		Middle	1.06	0.34	3.30	0.78	0.17	3.63
		High	0					
	Distance to campus		0.11***	0.03	0.44	0.20**	0.04	0.92
	Employment status	Faculty	1.99	0.72	5.49	1.61	0.48	5.38
		Staff	0					
AIC			440.28			361.23		

Log-likelihood	-202.14	-162.61

a. For the reference category of each independent variable, the parameter was set to zero.
*b. Significant level: *** P < 0.01, ** P < 0.05, * P < 0.1*

The regression outcomes of both models showed that age, income level, and commute distance were significantly associated with essential workers' mode choice. Older essential workers were less likely to choose public transit than to choose driving alone. Income level had a relatively larger influence on essential workers' mode choice than other factors. Low- and middle-income workers were much more likely to ride public transit instead of driving alone. The model that included workers without cars showed that a low income was associated with the highest probability of taking public transit versus driving alone. This model captured an additional effect of income on mode choice through car ownership. Moreover, the two models showed that commuting distance was significantly and negatively related to essential workers' probabilities of taking non-motorized modes (i.e., biking and walking) versus driving alone. The farther workers lived from the campus, the less likely they were to commute by bike or on foot before the pandemic.

3.5.2 Modeling Mode Choice During COVID-19

Table 3.7 shows the parameter estimates of the models for essential workers' mode choices during the pandemic.

Table 3.7 Parameter estimates of the commuting mode choice model, during COVID-19

Mode choice (ref category: driving alone)	Variable		Model including w/o car (N=266)			Model excluding w/o car (N=235)		
			Odds Ratio	95% Confidence Interval for Odds Ratio		Odds Ratio	95% Confidence Interval for Odds Ratio	
				Lower Bound	Upper Bound		Lower Bound	Upper Bound
Public transit	Intercept		0.05***	0.01	0.27	0.05***	0.01	0.43
	Age	55 or older	0.87	0.25	2.96	0.82	0.19	3.58
		35-54	0.43	0.13	1.42	0.21*	0.04	1.06
		18-34	0					
	Gender	Female	0.83	0.32	2.12	0.70	0.21	2.35
		Male	0					
	Race	White	1.37	0.50	3.79	1.37	0.36	5.20
		All other races	0					
	Income	Low	9.26***	1.80	47.68	2.13	0.17	27.03
		Middle	7.16***	2.23	23.00	6.35***	1.51	26.71
		High	0					
	Distance to campus		1.08	0.71	1.62	1.29	0.81	2.04
	Employment status	Faculty	1.29	0.44	3.79	0.80	0.20	3.21
		Staff	0					
Bike/ Walk	Intercept		0.07***	0.01	0.34	0.04***	0.01	0.31
	Age	55 or older	0.37*	0.12	1.09	0.56	0.15	2.20
		35-54	0.56	0.21	1.49	0.52	0.14	1.95
		18-34	0					
	Gender	Female	1.42	0.65	3.11	1.89	0.71	5.05
		Male	0					
	Race	White	1.22	0.50	3.02	1.68	0.51	5.53
		All other races	0					
	Income	Low	3.00	0.65	13.80	2.80	0.42	18.78
		Middle	1.10	0.42	2.89	0.94	0.28	3.22
		High	0					
	Distance to campus		0.11***	0.04	0.36	0.22***	0.07	0.69
	Employment status	Faculty	2.01	0.84	4.78	1.71	0.63	4.65
		Staff	0					
AIC			353.13			257.84		
Log-likelihood			-158.56			-110.92		

a. *For the reference category of each independent variable, the parameter was set to zero.*

b. *Significant level: *** P < 0.01, ** P < 0.05, * P < 0.1*

During the pandemic, the effect of age on the probability of choosing public transit instead of driving alone was only significant for the category of 35 to 54 years old in the model, excluding essential workers who did not have a car. In focusing on choosing between biking/walking and driving alone, only the 55 or older age group generated a significant effect in the model, including respondents without cars. Similar to the pre-pandemic models, income level was the factor that was most strongly associated with essential workers' commute mode choice during the pandemic. However, in the model excluding essential workers without cars, there was no significant difference between low-income workers and higher-income groups in the probabilities of taking public transit and driving alone.

3.5.3 Expected Probability of Mode Choice for Population Groups

Because income level was significantly and largely associated with essential workers' mode choices before and during the pandemic, we calculated the expected probabilities of choosing each mode for income groups based on the estimates of the multinomial logistic models (tables 3.6 and 3.7). We show the results of the models, including and excluding essential workers without cars, respectively, in figure s3.4 and 3.5. The X axis in the graphs refers to the standardized commute distance that was obtained by calculating standard deviations from the average. The lower the value is, the shorter the commute distance was. A solid line in the graphs is the mean of estimated probability (i.e., expected probability) of choosing a particular mode, whereas the shaded area around a solid line shows the 95 percent confidence interval of expected probability.

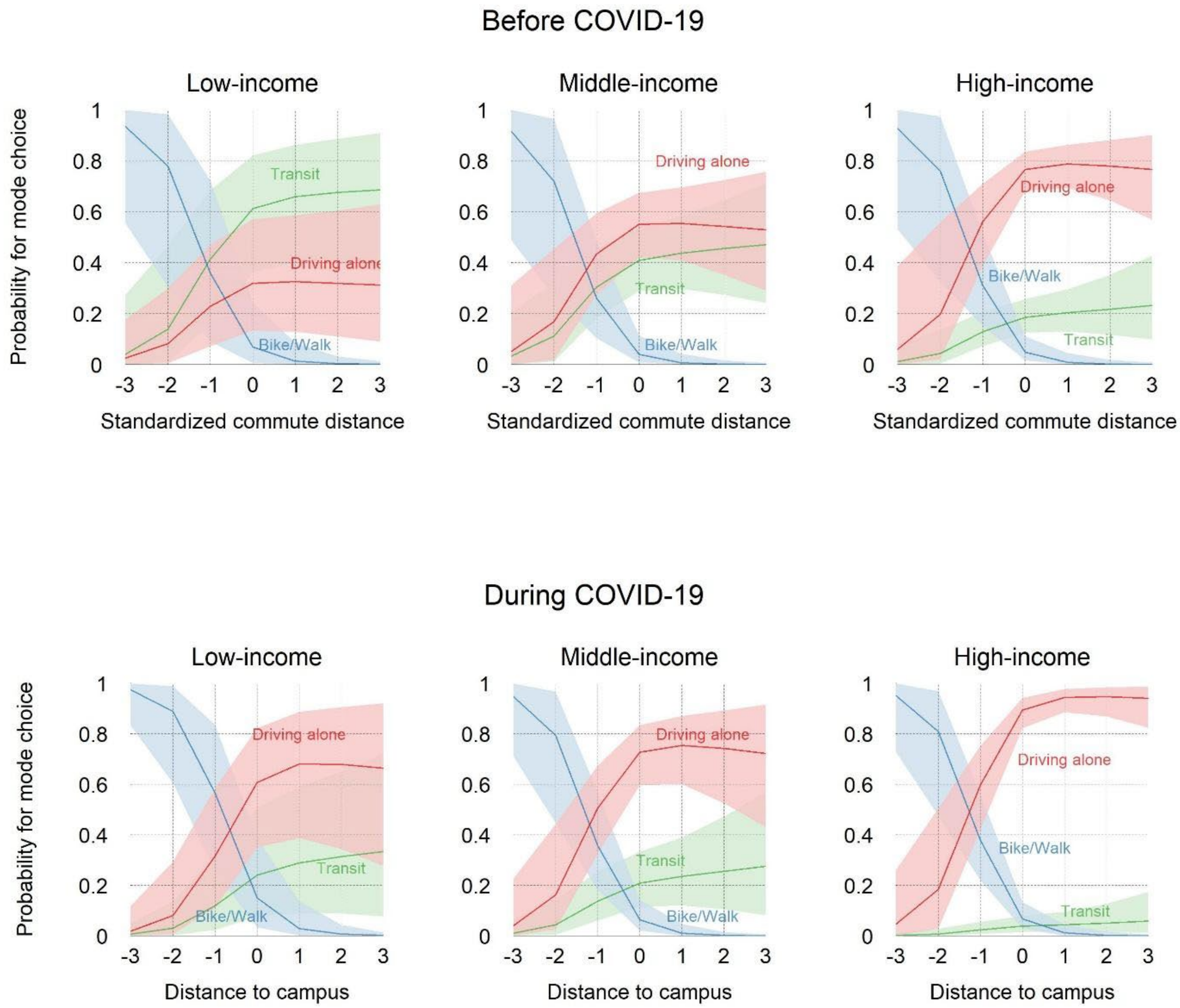


Figure 4 Expected probabilities of mode choice for low-, middle-, and high-income households before and during the pandemic (based on the estimation of the model that included w/o a car, N=266)

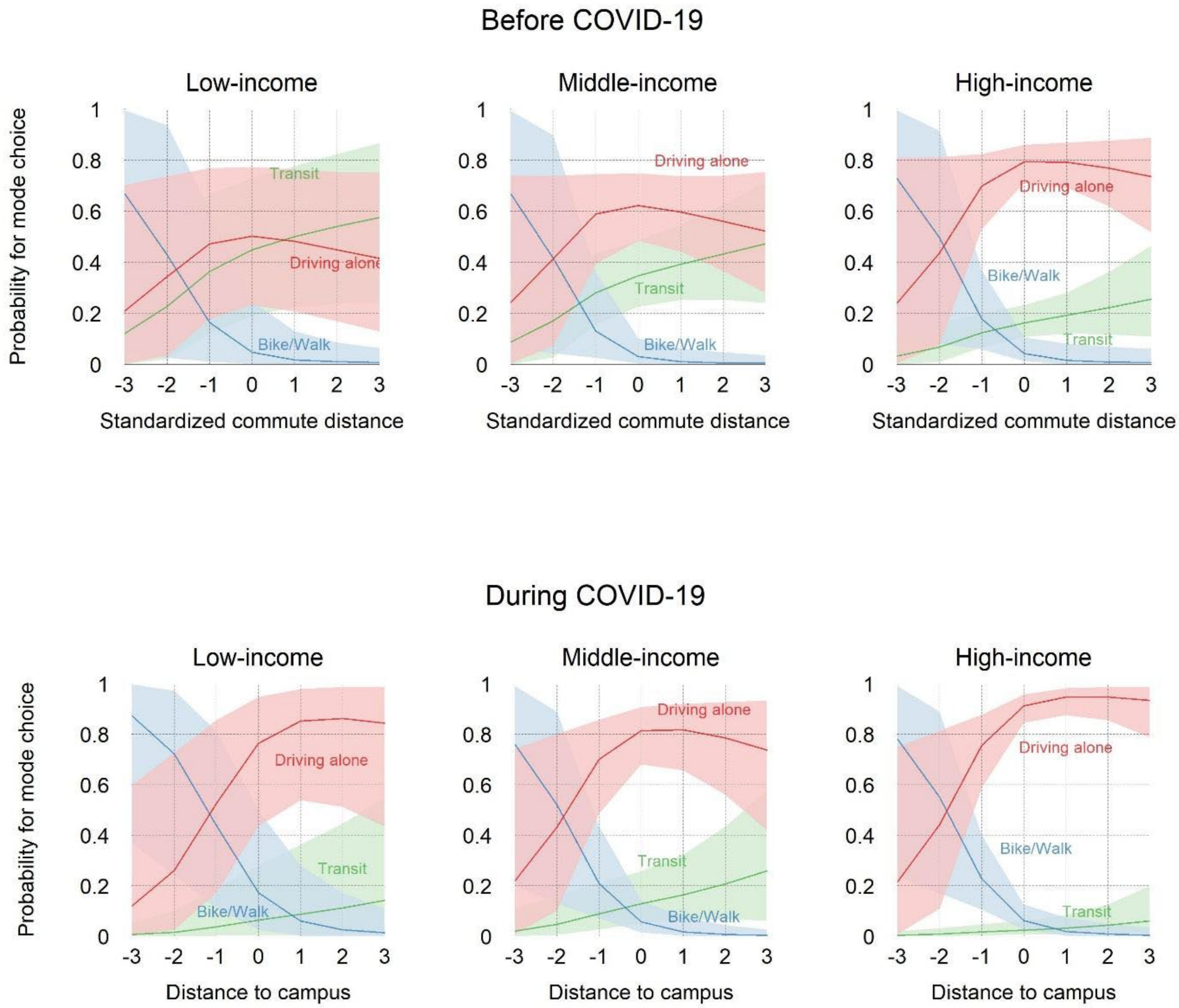


Figure 5 Expected probabilities of mode choice for low-, middle-, and high-income households before and during the pandemic (based on the estimation of the model that excluded w/o a car, N=231)

There was not much difference between the corresponding modal shift trends shown in figures 3.4 and 3.5. First, essential workers were more likely to choose public transit as their commute distance increased before and during the pandemic. For driving alone, on the other hand, the expected probability first increased and then decreased as distance increased. The probability of using a bike or walking, not surprisingly, kept decreasing as distance to the campus increased.

Before the pandemic, low-income essential workers were more likely to choose public transit than driving alone. For the middle-income group, the probabilities of choosing public transit and driving alone did not differ substantially. As for high-income essential workers, the probability of choosing driving alone was consistently much higher than that of choosing public transit, and the difference was the largest when they lived at roughly an average distance from the campus (i.e., the standardized commute distance was roughly 0).

COVID-19 caused significant changes in these workers' mode choices. During the pandemic, for every income group, the probabilities of choosing driving alone increased substantially and were much higher than those of choosing public transit, which clearly dropped. The changes, and the resulting gaps, were especially pronounced among high-income essential workers, to whom driving alone appeared generally more attractive than other modes during the pandemic. The gaps were narrower among middle-income essential workers and smallest among low-income essential workers. Note that the largest gaps were observed at approximately the average commuting distance for all three income groups. Moreover, the general modal shift from biking or walking to taking public transit also occurred at around the average commute distance.

3.6 Essential Workers' Perspectives on Commuting for the Recovery Phase

The survey data clearly indicated the essential workers' perspectives on commuting when all faculty and staff returned to work on campus. Among the 279 respondents, 233 said that they would continue to choose the modes that they primarily used during the pandemic, whereas 37 of the remaining 46 planned to return to taking public transportation. Essential workers' prospective modal shifts from the pre-pandemic period to the recovery phase are shown in figure 3.6.

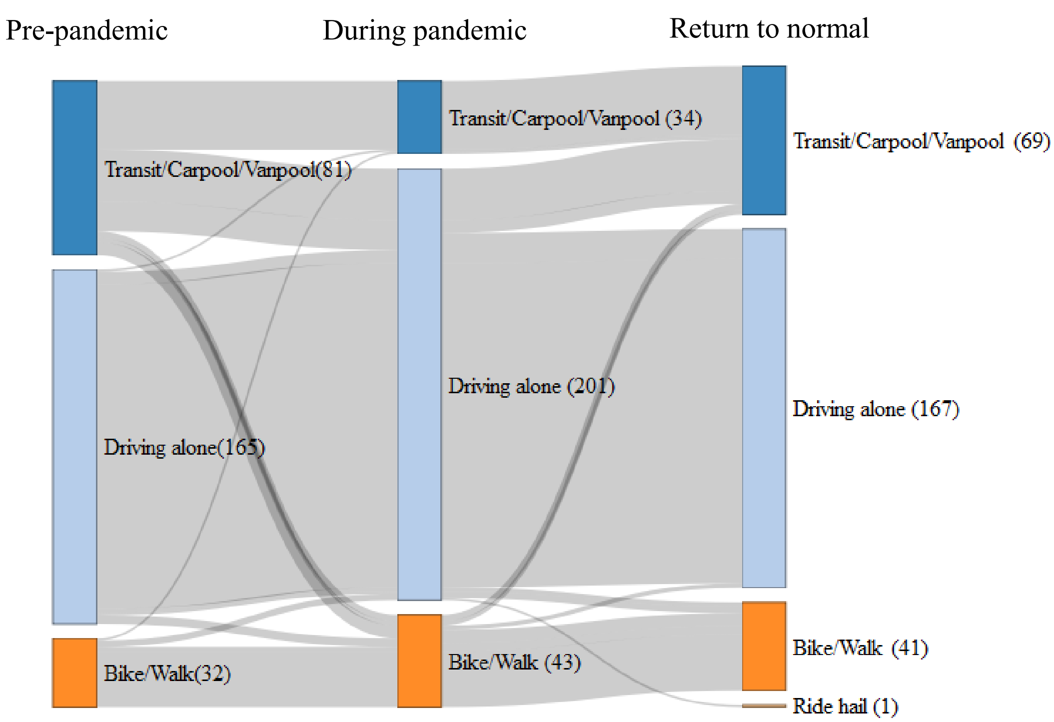


Figure 6 Modal shift of essential workers from the pre-pandemic period to the recovery phase (N=278) (one worker didn't provide an answer to related questions)

As shown in figure 3.6, essential workers generally expressed great confidence in returning to their previous modes, especially public transit. For each commute mode, its share of users would not change much in comparison to the pre-pandemic period. There would be slightly fewer transit riders but some additional users of non-motorized modes. As for the frequency of commuting trips in the recovery phase, 21.35 percent of essential workers thought they would commute less often than before the pandemic, 3.20 percent planned to commute more, and the remaining great majority anticipated roughly the same. Furthermore, other than their primary mode for commuting, some essential workers were interested in taking public transit as an alternative. Specifically, 26.33 percent of the respondents indicated an interest in trying public transport in the recovery phase, and 18.51 percent said they would like to try teleworking.

3.7 Discussion and Conclusions

The empirical results of our analysis indicated that the COVID-19 pandemic drove many essential workers to switch from taking public transport to driving alone. That modal shift can be partially attributed to the common concern about infection risk and inconvenience caused by reduced public transit services. Subsidies for car parking, such as free on-street parking, and large reductions in congestion during the pandemic most likely also contributed to this modal shift. These factors financially and psychologically decreased the travel cost of driving alone and hence made this mode more attractive relative to public transit. This modal shift was most pronounced among essential workers with higher incomes. However, public transit remained an important mode for lower-income groups, confirming the findings in previous studies (Parker et al., 2021; Tao and Cao, 2021).

Commute distance and household income level were shown by our regression models to be key explanatory factors for essential workers' mode choices both before and during the pandemic. An interesting finding was that for both periods, the probability of choosing driving alone over public transit did not continue rising with increasing commute distances, which was consistent with previous findings (Shen et al., 2016; Vredin Johansson et al., 2006; Whalen et al., 2013). Instead, it first increased in a non-linear way, and then decreased. Therefore, modal shift from driving alone to public transit will likely occur once commute distance has reached some critical value, which should be investigated in future research. Modal shift from biking or walking to other options usually occurred when commute distance was below the average, as predicted by the models.

Moreover, the patterns of essential workers' modal shifts varied by income levels. Our estimated models showed that with a higher household income, the probability for public transit users to switch to driving alone increased significantly. This tendency was more obvious during the pandemic, suggesting that lower-income essential workers were more likely to be transit-dependent. However, we did not find consistently significant associations between mode choice and other sociodemographic variables.

Our analysis of essential workers' future commuting prospects depicted a reasonably clear picture. The survey found that the respondents commuted 4.6 days on average in a typical week before the pandemic, with 63.8 percent of them commuting five days a week. About one quarter of the respondents expected to reduce commute frequency in the long term, but the great majority of essential workers planned to work on-site at roughly the same frequency as they did before the pandemic while following a more flexible timetable. In addition, there may not be much change in essential workers' primary mode choice in the recovery phase. Specifically, more than half of them showed no interest in using alternative modes. These findings suggest that essential workers' travel demand and mode choice will probably return to normal when the pandemic is under control. Therefore, it is important for transit agencies to maintain stable and frequent public transportation services and to facilitate safe and convenient non-motorized travel alternatives.

The COVID-19 pandemic presented a challenge, as well as an opportunity, for transforming the current mobility landscape. The literature showed that there are emerging approaches, which are mostly enabled by new technologies, to support commuting (Lyons, 2018; Rotaris and Danielis, 2018; Sioui et al., 2013; Wang et al., 2021). While some of those options appeared to be less attractive during COVID-19 (Meredith-Karam et al., 2021), they will likely become more important in the post-pandemic period. More importantly, in the longer term, transportation planners and policymakers need to seek innovative ways to ensure mobility for essential workers, especially during disruptive events and major crises. For those essential workers who do not own a car, transit agencies should provide them with accurate and timely information on service availability, while creating on-demand options to bridge service gaps. Employers, in the meantime, can facilitate additional transportation means by collaborating with mobility service providers and incentivizing shared rides among employees.

The study had some limitations, which should be overcome in future research. First, the survey data were collected from a sample of essential workers employed by a single academic institution (i.e., the University of Washington), which may have resulted in some bias in sample selection and model estimation. Future studies that draw data from more diverse employers in different cities will be essential for a more thorough understanding of essential workers' travel needs, options, and barriers. Second, the data did not provide a comprehensive list of explanatory variables for estimating more sophisticated models of mode choice, such as two-stage least squares models that control for the endogenous relationship between car availability and mode choice. If the pandemic is expected to have a lasting impact on essential workers' commute mode choice, future travel surveys should be conducted with additional pandemic-related questions to collect a richer set of data for monitoring and analyzing travel behavior changes. Third, to satisfy essential workers' travel demand in the recovery phase, future studies need more emphasis on examining employers' attitudes toward, and efforts in, supporting new mobility options for essential workers' commuting.

CHAPTER 4 INVESTIGATING THE IMPACT OF COVID-19 ON COMMUTING MODES AND PATTERNS: FOCUS GROUP DISCUSSIONS

4.1 Background

The COVID-19 pandemic severely disrupted transportation services of all kinds. Pandemic-related policy measures limited the number of people who could move around, forcing millions to stay at or work from home. Such drastic changes in mobility were exacerbated by concerns over the safety of shared rides, leading to a dramatic reduction in the demand for public transportation (Molloy et al., 2020; Astroza et al., 2020; Dixon, 2020; Ewoldsen, 2020; Hadjidemetriou et al., 2020; Nguyen et al., 2020). In light of this unprecedented reduction in public transportation ridership, transit agencies were faced with many operational challenges and uncertainties about the future shape of transit (Huang et al., 2020). While the reduced demand facilitated transit agencies' response to federal and local pandemic regulations to reduce the occupancy rate of vehicles and increase sanitization measures, it also resulted in service cuts. The negative impact on transit routes, schedules, and service frequency made public transportation an unreliable commute option for people—particularly essential workers who depended on it (Abdullah et al., 2020).

Public transportation normally provides a lifeline for many essential workers, defined in this study as employees who play a critical role in maintaining the basic functioning of society and therefore must continue to make frequent commute trips. As many large institutions and firms have recently resumed in-person operations, transit agencies have recognized the urgency to identify the best approaches for restoring transportation services post-pandemic (Grant and Bowen, 2020; Weiner and Armenta, 2020). Although reopening businesses and institutions should increase transportation demand, the lasting impacts of COVID-19 have reshaped commute patterns and mode choices for many individuals. Barriers to the recovery of public transportation might arise from continued safety concerns of shared mobility travel options and the inadequate technological capacity of public transit to enable contactless payments and provide timely and accurate information about service schedules. While it is difficult to predict future commute patterns, it is vital to examine how the pandemic changed the transportation needs of commuters, the determining factors for commute mode choice, and riders' perceptions of public transportation, app-based travel, and new mobility options (Grant and Bowen, 2020). Although there are many uncertainties about the returning ridership and commute patterns, transit agencies can see the transition to a post-pandemic society as an opportunity to improve public transportation services and resiliency by adopting long-term safety measures and deploying technological innovations.

This focus group study was a collaborative effort between researchers at the University of Washington (UW) and professionals working in the UW Transportation Services department (UWTS) to gain deeper insights into essential workers' changing travel needs due to the COVID-19 pandemic and to assess the role of public transit in meeting those needs post-pandemic. As a large and complex academic institution, the UW has a large and highly diverse workforce of more than 70,000 employees, including a wide range of essential workers, in terms of job type, income, gender, and age group. Public transit, including bus and light rail services, was the main commuting mode for over 44 percent of UW employees and students before the pandemic, which makes the UW an appropriate case study to inform future transportation planning and transit service decision-making.

This study was based on a series of focus group discussions with UW essential workers who were pre-pandemic transit riders to examine commute mode choice and commute patterns during the COVID-19 pandemic and to explore different approaches to recover public transportation demand post-pandemic. The study focused on four questions:

1) How did employees' commute mode, duration, and frequency change during the pandemic? How did COVID-19 impact transit riders' perceptions of different commute modes?
2) What are the anticipated post-pandemic changes in commute mode choice and commute patterns?
3) What can employers and transit agencies do to facilitate commuting using public transportation options post-pandemic?
4) What were the determining factors for commuters' mode choices during and after the pandemic? Moreover, what role can technology interventions, including smartphone apps, play in influencing commute mode choice?

4.2 Method

4.2.1 Sampling

The selected sample for focus groups included UW professional staff and contract-classified staff who responded to the UW Needs Assessment Survey and agreed to be contacted for future studies. Sampling occurred two phases. First, staff who met the following two criteria were recruited using a probability approach: 1) they used transit or carpooling/vanpooling to commute to campus before the pandemic, and 2) they were essential workers and still commuted to campus during the pandemic.

A total of 105 employees met the criteria and were contacted with an email letter inviting them to participate in the focus group study. Through the email, they were informed about the purposes and ground rules of the focus groups, the planned dates and times for the sessions, and their expected role and responsibilities. Employees interested in participating were directed to a pre-focus-group survey with questions about their availability for focus group sessions and their commute mode before and during the pandemic. They were also informed that participants would be compensated with a modest monetary incentive in the form of an electronic gift card.

Twenty people agreed to participate, but only 14 attended the first three rounds of focus groups. Because this sample overrepresented people who worked as professional staff, many of whom came from the Medical School, we decided to expand the sample by adding one more session focusing on contract-classified staff largely consisting of blue-collar workers.

In this second sampling phase, the team contacted contract-classified staff through snowball sampling, a nonprobability approach, and asked a volunteer manager in the University of Washington Building Services Department to help recruit participants. Recruitment efforts focused on essential staff in Building Services, primarily representing custodial, maintenance, and administrative staff in contract-classified positions. Per the recommendation from the department leadership, the focus group session was conducted during employee work hours to maximize participation. Seven participants attended the fourth focus group of the study.

All participants agreed to join the focus groups virtually using Zoom video conference software and provided necessary consent for the recording and for their comments to be used for research purposes. All focus group discussions lasted about an hour and a half and were facilitated by one research team member in English. At least one additional research team member was present as an observer and technical assistant at all focus group sessions.

4.2.2 Focus Group Protocol

The focus group protocol included a semi-structured discussion guide for the moderator's use, including scripts to welcome participants, introduce the study, establish ground rules, ask questions, make transitions between topics, and close the discussion. This protocol aimed to create a welcoming and comfortable environment and guide participants to exchange their experiences and thoughts regarding commuting. The design and the format of the focus group protocol were based on the instructions offered by Breen (2006), Johnson (2014), and Krueger (2002). We also referred to previous studies that had conducted focus groups on individuals' travel behaviors and preferences and studied their protocols for best practices to design and frame transportation planning and community resilience questions (Coughlin, 2001; Lee, 1996; Lovejoy and Handy, 2007; Simons et al., 2014). The draft of the focus group protocol was reviewed for several rounds by the research team, UWTS professionals, and professional experts in focus groups from Puget Sound Regional Council, and the revised version was tested by the team members and volunteers from UWTS in a pilot session.

The finalized focus group protocol consisted of four main sets of questions, shown in table 4.1. The first section contained introductory questions and transition questions about commuting mode choice before and after the pandemic. The second section consisted of questions about the challenges and benefits associated with different commute modes before and during the pandemic. Key questions targeted specific groups (e.g., participants who switched to driving during the pandemic and participants who continued to use transit), focusing on their commuting experience, determining factors for their mode choice, and anticipated post-pandemic commuting mode choice and patterns. The third section consisted mainly of key questions focusing on the role of institutions (e.g., the University of Washington) and transit agencies (e.g., public transportation operators in the Seattle region) in assisting employees' daily commute. The last section focused on the role of technology and smartphone apps in facilitating essential workers' commutes.

The discussion time was divided more or less equally among the sections, while variations in time depended on the level of participation. The moderator used the protocol to facilitate the discussion, leaving enough time for participants to think and respond to questions. Participants were encouraged to reflect on each question and each other's answers in a conversation-like discussion.

Table 4.1 Focus groups guide and questions

Question type	Purpose	Question	Min.
Introduction section			
Opening	*Introduction/ Ice breaker*	Tell us your name, job title, and in which university department or the unit you work?	1
Transition	*To move to key questions about commuting experience*	Can you briefly tell us how you typically commuted to work before the outbreak of the pandemic? How long did it typically take?	2
Transition		Can you briefly tell us how you typically commute to work during the pandemic? How long does it typically take?	2
Second section (mode choice and the pandemic)			
Key	*To understand Transit experience before Covid-19*	What were the reasons you chose to use transit or carpool before COVID -19 (i.e., before March 2020)?	5
Key		What challenges did you experience using transit or carpooling before COVID-19?	5
Key	*To understand mode choice during Covid-19*	During COVID-19 (i.e., after March 2020), what new challenges did you encounter getting to work?	5
Key		What do you feel are the top 1-2 advantages and challenges of using transit and carpooling during COVID -19?	5
Transition	*To move towards key questions*	During COVID-19, did you consider/are you considering switching to driving for your commute?	5
Key	*To understand determining factors to mode choice*	If yes, what are the circumstances in which you would switch to driving? If no, why not?	5
Key		What do you feel are the top 1-2 advantages and challenges of a drive-alone commute during COVID -19?	5
Key		Under what circumstances would you return to using transit for your commute when instructions are in-person again?	5
Third section (the role of employers and transit agencies)			
Key	*To explore riders desired improvements*	What are the top 1-3 things that your employer, UW, could do to assist your use of transit or carpooling for your commute?	10
Key		What are the top 1-3 things that transit agencies could do to assist	10

Question type	Purpose	Question	Min.
		your use of transit for your commute?	
Fourth section (the role of commute smartphone Apps)			
Transition	*To investigate interest in UW commute App and desired features*	Would you like the UW to develop a smartphone app that provided information to support your commute decisions?	5
Key		If yes, what features or information would be useful? If you are not interested in using an app for your commute, why not?	5
Key	*To investigate interest in UW carpooling app*	Would like to access an app that facilitates carpool matching with UW employees who live nearby change the way you commute?	5
Key	*To investigate interest in professionals carpooling app*	Do you think UW should partner with nearby businesses and employers to facilitate carpool matching with commuters?	5
Key		What conditions need to be met for you to choose to carpool with non-UW employees?	5
Ending	*To identify other impacts of commute*	How has commuting during the Covid-19 pandemic impacted your work life and personal life?	2
Ending	*To close the conversation*	Why are you interested in the focus group?	2

4.2.3 Focus Group Structure

Between June and July 2021, the research team conducted semi-structured focus group discussions with 21 UW staff members, including research scientists, department managers, administrators, program coordinators, and custodians working at various departments at the University of Washington. Two-thirds of focus group participants were professional staff, and one-third were contract-classified staff. The goal was to hold focus groups until adequate diversity in participants' job types had been reached and until all questions had been investigated and no more new concepts emerged. Four focus groups were held, with five participants in the first one, four participants in the second one, five participants in the third one, and seven participants in the fourth one. The first three focus groups were conducted with 14 professional staff and one contract-classified staff. The last focus group contained four contract-classified staff, mainly custodians, and three professional staff who worked closely with custodians as managers and directors. Focus group discussions were recorded in the Zoom video-conference software as video and audio files.

4.2.4 Data Analysis

4.2.4.1 Concepts and Terminology

We used NVivo 12 Pro, a computer-aided qualitative analysis software, to conduct a thematic analysis and to identify patterns and commonalities among the responses to questions posed. We analyzed the data and summarized the results by case classification (participant attributes). NVivo uses unique terminology, which is defined in table 4.2.

Table 4.2 NVivo terms and definitions

Nvivo Term	**Definition**
File	A document that is inserted in NVivo for analysis. In this project, each focus group was a separate file.
Case	The person whose text is being analyzed in NVivo. In this project, each case was a unique participant of any of the focus groups.
Quote	Phrases or parts of phrases made by participants containing the same key words are referred to as "quotes."
Reference	Each unique quote is called a reference in NVivo.
Code	A label (abstraction) assigned to quotes (phrases or parts of phrases containing the same key words) that represent important and recurring ideas in the comments made by the participants. Thus, a code is a group of quotes or references.
Coding	The process of grouping references (quotes) into a code. In Nvivo, each code is stored in a container called a Node.
Node	Node is an NVivo container for codes.
Code validation	The process of reviewing the codes (the grouping of quotes). This process can include recoding, uncoding, merging, deleting, or renaming initial codes.
Thematic analysis	Identifying and analyzing patterns of concepts and ideas within the data. Thematic analysis may be generated theoretically or empirically and may differ from one researcher to and another when analyzing similar data.
Case attribute	Descriptive information on the sociodemographic, economic, and other characteristics of the cases (participants) (e.g., gender, age, job, etc.).

4.2.4.2 Data Processing and Analysis

Focus group discussion video recordings were automatically transcribed in Zoom verbatim. The generated transcriptions were then proofread word by word, compared to the recording, and checked for any errors by a team member who served as the moderator for the first three sessions and the observer for the last one, referred to hereafter as "LA."

The discussion narratives of each participant were analyzed and coded by LA, who had observed emerging codes and themes throughout the focus groups and transcription proofreading and was aware of the nuances, emotions, and context of each response. Subsequently, LA organized the focus group transcripts into document files, each containing the questions and answers for every focus group separately.

The first step of the qualitative data analysis started with an initial round of coding of the focus group files. LA assigned quotes that included specific phrases or parts of phrases to codes or multiple codes based on their relevance to the study goals. Each code was weighted by the number of focus groups (files), unique participants (cases), and the number of mentions (references) included in it. Codes were then reviewed for duplication, repetition, or misinterpretation, which resulted in the addition, deletion, or moving of certain quotes across codes and renaming some codes. A second coder, "MC," carried out an additional round of code validation, and doubts or disagreements were discussed by the entire research team and resolved accordingly.

In the second step, the finalized codes were grouped into themes for identifying and analyzing patterns of concepts and ideas within the data. The two coders also validated the resulting themes. Additionally, the themes were grouped into three different time periods: pre-pandemic, during the pandemic, and post-pandemic.

The final step included analyzing the codes by participants' attributes (referred to as case classification in NVivo). To ensure data confidentiality, the names of participants (referred to as cases in NVivo) were removed after their attributes—i.e., gender, age, home location, and job type—had been coded. The entire transcript was coded by each attribute (e.g., home location), which was defined by two values: inside Seattle and outside Seattle. We built different charts to visualize the relationship between code frequency and case classification for each theme and discussed our results accordingly. We used participants' attributes to provide deeper insights into the differences and similarities of codes for each theme. The resulting charts showed the number of cases whose responses were coded for each code, normalized by the total number of cases in each case classification to show the coding intensity per case classification. For example, the number of cases was broken down to show the percentages of men and women whose answers were included for every code within the theme.

Table 4.3 Cases classification based on participants' attributes

Attributes	Case classification
Gender	Male
	Female
Home location	Inside Seattle
	Outside Seattle
Job type	Professional staff
	Contract classified staff

4.3 Results

4.3.1 Descriptive Analysis

Table 4.4 shows participants' demographics and commute patterns. Almost two-thirds of the focus group participants were professional staff, and one-third of participants were contract-classified staff, mainly participants of the fourth focus group. Almost two-thirds of participants were women between 30 and 65 years and lived outside Seattle. All participants were pre-pandemic transit users, and one-third of participants had switched to driving in the first three to five months of the pandemic. While everyone was asked about the duration of their commute before the pandemic, some did not answer, resulting in percentages that do not add up to 100 percent.

Table 4.4 Participants' demographics and commute patterns

Demographics and Commute Patterns	**Count**	**%**
Total number of participants (n)	21	100%
Contract classified	7	33%
Professional staff	14	67%
Age (20 - 30)	5	24%
Age (30 - 65)	12	57%
Age (65 or more)	4	19%
Female	11	51%
Male	10	49%
Living inside Seattle	7	33%
Living outside Seattle	14	67%
School of Medicine	7	33%
Have access to a car	17	81%
Pre-pandemic commute duration using transit		
(10 - 30 min)	5	24%
(30 - 60 min)	7	33%

Demographics and Commute Patterns	**Count**	**%**
(More than 1 hour)	5	24%
No answer	4	19%
Commute mode during the pandemic		
mainly transit)	11	52%
mainly drive)	7	33%
mainly bike)	1	5%
mainly vanpool)	2	10%
Mainly telecommuting during the pandemic	4	19%

4.3.2 Thematic Analysis

The qualitative data analysis identified 16 themes structured into three different periods: pre-pandemic, during the pandemic, and post-pandemic. Generally, the themes included challenges, benefits, factors, and patterns of different commute modes. Figure 4.1 shows the structure of the thematic analysis and top-down hierarchy of results from left to right. We use the same hierarchy to present the results, starting with the three time periods (pre-pandemic, during the pandemic, and post-pandemic), followed by the themes for each period and the codes grouped into each theme while highlighting quote examples for each code. Figure 4.2 shows the resulting themes for each pandemic-related period. Tables showing the codes corresponding to each theme, and graphs describing the codes by case classification, are presented only for the first theme (pre-pandemic transit challenges, presented in the next section); the rest are included in the supplementary material.

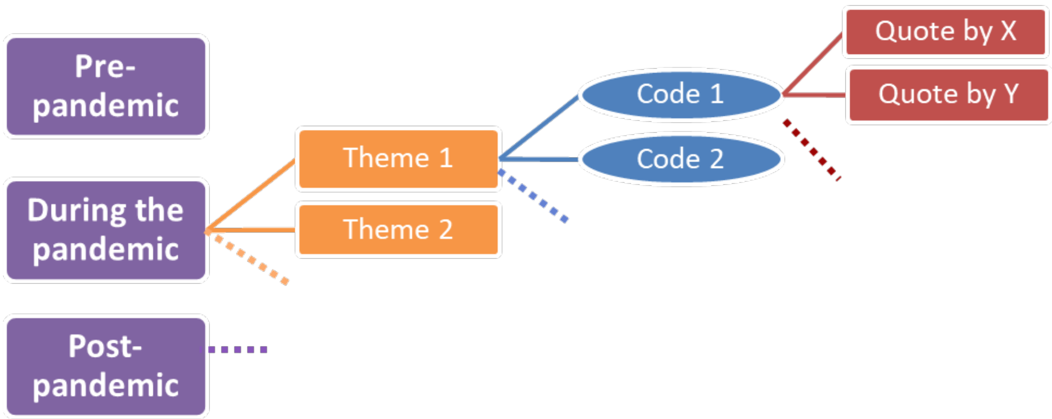


Figure 4.1 Structure of the thematic analysis

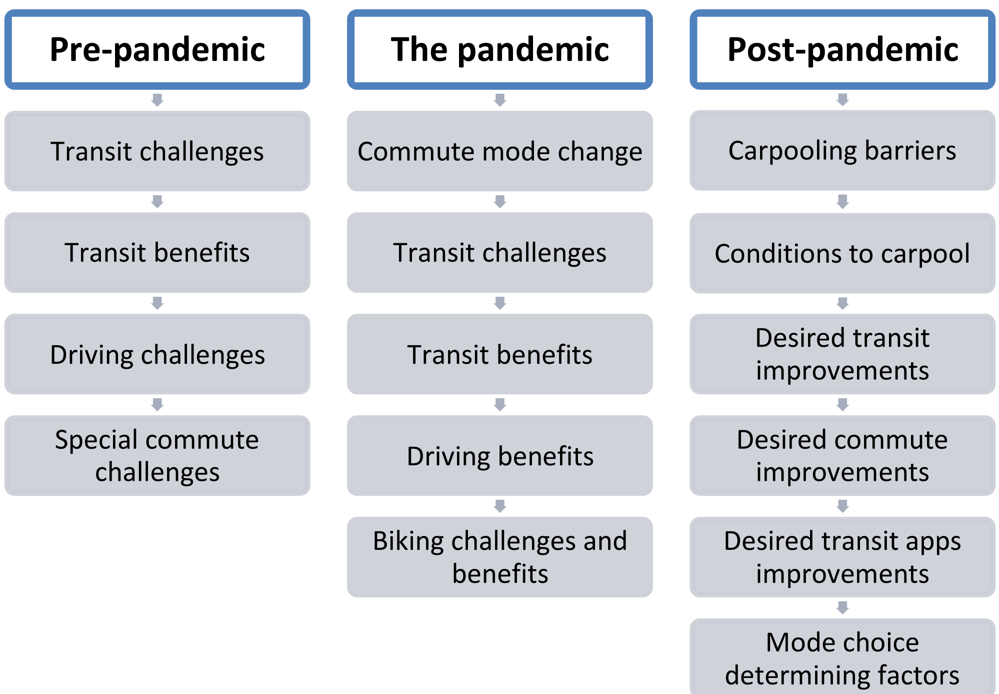


Figure 4.2 Resulting themes and sub-themes

4.3.3 Pre-pandemic Themes

4.3.3.1 Pre-pandemic Transit Challenges

Table 4.5 shows the list of codes for the transit challenge theme with examples of quotes. The table also tallies each code's number of files (focus groups), references (number of mentions), and cases (number of participants). Participants from all focus groups highlighted several pre-pandemic transit issues. The most frequently mentioned issue was the misinformation and unreliability of transit apps (eight participants). Incidents such as when an app communicated false transit timing could cause major commute issues, such as arriving late to work or using another costly mode. Many participants noted safety-related issues, mainly because of many homeless people taking shelter in buses and light rail (six participants). Some participants also complained about transit scheduling and frequency issues, which rendered transit unreliable, especially when riders had multiple transfers during their commute (five participants). Participants who were mainly parents indicated that using transit made them feel confined to one place, especially when they had to respond to emergencies such as school calls, as they had to make long trips to reach destinations other than their workplace (four participants).

A few participants mentioned the lengthy bus rides due to numerous stops (two participants), the inconvenience of carrying heavy items, including food (two participants), seasonal challenges, especially during wintertime (two participants), and inconsistency of payment channels, which included transit apps, paper tickets, and transit cards (one participant).

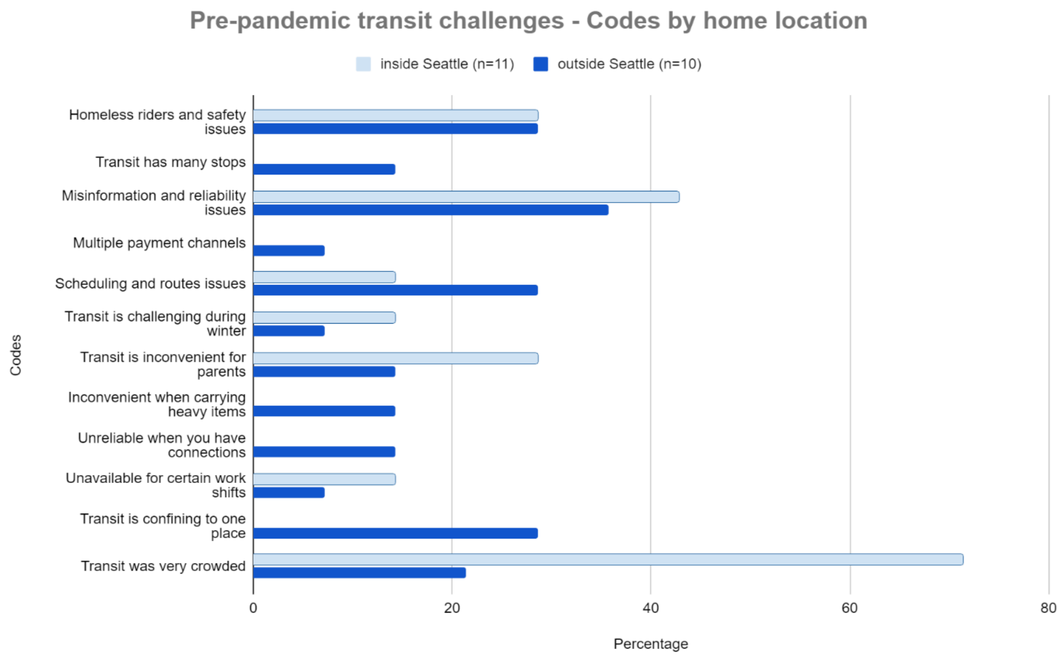
Table 4.5 Codes for theme pre-pandemic transit challenges

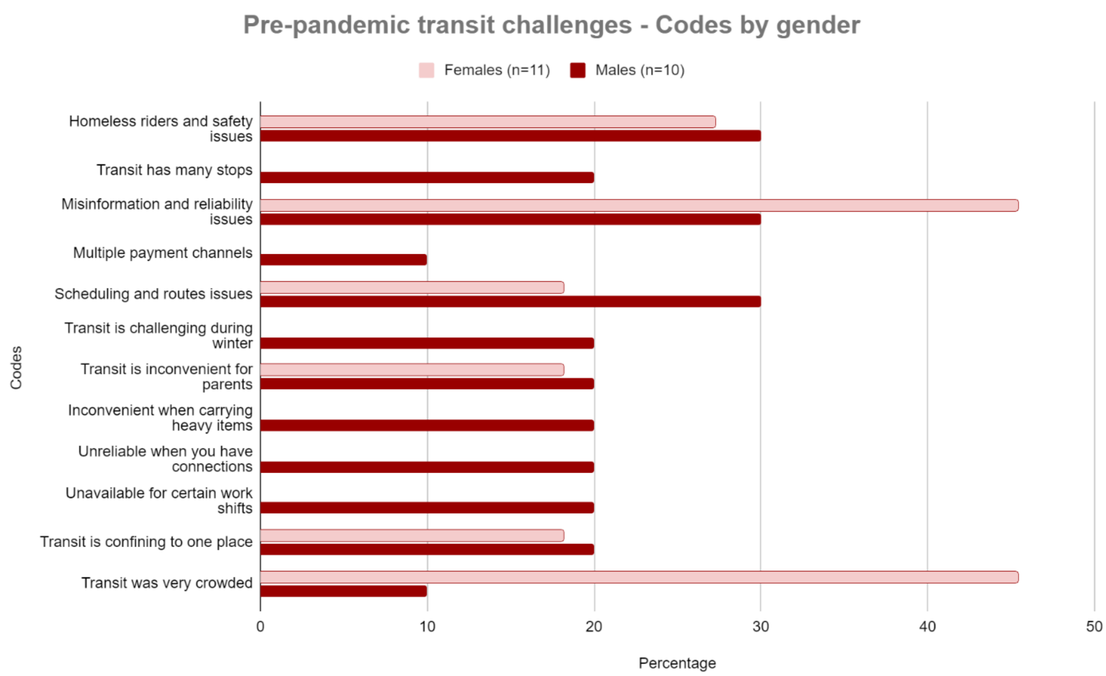
Codes	**Example quotes**	**Files**	**Ref**	**Cases**
Misinformation and reliability issues	*"It happens often that the App would say there are no buses coming, and I see a bus coming"*	**3**	**11**	**8**
Transit was very crowded	*" It gets full to the Point where it's unsafe to drive because the driver can't even see the mirrors"*	**4**	**7**	**6**
Homeless riders and safety issues	*"I had some instances, dealing with transient folks, and it did not make me feel safe"*	**3**	**6**	**6**
Transit has scheduling and routes issues	*"Link was only running every half hour, which was incredibly inconvenient. It would double my commute time if I missed one"*	**2**	**8**	**5**

Codes	Example quotes	Files	Ref	Cases
Transit is confining to one place	*"That same feeling of being trapped in any one place when you have to be home is stressful!"*	**1**	**6**	**4**
Transit is inconvenient for parents	*"I've had times in the past where the school called and tell you your kid is sick and the next bus needs an hour, and I've had to call my mom"*	**2**	**4**	**4**
Transit is challenging during winter	*"During the winter time. It gets really packed like pre COVID, it was shoulder to shoulder"*	**1**	**2**	**2**
Transit has too many stops	*"The drawback with the bus was that it had to stop at many stops it wasn't an express bus"*	**1**	**2**	**2**
Inconvenient when carrying heavy items	*"Lunch things in your backpack gets a bit heavy so I tend to drive for some parts of the trip"*	**1**	**2**	**2**
Unreliable when you have connections	*"Bus connections have many issues. the frequency of options should be improved"*	**1**	**2**	**2**
Unavailable for certain work shifts	*"Transit is not an option for us, because we work very early in the morning"*	**1**	**2**	**2**
Multiple payment channels	*"I use the TransitGo app and it just feels more disconnected from the other ways that you pay"*	**1**	**1**	**1**

Figure 4.3 shows the codes that corresponded to pre-pandemic transit challenges by case classification, normalized by the total number of cases, e.g., the percentage of males from all male participants for each code. Codes are shown on the left side of the chart, and each theme corresponds to the case classification, which is further illustrated in the legend. Figure 4.3 shows that participants who lived outside of the City of Seattle, and hence were farther from the University of Washington main campus and had a longer commute, mentioned a wider range of challenges they faced, mainly as a result of having multiple connections or transferring from one mode to another and the inconvenience of carrying heavy items. Similarly, participants living outside Seattle faced more challenges with transit schedules and routes, which could result from the dearth of routes leading to their final destination; hence their commute was generally more sensitive to delays and route changes. Codes by gender indicate that men faced a wider range of

challenges than women. Codes by job type indicate that some contract-classified staff suffered from an unavailability of transit for their work shift hours. As a result, several contract-classified staff indicated that they chose to rely more on vanpools for their commute and therefore mentioned fewer transit-related challenges than professional staff.





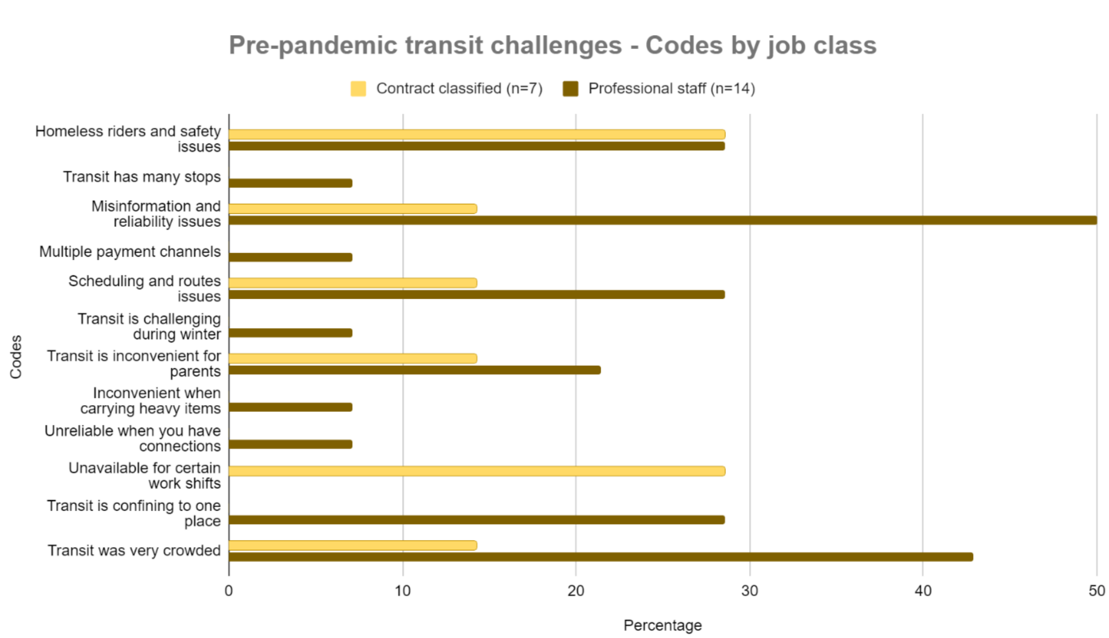


Figure 3 Codes by home location, gender, and job type for the theme pre-pandemic transit challenges

4.3.3.2 Pre-pandemic Transit Benefits

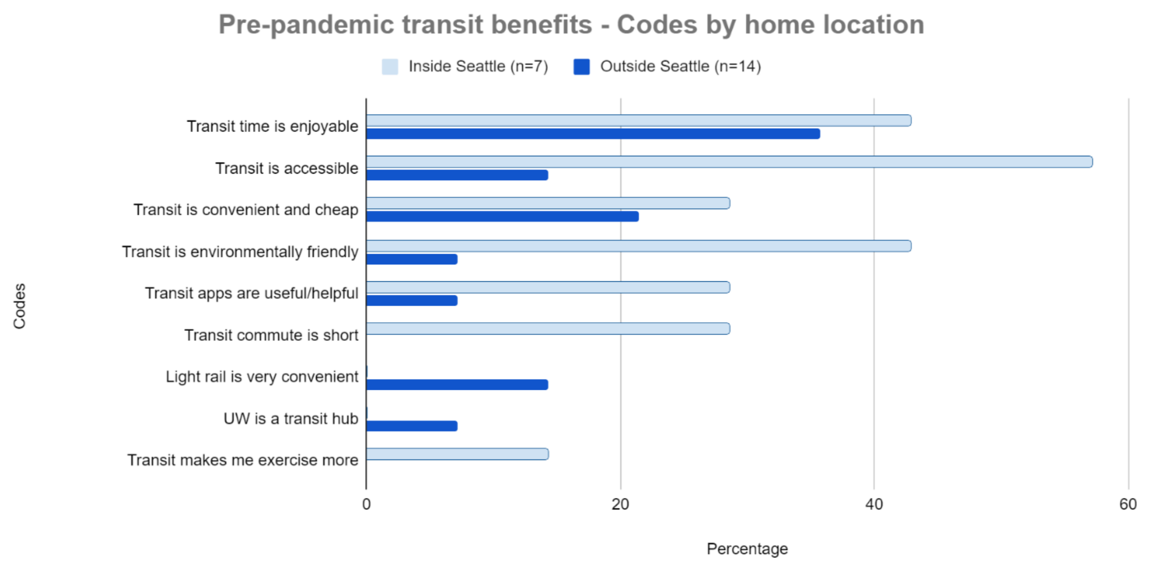
Table 4.6 shows the list of codes used to understand pre-pandemic transit benefits. While many participants talked about the reliability issues of transit apps, some indicated that apps were very beneficial to their commute (three participants). Many participants indicated that the main benefit of commuting by transit before the pandemic was the high value of travel time, allowing riders to use commute time for meditation, listening to music, or getting some work done (eight participants). Similarly, many participants indicated that accessibility (six participants), affordability (five participants), and sustainability (four participants) were significant benefits of commuting by transit. Lastly, only two participants indicated that their transit trips were fast.

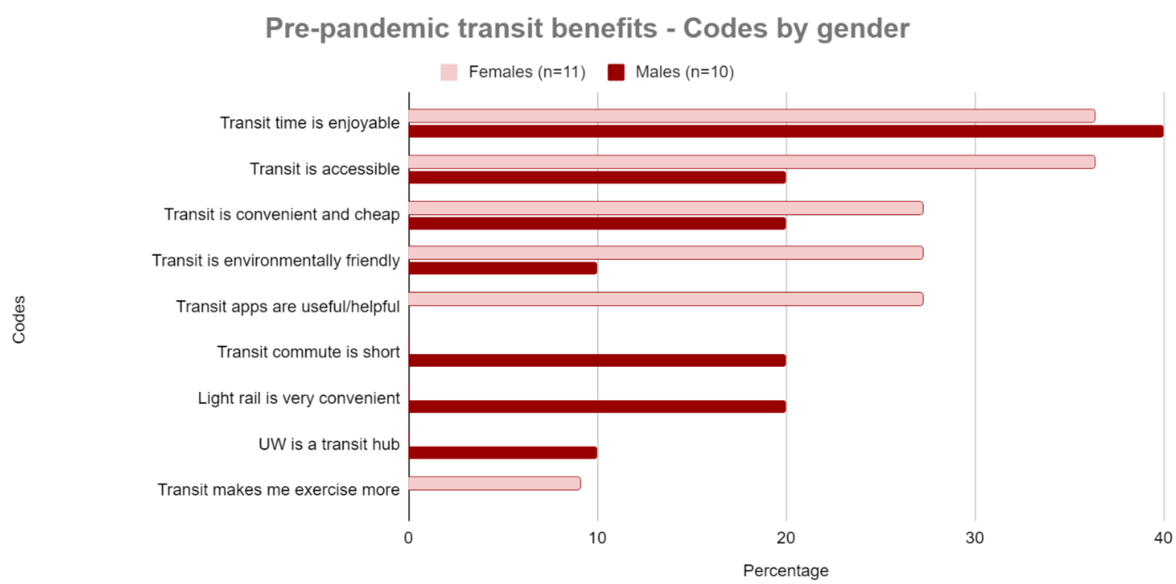
Table 4.6 Codes for the theme pre-pandemic transit advantages

Codes	Example quotes	Files	Ref.	Cases
Transit time is enjoyable	*"I really enjoyed my bus. It is easy to just relax and read a book or play a game "*	4	8	8
Transit is accessible	*"I didn't have a much challenges before Covid-19, the buses were very frequent"*	2	12	6
Transit is convenient and cheap	*"U-Pass transit is much more affordable and the bus is pretty frequent"*	3	7	5
Transit is environmentally friendly	*"I used transit because better for the environment"*	2	4	4
Transit apps are useful/helpful	*"I like the apps, they're super helpful, but having a more reliable one would be great"*	2	4	3
Transit commute is short	*"My commute is only 12 minutes by transit"*	2	2	2
Light rail is very convenient	*"It is great that Link is extending further my way. I didn't have to pay attention to anything when using it"*	1	3	2
UW is a transit hub	*"And the nice thing about working at the UW, it is a hub for almost any bus"*	1	1	1
Transit makes me exercise more	*"Using transit to work guaranteed 30 minutes of walk for me a day"*	1	1	1

Figure 4.4 shows the different codes by case attribute, which were normalized by the number of cases in each case classification, e.g., percentage of males from all male participants for each code. Examining the codes by case classification shows that participants who lived inside Seattle gained more benefits from using transit than those who lived outside Seattle, and that they found the commute by transit to be short, enjoyable, and accessible. More women than men found transit cheap, environmentally friendly, and healthy because of increased exercise levels and found transit apps useful.

Professional staff found transit more beneficial than contract-classified. Although contract-classified staff considered transit generally affordable, it was unavailable during their work shifts.





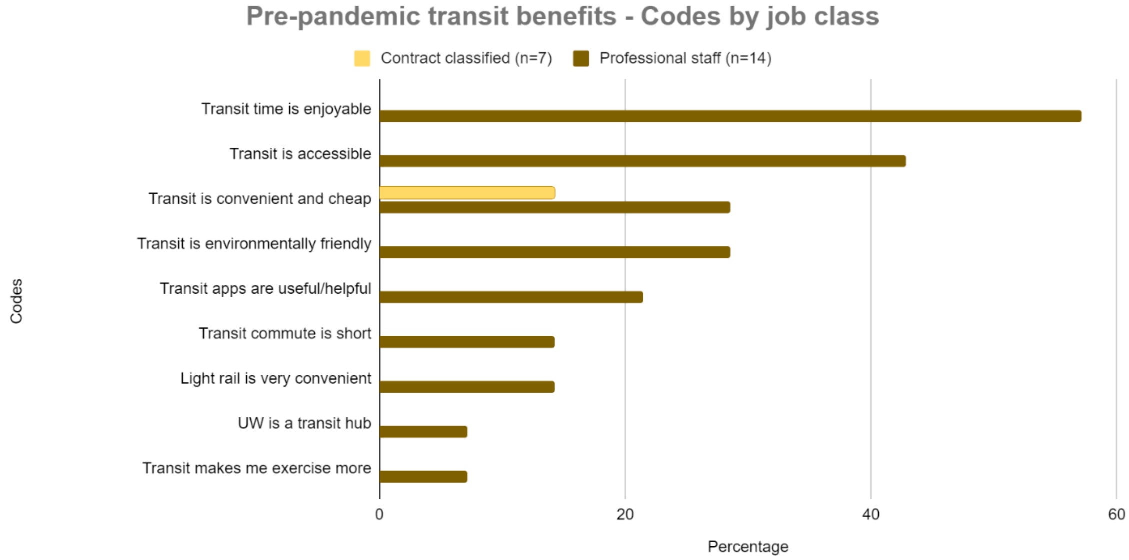


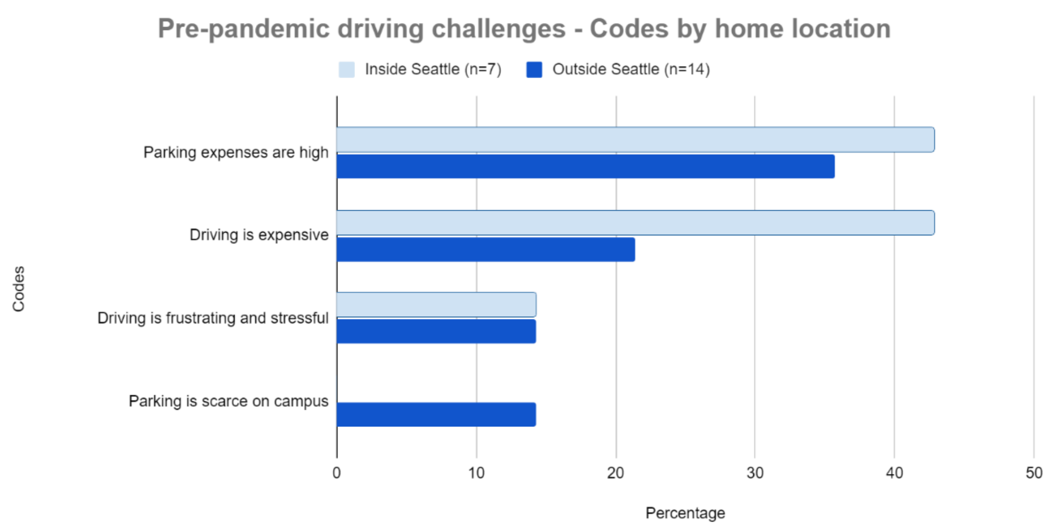
Figure 4 Codes by home location, gender, and job type for the theme pre-pandemic transit benefits

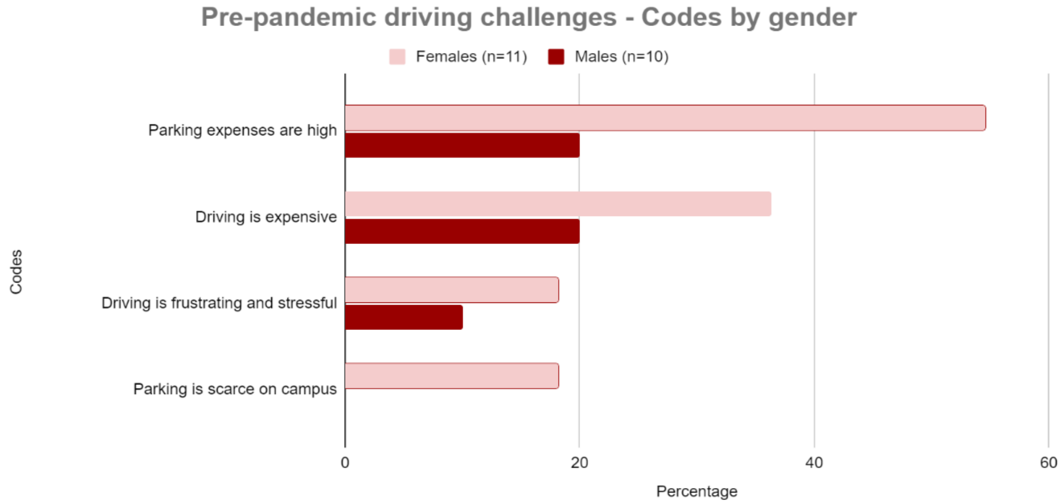
4.4.1.3 Pre-pandemic Driving Challenges

Table 4.7 shows the list of codes used to explore pre-pandemic driving challenges. Many participants indicated that the biggest challenge of driving to work before the pandemic was driving expenses (six participants), especially the high parking costs at the UW (eight participants). While most complaints about driving costs came from professional staff who lived outside Seattle, all contract-classified staff who drove (three participants) indicated that parking costs and the availability of parking were the main challenges to driving. Three participants indicated personal issues with driving, such as anxiety and frustration.

Table 4.7 Codes for the theme pre-pandemic driving challenges and drawbacks

Codes	Example quotes	Files	Ref.	Cases
Parking expenses are high	*"It was just cheaper to take public transit. I couldn't really afford to park"*	**2**	**10**	**8**
Driving is expensive	*"there's not really any downsides to driving, except that if I were to go on more days that would be more expensive."*	**4**	**7**	**6**
Driving is frustrating and stressful	*"My wife have noticed how miserable I am because I was driving! It is very frustrating"*	**2**	**4**	**3**
Parking is scarce on campus	*"There aren`t many parking places on campus, and I can`t afford more tickets!"*	**1**	**4**	**2**





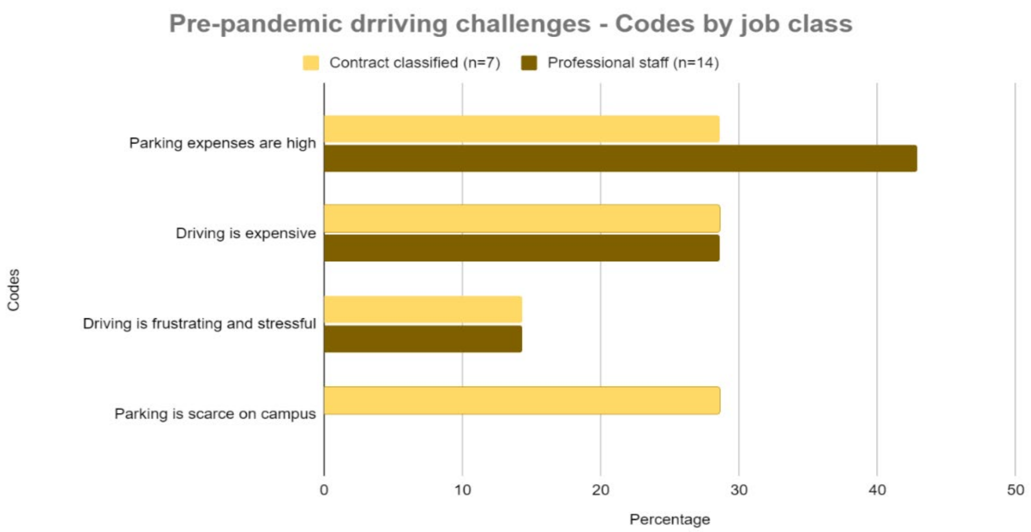


Figure 5 Codes by home location, gender, and job type for the theme pre-pandemic transit advantages

Figure 4.5 shows the different codes by case attribute, which were normalized by the number of cases in each case classification, e.g., percentage of males from all male participants for each code. Examining codes by case classification showed that participants who lived outside Seattle indicated that driving time and congestion were significant concerns. Similarly, participants who lived inside Seattle found driving more challenging before the pandemic because of the high parking and other costs associated with driving.

More women than men found driving challenging because of its high cost and the scarcity of parking on campus. Lastly, contract-classified staff faced more issues with parking availability, which may have been related to their different work shifts.

4.4.1.4 Pre-pandemic Special Commuting Challenges

Other general challenges to commuting included different work shifts, specifically for custodians and medical staff who had very early or late shifts and needed to transfer multiple times during their commute, mainly for participants who lived outside Seattle, as shown in figure 4.6. Table 4.8 shows the code list used to examine peculiar commuting challenges. Figure 4.6 shows that participants who lived outside Seattle suffered more from the need to transfer or use multiple modes to commute. Similarly, women and contract-classified staff faced more safety challenges while commuting to work.

Table 4.8 Codes for the theme pre-pandemic special commuting challenges

Codes	Example quotes	Files	Ref.	Cases
The need to transfer multiple times	"I use the train to the Link station, then I take the light rail to campus, and I bike to my department."	**2**	**5**	**5**
Unsafety of commute during early or late shifts	"It is really dark when we arrive to campus, and I never felt safe at the stops or parking lots"	**1**	**3**	**3**

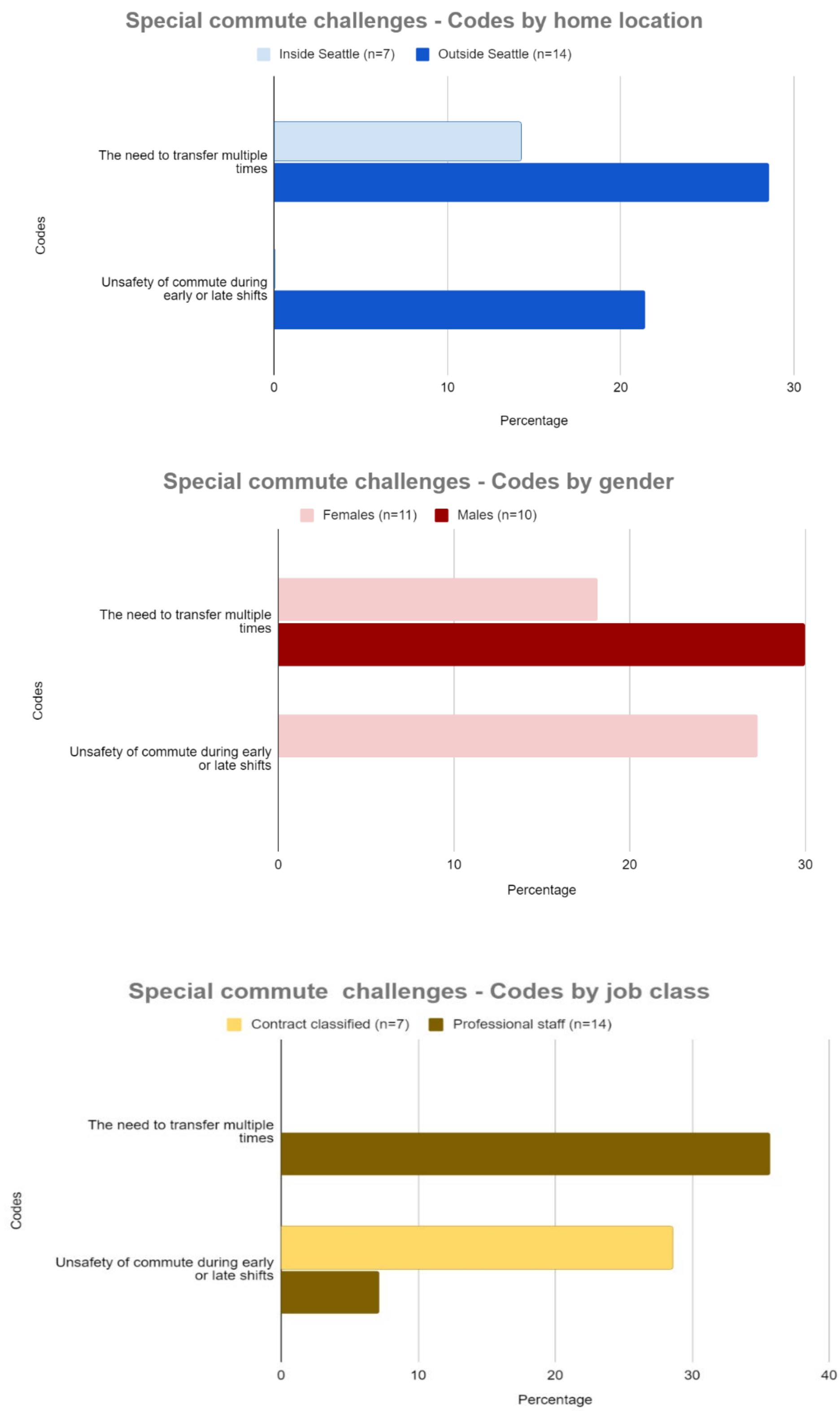


Figure 6 Codes by home location, gender, and job type for the theme special commute challenges

4.4.2 Commuting During the Pandemic

4.4.2.1 Commute Mode Changes During the Pandemic

The majority of participants indicated that they had switched away from transit at the beginning of the pandemic (within the first three months of the outbreak) to primarily driving alone, and only two participants had switched to biking/walking. After the first three months of the pandemic, only four participants indicated that they had switched back to commuting by transit. Many participants had switched to mainly driving alone (11 participants), while the rest either vanpooled (two participants), used park and ride (two participants), or biked to work (one participant). Table 4.9 shows the codes with quote examples for the changes in commute mode.

Table 4.9 Codes for the theme commute mode changes during the pandemic

Codes	**Example quotes**	**Files**	**Ref.**	**Cases**
Drove at the beginning	"The first three months of this pandemic I drove so instead of taking the bus"	**4**	**10**	**10**
Telecommuted at the beginning	"I would say, for the first I think two or three months after the pandemic didn't come into campus at all"	**3**	**5**	**5**
Switched to driving	"I drove primarily by myself; it takes me about 15 - 30 minutes"	**3**	**6**	**4**
No change in commute	"I think my commute remains the same than like a before and after COVID"	**3**	**3**	**3**
Switched to park and ride	"I started using Park and ride, it is really convenient"	**1**	**2**	**2**
Switched back to transit	"But other than that, I just took the bus every day at least twice"	**1**	**2**	**2**
Vanpooled	"I have been a vanpool rider since the beginning of my work here"	**1**	**2**	**2**
Switched to NMT (biking)	"I biked pretty much. I only biked just for my safety and my fellow coworkers`"	**1**	**2**	**1**

Codes	Example quotes	Files	Ref.	Cases
Occasionally drove	"Very occasionally I have work at the Eastlake campus, then I would Drive"	**1**	**1**	**1**
Biked at the beginning	"I biked pretty much, I only biked just for the safety of me and my coworkers"	**1**	**1**	**1**

Figure 4.7 shows the codes by different case attributes. Examining codes by gender showed that women made more mode changes during COVID-19, with the majority of them switching to driving alone and partial telecommuting. All participants who switched to park and ride were women who lived outside Seattle, and all riders who switched to biking were men who lived inside Seattle. At the same time, professional staff experienced more changes in their commute mode, as most contract-classified staff depended mainly on vanpooling, which did not undergo significant changes or disruptions during the pandemic. Only participants who lived inside Seattle switched to biking or walking at some point during the pandemic.

Participants who switched to driving explained that driving was more convenient during the pandemic because they telecommuted for most days and only drove for a few days of the week. Similarly, participants who were parents indicated that driving enabled them to run other errands while commuting, and it made socializing easier during a challenging time, as they were able to pick up their kids or visit their relatives or friends as part of their commute.

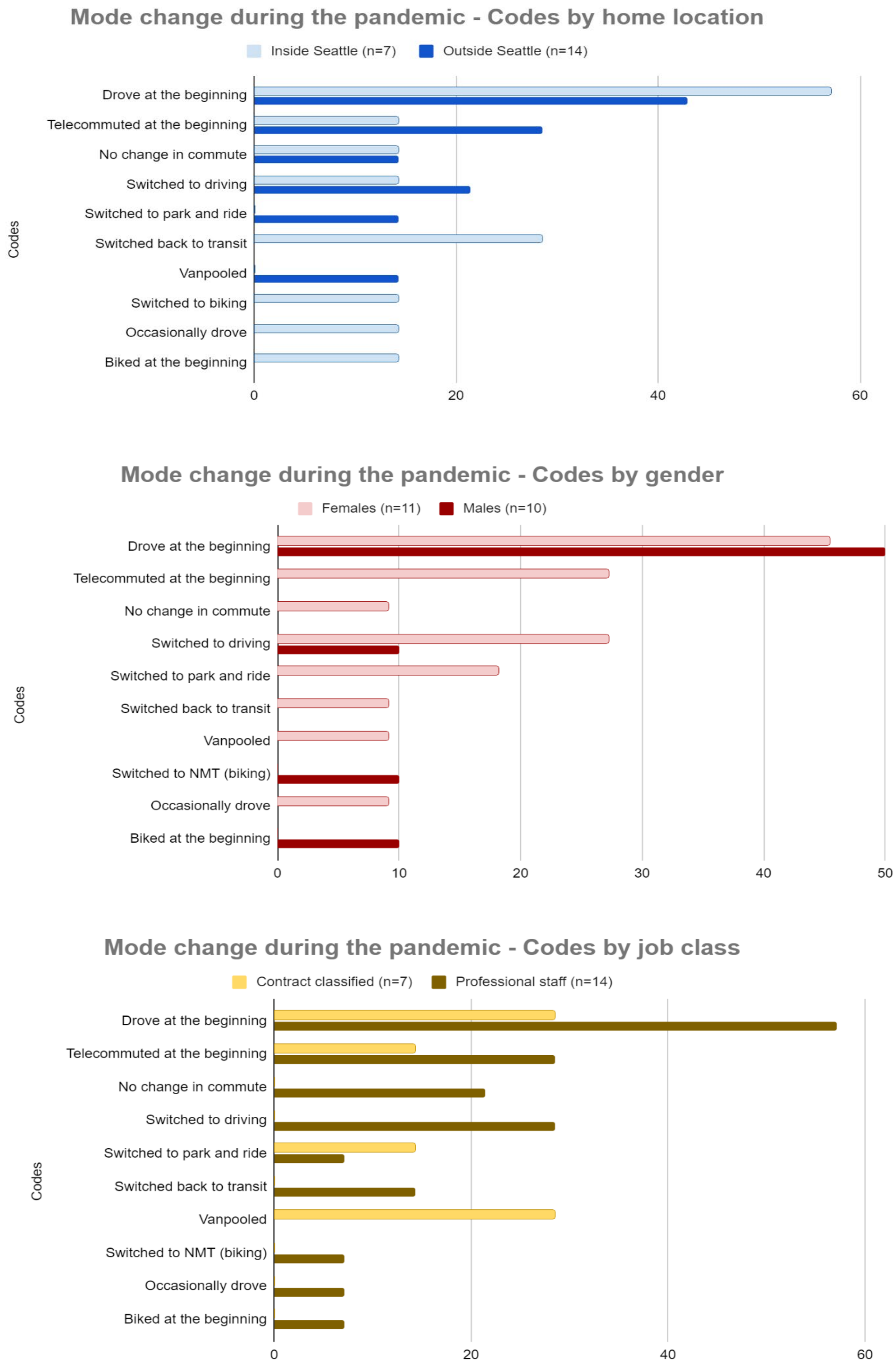


Figure 7 Codes by home location, gender and job type for the theme mode change during the pandemic

4.4.2.2 Transit Challenges During the Pandemic

Many participants indicated that they faced multiple issues with transit schedules, frequency, and reliability, especially at the beginning of the pandemic. While buses were still coming, there was a lack of a clear timetable, with many delays, capacity limitations, and frequency changes (ten participants). However, only one participant experienced a complete suspension of a bus route. Many participants indicated that safety was a major challenge for using transit during the pandemic (ten participants), mainly because of incompliance among riders with the pandemic-related measures (three participants) and a lack of ventilation with windows being closed most of the time, especially during winter (five participants). Two participants also indicated that racism made them uncomfortable taking public transit, especially anti-Asian hate that arose during the pandemic. Participants mentioned other continuing safety concerns, including homeless riders (two participants) and harassment issues (one participant). Table 4.10 shows the codebook used to analyze transit challenges during COVID-19.

Table 4.10 Codes for the theme transit challenges during the pandemic

Theme	**Description/codes**	**Files**	**Ref.**	**Cases**
Transit has frequency issues	"Some of the buses never showed up and some were just late”	**4**	**10**	**10**
Transit is unsafe from the pandemic	"So actually, when I took the bus before I was vaccinated, I felt uncomfortable, especially when windows were closed"	**1**	**10**	**10**
Transit has ventilation challenges	"I think the ventilation question is always important. I know it's not ideal in the winter but having windows open when possible”	**3**	**5**	**5**
Incompliance with safety measures	“I think the biggest challenge is the mask during the early days of the pandemic most people didn't believe in masks”	**3**	**3**	**3**

Theme	Description/codes	Files	Ref.	Cases
Transit was hugely disrupted at the beginning	“It was kind of crazy at the beginning, and I believe, for the first two or three weeks I had so much trouble just getting to work”	**3**	**6**	**3**
Ridership limitation makes it risky	"I don't want to use the bus, because of ridership limitations, so I don't want to be waiting for a bus and not be able to ride it"	**2**	**3**	**3**
Harassment and safety issues	"I had some instances, dealing with transient folks on the bus, that made me feel unsafe”	**1**	**2**	**2**
Racism and hate issues	“With Trumps anti-Asian remarks, I felt uncomfortable taking the bus so I drove”	**1**	**2**	**2**
Very long transit commute	"Sometimes it took me two hours to just one way to get to work, and another way, maybe one half an hour back"	**2**	**3**	**1**
Bus route suspension	“I wasn`t able to take the bus because the route I take was suspended”	**1**	**1**	**1**

Figure 4.8 shows coding by different case attributes. Examining codes by case classification showed that riders living outside Seattle encountered more challenges in using transit during COVID-19, especially regarding the frequency of buses, timetables, and transit services, making it a less reliable commute mode. Safety concerns caused by the pandemic were consistent among participants of all types, but more women showed concerns about safety issues caused by transient riders and harassment while using transit.

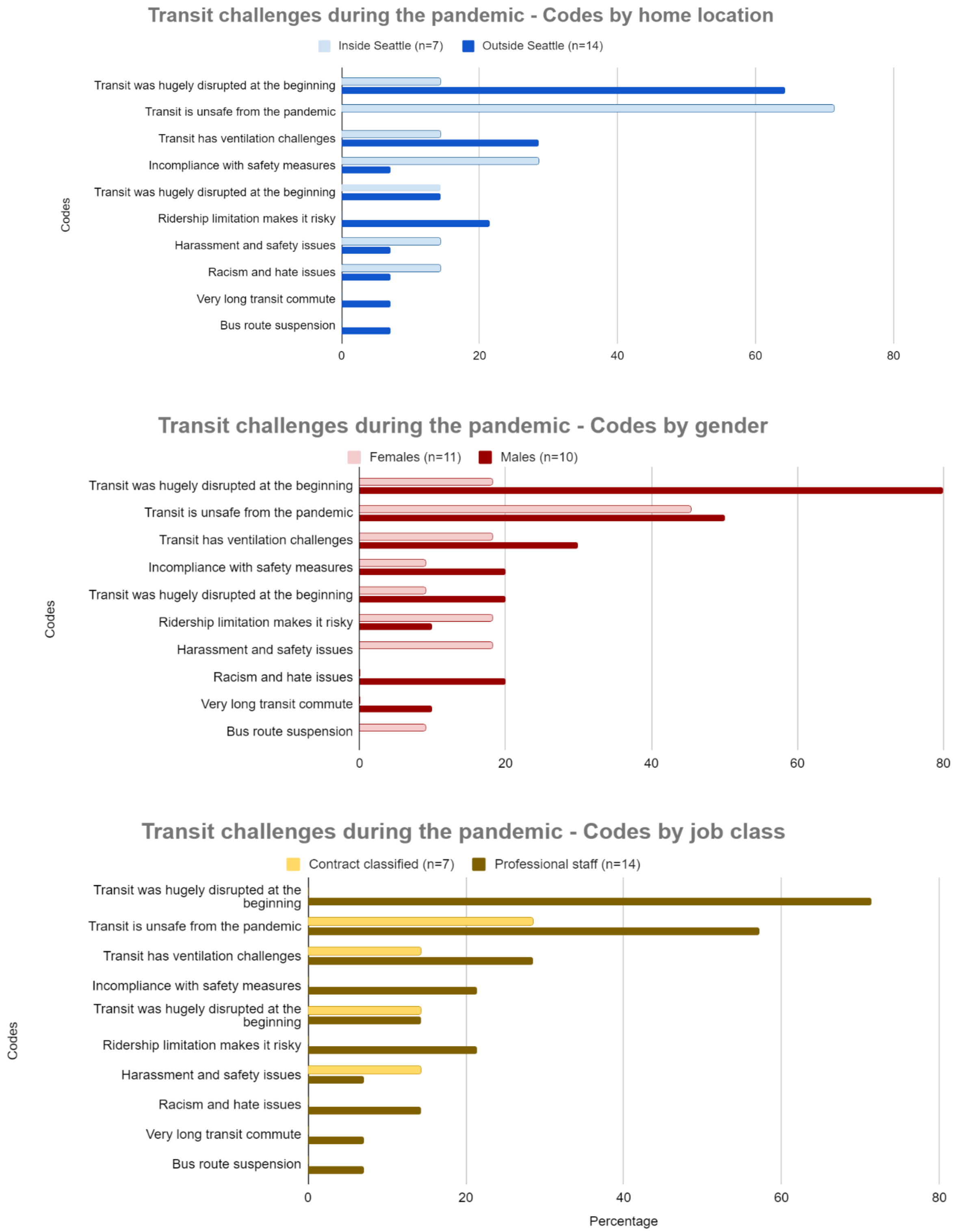


Figure 8 Codes by home location, gender, and job type for the them: transit challenges during the pandemic

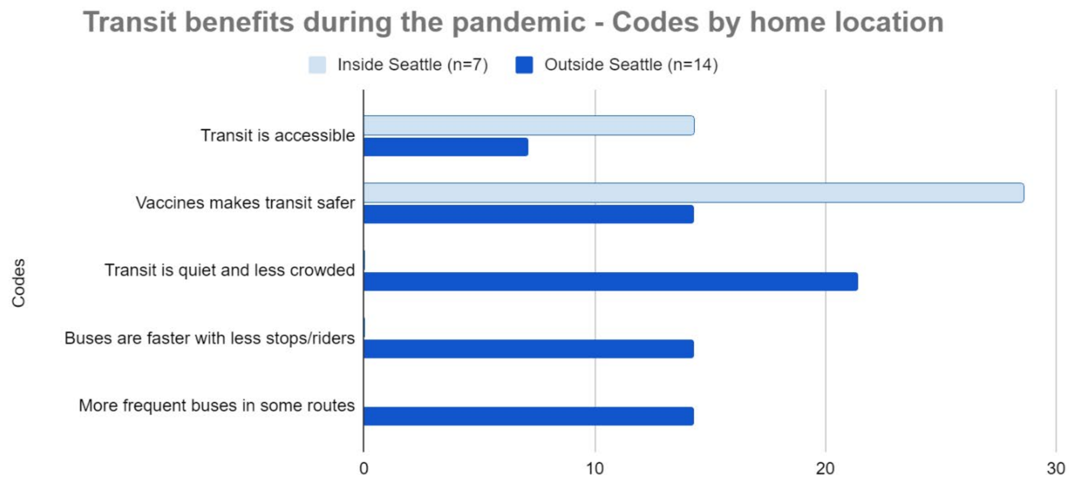
4.4.2.3 Transit Benefits During the Pandemic

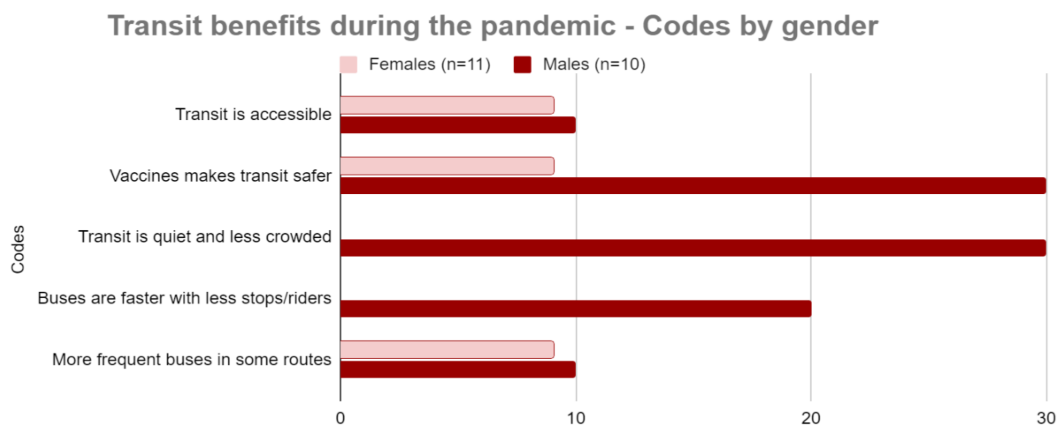
While participants expressed many challenges in using transit during COVID-19, some found it advantageous to have quiet bus rides with very few riders (two participants), fewer stops (one participant), faster commute times (one participant), and more frequent service for some routes (one participant), which mostly resulted from having fewer riders. Although safety was a major drawback and one of the main reasons that riders refrained from using transit, vaccine availability made it easier for some to switch back to using transit (three participants). Table 4.11 shows the codebook used to examine transit benefits during COVID-19.

Table 4.11 Codes for the theme transit benefits during the pandemic

Theme	**Description/codes**	**Files**	**Ref.**	**Cases**
Vaccines makes transit safer	"I was a little uncomfortable needing to take public transit especially pre being vaccinated"	**2**	**4**	**4**
Transit is quiet and less crowded during Covid-19	"It's kind of nice to have quiet rides, I mean that little alone time! Imagine riding a bus with just the driver and you"	**2**	**3**	**3**
Buses are faster during Covid-19	"The bus actually goes faster now with less riders and stops requested"	**1**	**2**	**2**
More frequent buses and routes	"Some buses are actually more frequent now"	**1**	**2**	**2**
Accessible transit during Covid-19	"No, I am on a bus and that comes pretty frequently and I pretty much always can catch a bus, even during Covid-19"	**1**	**2**	**2**

Figure 4.9 shows that white collar workers who lived outside Seattle found transit during COVID-19 faster and less crowded, with increased frequency at some locations, while participants who lived in Seattle found it more accessible during COVID-19.





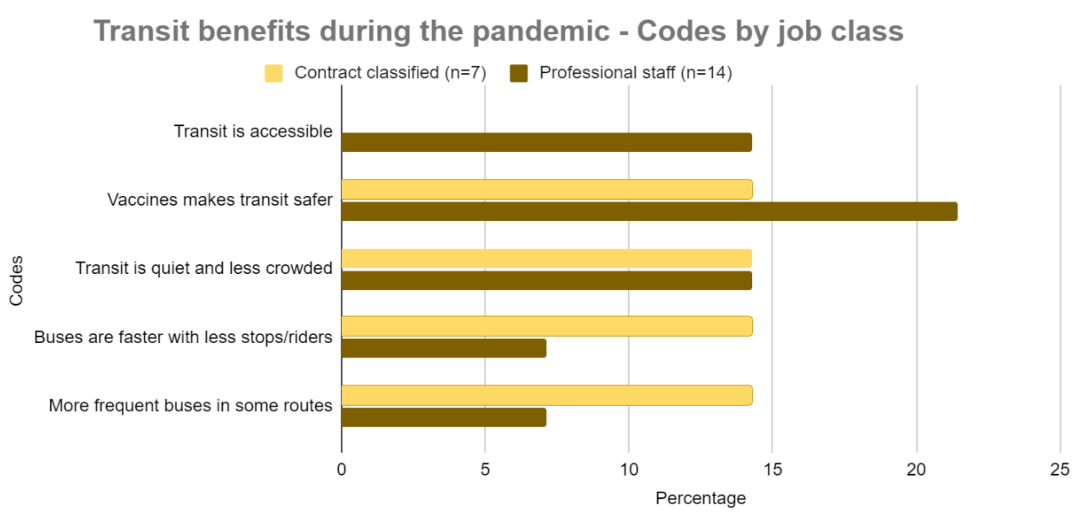


Figure 9 Codes by home location, gender, and job type for the theme transit advantages during the pandemic

4.4.2.4 Driving Benefits During the Pandemic

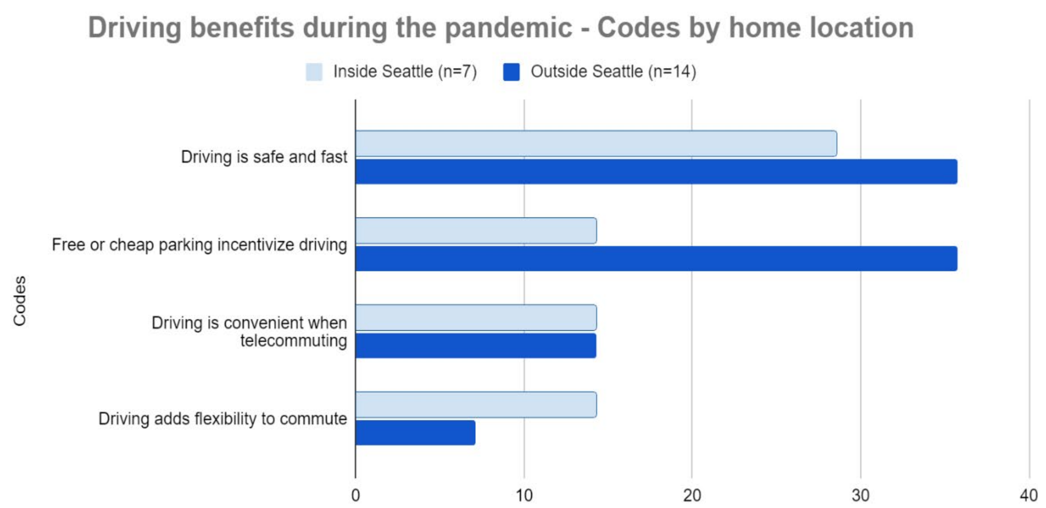
Table 4.12 shows the codes associated with the benefits of driving during COVID-19. During the pandemic, driving emerged as one of the most convenient modes; participants mentioned many of its benefits with negligible challenges during the pandemic. Many participants mentioned that safety and short/fast commute times were the main benefits of driving during the pandemic (seven participants). Similarly, most participants agreed that the lower city parking rates and increased parking availability made driving more affordable than before—and in some cases, even more affordable than public transit (nine participants). Hence, some could benefit from the flexible commutes offered by driving that made running errands and connecting with family members easier.

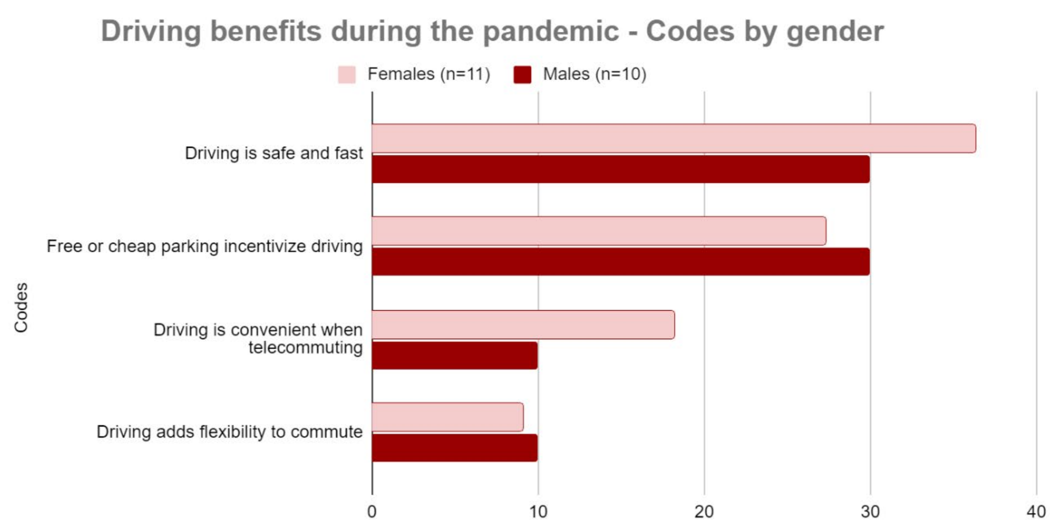
Table 4.12 Codes for the theme driving benefits during the pandemic

Theme	**Description/codes**	**Files**	**Ref.**	**Cases**
Driving is safe and fast	“In the early days when nobody was on the freeway I could get to the university in about a half an hour”	**3**	**13**	**7**
Free or cheap parking incentivize driving	“I stopped my U-Pass, and right now because I telecommute my parking is less per month than U-Pass”	**3**	**9**	**6**
Low parking cost during COVID	"We have our own parking lot next and it costs $4 all day, and if you get early enough there's free on-street parking"	**1**	**3**	**3**
Driving adds flexibility to commute	“It's kind of nice to be able to stop and visit my mom on the way home or you know go straight to the grocery store”	**1**	**2**	**2**

Figure 4.10 shows that professional staff found driving more advantageous during COVID-19 than others, which was especially true for participants who indicated that they had children or were caring for family members. Driving helped them run other errands during their

commute, visit family, and share their ride with other family members. Driving benefits outweighed transit during COVID-19, as more riders had access to cheaper or free parking options, making it as affordable as transit. The coding by job type showed that professional staff had more access to affordable parking spaces than contract-classified staff. This can be attributed to their different work locations on campus and their work mode, as many professional staff members were able to partially telecommute, whereas contract-classified staff mainly worked in-person. This may have led to increased competition for accessible parking areas for contract-classified staff working on campus.





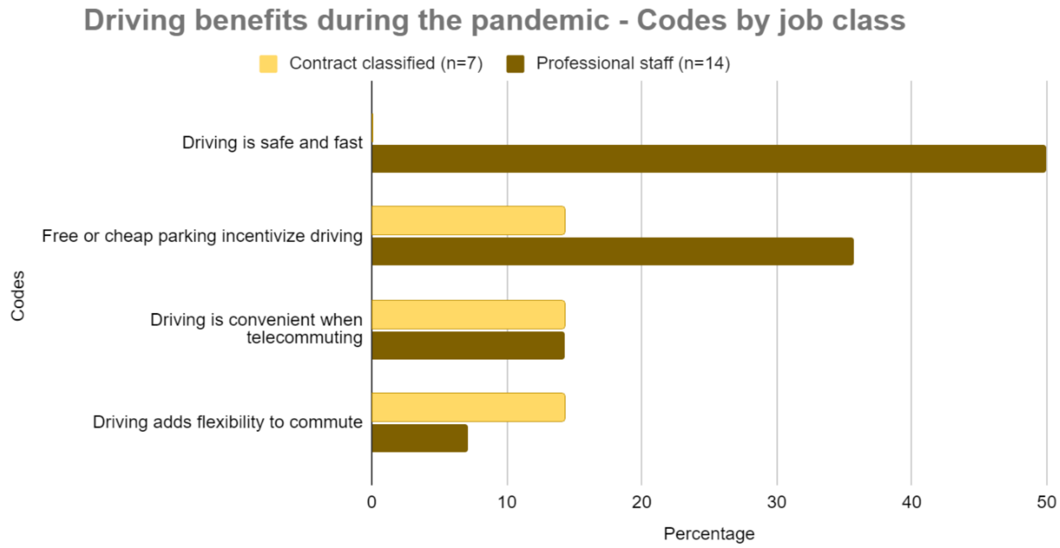


Figure 10 Codes by home location, gender, and job type for the theme driving advantages during the pandemic

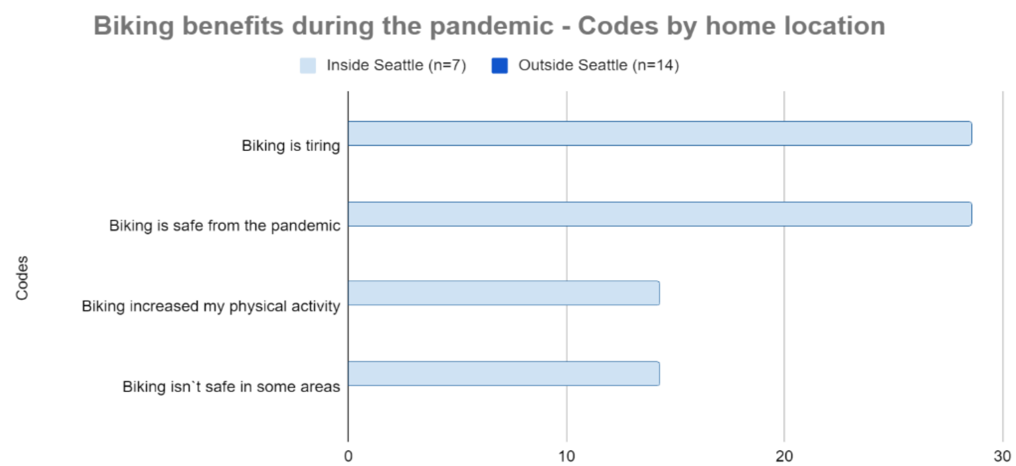
4.4.2.5 Biking Benefits During the Pandemic

Table 4.13 shows the codes associated with the benefits of biking during COVID-19. Biking emerged as a safe alternative to transit during the pandemic, but few participants switched to biking during COVID-19. One participant indicated that they biked at the beginning of the pandemic because it was safer from COVID-19 infection than transit. Also, only one participant switched to biking beyond the first three months of the pandemic because it helped that participant maintain some activity, especially when most gyms were closed during the pandemic. Two participants indicated that the main disadvantage of biking was the required physical activity that could be exhausting after long hours of work with masks on, especially at the beginning of the pandemic, when masks were required outdoors.

Table 4.13 Codes for the theme biking challenges and benefits during the pandemic

Theme	**Description/codes**	**Files**	**Ref.**	**Cases**
Biking is tiring (high physical activity)	"I have to go up a hill to get back to basically green lake area, so it was just way more convenient just to take the bus"	**1**	**2**	**2**
Biking is a safe mode during Covid-19	"I would say, for biking it was always a safety thing"	**1**	**2**	**1**
Biking increased my physical activity during Covid-19	"Cycling's been great for my sanity. I`ve been getting regular exercise and it's been wonderful and a great change"	**1**	**1**	**1**
Biking is not safe in some areas	"Biking isn't super safe, where I live"	**1**	**1**	**1**

Figure 4.11 shows that there were more safety concerns regarding biking for women, especially in certain areas because of high crime rates.



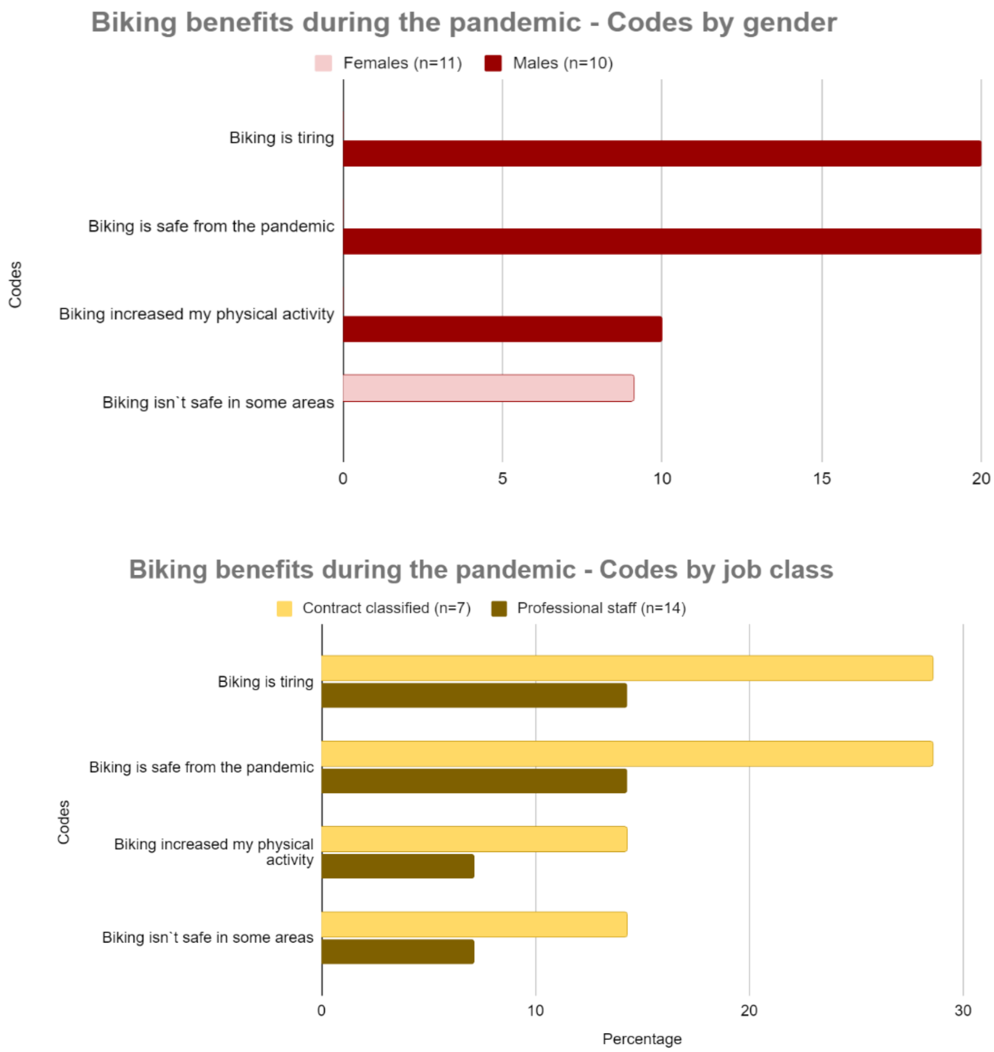


Figure 11 Codes by home location, gender, and job type for the theme biking benefits during the pandemic

4.4.3 Post-pandemic Commute

4.4.3.1 Carpooling Barriers and Drawbacks

Table 4.14 shows the codebook used to understand the challenges of carpooling mentioned by participants. Many participants indicated their unwillingness to carpool to work, even with the availability of an app to connect people who worked at the UW or other institutions. As indicated by seven participants, the major drawback in carpooling was the need to coordinate and match schedules with other individuals to carpool together. Three participants also indicated that social interaction and safety concerns were significant challenges to carpooling, especially if they were to carpool with strangers or people outside their social circles. Coding by case classification showed that women were more concerned about safety and harassment issues when carpooling with strangers. Contract-classified staff, whose jobs required more physical activity, found distant drop-off locations a major barrier to carpooling.

Table 4.14 Codes for barriers to carpooling theme

Theme	**Description/codes**	**Files**	**Ref.**	**Cases**
Schedule coordination and dependence issues	"The idea of trying to match your schedule to somebody and then not know who they are is not a pleasant experience"	**5**	**7**	**5**
Carpooling with strangers is unsafe	"As a woman, I want to be able to contact police or someone security to help me"	**3**	**5**	**5**
Carpooling involves unwanted social interaction	"It will be awkward if I don`t get along with the other person or disagree on a topic"	**1**	**3**	**3**
Carpool pick-up/drop-off locations may be distant	"Custodians are already walking all day on their shift. The last thing they need is to walk to somebody's building in the university district that's not in their way."	**1**	**3**	**2**
Carpooling has a dependability factor on others	"To me, the disadvantage of carpooling is the dependability factor upon another individual`s time and schedule"	**1**	**1**	**1**
Carpooling with a mask is inconvenient	"I imagine if I had a carpool that would be a challenge for me is to have to wear the mask the entire time down"	**1**	**1**	**1**

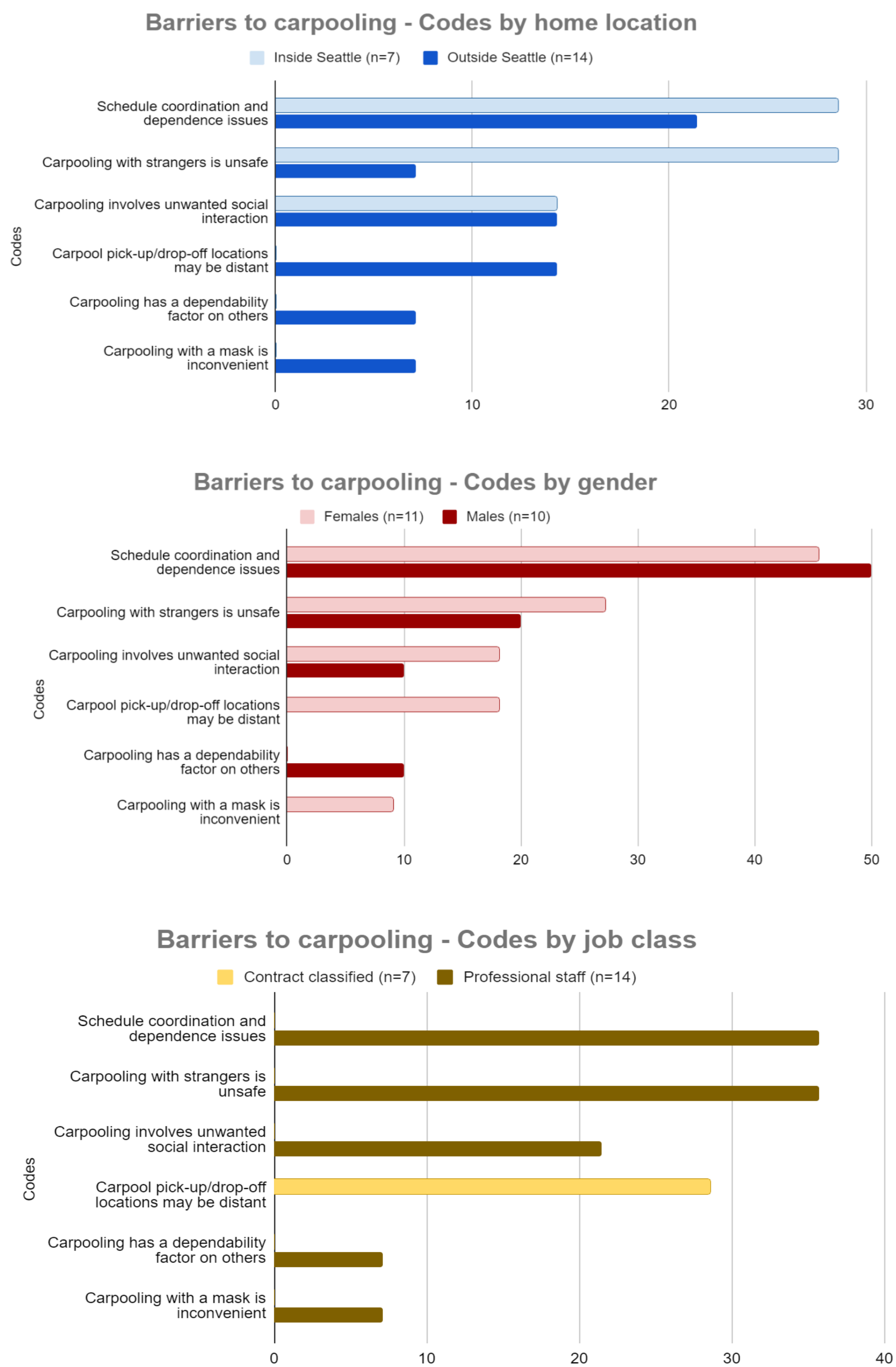


Figure 12 Codes by home location, gender, and job type for the theme barriers to carpooling

4.4.3.2 Conditions for Carpooling

Table 4.15 shows the conditions for considering carpooling as a primary commute mode. While many participants indicated their unwillingness to carpool even if using a UW-only carpooling app, they mentioned some conditions that might make it a viable option, including equitable monetary incentives for carpoolers, access to carpooling lanes, and free carpool parking. Moreover, female participants were more concerned about establishing alleged harassment and safety guidelines and adhering to them. Similarly, professional staff showed more willingness to carpool should the aforementioned conditions be met. On the other hand, contract-classified staff, who generally relied on vanpooling for their commute and found it convenient, indicated their unwillingness to carpool whatsoever.

Table 4.15 Codes for post-pandemic conditions to carpool theme

Theme	**Description/codes**	**Files**	**Ref.**	**Cases**
Adding vaccines check in carpooling apps	"I would want to know if they're vaccinated, and I don't know if that's possible but that's important to me"	**1**	**2**	**2**
Carpooling lane incentivizes carpool	"I would ride with people I knew so that we could use the carpooling lane"	**1**	**1**	**1**
Equitable incentives for carpoolers	"If they do partner with other institutions, everybody needs to be on a level playing field"	**1**	**1**	**1**
Establish harassment guidelines with other carpool employers	"There has to be clear harassment policies and guidelines"	**1**	**1**	**1**
Free carpool parking incentivizes carpool	"If you were part of a carpool, you could have free parking, which is a significant encouragement"	**1**	**1**	**1**

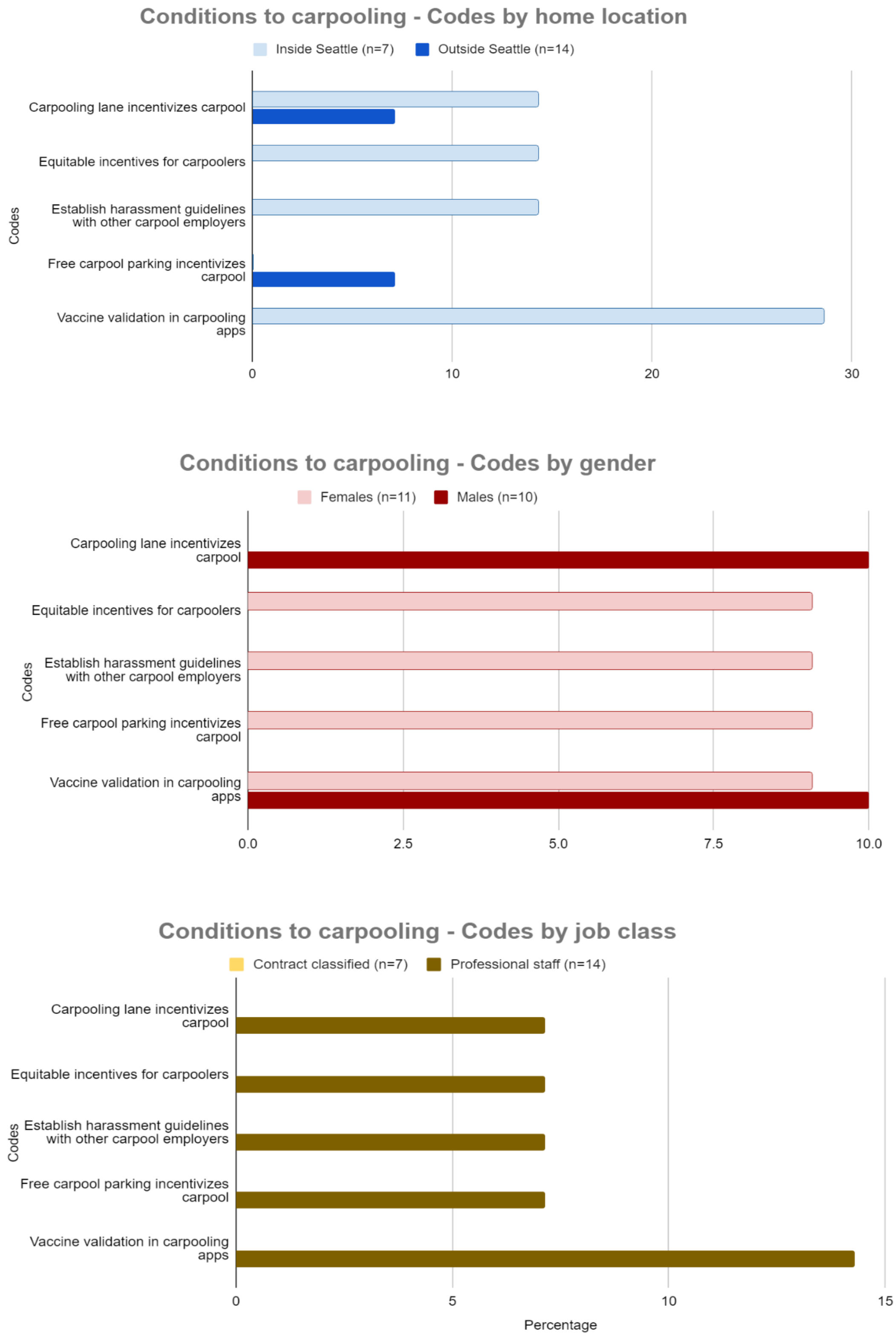


Figure 13 Codes by home location, gender, job type for the theme conditions to carpool

4.4.3.3 Desired Improvements to the Commute

Table 4.16 shows improvements to commuting that participants said they would wish to see in the future, including the provision of teleworking alternatives that would necessarily reduce the need to commute. Participants also indicated the need for employers to provide cheaper and more equitable parking areas near the workplace for those who did not have better alternatives than driving to work. This was especially important to contract-classified staff who did not have equal access to transit, as it was unavailable or infrequent during their work shifts, and who generally had lower incomes than others and could not afford market-rate parking.

Table 4.16 Codes for the post-pandemic desired improvements in the commute theme

Theme	Description/codes	Files	Ref.	Cases
Lower parking rate	"I agree, if they lower parking prices that would be great"	**1**	**2**	**2**
More fixed teleworking days	"I think one thing our employer could do is continue to allow people to work from home as much as possible, because it keeps people off the roads."	**1**	**3**	**2**
Provide free or discounted parking for people with different work shifts	"I can`t pay more tickets to UW! If we can have free parking it will be great"	**1**	**1**	**1**

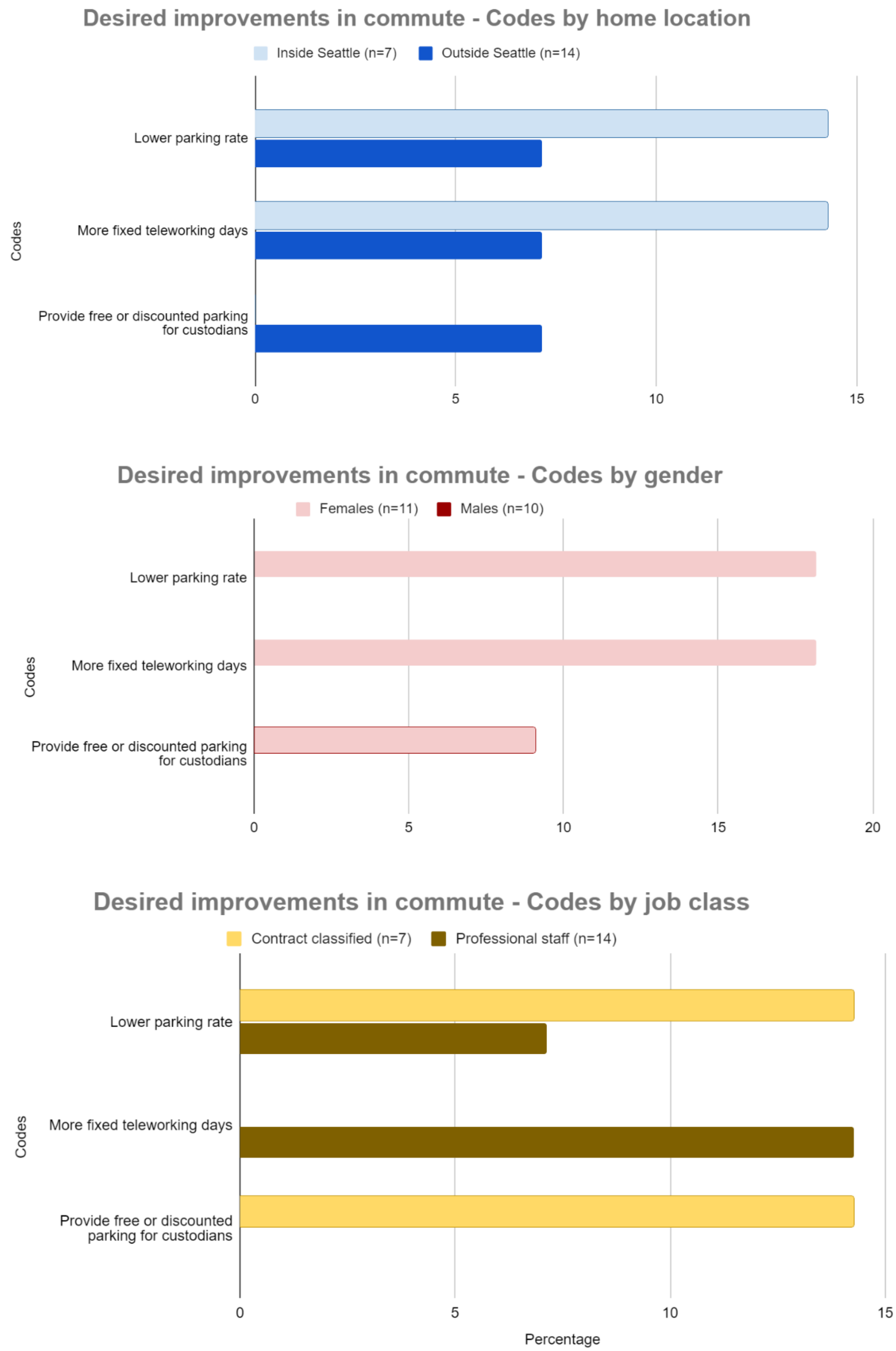


Figure 14 Codes by home location, gender, and job type for the theme desired improvements in the commute

4.4.3.4 Desired Improvements in Transit

Table 4.17 shows the different improvements weighted by the number of focus groups, mentions, and participants. Participants suggested many transit improvements that would facilitate their post-pandemic commute. The main improvement in transit indicated by many participants was to make it more affordable by further subsidizing the U-Pass (the transit pass offered by the UW) or by making it entirely free for all UW staff (seven participants). Many participants also indicated the need to extend service hours (four participants), increase service frequency (six participants), enforce safety (four participants), and make the information available through improved timetables and real-time updates (one participant).

Table 4.17 Codes for the post-pandemic desired improvements in transit theme

Theme	**Description/codes**	**Files**	**Ref.**	**Cases**
Free or subsidized U-Pass	"I guess I'll say the free U-Pass would make a big difference!"	**3**	**14**	**8**
Consistent and frequent bus times	"The convenience and frequency is for the transit people and some coordination between the two"	**3**	**9**	**7**
Enforced safety measures in transit	"Just having masks available and enforcing it"	**2**	**6**	**5**
Extended transit services times and coverage	"They should consider people with different working shift"	**1**	**4**	**4**
Free or subsidized park and ride	"We are stopping there to take transit and there should be more free parking"	**1**	**3**	**2**
More routes in crowded areas	"I just don't have an answer for a full bus except having more buses. Is I know the buses that are full then metro knows it"	**2**	**2**	**2**
Community based routes and stops planning	"Maybe transit agencies can conduct focus group discussions when changing routes and locating stops"	**1**	**2**	**2**
Remove mask mandates	"I will be also grateful when the mask mandate from the Federal Government is	**1**	**1**	**1**

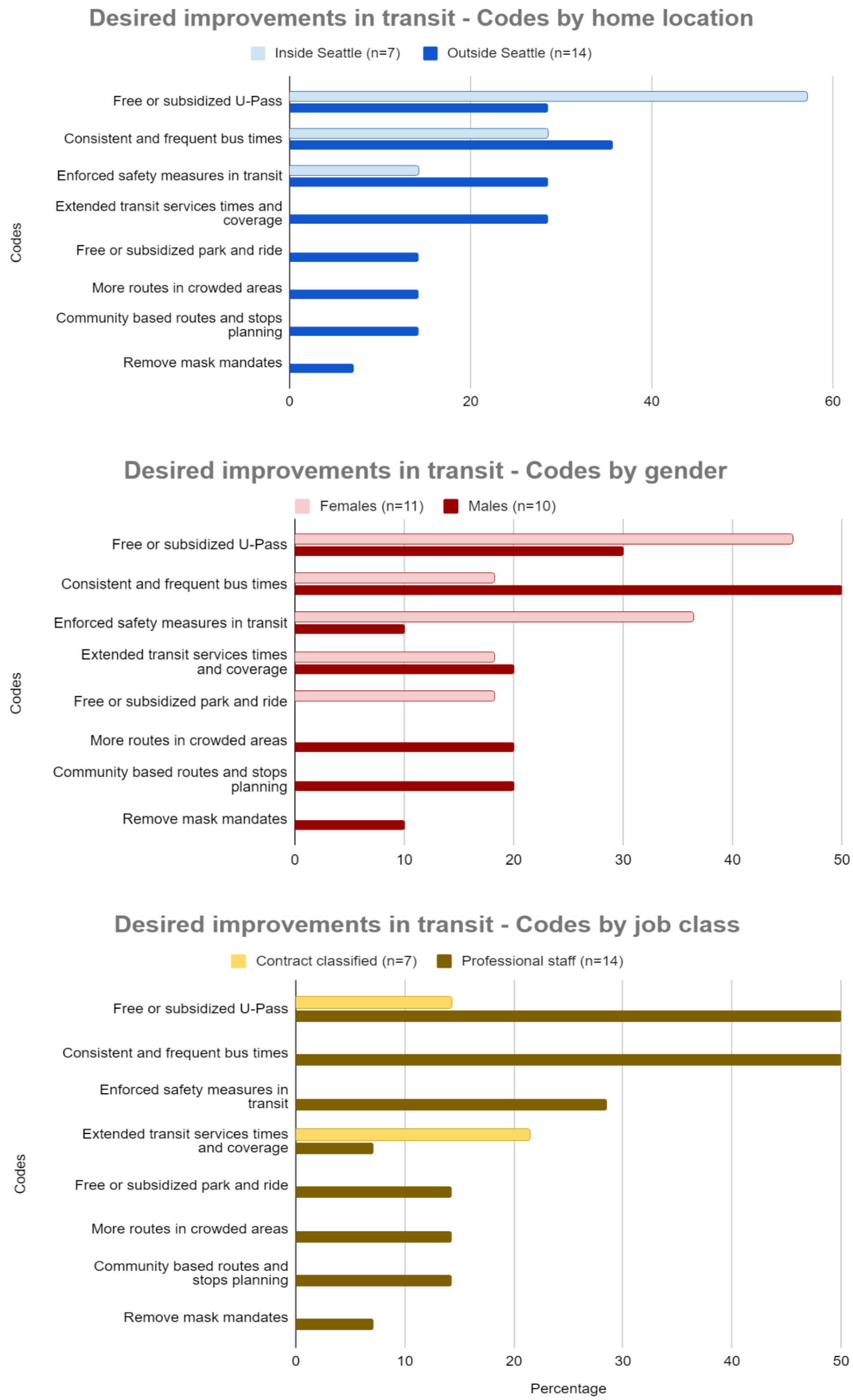


Figure 15 Codes by home location, gender, and job type for the theme desired improvements in transit

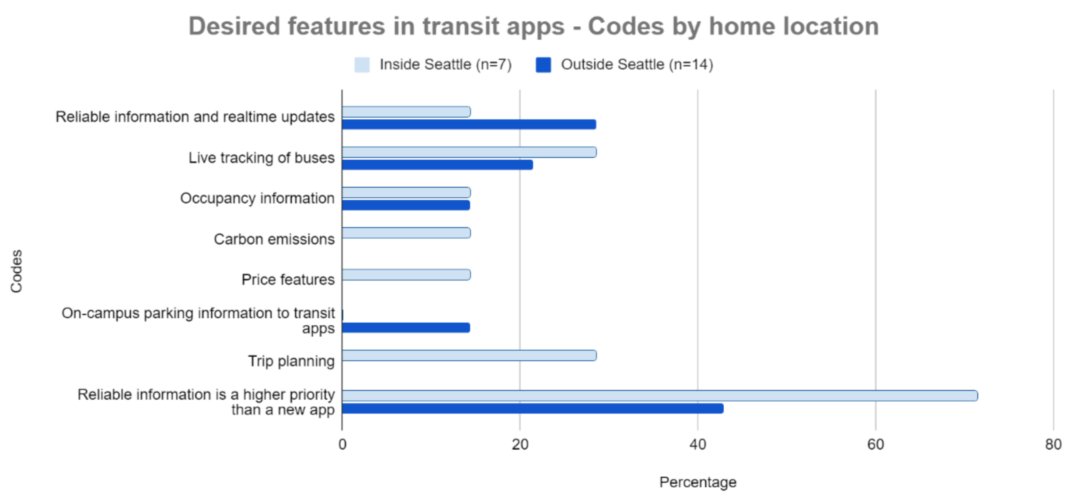
4.4.3.5 Desired Improvements in Transit Apps

Table 4.18 shows how participants expressed their desire for many improvements to transit apps. Many participants indicated the need for real-time information and updates on bus locations, delays, and trip duration (four participants), which could be made available through apps providing reliable real-time information (five participants). Fewer participants mentioned the need for capacity information (three participants), especially on busy routes, and parking information (one participant). Other features mentioned included trip planning tools, especially for multiple stops and routes, and vaccination information, especially for carpooling apps (two participants). Many participants suggested that future efforts should focus on improving existing apps and providing real-time updates by transit agencies rather than developing new apps by individual employers.

Table 18 Codes for the post-pandemic desired improvements in transit apps theme

Theme	**Description/codes**	**Files**	**Ref**	**Cases**
Reliable information is a higher priority than a new app	"There are many transit apps out there. Improving the real-time bus information is more important than a new app"	**4**	**11**	**11**
Reliable information and real-time updates	"If they had a more reliable app out there to let us know when things come and don't come, that would be great"	**2**	**8**	**5**
Live tracking of buses	"To have a feature to track the bus and tell how many stops away the bus is"	**3**	**5**	**5**
Occupancy information	"I think, having some sort of feature - so on Google maps sometimes they have like how busy places are. For example: oh, it's like 75% full, that would be helpful"	**2**	**3**	**3**

Theme	Description/codes	Files	Ref	Cases
On-campus parking information to transit apps	"It would be useful to also have information about on-campus parking"	**1**	**2**	**2**
Carbon emissions	"Desired improvements in transit apps"	**1**	**1**	**1**
Price features	"I would like the app to have different routes that I could take and the prices of all these different routes"	**1**	**1**	**1**
Trip planning	"To have a trip planning feature than includes multiple stops and reminders"	**1**	**1**	**1**



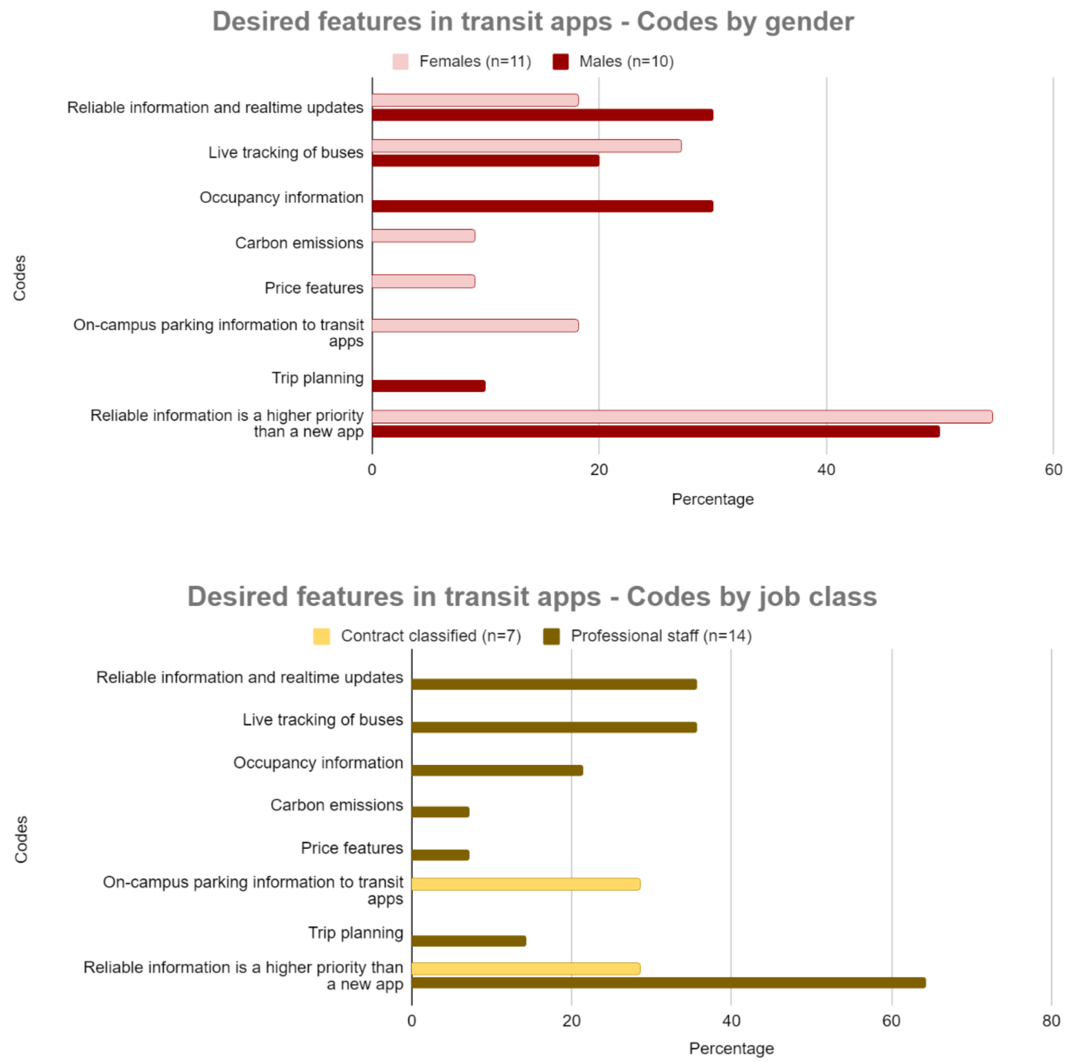


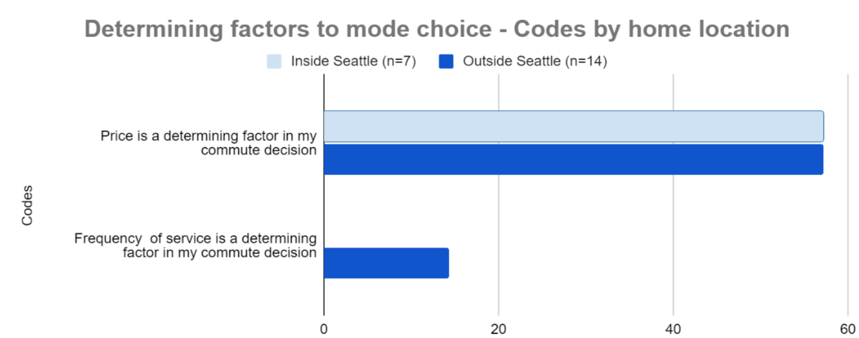
Figure 16 Codes by home location, gender, and job type for the theme desired improvements in transit apps

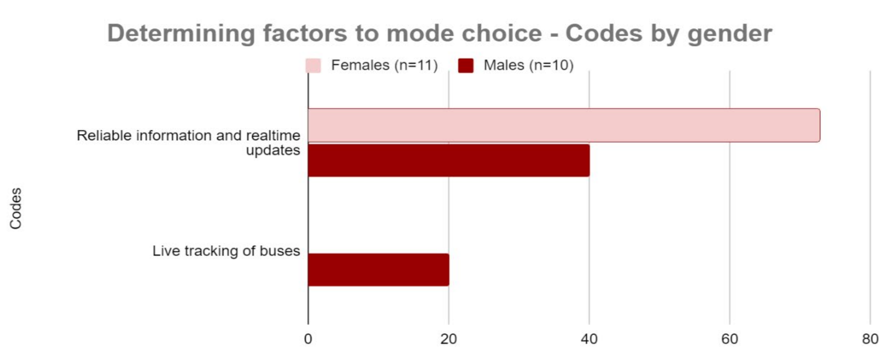
4.4.3.6 Determining Factors to Commute Mode Choice

Table 4.19 shows the codebook used to understand the determining factors for mode choice. The majority of participants indicated that price was the main determining factor in their commute mode choice post-pandemic (12 participants). Hence, monetary subsidies, including a fully subsidized U-Pass, free parking, or carpooling incentives, would facilitate their switch back to transit post-pandemic. Coding by case classification showed that price was the main determining factor for those women and mid-aged participants who were parents. Younger professionals also indicated that transit frequency and reliability were important factors for their mode choice. Figure 4.17 illustrates that price was significant to women and mid-aged participants who mostly were parents with multiple financial commitments.

Table 4.19 Codes for the post-pandemic determining factors for commute mode choice theme

Theme	**Description/codes**	**Files**	**Ref.**	**Cases**
Price is a determining factor in my commute decision	"But I will take the bus again as soon as I have to be there three days a week, If U-Pass was free, I might be on the bus now"	**3**	**12**	**12**
Frequency of service is a determining factor	"It is really dark when we arrive to campus, and I never felt safe at the stops"	**1**	**2**	**2**





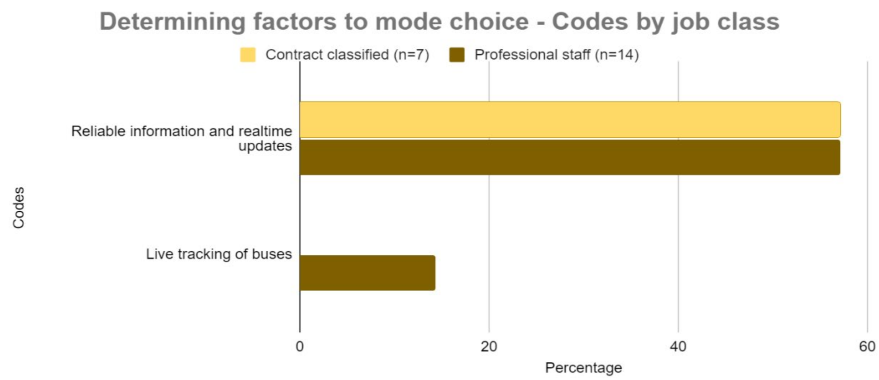


Figure 17 Codes by home location, gender, and job type for the theme determining factors for commute mode choice

4.5 Discussion

4.5.1 Commute Changes During the Pandemic

The pandemic severely affected transportation, with public transit facing the most significant challenges. Because transit serves shared rides, safety related to being infected by COVID-19 was the most significant concern among riders, especially at the beginning of the pandemic. As a result, all the focus groups participants who had been pre-pandemic transit riders switched away from transit and used other modes (telecommuting, driving, and non-motorized transportation) during the first three months of the outbreak. However, some 50 percent of the participants gradually switched back to transit with the availability of vaccines and more stringent safety measures in place. In addition to safety concerns, many participants indicated that transit was an unreliable option at the beginning of the outbreak, as buses were less frequent than pre-pandemic levels, with limited to no access to timetable updates and real-time information.

Some participants who had to work in person at the beginning of the outbreak and lived near campus commuted to work using non-motorized options such as walking and biking. Other participants, including those who lived far from campus or telecommuted for most days (five participants) found it more convenient to drive to work, especially for the few days they worked in person. Telecommuting and free and cheaper parking options available during the pandemic made driving more affordable and convenient than transit, causing many employees to continue to drive to campus. Hence, more than 30 percent of participants had continued to drive alone until the time when focus groups were held. These participants, however, indicated that their post-pandemic commute plans would highly depend on the affordability of the different travel modes, and they might eventually switch back to transit.

4.5.2 Perceived Challenges and Benefits of Commute Modes During the Pandemic

4.5.2.1 Public Transit

The pandemic altered people's perceptions of the safety of shared commute modes, as concerns about getting infected by COVID-19 rose significantly for transit. Ten participants (48 percent) indicated that they did not find transit a safe mode during the pandemic, and five participants (29 percent) expressed concerns about infection due to crowds and lack of compliance with pandemic safety measures. For the majority of participants, the sense of safety in public transit depended on the enforcement of mask-wearing, social distancing, validation of the vaccination status of riders, and provision of masks and sanitizers. These new safety challenges added to other long-standing safety issues, including proper treatment of transient riders, better street furniture, lighting at transit stops, and improved frequency and availability during late or early work shifts. Only one participant mentioned opposition to mask-wearing, especially for vaccinated people. Other long-standing transit challenges unrelated to the pandemic included long commutes, especially with riders having to transfer between bus lines or switching modes, crowded and busy routes, unreliable information and timetables, and a lack of real-time updates.

On the other hand, transit users indicated many benefits to using transit. As indicated by eight participants, transit before the pandemic was accessible. Six participants indicated that the main benefit of transit was the value of travel time, as riders could use transit time to carry on some tasks, listen to music, or meditate. Similarly, five participants talked about the affordability of transit, especially with the subsidized U-PASS. However, these benefits changed during the pandemic, and the only advantages to transit during the pandemic, as seen by participants included reduced crowds and faster commutes because of fewer riders.

4.5.2.2 Driving Alone

Driving emerged as the most convenient mode for many participants during the pandemic. Although participants mentioned many challenges to driving to work before the pandemic, there were minimal challenges during the pandemic, as the benefits of driving outweighed its challenges. Fourteen participants (68 percent) indicated that expenses related to driving were the most significant challenge, primarily because of high parking costs. A few participants mentioned that pre-pandemic driving was challenging because of increased stress, long driving times because of traffic, and a lack of available parking on campus.

During the pandemic, however, driving emerged as a convenient mode because of the provision of free parking spaces, telecommuting, and reduced traffic. Seven participants indicated that the main advantage of driving during the pandemic was the safety from COVID-19 infection, fast commutes, and low parking costs. For staff who had to work in an office for a few days each week, the parking cost was comparable to that of the U-PASS for using transit. For four of the participants who telecommuted during COVID-19, driving added flexibility to their commute, as many participants found it convenient to run other errands such as grocery shopping, picking up their family members, or visiting their friends and family as part of their commute. Although nine participants (43 percent) mentioned that parking was widely available for a reduced cost, custodians, primarily contract-classified staff, indicated a lack of parking and high parking cost, especially because demand did not significantly drop as most custodians were still working on campus.

4.5.2.3 Biking/Non-motorized Transportation

Biking and walking to work emerged as safe and affordable alternatives, especially for staff who lived in Seattle and had a relatively short commute. Non-motorized transportation (NMT) was a safer mode than transit in terms of COVID-19 infection risk. Nevertheless, one participant mentioned safety challenges to biking that depended on the rider's gender and safety in terms of crime rates in urban spaces. Hence, none of the female participants considered biking a primary commute mode, even though some of them lived near campus.

Only four participants switched to NMT for some time during the pandemic, mainly because they lived near the campus and perceived NMT as a safer option than transit. However, one participant reported switching to biking as a beneficial way to get regular exercise, especially during the pandemic when gyms and other amenities were closed. One of the staff who worked in person and wore full PPE indicated that biking after work was more challenging and physically tiring, primarily when mask mandates were enforced outdoors.

4.5.3 Determining Factors for Commuters' Mode Choices

At the beginning of the pandemic, especially within the first three months, safety from infection was the main determining factor for most riders; hence, all participants who had to work in person indicated that they had switched away from shared mobility and public transit. However, two participants indicated that they had switched away from transit because it was either unreliable or no longer available where they lived. At a later stage of the pandemic, when

COVID-19 vaccines became available, parking price, in-person work schedule, and frequency of transit service became the primary factors for mode choice. Like many institutions, the UW adopted different TDM policies, including removing parking fees for employees in one campus parking lot until September 2020 and adopting a policy to reduce the minimum passenger requirement for vanpool riders from five to two riders to accommodate social distancing while ridesharing. As a result, commute mode changes varied past the first three months and after vaccines became available. Riders who switched from transit to SOV until the 2021 focus groups mainly included staff who lived outside Seattle and had longer commutes, parents who had to run other errands as part of their commute, and staff who mainly telecommuted and worked in the office just a few days a week. For these riders, the reduced driving expenses made driving more beneficial than transit, as it increased the flexibility of their commute and their ability to connect with other family members and run other errands as part of their commute.

With respect to carpooling, four participants indicated that monetary incentives, including a free or fully subsidized U-PASS, free carpool parking, and financial incentives such as commute compensations, would make them switch to carpooling to work. Some participants also indicated that a higher frequency of transit service and access to real-time updates would be sufficient to switch back to transit. This was especially the case for riders outside Seattle and living in less transit-accessible areas. Finally, participants who mainly vanpooled before the pandemic indicated that the unavailability of transit for their work shifts, the safety of transit, and safety concerns in buses and at bus stops were the main factors that stopped them from using transit. Most vanpoolers were contract-classified staff who had very early or late work shifts when public transit service was not running. All vanpoolers indicated that vanpooling generally was a convenient and straightforward option. The challenges to vanpooling, indicated by some of the custodians, were the lack of potential co-riders in areas outside Seattle such as Bellevue, possible difficulties interacting with other riders socially, and the dependability of commute times to vanpoolers’ working areas.

4.5 Conclusions

The COVID-19 pandemic disrupted mobility, especially commute trips, in many ways. Both long- and short-term travel behavior choices of commuters were affected, in addition to possible changes in work modes, lifestyles, and perceptions of transportation modes. These effects were particularly critical for essential workers, whose commute challenges were amplified by the dearth of accessible, safe, and reliable public transportation options during COVID-19. It is no surprise that COVID-19 presented a tipping point for public transportation ridership. As revealed in the focus group discussions, within the first three months of the pandemic, almost all participants switched away from transit, and even those with no other alternatives purchased cars or bikes to use for their commute.

Although transit ridership picked up again, especially after vaccines became available, the long-term changes in work modes and perceptions of the different transportation options imply a long and lagging recovery of the pre-COVID commute. Pandemic-related issues such as safety and compliance, coupled with long-standing frequency and real-time information reliability challenges, affected riders' perceptions of transit benefits, leading many to switch away from transit. Similarly, the convenience and safety of driving alone were tempting for many riders, especially with the rise of telecommuting and the reductions in congestion, parking demand, and costs. Although driving costs will likely increase again as more employees start to commute to work physically, changes in riders' perceptions of driving are not only a short-term trend, especially as critical factors, such as teleworking, may remain for a while.

As many essential workers continue to rely on public transit for their commute, planning for post-COVID recovery and resilience requires a major rethinking about providing an efficient and effective transport system and a more fundamental approach to long-term policy for transport as a whole. As the new normal reveals many uncertainties about and critical changes to travel behaviors, it will be important to understand the interplay of private and social norms in commute mode choice and to respond with a holistic approach that addresses questions of transport justice, such as accessibility to transport for essential workers.

ICT-enabled improvements in urban mobility should also be utilized to increase the competitiveness of transit by making real-time information on buses, trip planning, cashless payments, and transit passes available through transit apps. A wider adoption of technology in public transit could facilitate a smooth transition into a multi-modal mobility strategy or mobility-as-a-service (MaaS), which is expected to be key in enabling a shift away from cars. At the same time, disincentivizing car commuting, especially by adopting market-rate parking policies, will be essential to the success of multi-modal programs. However, because low-income and essential workers, who often lack viable mobility alternatives, may bear a disproportionate share of increasing travel costs, it will be critical to provide them with reliable alternatives and targeted reductions in mobility costs, including subsidized parking for low-income workers and late-night workers, especially at large institutions like universities or hospitals. Local policymakers may consider partnering with transportation network companies and shuttle operators to provide sufficient subsidies for first/last-mile connection trips and pooled trips to motivate behavioral changes.

While already low, transit fares can be further revised to reduce transfer costs and provide subsidized passes for low-income transit commuters. Future research should focus on policy adjustments and strategies for recovery from the COVID-19 crisis, which will set the stage for the longer-term resilience of urban transportation. More research efforts are needed to proactively address issues of car ownership and increased usage, and to plan for the next steps that will jointly shape the new normal in commuting and induce shared and sustainable mobility solutions.

CHAPTER 5. UNIVERSITY STUDENT TRAVEL BEHAVIOR AND EXPERIENCE

5.1 Introduction

Humans are creatures of habit. Can this adage explain travel behavior? Every year millions of Americans move to a new home and are faced with new travel choices. In 2021, nearly 28 million people changed residence, of which roughly 30 percent moved across state lines or to a different county within the same state (Kerns-D'Amore et al., 2022). Domestic migration is common in the United States, but it dramatically increased with the COVID-19 pandemic (Frey, 2022; Toukabi, et al., 2022). Population demographers have noted that in some ways the pandemic only accelerated existing trends that are likely to continue, such as the already increasing prevalence of work from home (an occasional or temporary occurrence) and remote work (a permanent situation that allows moving far from one's workplace) (Milder, 2020; Javadinasr, et al., 2022). Meanwhile, the long-standing trend for civilization has been toward urbanization, in which residents from rural and small towns migrate to find better employment opportunities (Ritchie and Roser, 2018). Together these trends will likely continue the growth (and sprawl) of medium-sized cities that encircle urban centers.

It is important for transportation planners and policy makers to understand how people adapt (or don't adapt) their travel behavior in new environments. For small towns and suburbs that are experiencing an influx of people accustomed to traveling by public transit, walking, and biking, transportation planners may want to re-prioritize infrastructure investments to appease the proclivity of their new residents. On the other hand, policy makers in urban cities that see an increase in transplants from rural towns and car-oriented regions may want to establish programs that help facilitate a transition toward more sustainable forms of transportation. Likewise, employers may find value in understanding the past multi-modal travel experiences of new recruits and find benefit from providing programs that help their employees adjust to unfamiliar mobility environments.

The administrators for the University of Idaho (UI) Parking and Transportation Services (PTS) contemplated the potential benefit of such a program. The UI campus is located in a community that prides itself on being a "20-minute city," in which most destinations are easily accessible by bus, biking, or walking within 20 minutes (Capasso Da Silva, et al., 2019). However, most of the students are transplants from rural and suburban car-oriented communities throughout Idaho and neighboring states (Oregon, Washington, Utah, Montana, and Alaska). The PTS administrators have struggled to increase the mode shares of riding the bus, biking, and walking. They have cited significant resistance from students to parking fees and a lackluster response to multimodal investments and policy initiatives, such as the campus shuttle service, the free-fare city bus (which has changed its routing to better accommodate student needs), long-term car storage, a shared-car program (Zipcar), a phone app ridesharing service (Zimride), special long distance bus service for holiday travel, increased covered bike parking, and the installation of traffic calming measures throughout campus. The PTS's periodic mode share surveys have been disappointing in terms of its goals to increase sustainable travel. Yet, it is aware that some students are eager to travel by bus, bike, and foot. Furthermore, it has noted that the university attracts students from all over the country and abroad, including from urban cities where non-automobile travel is common.

These factors led to the following research questions:

1) Do university students from rural and suburban communities lack experience with non-automobile modes of transportation, i.e., bus, bike, walking, taxicab, Uber/Lyft, light rail, commuter rail, and bike/scooter share?

2) Do university students who lack multi-modal experience tend to drive to campus and around town more than students who have experience with alternative transportation modes?
3) Can providing exposure to riding the bus, walking, and biking motivate university students to use these modes more frequently?

To answer these questions, three surveys and an experiment were conducted.

5.2 Background

Other studies have investigated similar questions regarding how previous experience relates to current travel behavior. One relevant study was done by Burbidge (2012), who surveyed 662 students from a private Christion university, of whom 52 percent had spent extensive periods abroad (more than 60 consecutive days), typically for religious service. She found that students who had lived in other countries where walking, biking, and public transit was common exhibited a tendency to use those modes more upon return. However, the analysis suggested that over time the respondents tended to acclimate back to the status quo of their surroundings. Monteiro et al. (2021) studied the travel behaviors of transnational migrants and found that they struggled to adapt to the travel culture of their surroundings. The authors suggested providing timely and persuasive information immediately after migration to facilitate adaption. Glover (2011) also studied how international students adapt to their new surroundings and found markedly different travel behaviors in comparison to domestic students. Furthermore, the study found that passage of time did not result in international students acclimating to their mobility environment.

Various studies have explored how attitudes and culture impact the use of public transportation (Beirao and Cabral, 2007; Roos et al., 2020). Brown et al. (2003) found that intervention programs that provide exposure can be an effective means to increase public transit use. Balsas (2002) made the argument that college campuses are an ideal place to promote and expose people to sustainable transportation opportunities. Wiers and Schneider (2022) studied the extent of university student resistance to and anger about parking fees and concluded that thoughtful policies are needed to constructively change attitudes and behaviors. Nordfjaen and Rundmo (2015) demonstrated the effectiveness of policies that promote more public transit.

5.3 Method

The researchers conducted three surveys and an experiment. The first survey sought to understand the relationship between past multimodal experience and current travel behavior. The survey was an online questionnaire, developed using Qualtrics software and sent to every student with a valid university email address. Twenty-eight questions were organized into three sections: past multimodal experience, current travel behavior, and demographics. Participation was incentivized with a raffle to win one of four $50 gift cards from Amazon. The students received two reminder emails and had three weeks for completion. The survey was approved by the UI Institutional Review Board.

To understand past multimodal experience, one question asked how often the students had used various modes of transportation to get to high school. The modes included driving alone, carpooling or being dropped off by others, riding a city/school bus, riding a bike/scooter, and walking. The response was a Likert scale (*never*, *sometimes*, *often*, and *most of the time*). Another question asked about their experience with public and private transit, including city bus, light rail/streetcar/ trolley, commuter rail/long distance, Uber/Lyft, and taxicab. The response was a Likert scale (never, less than 5 times, and more than 5 times). Another question asked about the amount of "…time spent in an urban setting where buses, light rail, walking, biking, or taxis are common travel methods (for example, downtown Seattle).” The question further clarified that they should consider the total amount of time for all visits together. The respondents who had visited an urban setting were asked to rate their mobility experience in terms of negative, neutral, or positive. Finally, the students were asked to self-identify their hometown as rural, suburban, or urban.

To understand current travel behavior, the students were asked how often they traveled to campus and around town by bus, bike, and on foot. The response was a Likert scale (*never*, *sometimes*, *often*, and *most of the time*). This is called a “stated preference” question because it captured the respondent’s stated opinions about or preferences regarding a topic. Such questions can be useful because they can capture behavior over an undefined timeframe; however, stated preference questions can suffer from hypothetical bias (the respondent’s wishful response) and recall bias (the respondent’s inability to recall events over an undefined timeframe). The respondents were also asked to indicate the travel mode (car, carpool, bus, bike, or walking) they used each day in the previous week for each trip. This is called a “revealed preference” question because it revealed actual behavior that had occurred. Such questions can be useful to avoid hypothetical bias and reduce recall bias; however, revealed preference questions may miss behaviors or misrepresent abnormal behaviors.

Two-way cross-tabulations (contingency tables) were created to determine whether there was any relationship between current behavior and previous experience. Cross-tabulations place the categories of one factor in the rows and the categories of another factor in the columns, with the count of matching categories in the table cells. This allows inspection of possible relationships between the categorical variables. Chi-squared tests were conducted to investigate the statistical significance of the observed differences (the count in the table cells). Chi-squared tests determine the likelihood that the categorical variables are independent in influencing the values within a contingency table. For small samples, when N < 120 or rmore than 20 percent of the cell values are less than 5, then the Fisher Exact test is more appropriate (Kim, 2017).

To capture the relationship of multiple factors simultaneously, two new index variables were constructed. The first we called the Past Experience Score. The calculation was a summation of the points shown in table 5.1. The score sought to represent the respondent's previous experience with multi-modal travel. The second index was called the Travel Behavior Score and was equal to the summation of the points shown in table 5.2. A high Travel Behavior Score indicated more use of a bus, bike, and walking. The point scheme for each score was intentionally *ad hoc*—devised before data collection with blunt, integer point evaluation and simple calculus. The intent was to develop an *a priori* measure that could be tested without the influence of the data sample. Certainly, some technique for data mining or factor analysis could identify a point system (factor coefficients) that could more precisely produce the expected relationship (perhaps with point values to an absurd decimal place). Instead, the goal was to investigate whether a rudimentary combination of variables could identify the hypothesized relationship, i.e., that previous experience correlates with current behavior. The scores were plotted, and a Pearson correlation was calculated. Only one change was made to the scoring system post data collection: walking to campus was removed from the Travel Behavior Score because it seemed that many respondents conflated walking *on* campus between classes with walking *to* campus. Also, although the students were asked about their experience with a commuter/long-distance train, this was not included in the Past Experience Score because we determined that, for this region, a high percentage of students would not have had such experience.

Table 5.1 Points for past experience score

Question	Response Options	Past Experience Points
Hometown		
	Rural (countryside or not in town)	0
	Suburban (residential area surrounding a city)	1
	Urban (core area of a city)	2
Travel to High School[a]: Bus, Bike, and Walk		
	Never	0
	Sometimes	1
	Often	2
	Most of the time	3
Travel to High School: Drive alone		
	Never	3
	Sometimes	2
	Often	1
	Most of the time	0
Experience with Modes[a]: City Bus, Light Rail, Bike/Scooter Share, Uber/Lyft, and Taxicab		
	Never (for all modes combined)	-1
	Never	0
	Less than 5 times	1
	More than 5 times	2
Long-stay Experience in Urban Setting (more than 1 month)		
	Negative experience	-1
	No long-stay experience	0
	Positive experience	1
Experience Paying for Parking		
	Never	0
	Yes	1

[a] Points assigned for each mode.

Table 5.2 Points for current travel behavior score

Question	Response Options	Travel Behavior Points
Travel to Campus[a]: Bus, Bike/Scooter, and Uber/Lyft/ Taxicab		
	Never	0
	Sometimes	1
	Often	2
	Most of the time	3
Travel to Campus: Drive alone		
	Never	2
	Sometimes	0
	Most of the time or Often	-2
Travel around Town[a]: Bus, Bike/Scooter, Walk, and Uber/Lyft/ Taxicab		
	Never	0
	Sometimes	1
	Often	2
	Most of the time	3
Travel around Town: Drive alone		
	Never	2
	Sometimes	0
	Most of the time or Often	-2
Previous Week Mode Share to Campus[a]: Bus, Bike, and Walk		
	Zero trips	0
	Percent of Trips multiplied by 1 point for each day	7
Previous Week Mode Share around Town[a]: Bus, Bike, and Walk		
	Zero trips	0
	Percent of Trips multiplied by 1 point for each day	7
Used the Local City Bus (Ever)		
	Never	0
	Yes	3

[a] Points assigned for each mode.

The next phase of the study involved two more surveys and an experiment. Working with the PTS administrators, we developed a multimodal tour that would explore the community via bus, bike, and walking. The tour was advertised at the start of fall semester as one of many other orientation events sponsored by the university. Flyers for the event were included in the in-coming freshman orientation packets and posted on bulletin boards throughout campus, especially in on-campus housing buildings. The flyer indicated that the tour would take 90 minutes and involve riding a bike three miles and walking one mile (bikes were rented from the local bike store and provided to participants for free). Participation was incentivized with a raffle to win one of two $50 gift cards from Amazon and the promise of a free ice cream cone from a popular local shop at the end of the tour. Figure 5.1 shows the map of the tour. Participants were asked to meet at the Intermodal bus station on campus (a layover point for the city bus, Greyhound, and other regional bus providers).

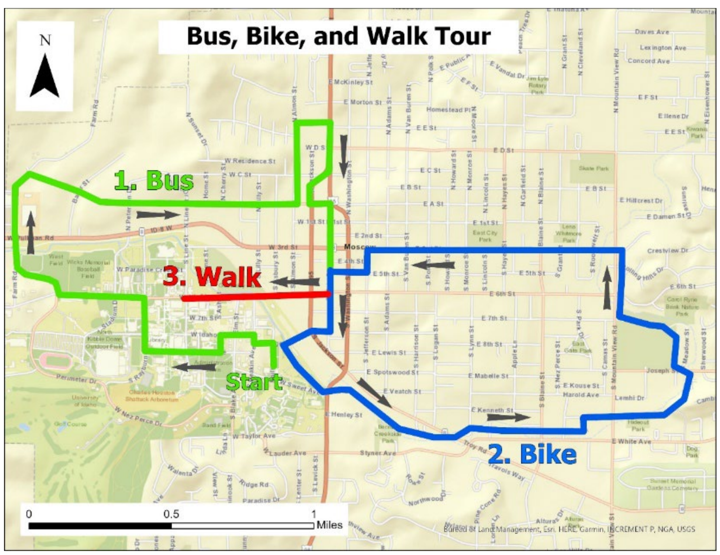


Figure 5.1 Map of the multimodal exposure tour

The tour included information, maps, and brochures about mobility options in the area. The tour guides were given a script that highlighted key bus stops, off-street pathways, and bike routes. The script included positive reinforcement statements about travel by bus, bike, and on foot, for example, “We are now passing on your left the Hartung Performing Arts Theater. Many students walk or bike to the theater because of its convenient location." Another example: "This paved pathway goes all the way to Pullman. Many students enjoy biking to WSU along this path [Washington State University is in a neighboring city with cross-listed courses]. It was an old railroad that was converted into a pathway for students to enjoy biking, running, and walking through the Palouse. This path also goes east all the way to Troy, Idaho, about 12 miles away. It is well used for recreation and commuting."

Before the tour, as part of tour registration, participants completed a survey. This "before" survey was identical to the larger survey previously sent to the whole student body. Then, six months later at the end of spring semester, the participants were asked to complete an "after" survey. The "after" survey included the questions about current travel behavior and additional questions to assess the impact of the tour. Furthermore, another group of students who did not participate in the tour were administered the same before and after surveys for comparison as a control group.

5.4 Results

5.4.1 Experience with Multimodal Travel

The first survey received 864 responses. The median completion time was 7.8 minutes. To focus the analysis on walking, biking, and public transit opportunities, 47 respondents were removed because they lived outside the city limits, and 19 respondents were removed because they had a mobility limiting impairment that prevented them from using these travel modes. The remaining 798 responses were analyzed.

Table 5.3 shows respondents' demographics. On the basis of discussions with university enrollment specialists, gender and age demographics coincided reasonably well with the general student body population (11,507 students). Only 9 percent of respondents identified their hometown as urban. Table 5.3 shows that self-identification of rural, suburban, and urban was consistent across gender, age, time living in Moscow, Idaho, and on-campus or off-campus residence. Half of the respondents had lived in this town for a period of less than two years and 90 percent had lived here less than five years, confirming that this was a transplant residential university and a suitable population for studying travel behavior acclimation.

Table 5.3 Respondent demographics and hometown identity

Demographic	Count	Rural	Suburban	Urban
All Students	798	34%	57%	9%
Gender				
Male	295	35%	54%	11%
Female	482	34%	58%	8%
Non-binary/No Answer	21	29%	71%	0%
Age				
18-21	488	35%	58%	8%
22-25	169	34%	54%	12%
26-25	49	33%	55%	12%
30+	49	37%	57%	6%
No Answer	43	33%	58%	9%
Time in Moscow				
< 1 Year	212	27%	61%	12%
1 to 2 Years	196	41%	53%	6%
2 to 3 Years	135	38%	54%	8%
3 to 4 Years	127	31%	58%	11%
4 to 5 Years	46	37%	54%	9%
5+ Years	82	35%	60%	5%
Residence				
On-Campus	364	32%	59%	9%
Off-Campus	434	36%	55%	9%

Table 5.4 shows that many of the students had never used the public and private transit modes that are commonly available in urban cities. Bike/scooter share had the highest percentage of *never* responses (70 percent), despite the availability of bikes/scooters in every major city in the region, including in the neighboring city of Pullman, Washington, just nine miles away.

Commuter/long-distance rail also had a high percentage of *never* responses (65 percent), but this low level of experience was less surprising because commuter rail is not available in Idaho, and Amtrak passes through only a small portion of the northern Idaho panhandle. However, although light rail was also not available in the immediate region, 58 percent of respondents reported having experience with light rail. More students had experience with Uber/Lyft than with taxicabs. One third of the respondents said they had never ridden a city bus. Furthermore, 14 percent of the respondents said they had never used any of the modes shown in table 5.4.

Table 5.4 Experience with public and private transit

Public/Private Transit	Never	Fewer than 5 times	More than 5 times
Light Rail, Streetcar, and Trolley	42%	34%	24%
Commuter/Long-Distance Rail	65%	28%	8%
City Bus	30%	38%	32%
Bike/Scooter Share	70%	20%	10%
Uber/Lyft	37%	38%	25%
Taxicab	48%	39%	13%

Public and private transit are available in the broader region, including in Seattle, Washington, and Portland, Oregon, which are 300 and 350 miles away, respectively. Some respondents claimed those urban areas as their hometown, and many more students had likely visited those cities and other urban places. Table 5.5 shows the response for "…time spent in an urban setting where buses, light rail, walking, biking, or taxis are common travel methods (for example, downtown Seattle)." The question further clarified that they should consider the total amount of time for all visits together. Seven percent of the respondents had never had such an experience at all, and only 29 percent had experienced more than one month in an urban setting. The respondents who had visited an urban setting were asked to rate their mobility experience in terms of negative, neutral, or positive. Students who had spent more than one month in an urban setting reported a higher percentage of positive rating than students with less than one month in an urban setting (30 percent compared to 6 percent).

Table 5.5 Mobility experience in an urban setting

			Perception of Mobility Experience		
Amount of Experience (All visits total)	Percentage	Count	Negative	Neutral	Positive
No Experience	7%	58	NA	NA	NA
Short Experience (less than 1 month)	64%	506	14%	80%	6%
Extended Experience (more than 1 month)	29%	234	6%	64%	30%

NA = Not applicable

5.4.2 Current Behavior versus Experience

The first survey asked about current travel behavior. Various two-way cross-tabulations (contingency tables) were created to determine whether there was any relationship between current behavior and previous experience. One set of questions asked the participants about the frequency of mode they had used in the past semester to travel around town and to get to campus. Table 5.6 shows their stated mode frequency for traveling around town. (The response for Uber/Lyft and taxi are not included in the table. The carpool response is included with car.) The results showed that urban students were less likely to travel by car. They had the highest percentage of *never* responses for car travel in comparison to students from suburban and rural hometowns (19 percent compared to 13 percent and 8 percent, respectively) and the lowest response for *most of the time* or *often* (67 percent compared to 75 percent and 81 percent, respectively). Instead, urban students said that they rode the bus and biked with more frequency. The urban students' combined responses for *sometimes*, *often*, and *most of the time* was 20 percent in comparison to 10 percent and 6 percent for suburban and rural students, respectively. The responses for bicycle travel were similar between urban and suburban students, but lower for rural students; 10 percent more students from rural backgrounds said they never rode a bike to get around town. Walking was the only mode that didn't show strong differences across hometown identities.

Chi-squared tests were conducted for each mode, shown in table 5.6, to investigate the statistical significance of the observed differences (the count of responses for each category). The observed differences were statistically significant at the 90 percent confidence level for car, bus, and bike.

Table 5.6 Current travel mode frequency around town vs hometown identity

		Car			Bus			Bike			Walk		
Hometown	**Count**	**N**	**S**	**M**	**N**	**S**	**M**	**N**	**S**	**M**	**N**	**S**	**M**
Rural	274	8%	10%	81%	94%	5%	1%	82%	14%	4%	26%	44%	31%
Suburban	454	13%	12%	75%	90%	9%	1%	72%	19%	8%	19%	42%	39%
Urban	70	19%	14%	67%	80%	13%	7%	71%	24%	4%	24%	41%	34%

N = Never, S = Sometimes, M = Most of the time or Often
X^2 (1, N = 798) Car: $p = 0.066$, Bus: $p = 0.000$, Bike: $p = 0.011$, Walk: $p = 0.144$

In Moscow, Idaho, the public and private transit that is available includes the city bus, three taxi companies, and Uber and Lyft. Table 5.7 shows the respondents' current use of these modes cross-tabulated with past multimodal experience. Students who had previous experience with public or private transit were more likely to currently use public or private transit. Likewise, students who said they had a positive experience with mobility in an urban setting for an extended amount of time (more than one month total across all visits) were more likely to use public or private transit currently. The observed differences were statistically significant at the 90 percent confidence level based on chi-squared tests.

Table 5.7 Current use of public/private transit around town vs multimodal experience

Experience	Count	Using Public/Private Transit[a] No	Yes
Public/Private Transit[a]			
No Experience	100	95%	5%
Yes Experience	698	87%	13%
Mobility in Urban Setting			
No Experience or Negative	729	89%	11%
Positive Extended Experience	69	78%	22%

[a] City bus, Uber, Lyft, or Taxi
X^2 (1, N = 798) Transit experience: p = 0.040, Positive urban experience: p = 0.011

The students were asked about the travel mode they had used for each trip in the previous week to campus and around town. The results for trips around town were cross-tabulated with the mode they had typically used for travel to high school (see table 5.8). Four groupings were created based on typical high school mode: drove (lone and carpool), rode the bus, rode a bike, and walked. Group inclusion was based on whether their response about each mode was *most of the time* or *often*. (Some students were grouped into more than one group.) Students who had typically driven to high school had the highest percentage of trips the previous week by car, zero trips by bus, and the lowest percentage of trips by bike. The observed differences in number of trips for each group were statistically significant at the 90 percent confidence level based on chi-squared tests.

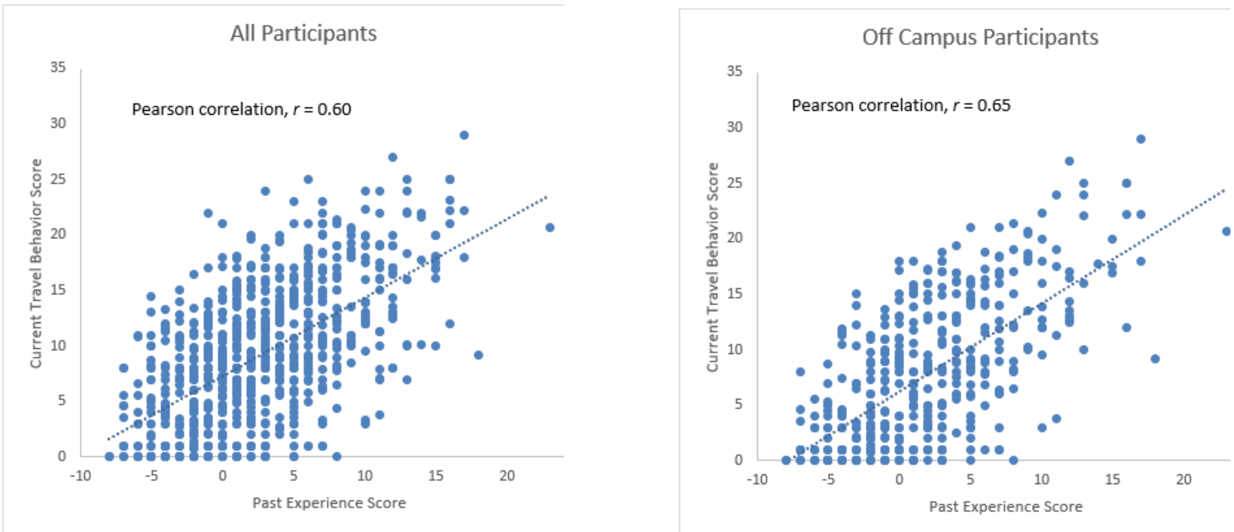
Table 5.8 Previous week mode share for trips around town vs typical high school travel mode

			Previous Week Mode Share			
Group[a]	Students	Trips	Car	Bus	Bike	Walk
Typically Drove to High School	575	4049	74%	0%	2%	23%
Typically Rode Bus to High School	196	1332	61%	2%	8%	29%
Typically Rode Bike to High School	71	520	64%	2%	7%	27%
Typically Walked to High School	125	902	60%	4%	4%	32%

[a] Group inclusion if response was *most of the time* or *often*. Some students are in multiple groups.
X^2 (9, N = 6803), p = 0.000

Several other cross-tabulations were explored to compare previous experience (hometown, high school mode, transit experience, and urban setting experience) with current behavior. For example, the questions shown in table 5.6, table 5.7, and table 5.8, which are for travel around town, were repeated for travel to campus. However, the relationships were less pronounced and/or not statistically significant. This was likely due to two reasons. First, it seemed that many respondents conflated walking *on* campus between classes with walking *to* campus because a dubious percentage of respondents selected *most of the time* or *often* for this question. Second, respondents living on on-campus disproportionally go to campus only by walking. In fact, when the same cross-tabulations were repeated only for respondents who lived off campus, the relationships between behavior and experience were even more pronounced than what are shown in table 5.6, table 5.7, and table 5.8. Finally, additional cross-tabulations showed that rural students were more likely to own a car, more likely to buy a parking permit, and less likely to own a bike.

The intent of the Past Experience Score and Current Travel Behavior Score was to capture the relationship between multiple variables simultaneously. Figure 5.2 shows the plots for the scores. The correlation between past experience and current behavior was fairly good (Pearson correlation coefficient, $r = 0.60$) and slightly better when only students who lived off campus were considered (Pearson correlation coefficient, $r = 0.65$). Table 5.9 provides the results of the ordinary least squares regression for predicting the Current Travel Behavior Score based on the Past Experience Score and living off campus (yes = 1). The model fit was fair ($R^2 = 0.39$), and the coefficients were statically significant at a 90 percent confidence level. The predicted travel behavior score was reduced by 2 points for those living off campus, i.e., predicting less travel by bus, bicycle, and walking. This was not surprising, since off-campus students were more likely to own a car than those living on campus (93 percent compared to 77 percent).



(a) (b)

Figure 5.2 Current Travel Behavior Score vs Past Experience Score for (a) all participants and (b) only off-campus participants

Table 5.9 Regression model to predict Current Travel Behavior Score

Variable	Coefficient	t Stat	p-value
Constant	8.5	31.17	0.000
Off Campus	-2.0	-5.78	0.000
Past Experience Score	0.7	20.84	0.000

[a] $R^2 = 0.39$, $N = 798$

5.4.3 The Impact of Multimodal Exposure

Twenty-one students participated in the fall orientation tour (i.e., the multimodal exposure event). The tours typically lasted about 1.5 hours and involved three to five students per tour. The time was spent approximately as follows: 10 minutes for instructions, bus ride 20 minutes, bike ride 45 minutes, and walk 15 minutes. Fourteen of the participants also completed the follow-up survey six months later at the end of spring semester. These 14 students were the "treatment group." Additionally, 11 students did not participate in the fall event but responded to the spring survey. These students were the "control group." Together, the participants from both groups self-identified their hometowns in proportions similar to those of the respondents from the previous, larger survey (rural 46 percent, suburban 50 percent, and urban 6 percent). Their gender identities also resembled those of the larger survey (female 60 percent and male 40 percent). However, the treatment and control group participants were younger and had lived in Moscow, Idaho, for less time than the respondents to the previous survey, which was not surprising because the recruitment for the exposure study targeted first year students.

In the follow-up spring survey, the treatment group participants were asked to reflect on the impact of the multimodal tour. One set of questions asked whether the tour had increased their knowledge about riding the bus, biking, and walking. The response was a five-level Likert scale from strongly disagree to strongly agree. Figure 5.3 shows that most participants believed their participation in the tour increased their knowledge about how to use the city bus, the walking distances to key destinations, and connections and routes of the bike pathway system.

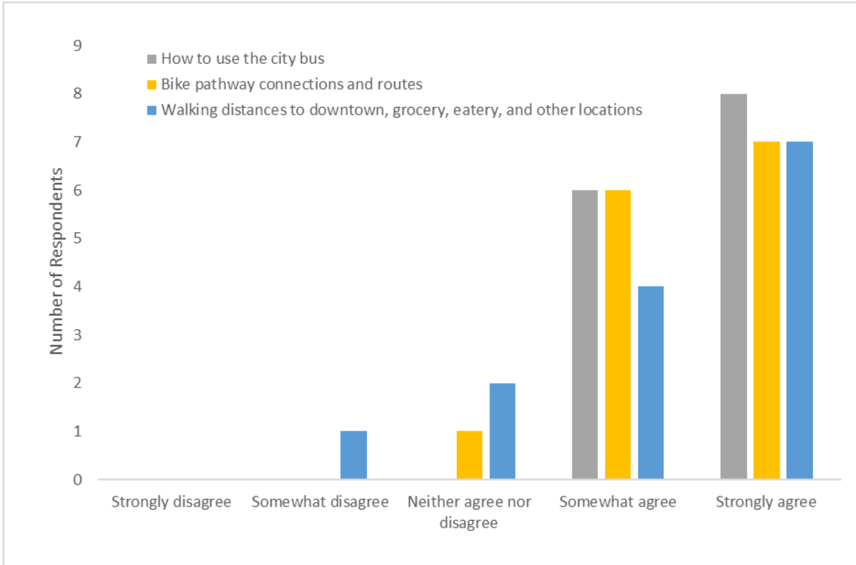
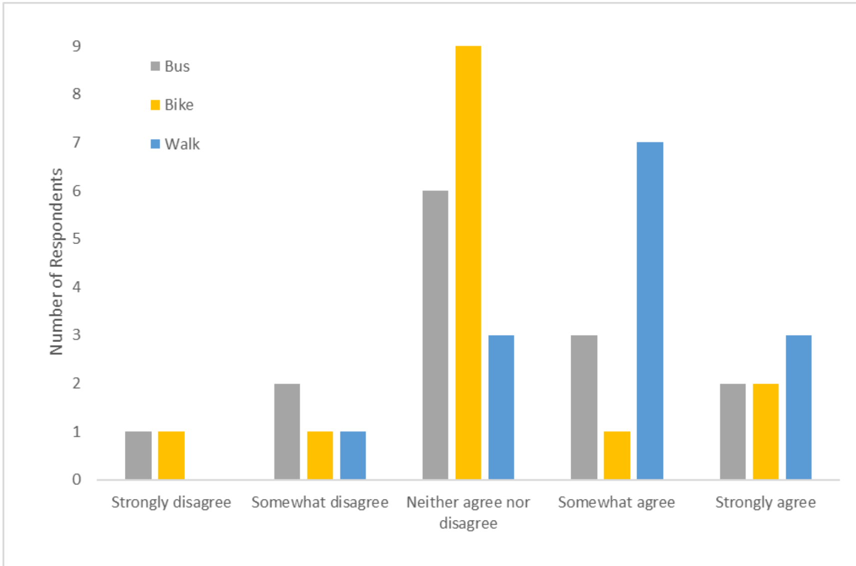
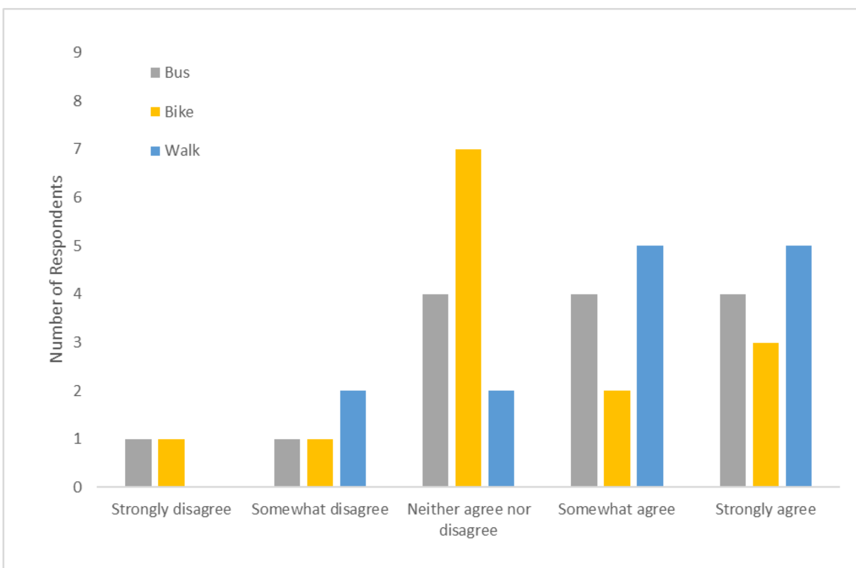


Figure 5.3 Tour participation increased my knowledge about travel mode opportunities

Many people in the treatment group said they had walked, biked, and ridden the bus more in the past six months because of their participation with the tour. The response was a five-level Likert scale from strongly disagree to strongly agree, as shown in figure 5.4. The impact seemed to be strongest for walking (blue bars, 71 percent of participants agreed with travel to campus and around town). For riding the bus, the strongest impact was for traveling around town (gray bars, 57 percent of participants agreed). The impact was not as strong for riding a bike (yellow bars, 21 percent agreed with riding to campus and 36 percent agreed with riding around town). One of the 14 tour participants strongly disagreed that the tour impacted the participant's frequency of riding the bus and biking; since nobody strongly disagreed in terms of walking, it is possible that the strong disagreement was because that participant did not have a bike available for use nor any bus route nearby that felt convenient.



(a)



(b)

Figure 5.4 Tour participation increased my use of travel modes in the past six months for travel (a) to campus and (b) throughout the community

To further understand mode behavior, the control group and the treatment group were asked to state how frequently they had used various modes in the past six months for travel to campus and around town (a "stated preference" question). The results for travel around town are shown in table 5.10. The control group said they never used the bus, and 18 percent said they sometimes biked. Meanwhile, the treatment group reported using the bus *sometimes* (21 percent) and *most of the time* or *often* (21 percent). A Fisher's Exact test was performed for each mode to see whether the observed difference in count data was statistically significant. The results were affirmative only for the bus response at a 90 percent confidence level.

Table 5.10 Stated mode frequency for control and treatment groups

		Car			**Bus**			**Bike**			**Walk**		
Group	**Count**	**N**	**S**	**M**	**N**	**S**	**M**	**N**	**S**	**M**	**N**	**S**	**M**
Control	11	9%	9%	82%	100%	0%	0%	82%	18%	0%	18%	36%	45%
Treatment	14	0%	36%	64%	57%	21%	21%	50%	50%	0%	14%	57%	29%

N = Never, S = Sometimes, M = Most of the time or Often
Fisher's Exact ($N = 25$) Car: $p = 0.243$, Bus: $p = 0.020$, Bike: $p = 0.208$, Walk: $p = 0.567$

Finally, the control group and treatment group were asked how they had traveled around town in the previous week (a "revealed preference" question). They were able to respond for more than one trip for each day of the week. The treatment group made 102 trips and the control group made 74 trips. Table 5.11 shows the mode share for the groups (car and carpool were combined). The control group primarily used a car and did not make any trips by bus or bike. The treatment group traveled relatively more by bus, bike, and walking. A Chi-squared test was performed to investigate the statistical significance of the observed differences. Because the count for bus and bike were less than 5, those categories were combined with walking for a 2x2 Chi-squared test. (Fisher's Exact test was not performed because the number of trips was $N >$ 120.) The observed differences were statistically significant at the 90 percent confidence level.

Table 5.11 Previous week mode share for control and treatment groups

Group	Students	Trips	Car	Previous Week Mode Share[a] Bus	Bike	Walk
Control	11	74	78%	0%	0%	22%
Treatment	14	102	57%	9%	4%	30%

[a] X^2 (1, N = 176) p = 0.005 for combined bus, bike, and walk

Travel behavior scores were calculated for the control and treatment groups for their first survey and again six months later after the follow-up survey. The first score was considered the "before" score and the second was the "after" score because it was after the treatment group had participated in the multimodal tour. Figure 5.5 shows box and whisker plots for the *before* and *after* scores. The initial scores for the treatment group were on average higher than for the control group, perhaps because of some amount of self-selection bias toward multimodal use. An increase was observed for both groups from the *before* survey to the *after* survey. However, the increase was more pronounced for the treatment group, from a mean value of 9.9 to 11.0 for the control group and a mean value of 12.6 to 15.4 for the treatment group. A two-sample *t*-test was conducted to determine whether the observed change in means was statistically significant. First, the *before* and *after* scores were paired for each participant to calculate *delta*, the change in score. The *t*-test was performed for the difference in mean values of *delta* for the two groups. The difference was statistically significant at the 90 pecent confidence level (one-tail *p*-value = 0.019).

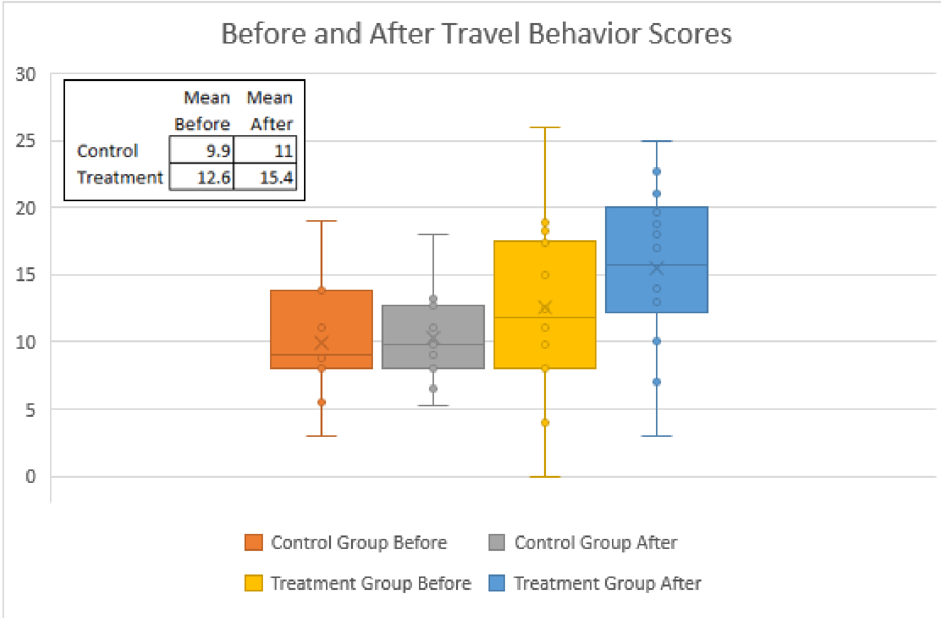


Figure 5.5 Changes in travel behavior scores after the multimodal exposure tour

<u>5.5 Conclusions</u>

This study involved three surveys and an experiment to investigate the relationship between past experience with multimodal travel and current travel behavior, as well as to explore whether exposure to multimodal travel can positively impact travel behavior. Nearly 800 students responded to the first survey. The results confirmed our first hypothesis that most of the students had come from rural backgrounds, had little experience with multimodal travel, and had spent little time in an urban setting. Various cross-tabulations supported the second hypothesis, that past experience with multimodal travel is indicative of current travel behavior. We found that students from rural communities who had frequently driven to high school and had little experience with public and private transit were more likely to be driving currently to campus and around town. Conversely, students who were from urban backgrounds and had had significant experience using public and private transit were more likely to be currently riding the bus, biking or walking to campus and around town. This relationship was further illustrated with the construction of two new index variables. The respondents' Past Experience Scores were shown to be correlated with their current Travel Behavior Scores.

In the second phase of this study a group of students was surveyed before and after participating in multimodal exposure tour (the treatment group). Their responses were compared to those of a group of students who completed the same surveys but did not participate in the tour (the control group). The results indicated that the treatment group had increased their use of bus, bike, and walking, both in terms of stated preference and revealed preference measures.

As with all travel surveys, there was potential for errors in how participants understood and responded to the questions about recent travel modes. For example, in this case study there was an apparent misunderstanding about how to indicate walk trips *to* campus (the high number of walk trips suggested that participants were referring to trips between classes from building to building). It is possible that the participants in the treatment group were already more multimodal minded than the general population, and for this reason they volunteered to participate in a multimodal tour. It is also possible that they were inclined to respond to the survey with confirmation because they felt inclined to express support for multimodal modes.

This case study serves as a microcosm for people throughout the country who move to new mobility environments. The findings can help planners, policy makers, business leaders, and university administrators better understand the travel behaviors of their constituents. The survey design and tour event provide a model for investigating previous travel experience and promoting change in mode choice.

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Appendix A: Questionnaire of University of Washington Needs Assessment Survey

Index	Questions	Options
Q1	**AGECAT** Are you…?	1. Under 18 years old 2. Between 18 and 24 3. Between 25 and 34 4. Between 35 and 44 5. Between 45 and 54 6. Between 55 and 64 7. 65 years old or older 8. Prefer not to answer
Q2	**GENDER** Do you identify as…?	1. Male 2. Female 3. Gender non-binary or non-confirming 4. Transgender 5. Some other gender identity *(please tell us)* 6. Prefer not to answer
Q3	**RACE** Do you identify as… *(Select all that apply)*	1. White 2. African American or Black 3. Hispanic, Latino/a, or Spanish origin 4. Asian 5. Hawaiian Native/Pacific Islander 6. American Indian or Alaska Native 7. Some Other Race, Ethnicity, or Origin or Combination of Races *(please specify)* 8. Prefer not to answer
Q4	**INCOME** What is your approximate annual household income? *(Do not count your family member's income)*	1. Under $10,000 2. $10,000 to $24,999 3. $25,000 to $34,999 4. $35,000 to $49,999 5. $50,000 to $74,999 6. $75,000 to $99,999 7. $100,000 to $149,999 8. $150,000 to $199,999 9. $200,000 to $249,999 10. $250,000 or more 11. I am a dependent / student and do not have a job / income of my own 12. Prefer not to answer

Index	Questions	Options
Q5	**TRANSPORTATION MEANS** Did you have any of the following regularly available for your commute to work at the UW during winter quarter 2020? *(Only select the ones that apply)*	1. Car or truck 2. Motorcycle or moped 3. Standard / human powered bicycle 4. Electric assisted bicycle 5. Scooter (standard or electrical assist) 6. Skateboard 7. Some other personal transportation device *(specify)* 8. Nothing, I had none of these available
Q6	**EMPLOYMENT** What would you say is your primary relationship with the UW? *(Select the single option that best describes you)*	1. I am a student at the UW (Includes graduate and professional students) 2. I am a UW faculty member 3. I am a UW staff member
Q7	**RESIDENCE** How many miles is it from where you lived during winter quarter 2020 to the UW main campus?	Number of miles: ___ *(Decimals allowed)*
Q8	**PRE-PANDEMIC PRIMARY MODE** What would you consider to be your primary mode of transportation for your commute to work at the UW during winter quarter 2020? *(Please select the one that covered the longest distance)*	1. Public transportation 2. Drive alone 3. Carpool 4. Vanpool 5. Bicycle 6. Walking 7. Ride-hailing service (e.g. Uber, Lyft) 8. Teleworking
Q9	**DURING-PANDEMIC MODE** What is your current primary mode for getting to work at the UW? *(Please select the one that covered the longest distance)*	1. Public transportation 2. Drive alone 3. Carpool 4. Vanpool 5. Bicycle 6. Walking 7. Ride-hailing service (e.g. Uber, Lyft) 8. Teleworking
Q10	**POSTCOVID1** When campus operations return to normal, do you envision traveling / commuting to campus as much as you did prior to the Stay-Home Stay-Healthy orders given in March 2020?	1. No, I do not plan to commute to campus at all when operations return to normal 2. No, I envision myself commuting less than before March 2020 3. No, I envision myself commuting more than I did prior to March 2020 4. Yes, I anticipate commuting to campus roughly the same amount as I did prior to March 2020

Index	Questions	Options
Q11	**POSTCOVID2** Which mode of transportation do you plan to use primarily for commuting to campus when operations return to normal?	1. Public transportation 2. Drive alone 3. Carpool 4. Vanpool 5. Bicycle 6. Walking 7. Ride-hailing service (e.g. Uber, Lyft) 8. Teleworking
Q12	**POSTCOVID3** Do you have any interest in trying to commute by any mode other than your primary mode?	1. Yes, I am interested in using public transportation 2. Yes, I am interested in carpooling 3. Yes, I am interested in vanpooling 4. Yes, I am interested in biking 5. Yes, I am interested in walking 6. Yes, I am interested in teleworking 7. No, I have no interest in using other modes

Appendix B: Survey Instrument for Student Travel Study

Travel Experience and Perception
Informed Consent for Survey

This survey has been sent to all University of Idaho students to help Parking and Transportation Services (PTS) learn more about how students get around campus and Moscow. Information gathered from this survey will help us focus our efforts to improve the campus transportation system.

Your participation will involve answering questions about your experience with different travel methods before and during your time in Moscow. The survey should take about eight minutes to complete. Your involvement in the study is voluntary, and you may choose not to participate or to discontinue the survey at any time. Your answers will be kept anonymous, secure, and confidential. The findings will be presented in summary form only. Providing personal data is optional and will only be used for the raffle drawing for a $50 Amazon gift card. Four gift cards will be awarded. The estimated odds of winning a gift card are 1 in 100. Winners will be notified via the email address they provide at the end of this survey. The gift card will be available for pick up at PTS offices from May 10 through May 20, 2021.

If you have any questions about this research project, please contact the Principal Investigators Michael Lowry at 208-885-0139 or Rebecca Couch at 208-885-6424 or parking@uidaho.edu. This survey was reviewed as IRB protocol: Student Transportation Experience and Perception. If you have questions regarding your rights as a research subject, or about what you should do in case of any harm to you, or if you want to obtain information or offer input you may call the Office of Research Assurances at 208-885-6340 or irb@uidaho.edu.

By clicking to the next page you certify that you are at least 18 years of age and agree to participate in the above described research study.

Experience

If you grew up in the USA, what is the zip code of the community you grew up in?

Leave blank or enter zero if you grew up outside of the USA.

____

How would you describe the community you grew up in?

- ○ Urban (core area of a city)
- ○ Suburban (residential area surrounding a city)
- ○ Rural (countryside or not in town)
- ○ Other ________

How often did you use the following travel methods to get to high school?

	Never	Sometimes	Often	Most of the time
Rode bike	○	○	○	○
Drove alone	○	○	○	○
Dropped off by household member	○	○	○	○
Drove with other students (carpooled)	○	○	○	○
Rode a city bus	○	○	○	○
Rode a school bus	○	○	○	○
Walked	○	○	○	○
Skateboard/Scooter/Etc.	○	○	○	○

Have you ever used the following travel methods?

	Never	Once	Less than 5 times	5-20 times	More than 20 times
Subway/Light rail	○	○	○	○	○
Long distance train	○	○	○	○	○
Airplane	○	○	○	○	○
Public city bus	○	○	○	○	○
Bike/scooter share program	○	○	○	○	○
Uber/Lyft	○	○	○	○	○
Traditional taxi	○	○	○	○	○

How much time have you spent in an urban setting where buses, light rail, walking, biking, or taxis are common travel methods (for example, downtown Seattle)?

- ◯ Never
- ◯ Short Period (less than 7 days total across all trips)
- ◯ Moderate Period (between 7 and 30 days total across all trips)
- ◯ Long Period (between one and three months)
- ◯ Extended Period (more than three months)

How would you rate your experience with getting around in an urban setting by bus, light rail, walking, biking, or taxi (in other words by any travel method other than personal car)?

Very negative	Somewhat negative	Neither positive nor negative	Somewhat positive	Very positive
◯	◯	◯	◯	◯

Do you have a personal vehicle in Moscow?

- ◯ Yes
- ◯ No

Did you buy a parking permit this school year?

- ◯ Yes
- ◯ No

Prior to attending the University of Idaho, where have you experienced having to pay to park?

	Never	Once	Less than 5 times	5-20 times	More than 20 times or purchased long term pass
At your High School	◯	◯	◯	◯	◯
In the community where you grew up	◯	◯	◯	◯	◯
On a college campus other than University of Idaho	◯	◯	◯	◯	◯
Visiting other cities	◯	◯	◯	◯	◯

Where is your current residence?

- ◯ On campus: Residence Halls/LLC's
- ◯ On campus: Apartments
- ◯ On campus: Greek Life
- ◯ Off campus

Did you relocate from outside Moscow to attend the University of Idaho?

- ◯ Yes
- ◯ No

Residence

What form of transportation did you use to move your belongings to Moscow to attend the University of Idaho? Please select all that apply.

- ☐ Drove myself
- ☐ Was dropped off by household member or someone else
- ☐ Carpooled with other student(s)
- ☐ Airplane
- ☐ Public bus

☐ Other

Distance to the Idaho Student Union Building (ISUB)

How far is your residence to the Idaho Student Union Building (ISUB)? See map.

- ○ < 1 mile to the ISUB
- ○ 1 to 2 miles to the ISUB
- ○ 2 to 3 miles to the ISUB
- ○ 3 to 4 miles to the ISUB
- ○ > 4 miles to the ISUB

Behavior

How often do you use these transportation methods to get to class and other activities on campus?

	Never	Sometimes	Often	Most of the time
Riding my bike	○	○	○	○
Driving myself	○	○	○	○
Driving with others (carpool)	○	○	○	○
Riding the bus	○	○	○	○
Walking	○	○	○	○
Taking Uber/Lyft	○	○	○	○
Taking a traditional taxi	○	○	○	○
Skateboard/Scooter/Etc.	○	○	○	○

Last week did you use these transportation methods to get to class and other activities on campus?

If you used more than one method on a single trip, then select the primary method used for the longest distance. For example, if you walked a short distance to the bus stop and then took the bus to campus you would select “Bus” for that trip.

More than one trip in a day can be recorded if multiple primary methods were used throughout the day.

	Bicycle	Drove Alone	Carpool	Bus	Walk	None
Monday	☐	☐	☐	☐	☐	☐
Tuesday	☐	☐	☐	☐	☐	☐

	Bicycle	Drove Alone	Carpool	Bus	Walk	None
Wednesday	☐	☐	☐	☐	☐	☐
Thursday	☐	☐	☐	☐	☐	☐
Friday	☐	☐	☐	☐	☐	☐
Saturday	☐	☐	☐	☐	☐	☐
Sunday	☐	☐	☐	☐	☐	☐

How often do you use these transportation methods to get around town? (i.e. grocery shopping, recreation, etc.)

	Never	Sometimes	Often	Most of the time
Riding my bike	○	○	○	○
Driving myself	○	○	○	○
Driving with others (carpool)	○	○	○	○
Riding the bus	○	○	○	○
Walking	○	○	○	○
Taking Uber/Lyft	○	○	○	○
Taking a traditional taxi	○	○	○	○
Skateboard/Scooter/Etc.	○	○	○	○

Last week did you use these transportation methods to get around town (i.e. grocery shopping, recreation, etc.)?

If you used more than one method on a single trip, then select the primary method used for the longest distance. For example, if you walked a short distance to the bus stop and then took the bus to campus you would select "Bus" for that trip.

More than one trip in a day can be recorded if multiple primary methods were used throughout the day.

	Bicycle	Drive Yourself	Carpool	Bus	Walk	None
Monday	☐	☐	☐	☐	☐	☐
Tuesday	☐	☐	☐	☐	☐	☐
Wednesday	☐	☐	☐	☐	☐	☐
Thursday	☐	☐	☐	☐	☐	☐
Friday	☐	☐	☐	☐	☐	☐
Saturday	☐	☐	☐	☐	☐	☐
Sunday	☐	☐	☐	☐	☐	☐

Barriers

Which of the following are your reasons for not riding the bus more? Please select all that apply.

- ☐ I'm concerned about my personal safety
- ☐ I'm concerned about traffic safety
- ☐ Riding the bus takes too long
- ☐ I don't know where the nearest but stop is located
- ☐ I've never used the bus and am unsure how to do it
- ☐ The nearest bus stop is too far from my residence
- ☐ I might miss the bus and be late to my class or appointment
- ☐ The bus might be full and I don't have time to wait for the next bus
- ☐ The bus doesn't drop me off close enough to where I need to go
- ☐ Another method is more convenient for me
- ☐ I am responsible for transporting others to their destination
- ☐ I have a mobility limiting impairment that prevents me from choosing the bus
- ☐ Other ________

Which of the following are your reasons for not bicycling more? Please select all that apply.

- ☐ I'm concerned about my personal safety
- ☐ I'm concerned about traffic safety
- ☐ Buying and maintaining a bike is too costly
- ☐ I don't have a bike
- ☐ It's too far to get to class

- Riding my bike takes too long
- My travel is too hilly
- I live close enough to walk
- I'm afraid my bike might get stolen
- Weather prevents me from biking
- I need to carry too many items
- Another method is more convenient for me
- I am responsible for transporting others to their destination
- I have a mobility limiting impairment that prevents me from riding a bike
- Other

Which of the following are your reasons for not walking more to campus or around town? Please select all that apply.

- I'm concerned about my personal safety
- I'm concerned about traffic safety
- It takes too long to walk
- Weather prevents me from walking
- I need to carry too many items
- Another method is more convenient for me
- I am responsible for transporting others to their destination
- I have a mobility limiting impairment that prevents me from walking
- Other

Knowledge

Have you ever used a SMART Transit bus in Moscow?

- Yes
- No

Before taking this survey, did you know that it is free to ride SMART Transit buses in Moscow?

- Yes, I knew the bus is free to ride
- No, I did not know the bus is free to ride

Before taking this survey, did you know that Parking and Transportation Services offers a free transportation service on campus, called Vandal Access, for students with temporary or permanent mobility limitations?

- Yes
- No

Before taking this survey, did you know about the pay-to-use Holiday Break Bus, which transports students between University of Idaho and some locations in Oregon, Washington, southern Idaho and Eastern Idaho?

- Yes
- No

Demographics

What is your age?

What is your gender?

- ◯ Male
- ◯ Female
- ◯ Transgender
- ◯ Non-binary / third gender
- ◯ Prefer not to say

How much time have you spent in Moscow?

- ◯ Less than one year
- ◯ 1 to 2 years
- ◯ 2 to 3 years
- ◯ 3 to 4 years
- ◯ 4 to 5 years
- ◯ More than 5 years

End

If you would like to share any comments about transportation on campus or in the local community, please use the space below:

Do you want to be included in the raffle for the chance to win a $50 Amazon gift card?

- ◯ Yes
- ◯ No

Please put your preferred contact information below. This information is only used for the raffle and will be discarded after the winners are selected.

Name (First & Last)

University Email

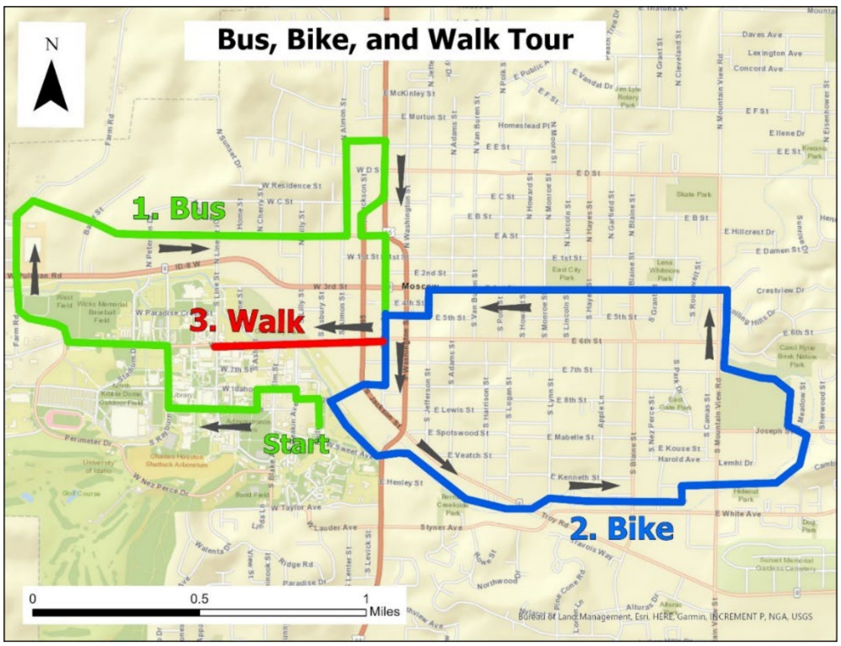
Appendix C: Student Orientation Tour Recruitment Flyer

The following flyer was included in the in-coming freshman orientation packets and distributed on bulletin boards throughout campus, especially in on-campus housing.

Appendix D: Tour Guide Instructions and Script

The following instructions and script were provided to the tour guides for the student orientation tour.

Primary goal: To encourage students to walk, bike, and bus more. We want students to know that Moscow is a community designed for walking and biking. The tour guides should frequently make comments about Moscow being small, walkable, and bikeable.



The following points should be made in your own words and when appropriate throughout the tour.

Welcome

- Today we will demonstrate how easy and convenient it is to travel around Moscow on the Free Bus, on a bike, and walking.
- We will do a loop that includes the entire city west to east.
- We are starting at the Moscow Intermodal Transit Center. This location is like Grand Central Station for transportation. The local bus routes start and stop here. As well as regional buses like Greyhound and the Break Buses, which we will explain in a moment.

Packet Contents

- Bus/Bike/walk event map
- City map from chamber of commerce
- SMART Transit map
- Panhandle coin
- Idaho Eats voucher
- PTS flyer
- Water bottle

Bus Ride

- Please take out of your packet the SMART Transit Fixed Route Map. There are two main routes: West (Green) and East (Blue). These routes have slightly different routes depending on the hour as indicated by the dark and light colors.
- We are on the Light Green Route. We will go up over campus, past the Mall and Winco, through the student housing area, and get off downtown. The Dark Green Route is similar but goes up to Walmart.
- The dots indicate bus stops.
- These are called "Fixed Routes" because they do not change. They are free to ride. SMART Transit also offers a free "Dial-a-ride" service for people with disabilities, although the advanced scheduled service is available to anyone for a small fee.
- The Fixed Routes are free to ride because the University of Idaho Parking and Transportation department and the City of Moscow pay for the service. So essentially all those who buy a parking permit to park on campus and everyone in Moscow helps pay for this service indirectly through parking fees and taxes. So you should definitely use this great system that you have already paid for!
- The bus stops here at the ISUB at about 12 minutes past the hour, every hour, so from here it's easy for students to catch the bus after classes to go run errands in town or get a ride home to the Wallace complex or an off campus residence on A Street.
- We are passing near the Kibbie Dome and the new Basketball Arena. Note these venues are very easy access by walking, biking, and the bus.
- On the other side of the Kibbie Dome is a parking lot called the "Economy Lot". It is for on-campus resident students to leave vehicles long term. It is inexpensive only $75 per year. Many students use that lot to store their cars and then walk, bike, and bus throughout the week, using their car only to get back home for breaks.
- We are passing near the Hartung Theater. This is where performances are held throughout the year. It is very convenient to walk or bike to the theater.
- We are approaching the highway that goes to Pullman, Washington. Washington State University is in Pullman. It is about 9 miles to Pullman.
- You can see the paved pathway that goes all the way to Pullman. Many students enjoy biking to Pullman along this path. It was an old railroad that was converted into a pathway for students to enjoy biking, running, and walking through the Palouse. This trail also goes east all the way to Troy, ID, about 12 miles away.

- The Moscow-Pullman Airport is only 6 miles from campus. Some students and faculty ride their bike to the airport. How cool is that to be able to ride your bike to the airport! There are also taxis, uber, and hotel shuttles that go to the airport. There are direct flights to Boise and Seattle, so essentially you can have connecting flights to anywhere in the world.
- The Winco stop is a very important bus stop. Here you can go to the mall, Target, a bunch of great restaurants, and Winco the low-cost grocery store.
- Now we are passing by whole bunch of student apartments. Many students in this area walk and bike to campus. And since the bus goes straight to Winco and downtown, many students don't even use their car very much for daily activities.
- It is possible to live in Moscow without a car because of the free bus and the community being so walkable. For holiday breaks you can use bus services to get home. Please take out of your packet this list of regional bus service information. The university sponsors the Vandal Break Bus program, which provides chartered trips to Boise, ID Falls, and Spokane for fall, winter, and spring break. For other destinations like Seattle and Portland, Wheatland Express or Greyhound services are available and affordable. Additionally, Wheatland provides a shuttle service to the Spokane airport around the academic breaks.
- This area is Moscow's Brewery district. There are great breweries that often have live music.
- Now we are passing near another grocery store, called Rosauers. As we drive along this street you will see there is access to various restaurants and stores over on the highway by hopping off the bus at the Rosauers stop.
- This is Main Street. The center of downtown with numerous cafes and restaurants. Both bus routes meet and transfer here. (Guide tell some of your favorite)
- From May through October many students walk to the Farmers Market on Saturdays which is held on Main Street.
- The highway used to go through the center of Moscow along this street, but it was removed so that Main Street could be more comfortable for walking and biking, creating the two one-way streets that run parallel with Main.
- Another grocery store called Moscow Food Coop is one block that way.
- Here we are at Friendship Square where we will hop off the bus and begin our bike ride from downtown.

Bike Ride

- Paradise Creek is one of two bike stores in Moscow. Moscow has great mountain bike trails on Moscow mountain and the Palouse is world class for road and gravel cycling. Point to Rolling Hills as you cross 6^{th} street.

- We are passing Gritman Hospital. It is nice to have a hospital in the center of town with easy walking and biking access. There is also a Quick Care center near Walmart that can be accessed with the Dark Green bus route.
- This is College Street and goes straight to campus.
- There is the Transit Center where we started our tour. Again that is where you will go for all bus connections as well as anything to do with parking on campus.
- This pathway goes west for 9 miles all the way to Pullman (recall we pointed that our previously) and it goes East for 12 miles to Troy. It is a beautiful pathway enjoyed by many people for walking, biking, and jogging. It was an old railroad converted into a pathway.
- Identity Apartments is a large new apartment complex in excellent walking distance to campus and downtown.
- Berman Creekside Park is one of many parks along this pathway.
- The first design of this underpass was done by UI engineering students to improve walking and biking in town.
- Safeway is the fourth and final grocery store in town. There are four grocery stores and now you have seen that all four are easily accessible by walking, biking, and the bus.
- This is the Fair Grounds. There are concerts here often and also of course the county fair every fall. This is also one place where people can vote. There are also voting locations on campus. The pathway makes it easy to access the fair grounds by walking or biking.
- This is Heron's Hideout, a great public park to see birds, turtles, and beavers.
- These soccer fields and baseball fields can be enjoyed by UI students and the community.
- That direction is the community center, community pool, and more public parks.
- We are now going on Third Street which goes straight to downtown and toward campus.
- East City Park is another great public park where many community events are held.

Walk Back to Campus

- We have done a complete loop around the entire city! It isn't very big. It is only about 2 miles wide and 2 miles tall. Very easy to get around by bike or foot.
- Now you are can walk back to campus or stay downtown. If you want to go to the Transit Center then continue down main street and cross at College Street like we did on the bike ride. Or you can turn and go straight down 6th Street. You will pass a few more great restaurants on your walk.
- Any questions?