

# Air Travelers' Ground Transportation Choices at Four Airports in Northern California

August 2024

A Report from the National Center for  
Sustainable Transportation

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## TECHNICAL REPORT DOCUMENTATION PAGE

<b>1. Report No.</b> NCST-UCD-RR-24-19	<b>2. Government Accession No.</b> N/A	<b>3. Recipient's Catalog No.</b> N/A	
<b>4. Title and Subtitle</b> Air Travelers' Ground Transportation Choices at Four Airports in Northern California	<b>5. Report Date</b> August 2024		
	<b>6. Performing Organization Code</b> N/A		
<b>7. Authors</b> Keita Makino, <a href="https://orcid.org/0000-0001-5080-2843">https://orcid.org/0000-0001-5080-2843</a> Junia Compostella, Ph.D., <a href="https://orcid.org/0000-0002-5668-8161">https://orcid.org/0000-0002-5668-8161</a> Yongsung Lee, Ph.D., <a href="https://orcid.org/0000-0002-1980-1225">https://orcid.org/0000-0002-1980-1225</a> Giovanni Circella, Ph.D., <a href="https://orcid.org/0000-0003-1832-396X">https://orcid.org/0000-0003-1832-396X</a>		<b>8. Performing Organization Report No.</b> UCD-ITS-RR-24-02	
<b>9. Performing Organization Name and Address</b> University of California, Davis Institute of Transportation Studies, Davis 1605 Tilia Street Davis, CA 95616		<b>10. Work Unit No.</b> N/A	
		<b>11. Contract or Grant No.</b> USDOT Grant 69A3551747114	
<b>12. Sponsoring Agency Name and Address</b> U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology 1200 New Jersey Avenue, SE, Washington, DC 20590		<b>13. Type of Report and Period Covered</b> Final Research Report (October 2019 – September 2022)	
		<b>14. Sponsoring Agency Code</b> USDOT OST-R	
<b>15. Supplementary Notes</b> DOI: <a href="https://doi.org/10.7922/G2TX3CPQ">https://doi.org/10.7922/G2TX3CPQ</a> Dataset DOI: <a href="https://doi.org/10.5061/dryad.vhmgqp3p">https://doi.org/10.5061/dryad.vhmgqp3p</a>			
<b>16. Abstract</b> Prior studies of travel mode choice in airport ground transportation identified several important relationships between traveler/trip attributes and the selected ground access mode(s). However, those studies did not comprehensively account for qualitative aspects of ground access mode choice, such as general and transportation-specific attitudes and perceptions of mode-specific airport infrastructure. To add insights into air travelers' ground transportation choices, this study collected a dataset with a survey administered among travelers using four major airports in Northern California in the post-pandemic era. Among the analyses presented in the report, airport ground access mode choice was analyzed, and its relationships with travelers' socio-demographics, attitudes toward transportation and related topics (e.g., environmental friendliness), and opinions about transportation infrastructure and services (e.g., airport parking fees). The authors identified relationships between air travelers' attitudes or opinions and their mode choice not examined in prior studies. Specifically, travelers with pro-environment attitudes preferred public transit and ridehailing services over private vehicles. Travelers are more likely to choose public transit often if they highly rate its service frequency and accessibility from their home to a nearby station. The results suggest policymakers, airport authorities, and transit agencies consider electrification of ridehailing fleets, expansion of bus and rail service availability, and higher parking fees to reduce driving in private vehicles to the airport.			
<b>17. Key Words</b> Airport ground access; Travel Mode Choice; Attitudes and Perceptions; Airport infrastructure; Transportation Network Company (TNC)		<b>18. Distribution Statement</b> No restrictions.	
<b>19. Security Classif. (of this report)</b> Unclassified	<b>20. Security Classif. (of this page)</b> Unclassified	<b>21. No. of Pages</b> 44	<b>22. Price</b> N/A

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## Acknowledgments

This study was funded, partially or entirely, by a grant from the National Center for Sustainable Transportation (NCST), supported by the U.S. Department of Transportation (USDOT) through the University Transportation Centers program. The authors would like to thank the NCST and the USDOT for their support of university-based research in transportation, and especially for the funding provided in support of this project. Additional funding was provided by the 3 Revolutions Future Mobility (3RFM) Program of the University of California, Davis. The authors would like to thank Farzad Alemi and Alimurtaza Kothawala for their contribution to the research. Several colleagues at the San Francisco International (SFO) Airport Authority and the National Renewable Energy Laboratory (NREL) provided useful recommendations and advice that enriched this research.

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# Air Travelers' Ground Transportation Choices at Four Airports in Northern California

## EXECUTIVE SUMMARY

This study, conducted by the research team in the 3 Revolutions Future Mobility Program at the University of California, Davis, investigated the choice of ground transportation access/egress modes among air travelers at four large airports in Northern California: the San Francisco International Airport (SFO), the Norman Y. Mineta San Jose International Airport (SJC), the Metropolitan Oakland International Airport (OAK), and the Sacramento International Airport (SMF). The study was motivated by the changing transportation conditions, and the large disruption introduced by the use of emerging ridehailing options as a means of travel to/from the airport and further disruptions in travel behaviors during the COVID-19 pandemic that greatly altered air travel and the use of airports. The research project focused on the factors affecting travelers' choices of ground transportation mode(s) to/from the airport to assess the new trends in airport ground transportation and help suggest policy implications for the post-pandemic world.

Through a revealed preference survey, administered through an online survey platform, we collected 1,038 survey responses among airport users from December 2022 to March 2023. We used a quota sampling approach to recruit respondents from the 21 Northern California counties—Alameda, Contra Costa, Marin, Napa, Solano, Sonoma, San Mateo, San Francisco, Santa Clara, El Dorado, Placer, Sacramento, Sutter, Yolo, Yuba, Merced, San Joaquin, Stanislaus, Monterey, San Benito, and Santa Cruz—that have used at least one of the four major airports in the Northern California region (SFO, SJC, OAK, and SMF). Sociodemographic targets were used to mirror the distribution of the characteristics of the population in the region of study. The survey collected information on the participants' socio-demographic characteristics, their attitudes toward various transportation-related statements, their retrospective travel behavior during their last air trip, and their opinion about the current transportation infrastructure at the airport and transportation services, bound for the airport.

The descriptive statistics of the air travelers' social demographics and trip characteristics, including their flight day/time, party size, amount of luggage, among others, revealed several notable patterns related to the travelers' airport access mode choice. For instance, and not surprisingly, the research shows that the amount of travelers' luggage (check-in or carry-on bags) is a major factor influencing the choice of public transit options. The time of day was found to be another important factor affecting travelers' use of certain modes; travelers whose flight is in the afternoon or evening were more likely to pick a ridehailing service to/from the airport vs. those traveling during the earlier part of the day.

Additionally, we investigated travelers' opinions about airport transportation infrastructure and transportation services in five different aspects: availability, ease-of-use, accessibility, affordability, and cleanliness. Results indicate a few notable insights about the perception and

satisfaction of air travelers in the four airports. For example, while travelers seem to rely on the presence of parking lot infrastructure for their private vehicles, their opinion of the affordability—the parking fee—is largely negative, implying that travelers use private vehicles to/from the airport despite the high parking fee because the other options, such as public transit, are more unattractive to them.

This report provides several key findings based on descriptive statistics, yet the survey dataset could be exploited by future studies with advanced models to further explore the relationship between travelers' characteristics or the attributes of their air travel and the mode choice to/from the airport. In subsequent following phases of this research building on the analysis of this dataset, an access mode choice model is being estimated. Further, the approach of this survey-based research project could be used in another study region to investigate similar research questions at other airports not included in this first study.

## Introduction and Background

Despite the significant disruption caused by the COVID-19 pandemic, air travel continues to expand globally. According to Brandon's (2022) projections, globally the total revenue passenger kilometers (RPKs) are expected to increase by 2.4% annually from 2019 to 2040, resulting in a total of 15.9 trillion RPKs in 2040 i.e., nearly double the amount recorded in 2019 (Graver, 2022). Proportionally, the demand for ground transportation options to/from airports has been growing. However, its growth does not uniformly happen across options. Understanding the profiles of air travelers and the factors that influence their transportation choices to/from the airport is essential to estimating the type of demand for airport ground transportation, as well as planning for a sustainable system that reduces traffic and emissions around the airport.

The transportation literature has been investigating air travelers and trip attributes that determine the selection of transportation modes to/from the airport. Even though airport ground transportation had been largely car-dominated for a long time in the United States, starting in the middle of the 2010s, the emergence of transportation network company (TNC) services, such as Uber or Lyft, brought a considerable change in the profile of airport ground transportation. Mandle and Box (2017) reported several disruptive effects of TNC services across airports in the United States (Mandle & Box, 2017). They have increased airport roadway congestion by 46%, resulting from the increased volume of TNC traffic coupled with some drivers of private vehicles being unfamiliar with airport regulations (Mandle & Box, 2017). Meanwhile, they decreased taxicab trips by 5% to 30%, shared ride vans by 18% to 30%, and reduced rental-car transactions by up to 13% (Mandle & Box, 2017). The availability of TNC services has also led to a decrease in transit ridership to and from airports; for example, Sturgeon (2019) reported that the ridership at the Bay Area Rapid Transit (BART) station at San Francisco International Airport (SFO) started to decline after the introduction of TNC services at the airport (Sturgeon, 2019). The author suggested that TNC services serve as a substitute for public transit rather than a complement to it (Sturgeon, 2019). Note that these effects were observed before the COVID-19 pandemic.

One of the most important trip characteristics that can affect a traveler's choice of transportation mode is the purpose of their trip. Not surprisingly, Hermawan (2018), based on a passenger survey administered at the Los Angeles International Airport (LAX), found that business passengers appear to be slightly more sensitive to travel time while leisure passengers are more sensitive to travel costs (Hermawan, 2018). As business travelers are less sensitive to travel costs than travel time, it is a challenging task for policymakers and transit agencies to encourage employers to adopt more sustainable modes for business travel, such as transit or shared modes as the primary mode for their employees when traveling to/from the airport.

Ge et al. (2021) investigated travelers' socio-demographic characteristics and other trip factors that influence the choice of ground transportation mode and parking options (e.g., valet parking, remote parking) at Dallas-Fort Worth (DFW) International Airport (Ge et al., 2021). The authors found that female airport users are more likely to choose drop-off (being dropped off by friends or family members) rather than driving by themselves (Ge et al., 2021). According to

the study, wealthier travelers prefer more convenient but expensive transportation modes such as TNC services or use more expensive parking options such as valet parking (Ge et al., 2021). Moreover, the authors found that a larger travel party size is more likely to use an airport shuttle or taxi to share with the group. It also indicated that the time of travel is also an important factor and that arriving at the airport in the early morning (before 10 am) increases the chance of driving and using parking lots while arriving in the late evening (after 8 pm) increases the chance of using TNC services (Ge et al., 2021). Capturing the impacts of travelers' characteristics and those of airport ground transportation and facilities such as parking options, is important to guide choosing (or avoiding) certain transportation modes and promote more sustainable options to/from airports.

The introduction of TNC services also impacted airports' sources of revenue such as parking and ground transportation fees. According to Henao et al. (2018), parking and ground transportation fees (e.g., operation fee for rental car companies) represent 41% of U.S. airport revenues (Henao et al., 2018). Since TNC vehicles do not park at the airport, if they substitute for the use of private vehicles and no sufficient TNC fees are imposed at airports, the more TNC services air travelers use, the less revenue the airport gains from the parking fee. Accordingly, Henao et al. (2018), based on datasets provided by airports, in Denver, San Francisco, Portland, and Kansas City, observed that even though the airports' annual passenger counts were increasing (pre-pandemic), the parking revenue per passenger started to decline soon after the introduction of TNC services (Henao et al., 2018). The study also suggests that airports could continue to grow without investing in additional parking infrastructure or consider repurposing existing land dedicated to parking lots for other uses (Henao et al., 2018). Understanding the present characteristics of air travelers who opt for private vehicles or have shifted to using TNC services as their preferred mode of ground transportation is crucial in determining if and to what degree airport parking facilities need to be repurposed.

Missing a flight can result in significant losses, such as monetary loss or the inability to attend an essential meeting. Based on an intercept passenger survey at Hong Kong International Airport, Tam, Lam, and Lo (2008) found that the arrival time "safety margin"—the time difference between expected arrival time and preferred arrival time at the airport—is a crucial factor that affects air travelers' choice of ground transportation mode to Hong Kong International Airport (Tam et al., 2008). In their study conducted at Taipei Songshan Airport, Chung and Tu (2021) also discovered that travelers experienced considerable inconvenience when arriving late for boarding, but arriving too early at the airport is also not desirable; the authors noted that travelers tend to select their mode to reach the airport based on an optimal "sweet spot" timing, which lies somewhere in the middle [10]. It suggests that, around the "sweet spot" time, travelers' mode choice is non-uniformly influenced by the expected arrival time prior to boarding [10]. Identifying the appropriate relationship between the timestamps associated with the ground transportation mode selected by the traveler will provide a better understanding of the underlying factors that influence the mode choice.

The onset of the COVID-19 pandemic had a profound impact on ground transportation to/from the airport. Yilmaz et al. (2021) provided valuable insights into the future of ground

transportation for airport employees in the post-COVID world at 27 UK airports (Yilmaz et al., 2021). The authors observed that the mode choice during the pandemic was influenced by two key factors: perceived impacts, such as fear of pathogens, and social distancing measures (Yilmaz et al., 2021). Despite public health progress in overcoming the COVID-19 pandemic, it remains crucial to investigate whether airport employees (as well as air travelers) still harbor concerns regarding the sanitation of airport transportation facilities such as the bus station or parking lot.

The choice of transportation mode to/from the airport depends on various factors, from travelers' characteristics to trip attributes. Also new services such as the emergence of ridehailing or disruptive events such as the COVID-19 pandemic affected how people travel to and from the airport in various ways, including the decreased use of public transit, increased traffic, reduced airports' revenue from the parking lots, and others. In this report, we focus on understanding the correlation between those factors and the mode choice in four airports in Northern California, which will help policymakers, airport authorities, and transit agencies plan a better system of airport ground access. Even though the number of travelers to/from airport accounts only for a small share of total trips generated in a region, several issues, for instance, congestions or development of massive parking lots at the airport, may lead to important economic or environmental impacts in society. Insights provided in this report are expected to help mitigate these negative impacts at the four airports in Northern California by promoting public transit or implementing better curbside management.

The report is organized as follows; in the Scope section we identify the research questions investigated in this report. The Data Collection describes the survey tool used in this research and the methodology used to sample and recruit the survey participants. The Data Analysis discusses the results from the analysis of the collected data. The Conclusion section presents discusses summary results from the study and potential policies that incentivize more sustainable mode choices to/from the airport, and discusses the limitations of this study.

## Scope

In the Introduction and Background section, we identified several factors and disruptive changes that affect airport ground transportation. In view of this consideration, the scope of this report is to examine how people travel to and from the airport, what factors influence the mode choice for airport ground transportation, including air travelers' characteristics, and trip and built environment attributes, and air travelers' attitudes and opinions on the existing mode options to and from the airport. Findings in this report are expected to provide a concise yet wide-range overview of the profiles of air travelers at one of the four airports in the Northern California region, helping airport authorities and policymakers build regulations on airport ground transportation in the post-COVID-19 era. Therefore, this study aims at answering the following research questions:

1. What are the factors that influence the choice of ground transportation, including travelers' socio-demographics, trip attributes, and the built environment characteristics (e.g., transit accessibility to/from the airport)?
2. What are the opinions and experiences of air travelers regarding transportation services to/from the airport and facilities associated with the airport, such as parking lots, public transportation, and ride-hailing pick-up/drop-off locations?

We investigated these research questions using a revealed preference survey administered among air travelers that have used one of four Northern California airports - Metropolitan Oakland International Airport (OAK), Norman Y. Mineta San Jose International Airport (SJC), Sacramento International Airport (SMF), and San Francisco International Airport (SFO). While we initially planned to administer the survey among travelers of several airports in various regions of the United States, the disruption of the COVID-19 pandemic largely limited our study scope. Consequently, in order to limit the scope of the project to have a manageable focus and to reduce complexity from administering the survey in very diverse regions with different regulations and local characteristics, these four airports in Northern California were selected based on location and size. All four airports are M- or L-size hub under the FAA classification (U.S. DEPARTMENT OF TRANSPORTATION Federal Aviation Administration, 2022).

The survey was administered between December 2022 and March 2023. The analysis of these data can help inform planning efforts of local jurisdictions and airport authorities to develop more sustainable and efficient transportation systems for airport ground access.

## Data Collection

To answer the research questions presented in the Scope section, we designed an online survey that specifically targets travel behaviors and attitudes towards ground transportation to/from four Northern California airports: Metropolitan Oakland International Airport (OAK), Norman Y. Mineta San Jose International Airport (SJC), Sacramento International Airport (SMF), and San Francisco International Airport (SFO).

To focus on air travelers who travel to/from these airports, the study area was limited to the 21 counties located in the Northern California megaregion: Alameda, Contra Costa, Marin, Napa, Solano, Sonoma, San Mateo, San Francisco, Santa Clara, El Dorado, Placer, Sacramento, Sutter, Yolo, Yuba, Merced, San Joaquin, Stanislaus, Monterey, San Benito, and Santa Cruz. We focused on these counties as those whose residents have the highest potential of having air travelers that traveled from/to one of these four airports in Northern California. We excluded those who traveled from outside of these counties (e.g., the other 3,000+ counties in the U.S.) to these four airports because of the low efficiency in the identification and recruitment of such travelers. The survey was administered using an online opinion panel from December 2022 to March 2023.

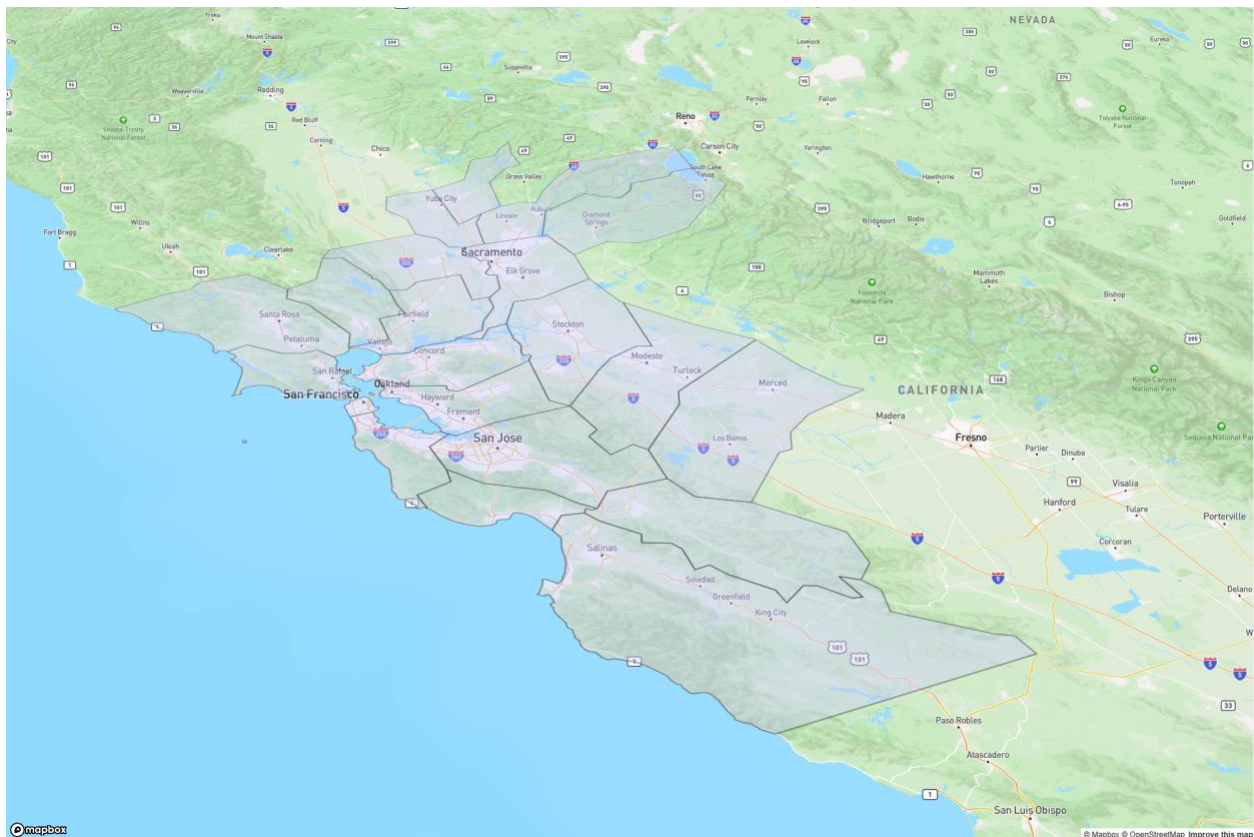


Figure 1. Study region of 21 counties in Northern California. Map generated by Mapbox.

The survey was distributed through an online opinion panel provide, Qualtrics. The survey participants were screened based on the following criteria:

1. *The zip code of the respondent's residential address.* If the zip code was outside the 21 counties in Northern California, their survey would be terminated.
2. *The age of the respondent to be 18 or older.* If they were younger, their survey would be terminated.
3. *Whether the respondent has flown to or from each of the following airports:* Metropolitan **Oakland** International Airport (OAK), Norman Y. Mineta **San Jose** International Airport (SJC), **Sacramento** International Airport (SMF), and **San Francisco** International Airport (SFO). If the respondent has not used any of these airports in the past three years, their survey would be terminated.

The main contents of the survey were organized as follows:

1. Section A focuses on individual attitudes toward various transportation-related topics, such as environmental friendliness, driver preference, or tech savviness.
2. Section B collects information on socio-demographic characteristics, such as the household income, age, gender, education, or employment, of the survey taker.
3. Section C focuses on the survey taker's air travel behavior such as the number of air trips in 2019 (pre-pandemic) and the previous 12 months before taking the survey. Section C of the survey also focuses on:
  - a. Details about the participant's most recent air trip including:
    - Date/time of the flight
    - Origin/destination airports
    - Number of accompanying people
    - Number of checked bags and carry-on bags
  - b. Details about the ground transportation during the trip, including the following subtopics:
    - Origin/destination of the access/egress trip to/from the airport
    - Transportation mode(s) chosen for the trip
    - Duration of the trip
    - Reason(s) for choosing the mode(s)
    - Alternative mode(s) considered
4. Section D focuses on the individual opinions about the airport transportation infrastructure for the mode(s) that the survey taker reported using vs. considering using for the ground transportation:
  - Service/facility availability
  - Easiness to use the service/facility
  - Accessibility of the service/facility
  - Affordability of the service/facility
  - Cleanliness of the service/facility



## Sampling

In this section, we describe the data that were collected and used for the study. We used a quota sampling approach to build the sample of participants and worked with the opinion panel company Qualtrics for recruiting the respondents. Table 1 presents the quotas that were used to construct a representative sample of the population. These quotas were based on the American Community Survey 2020 (5-year) population data. The sample was collected using the Qualtrics opinion panel, which allowed the survey to be distributed to residents in specific zip codes of the 21 Northern California counties included in this study, namely Alameda, Contra Costa, Marin, Napa, Solano, Sonoma, San Mateo, San Francisco, Santa Clara, El Dorado, Placer, Sacramento, Sutter, Yolo, Yuba, Merced, San Joaquin, Stanislaus, Monterey, San Benito, and Santa Cruz. The number of responses for each socio-demographic group was controlled based on the target population, as shown in Table 1.

**Table 1. Descriptive statistics of the socio-demographics.**

A comparison is made for the population of the 21 Northern California counties of the study area, based on American Community Survey 2020 (5-year) data, and our sample (n=1,038).

Demographics	Category	Population of the 21 counties	Sample
<b>Age</b>	18-34	30.7%	32.2%
	35-49	34.3%	34.4%
	55 or older	35.0%	33.4%
<b>Gender</b>	Female	50.3%	52.8%
	Male	49.7%	46.8%
	Prefer to self-describe	-	0.6%
<b>Household Income</b>	Less than \$49,999	27.3%	29.1%
	\$50,000 to \$99,999	25.4%	26.0%
	\$100,000 to \$149,999	17.5%	19.2%
<b>Hispanic</b>	\$150,000 or more	29.7%	25.6%
	No	72.2%	72.2%
	Yes	27.8%	27.8%
<b>Race</b>	White-alone	52.8%	53.4%
	Not White-alone	47.2%	46.6%
<b>Employed</b>	Yes	61.4%	64.9%
	No	38.6%	32.6%
	Other	-	2.4%

## Data Cleaning

The data collection was completed by March 2023. Following the completion of the data collection process, extensive data cleaning was performed, among other purposes, to identify survey participants who provided suspicious and inconsistent responses to the questionnaire. The identification criteria for suspicious cases include:

1. “Speeder” cases were those participants who:
  - a. Completed the survey in less than 5.6 minutes (which was identified as a minimum threshold to take the survey while paying attention to its content in coordination with the opinion panel provider)
  - b. Completed the survey in 11 minutes while reporting a round air trip during their last journey (about the double of the 5.6 minutes threshold) and satisfied any of the criteria in (2) to (4) below.
  - c. Completed the survey in 9 minutes while reporting a one-way air trip during their last journey (2 minutes subtraction from the round-trip cases) and satisfied any of the criteria in (2) to (4) below.
2. “Flatliners/zig-zaggers” cases were those participants who:
  - a. Selected the same choice for all (or almost all) rows in a matrix-type question.
  - b. Made a zig-zag pattern—i.e., selecting certain choices repeatedly—in a matrix-type question.
3. Participants who reported too many long-distance trips:
  - a. Those who reported 100 or more round air trips for leisure or business purposes in either 2019 or the last 12 months were identified as suspicious.
4. Participants who reported an invalid flight itinerary:
  - a. Those who reported an invalid flight origin and destination in a trip (e.g., flying to/from very close airports such as San Francisco to Oakland, or flying to a local airport and reporting they used a direct flight that does not serve that airport, or reporting an invalid airport name)

After the initial cleaning process, we identified 151 problematic responses that were replaced with new respondents in agreement with the opinion panel provider. We repeated this data scrubbing and data cleaning process in an iterative way. Finally, a sample containing 1,038 valid responses was obtained for this study.

## Data Analysis

In this section, we conduct an exploratory data analysis of the socio-demographic characteristics of survey respondents (the air travelers), their air trips to/from the four airports included in this study, as well as the trip features that may have impacted their selection of ground transportation mode(s) to/from the airport, and their views on airport services.

### **Air Travelers' Socio-Demographics and their Ground Transportation Mode Choice to/from the Airport**

Table 2 illustrates the conditional distribution of socio-demographics of the survey takers and the airport they used for the outbound flight. Responses from individuals who used an airport other than the four airports being analyzed or did not take a flight for the outbound trip are excluded from the table.

The tabulation in Table 2 shows that there is not a significant difference in the age distribution among the airports, although OAK travelers are slightly younger compared to the other airports, probably due to combination of the airlines and flights that serve this airport. The gender distribution is relatively similar across all airports. Income level, on the other hand, exhibits considerable variation, with SFO and SJC having a larger number of high-income flyers and SMF having fewer. Additionally, SJC also has a higher proportion of low-income flyers, resulting in a lower number of mid-income flyers at this airport.

The number of household vehicles does not vary significantly across the airports. However, there appears to be a lower proportion of flyers without a car in SMF, which is consistent with the area having weaker public transportation infrastructure compared to the other airports, where, e.g., SFO and OAK have a rail service (BART) that goes from/to the airport. In terms of race and ethnicity status, OAK and SJC have more Hispanic travelers, and SJC and SMF have more White-alone<sup>1</sup> travelers. The employment status is relatively uniform across the airports, except for SMF users.

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<sup>1</sup> "White-alone" refers to respondents who selected only "White" in the race question. This term is borrowed from the U.S. Census.

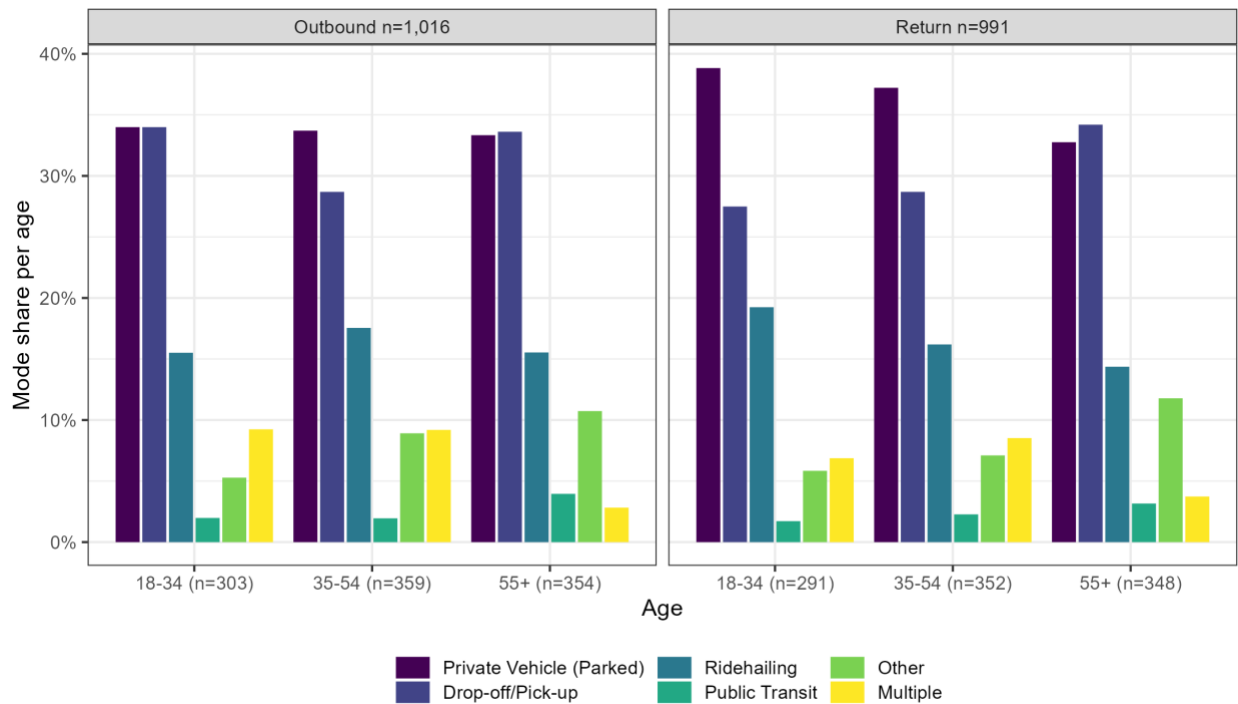
**Table 2. Distribution of the socio-demographic characteristics across airports (n=1,038).**

Demographics	Category	Airport used for outbound trip			
		OAK	SJC	SMF	SFO
Age	18-34	36.6%	30.0%	31.7%	30.6%
	35-54	33.7%	38.2%	34.2%	33.6%
	55 or older	29.7%	31.8%	34.2%	35.8%
Gender	Female	54.0%	53.5%	54.0%	50.5%
	Male	45.5%	46.5%	45.0%	48.9%
	Prefer to self-describe	0.5%	0.0%	1.1%	0.5%
Household income	Less than \$49,999	28.4%	32.9%	34.6%	21.6%
	\$50,000 to \$99,999	26.7%	24.1%	30.2%	23.5%
	\$100,000 to \$149,999	21.3%	14.7%	17.6%	21.9%
	\$150,000 or more	23.8%	28.2%	17.7%	33.1%
Number of household vehicles	0	4.0%	7.6%	1.4%	8.7%
	1	40.1%	30.6%	36.0%	36.9%
	2	36.1%	40.6%	43.5%	38.3%
	3	19.8%	21.2%	19.0%	16.1%
Hispanic or not	No	67.8%	67.1%	75.9%	75.1%
	Yes	32.2%	32.9%	24.1%	24.9%
Race	White-alone	50.5%	56.5%	60.1%	49.2%
	Not-White-alone	49.5%	43.5%	39.9%	50.8%
Employed	Yes	68.8%	67.0%	60.4%	66.9%
	No	29.7%	29.4%	37.4%	31.2%
	Other	1.5%	3.5%	2.2%	1.9%

In this section, with several figures, we will review the distributions of selected social demographic traits for the various mode options used to travel to/from the airport, as reported by the survey participants. In the figures, we classified the transportation modes into the following six categories:

- i) *Private Vehicle (Parked)* – Those who drove or used a private vehicle as a passenger and parked at the airport.
- ii) *Drop-off/Pick-up* – The traveler was dropped off (outbound) or picked up (return) by someone (e.g., family or friends) at the airport so they did not use the parking lot.
- iii) *Public Transit* – Bus or rail transit.
- iv) *Ridehailing and Taxi* – TNC services, including Uber or Lyft, and Taxi.
- v) *Other* – All the other transportation modes not listed above (e.g., shuttle services).
- vi) *Multiple* – A combination of any of the transportation modes listed above, including “Other” modes.

Figure 2 shows the relation between the ground transportation mode-choice to/from the airport and the age of the air travelers across all four airports. Most individuals, regardless of age (especially for the outbound journey), prefer to use their personal vehicle when traveling to the airport, while having a friend or family member drop them off/pick them up comes in second and ridehailing third.



**Figure 2. Ground transportation mode(s) vs. age group.**

In general, older travelers are the least likely to use multiple transportation modes.<sup>2</sup> Although less common (about 10% of the sample), older individuals also tend to use public transportation more frequently and ridehailing services less frequently, particularly on the return trip. In the sample, public transportation is used less by the younger cohort, which resonates the results by Zaidan and Abulibdeh (2018) for the Hamad International Airport (DOH) (Zaidan & Abulibdeh, 2018). However, this result somehow contradicts the results from the report by Gupta et al. (2008) that older people (55+) prefer being dropped-off than driving by themselves or using public transit (local bus) in the New York metropolitan region (Gupta et al., 2008). It should be noted, though, that New York is a very special case in the U.S. in terms of its high levels of public transport availability and use.

<sup>2</sup> It should be noted that the impacts of these findings might be attributable to other socioeconomic variables, e.g., income. While we present univariate and bivariate distributions relating sociodemographic characteristics with the mode choice to/from the airport in this report, future extensions of the research will focus on the estimation of mode choice models, which will help assess the impacts of various factors affecting the access/egress mode choice, all else equal, i.e., while controlling for the impacts of other variables.

When it comes to the outbound trip, the younger and older age groups are generally more likely to either drive themselves or arrange for someone else close to drive them, while the middle age group tends to prefer driving on their own. When it comes to the return trip, younger individuals prefer driving to and from the airport, while the older individuals are more likely to be picked up by friends or family. Ridehailing is more common among the youngest.

Figure 3 shows the relation between household income level and the selected ground transportation mode(s) to/from the airports. The figure shows that individuals with higher incomes are more inclined to use ridehailing services compared to other income groups. They also tend to rely less on being dropped off or picked up by others. In contrast, those with lower incomes use ridehailing services less frequently and rely more on being dropped off or picked up by others compared to those with higher incomes. These results are overall consistent with what Ge et al. (2021) reported for the DFW airport (Ge et al., 2021). The overall result implies a strong disparity between the low-income and high-income groups in terms of their travel behavior to/from the airport, which policymakers may need to consider when developing a new regulation or suggestions around airport ground transportation.



Figure 3. Ground transportation mode(s) vs. household income.

Figure 4 reports the choice of airport ground transportation by race group and shows that private vehicles are the preferred mode by White individuals, whereas non-White air travelers tend to rely more on ridehailing services. Interestingly, there seems to be limited knowledge and no specific prior studies that extensively explored these relationships with race. This could be further investigated in future analyses of this dataset.



**Figure 4. Ground transportation mode(s) vs. White-only race group.**

## Air Trip Characteristics and Ground Transportation Mode Choice to/from the Airport

In this section, we examine the descriptive statistics regarding the air travel patterns of the survey participants, as well as the ground transportation mode(s) they used to get to and from the airport during their most recent trips. Additionally, we explore the relationship between the ground transportation mode(s) selected and various trip attributes that (may have) impacted the travel experience and (may have) influenced the mode choice.

Figure 5 illustrates the distribution of airport travelers by the airport used for the outbound and return trips of their most recent air trip. In the figure, “Other or didn’t fly” represents those survey takers who either did not take a flight from or to one of the four airports, including those who traveled by another transportation means (e.g., the return trip was done with a long-distance bus or train). The addition of this group makes the sample size for the analyses reported in this table slightly different from the other figures in the report. As expected, a greater number of survey respondents reported using the San Francisco and Sacramento airports (SFO and SMF, which are larger in numbers of enplanements) than flying from/to the Oakland and San Jose airports (OAK and SJC).

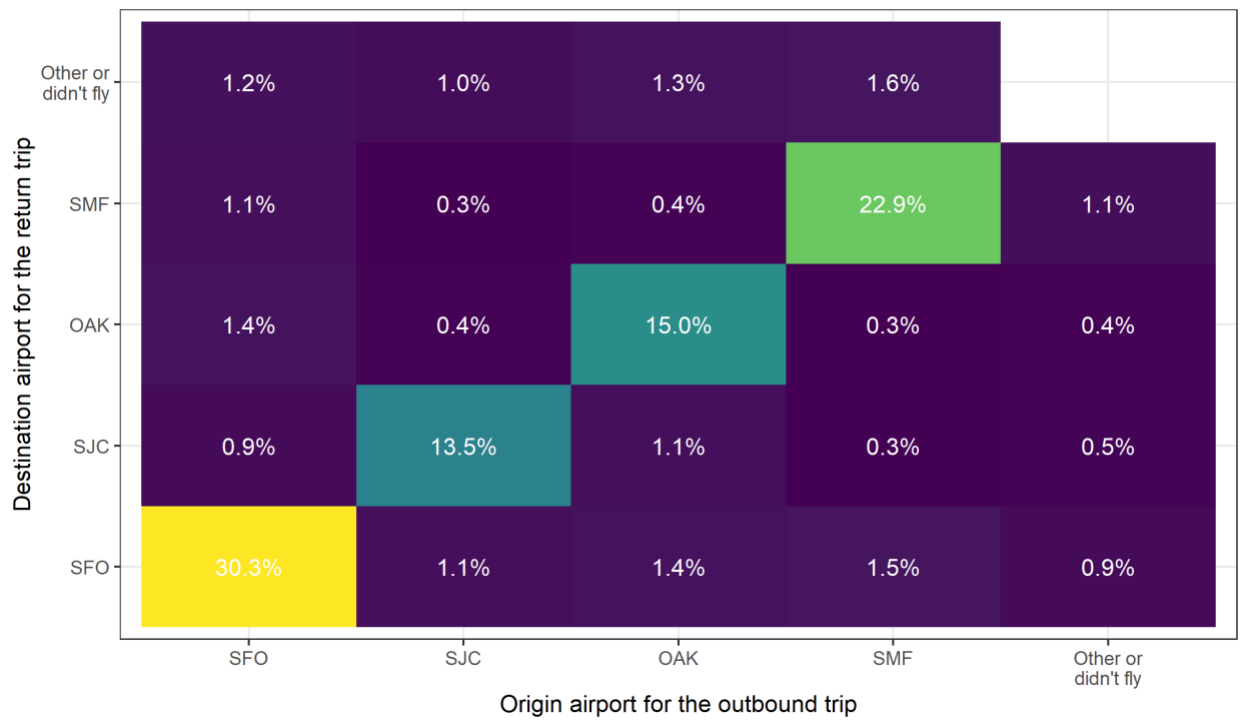
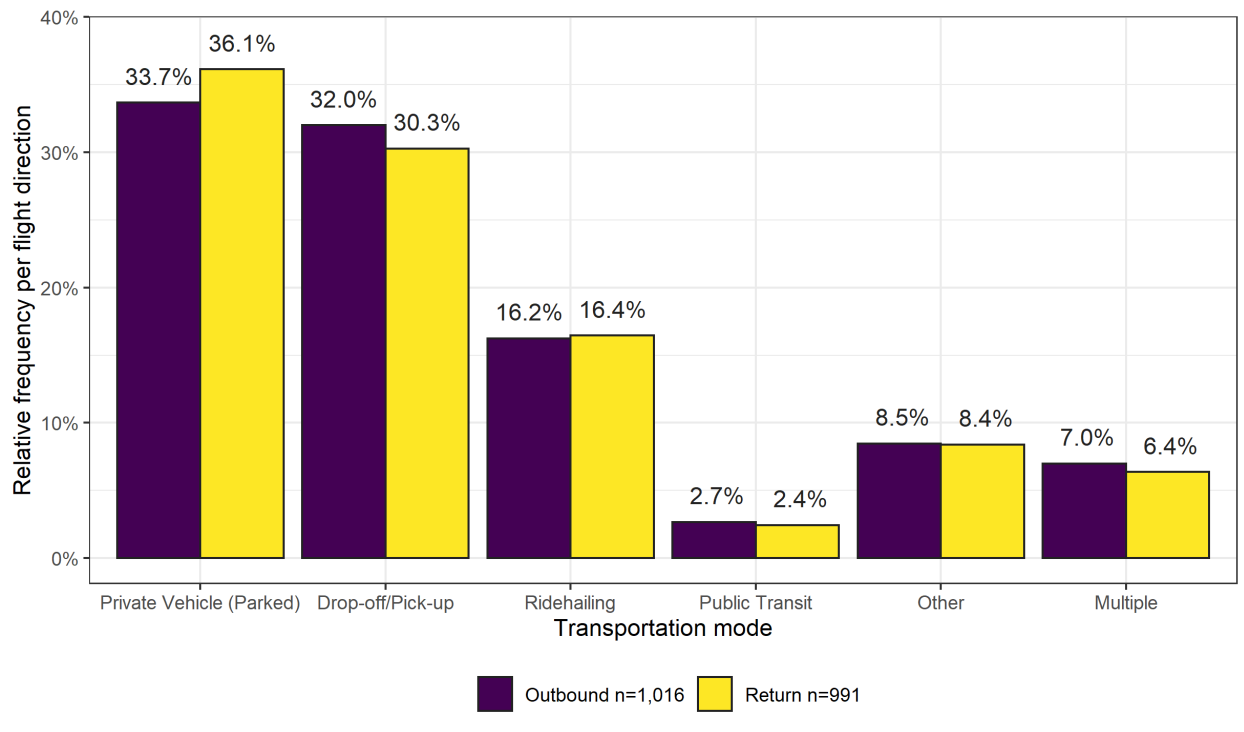


Figure 5. Distribution of the outbound and return air trips (n=1,045).



Figure 6 illustrates the airport ground transportation mode choice for the travelers' most recent air trip, across the four airports. Data show no noticeable difference between the mode share use in the outbound and return trip. The most used mode of ground transportation for air travelers is the use of private vehicles, while the second is being dropped-off/picked-up by an unpaid driver. The third most common ground transportation mode is ridehailing. Public transit options, such as trains or buses, make up only a small portion of the overall ground transportation used by air travelers, representing less than 3% of reported trips. Travelers who use multiple modes of transportation are between 6 and 7% of the total. These results, not surprisingly, indicate a strong preference for automobile-oriented transportation for passengers at Northern California airports.



**Figure 6. Ground transportation mode(s) used to/from the airport.**

Figure 7 shows the distribution of the survey takers most recent trips by mode and time of the year. For simplicity we divided the year into quarters, where Quarter 1 (Q1) represents January, February, and March, Quarter 2 (Q2) April, May, and June, Quarter 3 (Q3) July, August and September, and Quarter 4 (Q4) October, November, and December. Given that the survey was conducted from December 2022 to March 2023, we anticipated that the flight dates collected would be relatively recent, most covering few months ahead of this timeframe. Results show that traveling with a private vehicle is more popular in Q1 and declines in the other quarters (especially in the outbound trips), while ridehailing tends to go up in Q3 and Q4.

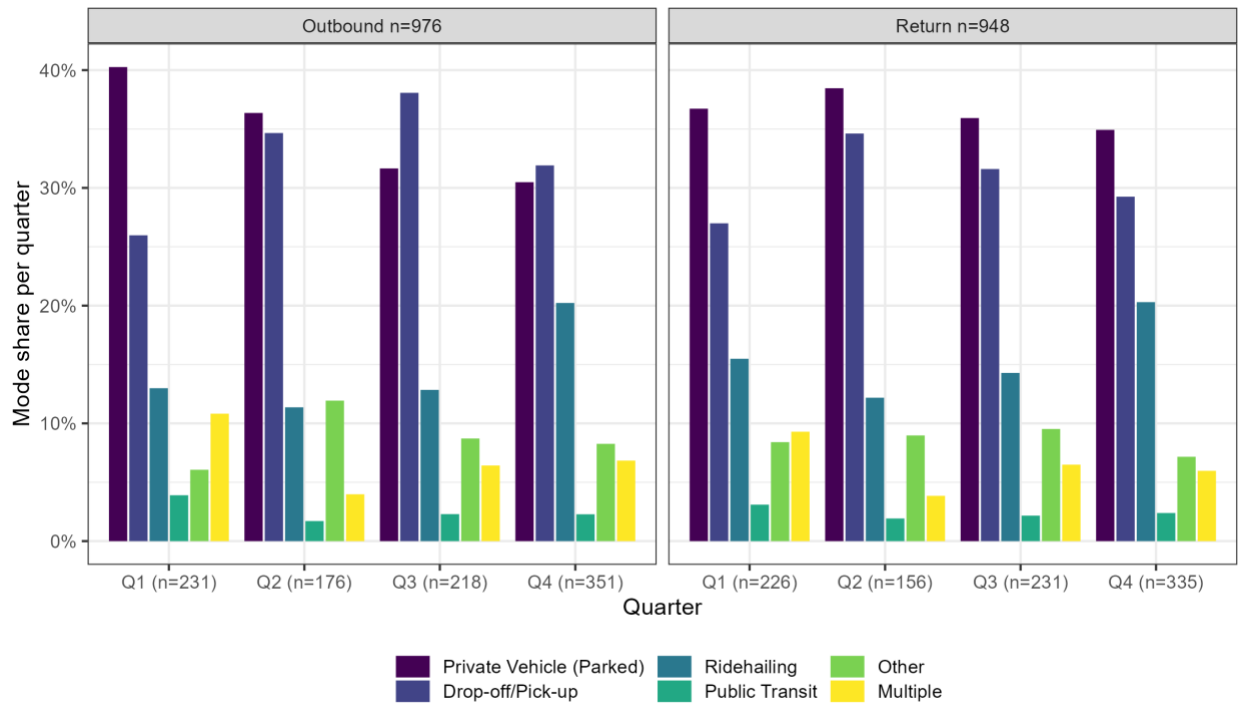


Figure 7. Ground transportation mode(s) vs. time of the year.

Figure 8 illustrates the distribution of the survey takers' latest air trip by day of the week (weekday or weekend), and Figure 9 by time of day of the flight scheduled departure (outbound) and arrival (return) time. The data in Figure 8 revealed that a larger proportion of survey respondents reported taking weekday flights, both for outbound and return trips. Our results are relatively consistent over the modes and day of the week types. Interestingly, we did not find a prior study that explicitly argued the effect of day of the week on the ground transportation choice. However, the lower share of public transit could be explained by sparser timetable of the transit services (e.g., BART departures at SFO featured four trains per 30 minutes in weekdays and only three trains per 30 minutes in weekends as of 02/13/2023 (Bay Area Rapid Transit (BART), 2023)). Also, the higher share of the pick-up option for the return trips in weekends could be because of the time availability of others who pick up the traveler (e.g., family or friends).

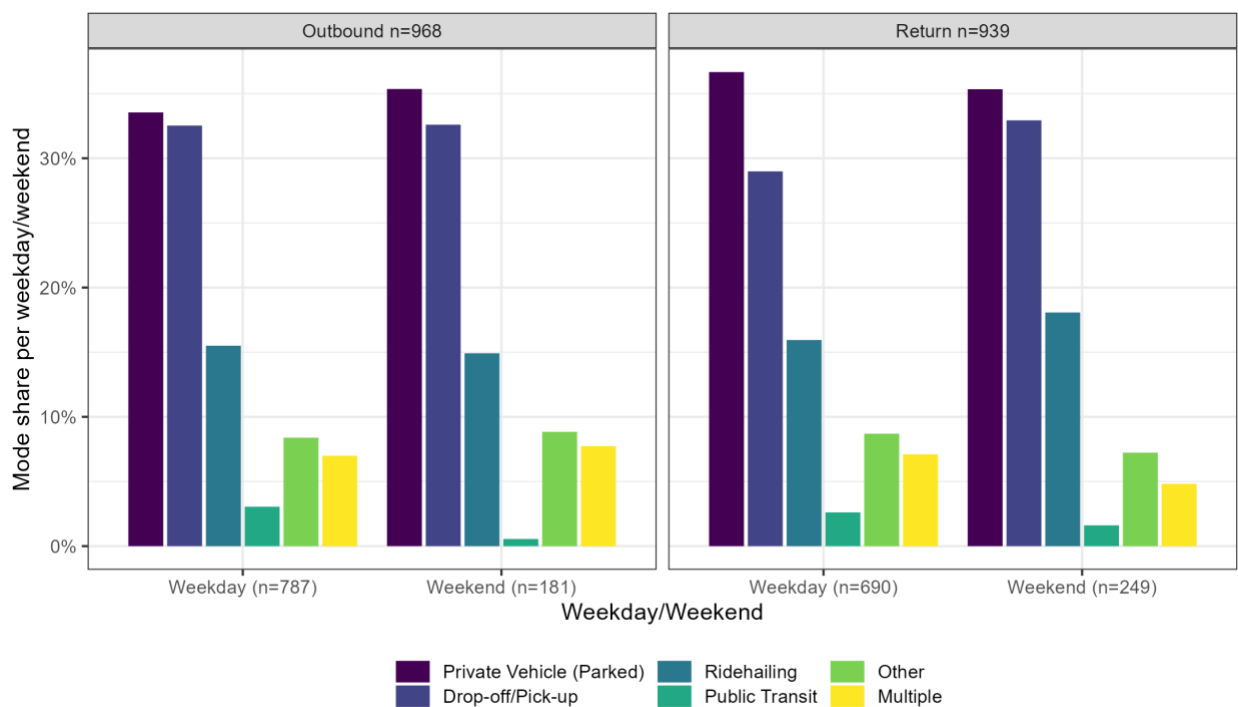
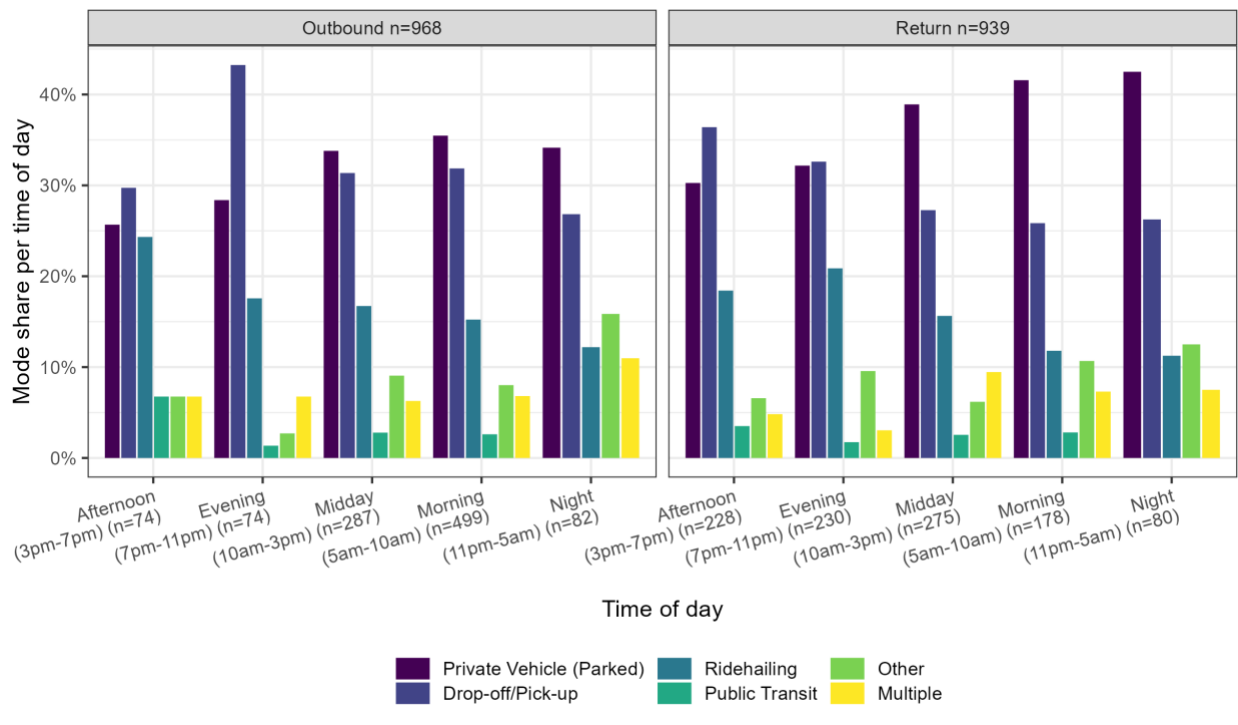


Figure 8. Ground transportation mode(s) vs. day of the week.

In Figure 9 the time distribution throughout the day indicated a significant peak in morning (5am to 10am) flights for outbound trips and a moderate skew towards midday (10am to 3pm), afternoon (3pm to 7pm), and evening (7pm to 11pm) flights for return trips.

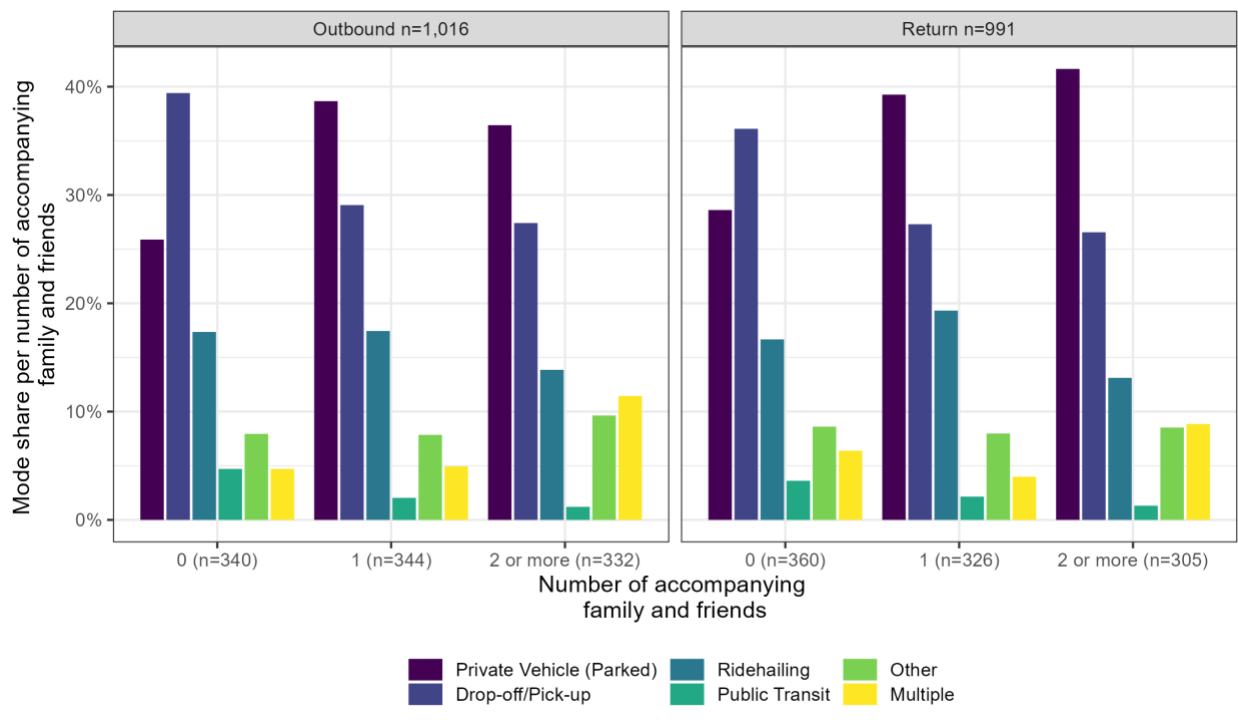
The figure shows that travelers are more inclined to use their own vehicle to reach the airport when they have to catch a late night or early morning flight. It also seems that travelers prefer to have someone else pick them up or drop them off during late night hours, whereas this becomes less popular in the afternoon or evening. This inclination is also noticeable for return flights. In other parts of the day, particularly in the afternoon or evening, travelers are more likely to opt for ridehailing services. Ge et al. (2021) reported that ridehailing use is more popular after 8pm to access the DFW airport (Ge et al., 2021). Although our result showed a peak in earlier time of day for the outbound direction, the result for the return direction is consistent with their indication.



**Figure 9. Ground transportation mode(s) vs. flight departure/arrival time.**

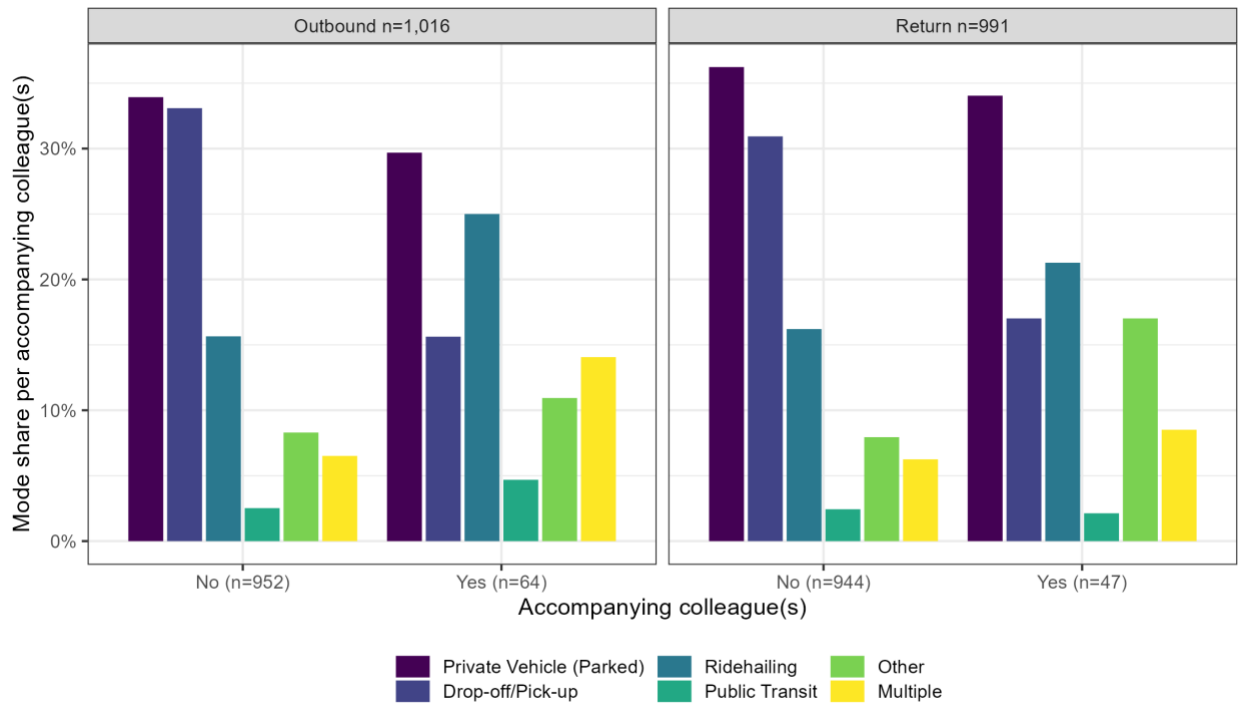
Left: Outbound (departure), Right: Return (arrival). This applies to all following figures until Figure 14.

Based on the data presented in Figure 10, there appears to be a relationship between the number of family members or friends who accompany the survey participant during their entire air travel journey and the use of a private vehicle as transportation mode to/from the airport. Specifically, a higher number of co-travelers is associated with a higher use of a private vehicle and a lower use of ridehailing services or being dropped off and picked up. This might be due to the convenience and comfort of using a private vehicle with more passengers such as family members and the reduced cost per person for the parking. Interestingly, the data shows that multimodal ground transportation approach to/from the airport becomes more common with more co-passengers. According to Akar's study of Columbus (2013), travelers with smaller groups are more inclined towards alternative transportation modes rather than driving to the John Glenn Columbus International (CMH) airport. However, our findings do not provide a confirmation of this relationship (Akar, 2013). Overall, most trips involve either no co-travelers or a maximum of one co-traveler from friends or family.



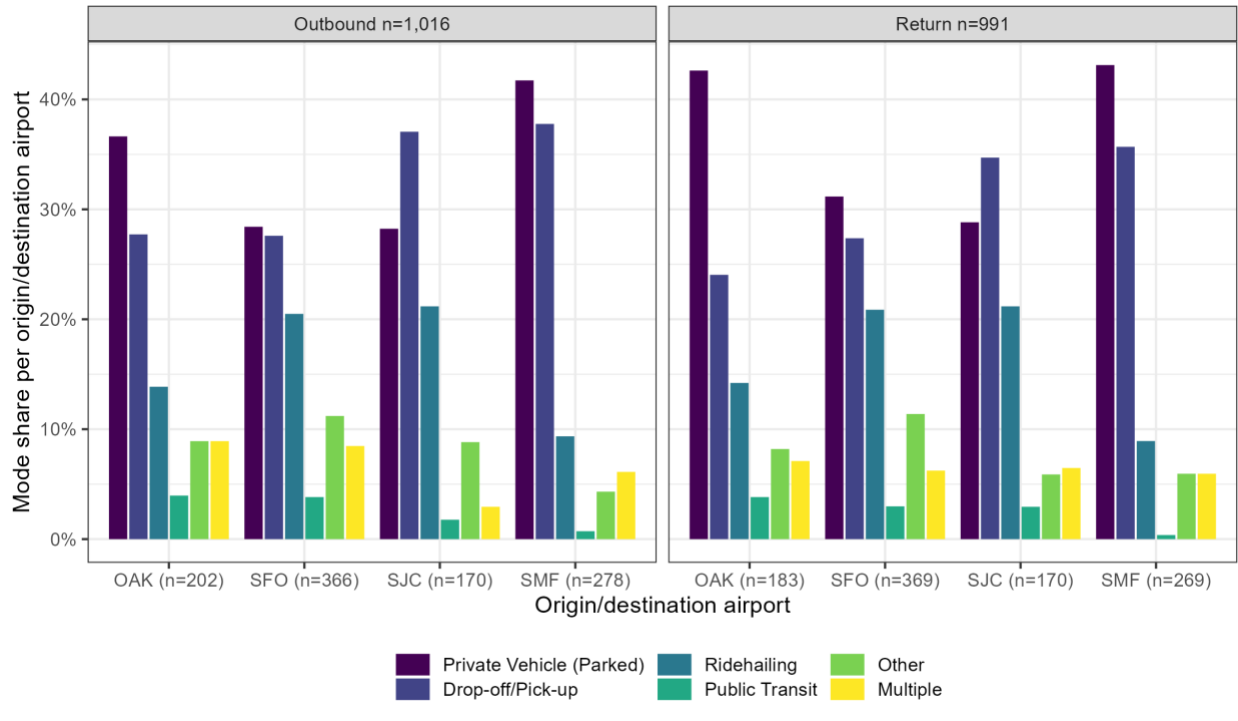
**Figure 10. Ground transportation mode(s) vs. number of accompanying family and friends.**

The data presented in Figure 11 indicate that there were very few instances in which the survey respondents were accompanied by (work) colleagues during their trips. Among these trips, it seems that they are more likely to use private car or ridehailing services, other transportation modes such as being picked up or dropped off, shuttle services, or multiple modes. Assuming that the comparison between two groups—those traveling with colleagues or not—highlights that for non-business and business travelers, the use of private vehicle modes is consistent with the result by Akar (2013).



**Figure 11. Ground transportation mode(s) vs. number of accompanying colleagues.**

According to the data presented in Figure 12, ridehailing appears to be a more popular transportation option to and from SFO and SJC airports than those to and from the other airports, while driving one's own car is more common for OAK and SMF airports. Additionally, being picked up and dropped off seems to be more popular among travelers using SJC and SMF airports. To the best of our knowledge, there have been no public surveys attempted to collect mode-choice information including the option of ridehailing in the four listed airports concurrently. Our dataset will help studies investigate the ground transportation mode choice behavior to/from airports in the Northern California region.



**Figure 12. Ground transportation mode(s) vs. origin/destination airport.**

According to the information presented in Figure 13 there appears to be a correlation between the number of checked bags and the use of a private car for transportation to/from the airport, as well as the lower probability of being picked up or dropped off or using ridehailing services. The likelihood of using public transit declines as the number of check-in bags increases. This is an intuitive result, as air travelers face increasing challenges when handling multiple pieces of luggage at transit facilities. Harvey (1986) also indicated that carrying extra luggage significantly diminishes the appeal of transit as a mode of ground transportation to SFO, OAK, and SJC (Harvey, 1986). Interestingly, our data also suggest that a higher number of checked bags is often associated with the use of multiple modes of ground transportation to and from the airport.

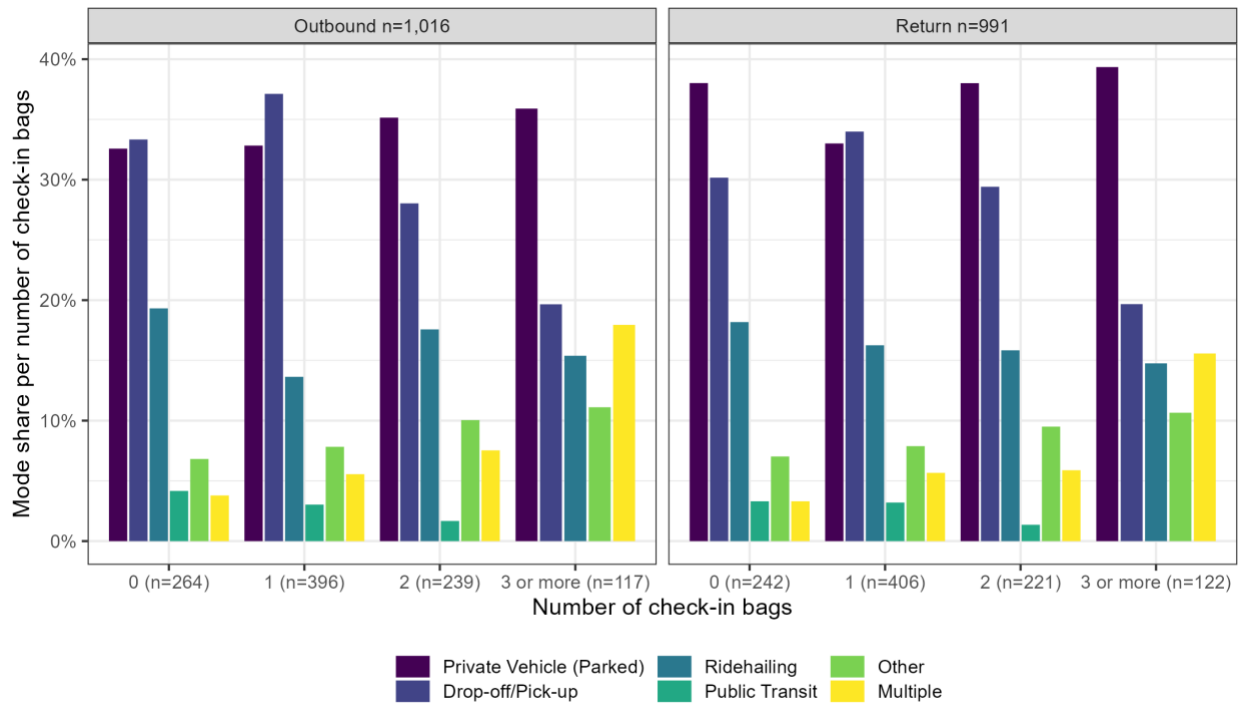


Figure 13. Ground transportation mode(s) vs. number of check-in bags.



The data presented in Figure 14 support the findings in Figure 13 regarding checked bags, indicating that also as the number of carry-on bags increases travelers are more likely to opt for private transportation options instead of being driven by someone else, using ridehailing services, or other forms of transportation to and from the airport. This is a reasonable outcome, as travelers with a significant amount of luggage would require a door-to-door transportation mode or more space, such as that provided by a private vehicle. Similarly to Figure 13, the data also suggests that as the number of bags increases, there is a higher probability of using multiple modes of ground transportation to and from the airport.

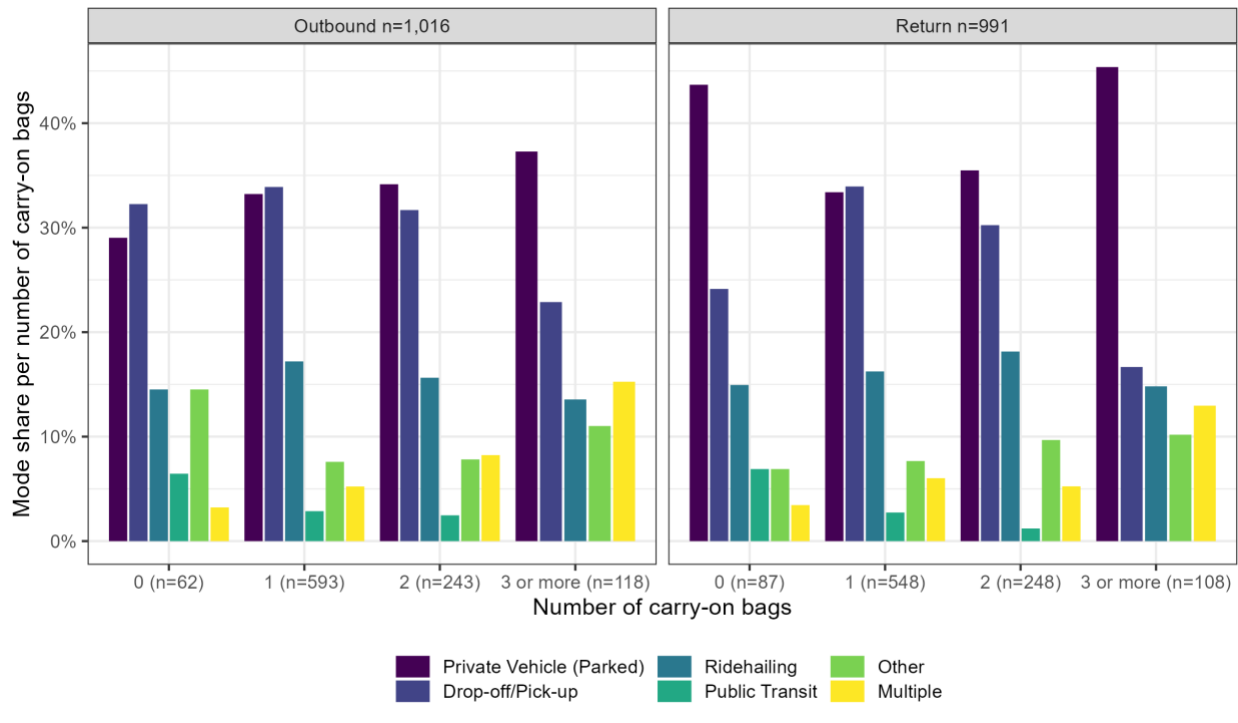


Figure 14. Ground transportation mode(s) vs. number of carry-on bags.

## Analysis of Air Travelers' Opinions of Ground Transportation Modes to/from the Airport and Airport Facilities

In this section, we focus on the survey questions that sought to gather the following opinions of air travelers regarding the ground transportation services to and from the airport, as well as the airport facilities:

- *Availability*: “How likely do you find the service/facility available for immediate use?”
- *Ease of use*: “How easy is it for you to use the service/facility?”
- *Accessibility*: “How easy is it for you to physically access the service/facility (e.g., in close proximity from your home and the airport terminal)?”
- *Affordability*: “How affordable is the service/facility?”
- *Cleanliness*: “How clean is the service/facility?”

To our best knowledge, this survey project uniquely attempted to collect these types of perceptions of the travelers flying to/from these four airports. Although prior studies indicated that the perception or satisfaction regarding the transportation modes (e.g., Tam et al. (2010) (Tam et al., 2010)), we aimed to reveal the influence of their perception regarding the transportation infrastructure bound to the airport.

### *Air Travelers' Opinions on Ridehailing Service*

Figure 15 displays the collective feedback of air travelers regarding the ridehailing as a service to/from the airport. In general, travelers seem to be satisfied with the use of ride-hailing services. While there is not much variation in evaluations across the airports, it appears that travelers at OAK and SJC have slightly higher evaluations of the accessibility of pick-up locations. The accessibility of drop-off locations is rated the lowest, suggesting that travelers might be more sensitive to the distance or accessibility between the drop-off point and the terminal. They could become more anxious when rushing to catch a flight compared to when they are seeking a ride back home.

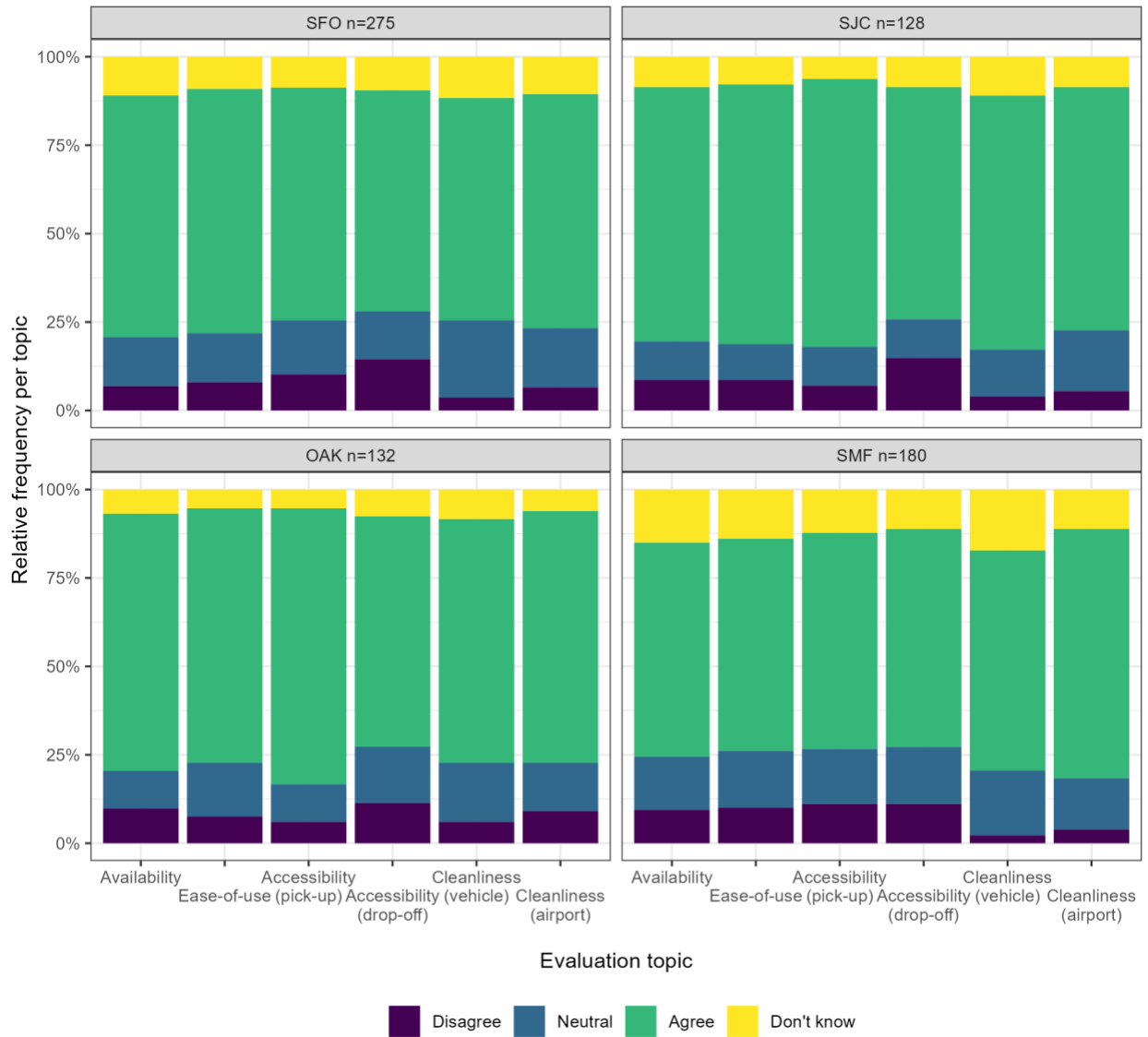


Figure 15. Opinions on ridehailing services to/from the airport.

## Air Travelers' Opinions on Parking Facilities

Survey takers evaluated the parking facilities of the airports. Results in Figure 16 highlight a dissatisfaction on the affordability of car parking, particularly at SFO, followed by SJC and SMF. As shown in Table 3, the parking cost is the most expensive at SFO for both domestic/daily and long-term/economy parking, which would result in the observed dissatisfaction among travelers. Note that, however, we have used quota for sample collection based on the population of the 21 counties in Northern California, which may not necessarily reflect the population of SFO users who could be overall wealthier and would not complain about the parking cost. Still, this result implies an equity issue for low-income travelers.

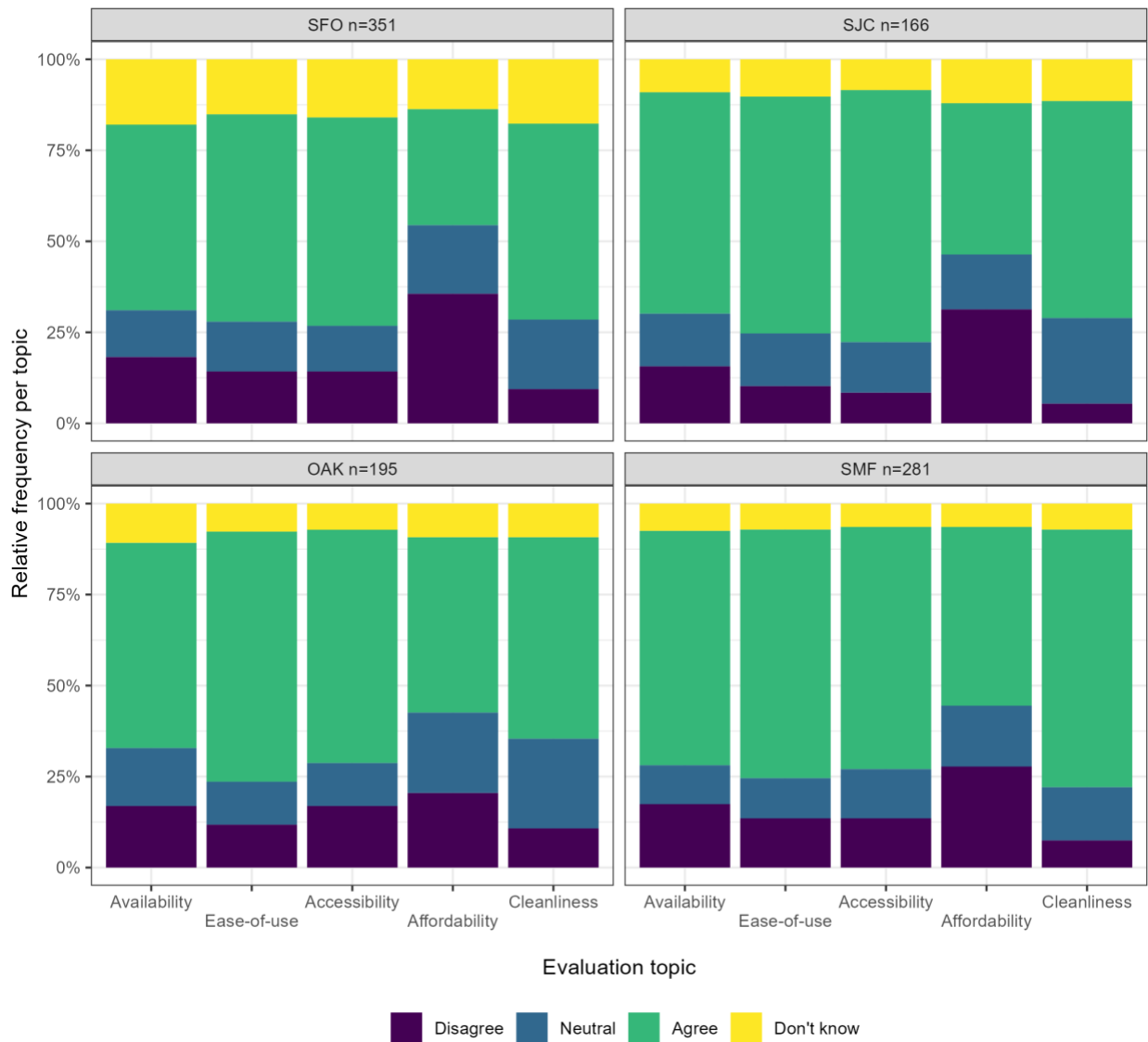


Figure 16. Opinions on the airport parking lot facilities.

**Table 3. Cost of parking lot use at each of the airports.**

Data from official websites (Oakland International Airport, n.d.; Sacramento County, n.d.; San Francisco International Airport, n.d.; San José Mineta International Airport, n.d.)

<b>Airport</b>	<b>Domestic / Daily</b>	<b>Long-term / Economy</b>
SFO	Up to 36 USD per 24 hours	Up to 25 USD per 24 hours
SJC	Up to 30 USD per day	18 USD per day
OAK	Up to 26 USD per 24 hours	Up to 18 USD per 24 hours
SMF	Up to 19 USD per day	Up to 11 USD day

### *Air Travelers' Opinions on Bus Services*

Although bus services were not a popular choice among air travelers for transportation to and from the airport, according to Figure 17, those who did use this service generally had a more favorable impression of it, or at the very least, did not have a negative one. Approximately 50-70% of individuals sampled at each airport expressed positive feedback regarding bus services' affordability. Especially OAK travelers displayed a high level of satisfaction. Additionally, travelers especially at SJC seem satisfied with the ease-of-use. This is a strong indication of a self-selection effect of air travelers who used a bus service to or from airport. In other words, encouraging travelers to try public transit services once may lead to a high retention rate of the use.

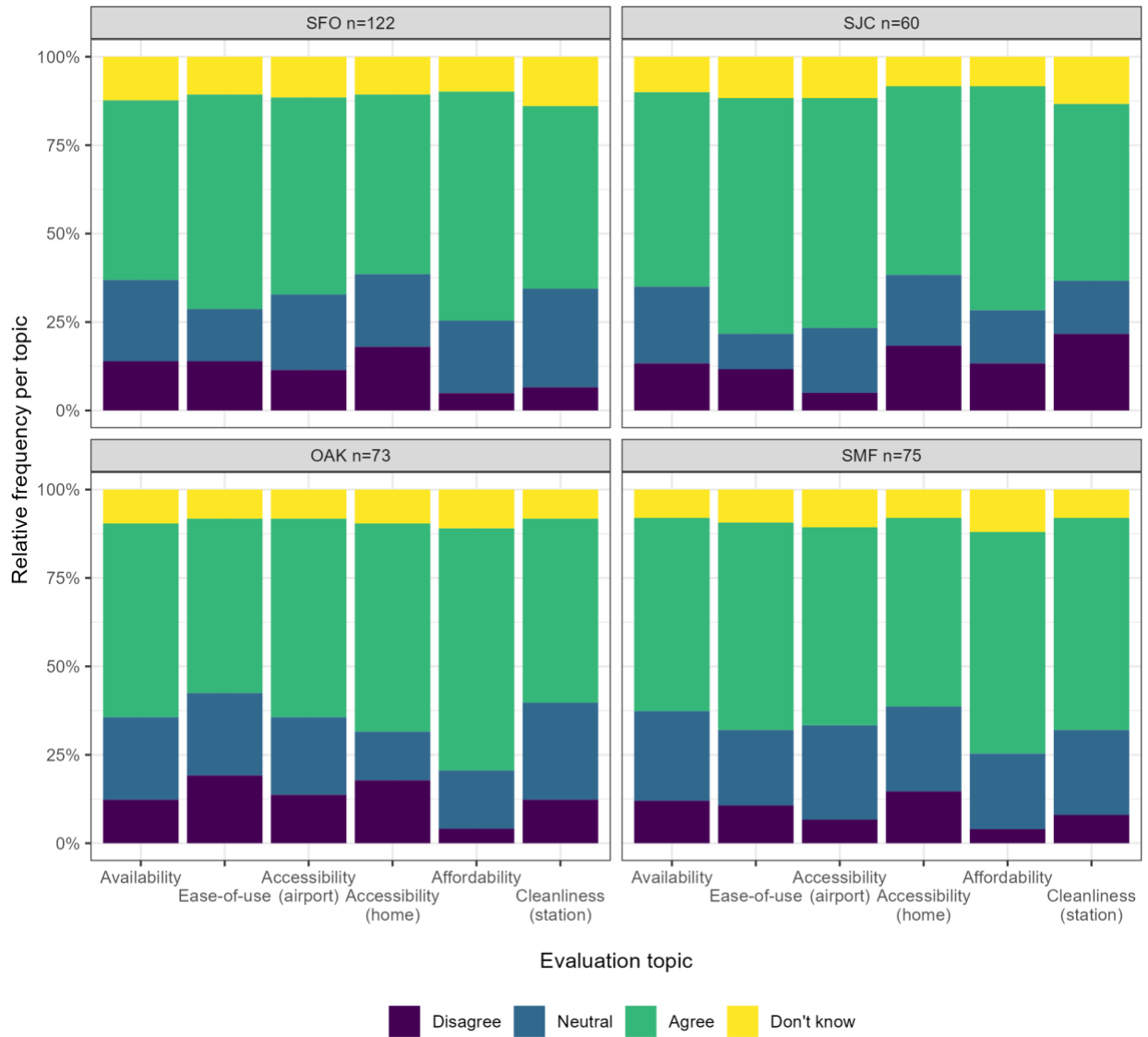


Figure 17. Opinions on the bus services to/from the airport.

### Air Travelers' Opinions on Rail Services

At present, there are no train transportation options available for travel to or from the SMF airport and therefore Figure 18 shows only the opinions about the rail-related topics at the other three airports. Figure 18 shows that the primary obstacle to choosing train services appears to be accessibility from home. Accessibility at the airport and ease of use appear to be an issue at the SJC airport. In addition, the perceived lack of cleanliness is also hindering air travelers' willingness to use rail services.

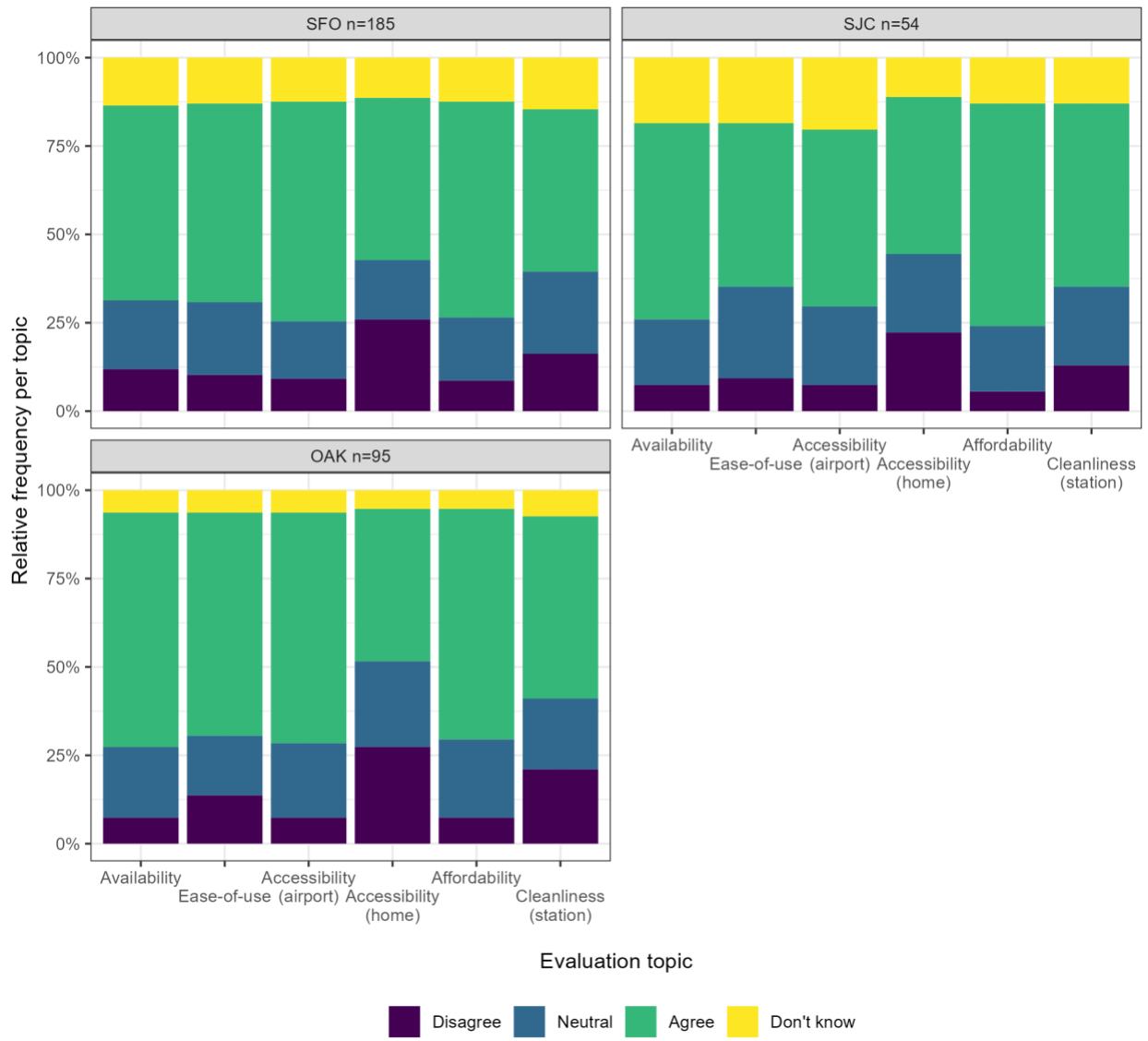


Figure 18. Opinions on the rail services to/from the airport.

## Conclusions

This study was based on the design, administration and analysis of data collected with a revealed preference travel survey administered between December 2022 and March 2023. The study focuses on the factors that influence air travelers' ground transportation mode choice to/from four major airports in Northern California—San Francisco International Airport (SFO), Norman Y. Mineta San Jose International Airport (SJC), Metropolitan Oakland International Airport (OAK), or Sacramento International Airport (SMF)—during their most recent trips.

The analysis produced several insights that could help transit agencies and airport authorities in improving services and facilities to travel to/from the airport via better planning, new sets of regulations to promote public transit services for air travel, and/or a better management of ridehailing pick-up/drop-off locations at the airport.

The investigation shows that ground transportation to and from OAK, SFO, SJC, and SMF airports is largely car-dominated; private vehicles are by far the most popular option to/from airports (35%), followed by having someone else (e.g., a family member or friend) to pick up or drop off the air traveler (31%), and ridehailing (e.g., Uber and Lyft) with 16% of the respondents. Public transit (3%) or multimodal travel (7%) to/from the airport are the least popular options.

Survey participants, overall, rated relatively high the parking lot facility at the airports in terms of availability, ease-of-use, and accessibility. Yet satisfaction level with affordability—parking fee—is much lower than the other evaluation topics. This indicates that many air travelers are unsatisfied with the cost associated with traveling with their private vehicle but still choose it for other reasons. As our survey did not dive into asking the underlying reasons among the use of private vehicles, future studies may aim to identify them by developing a set of stated-preference questions regarding various factors around using a private vehicle vs. other options to be used as an airport ground transportation means.

Raising parking fees could potentially serve as a future policy implementation to discourage solo driving to and from the airport. However, it is unclear if shifting travelers from driving to using other modes (e.g., ridehailing) would lead to desirable results in terms of vehicle-miles traveled (VMT). If someone travels with a private vehicle, driven by themselves, the total VMT generated by the airport ground access will be smaller than using a single-user ridehailing service by the amount equal to deadheading. Meanwhile, if they ask their family to drive them from their home, the vehicle needs to go back to the home, resulting in the VMT doubling from that with a private vehicle driven by themselves. These are all relevant and important questions for further investigation; however, they lie beyond the scope of this project.

Lastly, the cleanliness of the airport facilities was, on average, not badly evaluated by air travelers overall. This indicates that the airport authorities' efforts in sanitization and maintenance on its transportation infrastructure effectively work. Since this specific question was designed to capture public health concerns in the context of the COVID-19 pandemic,



future studies might want to continue to monitor whether this trends will maintain or not, though the attention on the topic will likely decline with the end of the pandemic.

A potential key factor that may need to be improved to increase the utilization of public transit is the accessibility. The evaluation of the accessibility of the bus/rail station near travelers' homes is considerably worse than other factors, which suggests that the primary barrier to using public transit to/from the airports is the distance between their home—often the origin/final destination of the travel journey—and the nearest bus/rail station. This is understandable since air travelers tend to carry a larger amount of luggage. A potential future policy would be to provide first and last mile services (e.g., ridehailing) to travelers in a bundled package so that they can use public transit as the main means to/from the airport, though the additional transfer is also found to be an unpopular feature affecting transportation mode choice. Future research may investigate if air travelers may be willing to opt out of car travel for the whole transportation to/from the airport in favor of a multimodal option if smoother transfers and fare integration are offered.

Finally, we highlight some limitations of the research presented in this report. First, in this report we included only basic descriptive statistics. More complex investigations of cause and effect relationships of the factors that affect air travelers' mode choice to/from the airport will be carried out in future phases of the study. This research could also be enriched by running a new stated preference survey and present air travelers with hypothetical scenarios and alternative options to capture individuals' relative importance they assign to different attributes or factors that affect their airport ground transportation mode choice. This will allow evaluating trade-offs and understanding how travelers weigh different factors when making choices. Further, our study region was limited to the counties in the Northern California area due to the limitations in sample recruitment. The survey project was initially planned to be administered in various airports across the United States, including some from the East Coast but the data collection was postponed due to the COVID-19 pandemic. The study could be further expanded to other airports in future extensions of the research.

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## Data Summary

### Products of Research

The data were collected using an online survey designed by the authors and that was administered through an online opinion panel between December 2022 and March 2023. The final dataset contains responses from 1,038 travelers. We used a quota sampling approach to recruit respondents from the 21 Northern California counties -- Alameda, Contra Costa, Marin, Napa, Solano, Sonoma, San Mateo, San Francisco, Santa Clara, El Dorado, Placer, Sacramento, Sutter, Yolo, Yuba, Merced, San Joaquin, Stanislaus, Monterey, San Benito, and Santa Cruz -- that have used at least one of the four airports in the Northern California megaregion. Sociodemographic targets were used to mirror the distribution of the characteristics of the population in the region of study.

The survey collected information on the participants' socio-demographic characteristics, their attitudes toward various transportation-related statements, their retrospective travel behavior during their last air trip, and their opinion about the current transportation infrastructure at the airport and transportation services on their way to the airport.

### Data Format and Content

The data file is available in a .sav file from the SPSS system.

Database: Each row represents a single survey respondent with a unique ID number assigned, and each column corresponds to one variable.

### Data Access and Sharing

The final data from this project is subject to the UC Davis Institutional Review Board (IRB) guidelines on the treatment of human subject data. A version of the dataset with no personal identifiable information (PII) is available online through the Dryad data repository.

### Reuse and Redistribution

The final data from this project is subject to the UC Davis Institutional Review Board (IRB) guidelines on the treatment of human subject data. A version of the dataset with no personal identifiable information (PII) is available online through the Dryad data repository. Data can be reused and redistributed with credit to this report and the authors of the research and to the funding agency that funded the original data collection.

Suggested citation for the data:

Makino, Keita; Compostella, Junia; Lee, Yongsung; Circella, Giovanni (2024). Dataset of air travelers' ground transportation choice at four airports in Northern California [Dataset]. Dryad. <https://doi.org/10.5061/dryad.vhhmgqp3p>