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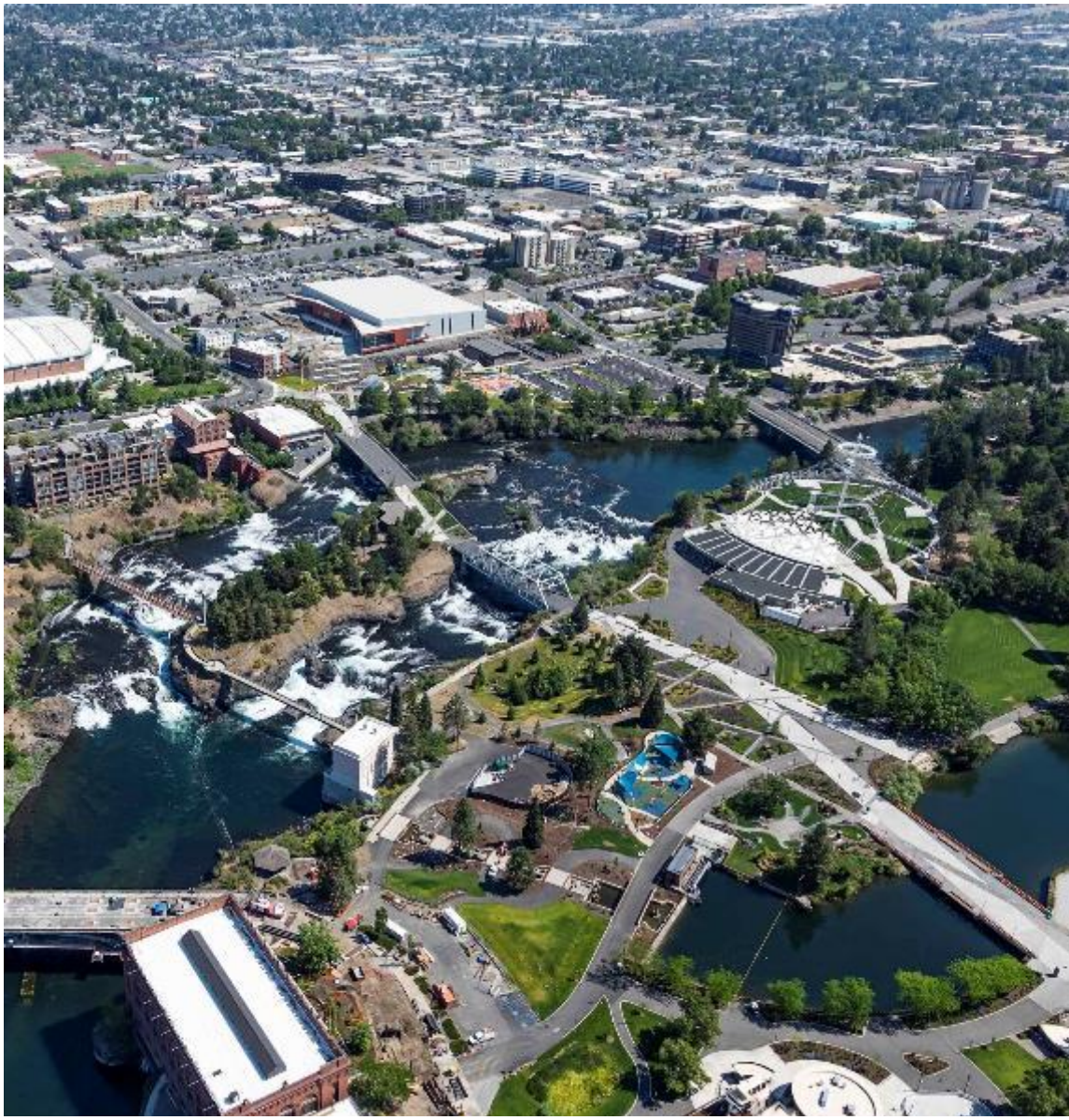
# 2022 SPOKANE REGIONAL TRANSPORTATION STUDY: FINAL REPORT



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2022 Spokane Regional Transportation Study: Final Report

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**Report Prepared for**:

Spokane Regional Transportation Council (SRTC)

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| | |
|---|---|
| ABS | Address-based sample |
| ACS | American Community Survey |
| BIPOC | Black, Indigenous, or Persons of Color |
| HH | Household |
| HTS | Household travel survey |
| SRTC | Spokane Regional Transportation Council |

# 1.0 EXECUTIVE SUMMARY

## 1.1 STUDY OBJECTIVES AND HIGHLIGHTS

The 2022 Spokane Regional Transportation Study used a modern research approach to collect demographic and travel pattern information from residents throughout Spokane County in Washington State.

The highlights of this innovative approach include the following:

- **A two-part study**:
  - Part one (the “recruit survey”) gathered data on the household’s demographic composition and typical travel behaviors.
  - Part two (the “travel diary”) gathered individual travel data during a specified travel period for all members of the household (HH).
- **Multiple modes of data collection**:
  - Households with smartphones had the option to complete their travel diaries using the rMove™ smartphone app for up to seven consecutive days.
  - Households without smartphones (or who preferred not to use smartphones) participated by completing their travel diary online (rMove for Web) or by calling into the survey call center. These households reported travel for one day (Tuesday, Wednesday, or Thursday).
- **An address-based sample (ABS) and mailed survey invitations**:
  - The study used address-based sampling (ABS) to select households for participation. ABS involves drawing a random sample of addresses from all residential addresses in that area. Using this probability-based method, all households within each defined area have an equal chance of selection for the sample. This approach improves confidence the weighted data results.
  - The ABS included compensatory and targeted oversampling to improve the representativeness and quality of the final dataset. Compensatory oversampling focused on low-income households and higher minority populations areas. Targeted oversampling focus on persons who were more likely to use active transportation and transit modes.
  - Invited households received a letter packet with comprehensive details about the survey and a “reminder” postcard over the course of approximately two weeks.

- **Aligned questionnaires**:
  - The smartphone-based (rMove) and online-based (rMove for Web) questionnaires were largely consistent to ensure a single, consistent dataset at the end of the survey.
  - The questionnaire for both instruments was tailored to account for COVID-19 impacts (e.g., asking both current and previous commute details).
- **Advanced technologies and methods**:
  - The rMove app was the primary mode for travel data collection, which offered significant benefits for data quality and quantity (e.g., detailed trip paths, and lower degrees of underreporting).
  - The Bing Maps API helped capture and validate location and travel data.
  - The survey employed American Community Survey (ACS) data, along with RSG's market research experience and expertise, to develop the sampling plans and data weighting approaches.
- **Minimized respondent burden and increased engagement**:
  - The survey offered gift card incentives to households that completed the survey to improve the response rates (and thereby lower the overall mailing costs) and representativeness of the dataset.
  - Survey respondents received customized reminders by email, telephone, or within the rMove smartphone app to encourage survey completion.
  - Survey respondents could also contact user support by telephone, email, or within the rMove smartphone app. Responses were generally provided within one business day.
  - The survey branding included an engaging logo and customized website to legitimize the survey and encourage responses.

### *Study Timeline*

Table 1 documents the project's schedule. RSG and SRTC conducted a small pretest to evaluate user experience in lieu of conducting a full pilot survey. This approach was designed to maximize the number of households and quality of data collected during the main survey.

**TABLE 1: STUDY TIMELINE**

| Phase | Timeline |
|---|---|
| Design the study approach and questionnaire | August – October 2021 |
| Create the sample plan, invitations, and outreach plan | September – November 2021 |
| Program survey instruments | October – November 2021 |
| SRTC test survey instruments | November – December 2022 |
| Conduct household travel survey | February – April 2022 |
| Clean and weight survey data | April – July 2022 |
| Finalize study documentation | August – October 2022 |
| Project closure | December 2022 |

## 1.2 STUDY RESULTS

The Spokane Regional Transportation Study collected a rich set of demographic and travel behavior data from a representative sample of 1,953 households in the Spokane Regional Transportation Council (SRTC) planning area. The study collected data from 3,879 persons, representing 34,627 trips across 9,397 complete person-days from February 10 to April 5, 2022.

**TABLE 2: RESULTS OVERVIEW[1]**

| | | |
|---|---|---|
|  | Households Surveyed<br>**1,953** | Weighted Households<br>**202,850** |
|  | Persons Surveyed<br>**3,879** | Weighted Persons<br>**494,540** |
|  | Complete Person-Days<br>**9,397** | Weighted Person-Days<br>**462,931** |

While the weighted households and persons have increased since the 2005 HTS[2], which represented 182,816 households and 397,437 persons, many of the characteristics have remained similar. For instance, the number of persons per household has remained 2.43. The

[1] After the survey data was collected, RSG weighted the data to represent the demographic and high-level (PUMA-level) geographic distribution of the county. The weighting process is described further in Section 7.0 below.
[2] Zmud, Johanna. 2005. *Spokane and Kootenai County Regional Travel Survey, Final Report.*

number of workers per household has decreased slightly from 1.21 in 2005 to 1.16 in 2022. The number of vehicles per household has also decreased slightly from 2.09 in 2005 to 1.97 in 2022. Additional comparisons to the 2005 survey are included throughout the remainder of the report where comparable data is available in the 2005 survey report.

**Key 2022 study findings include the following:**

- The overall trip rate for the region was 3.83 person trips per day. Most of those trips (3.32) were made by car. The 2005 HTS reported a trip rate of 4.4 trips per day, though these only included respondents aged 16 and older (whereas the 2022 trip rate includes all persons).[3] Filtering out respondents under age 16, the 2022 trip rate for those 16 and over was 4.4, the same as the trip rate reported in 2005.
- The median distance for car trips was 3.0 miles, and 2.6 miles for transit trips, though the median duration for car trips was 11 minutes compared to 15 minutes for transit trips. The longest trips by distance include work related trips (2.9 miles), work (3.2 miles), and overnight trips (3.3 miles), while the shortest trips by distance are school related trips (0.7 miles).
- Among those who travel to workplaces, the distribution of commute modes changed very little from before March 2020 to spring 2022.
- There has been little change in the distribution of modes used to commute to work among those who travel to a workplace. Eighty-nine percent (89%) of workers commuted by car before March 2020, compared with 90% who commuted by car in spring 2022. Before March 2020, five percent (5%) of workers commuted using transit, compared to four percent (4%) in spring 2022, suggesting a slightly increased preference for car as a commute mode since March 2020.
- There was an increase in the frequency of teleworking between March 2020 to spring 2022. Twenty-three percent (23%) of respondents reported teleworking 4 or more days a week, while 18% of respondents reported teleworking before March 2020. Over the same period, the percent of workers who never telecommute has dropped from 62% to 57%, suggesting that these workers now telecommute 4 or more days a week.
- All income groups have similar trip rates though those with incomes below $25,000 and within $50,000 - $74,999 have the highest trip rates at 4.1 and 4.3 trips per day, respectively. In 2005, trip rates generally increased with higher reported incomes, with the lowest trip rates reported for those reporting household incomes less than $49,999[4].

[3] NuStats. 2005. *Spokane and Kootenai County Regional Travel Survey, Final Report.*
[4] NuStats. 2005. *Spokane and Kootenai County Regional Travel Survey, Final Report.*

- Seven percent (7%) of respondents have ridden an STA bus within the last month, though 82% have never ridden an STA bus. Those reporting incomes less than $25,000 and adults aged 18-34 are slightly more likely to use transit and to walk.
- Affordability was the most common factor in residents choosing where they currently live (77%), followed by commuting distance to work (46%), and access to outdoor recreation and local parks (44%).

A full analysis of results is included in Section 8.0.

# 2.0 STUDY SAMPLING

## 2.1 SAMPLING GOALS

The 2022 study originally aimed to collect data from 1,500 households, resulting in a 0.7% target sample rate (based on the 2015–2019 ACS). The study collected data from 1,953 households (1.0% sample sate), surpassing the target by approximately 30%.

### Sampling Frame and Method

The sampling frame for this study was the list of all households in Spokane County, Washington. The study used ABS to select households for participation. ABS involves drawing a random sample of addresses from all residential addresses in that area. Using this probability-based method, all households within each defined area have an equal chance of selection for the sample. Using probability-based sampling also allows for greater confidence in the final weighted results. RSG purchased household mailing addresses from Marketing Systems Group, which maintains the Computer Delivery Sequence file from the US Postal Service. RSG stratified the sample using census block group data from the 2015–2019 ACS (the latest available at the time of sampling).

### Sample Stratification/Segmentation

The study used the following mutually exclusive and collectively exhaustive sample segments, which were intended to ensure representation of groups that are typically hard to reach and provide a larger sample of groups of particular interest.

1) **General population:** Comprised of census block groups in the study region that do not qualify for oversampling segments below.
2) **Hard-to-survey Oversample:** Comprised of the census block groups in the sample frame with at least 50% of households earning less than $25,000 per year (“low income“) and / or at least 40% of the households identified as Hispanic and/or Black, Indigenous, or Persons of Color (BIPOC).
3) **Walk/Bike/Transit Oversample:** Comprised of census block groups in the sample frame that have at least 15% households reporting walk, bicycle, or public transportation as the means of transportation to work.

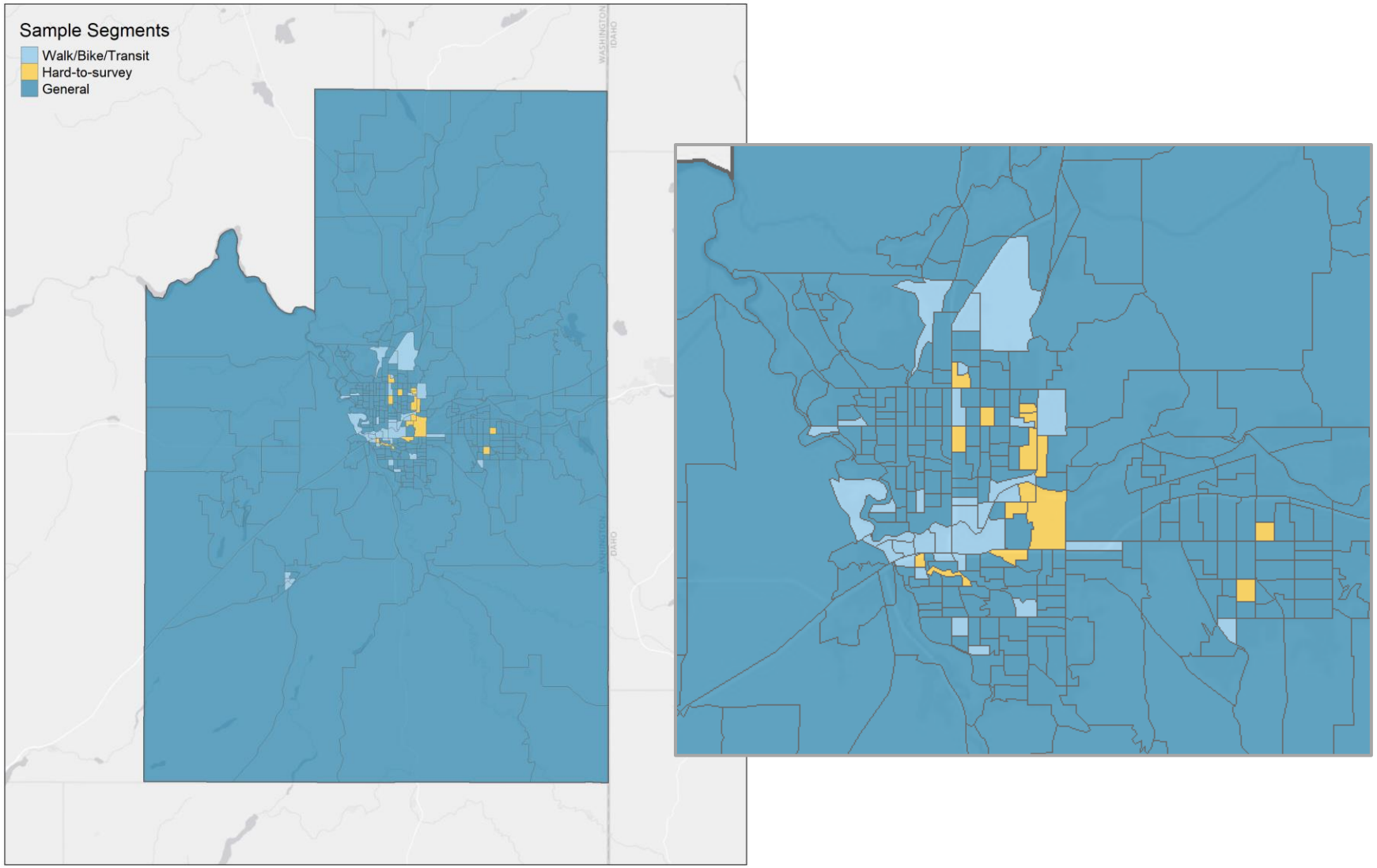
Block groups that qualified for both the Hard-to-survey and Walk/Bike/Transit segments were classified as Walk/Bike/Transit. The households in persons in the region by sample group are listed below.

**TABLE 3: STUDY REGION HOUSEHOLDS AND PERSONS, BY SAMPLE GROUP**

| SAMPLE SEGMENT | CENSUS BLOCK GROUPS | TOTAL HOUSEHOLDS | TOTAL ADULTS | ADULTS PER HOUSEHOLD |
|---|---|---|---|---|
| Walk/Bike/Transit | 36 | 18,228 | 36,727 | 2.01 |
| Hard-to-survey | 15 | 7,354 | 12,728 | 1.73 |
| General | 271 | 177,229 | 343,722 | 1.94 |
| **Total** | **322** | **202,811** | **393,177** | **1.94** |

Figure 1 below shows the geographic locations of the oversample regions.

**FIGURE 1: SAMPLE AND OVERSAMPLE REGIONS (WITH ZOOMED IN CITY OF SPOKANE)**



## Sample Rates

The resulting sample rates based on the segments, invitations, and response rates described above are delineated in Table 4 below. The total target sample rate of 0.7% was consistent with typical sample rates seen in many similar household travel survey regions (which generally range from about 0.5% - 1.0%). Ultimately, the study achieved a 1.0% sample rate.

**TABLE 4: EXPECTED SAMPLE RATES BY SAMPLE SEGMENT**

| SAMPLE SEGMENT | TOTAL HOUSEHOLDS | INVITATIONS | INVITATION RATE | ESTIMATED COMPLETED HOUSEHOLDS | SAMPLE RATE |
|---|---|---|---|---|---|
| Walk/Bike/Transit | 18,228 | 10,645 | 58.4% | 202 | 1.1% |
| Hard-to-survey | 7,354 | 3,865 | 52.6% | 54 | 0.7% |
| General | 177,229 | 65,490 | 37.0% | 1,244 | 0.7% |
| **Total** | **202,811** | **80,000** | **39.4%** | **1,500** | **0.7%** |

Section 8.2 below contain a more detailed evaluation of how the sample plan performed in practice.

# MEMO

## 3.0 SURVEY DESIGN

### 3.1 OVERVIEW

The 2022 study combined multiple data collection methods, including smartphone, online, and telephone. While 53% of households completed their travel diaries by smartphone, 91% of all trips were collected by smartphone due to the extended travel period from the smartphone app (up to 7 days) compared with the single-day online reporting. The survey design included two stages to recruit and collect data about households, their members, and their travel behaviors during the assigned travel period.

### 3.2 QUESTIONNAIRE & COVID-19 ADJUSTMENTS

The questionnaire for this study (provided separately) aligned closely with the household travel survey questionnaires for other agencies in Washington over the past several years, including the Whatcom Council of Governments, Skagit Council of Governments, and the Puget Sound Regional Council. RSG and SRTC also developed several region-specific questions to include in the survey, such as when residents last rode an STA bus.

### 3.3 STUDY STAGES AND PARTICIPATION METHODS

This study used an ABS approach with mailed recruitment materials (shown in Section 4.0). The mailed materials instructed households to visit the study website or call a toll-free number to complete Part 1 (the demographic “recruit” survey). Households received instructions for Part 2 (the travel diary) shortly after completing Part 1.

#### Participation Group Assignments

Part 1 of the study asked adults (age 18+) to share whether they had Apple or Android smartphones. Households in which all adults had Apple or Android smartphones were offered the option to report their travel in the rMove app for seven consecutive days. All other households as well as those who opted out of rMove app participation reported their travel online for one day using rMove for Web.

#### Travel Date Assignments

rMove app households were assigned to a seven-day travel period beginning 1 – 4 days after completing part 1 (depending on household size and the day on which they completed Part 1).

rMove for Web households were assigned to the next Tuesday, Wednesday, or Thursday (assigned roughly proportionally across each of the three weekdays).

## Study Components

Part 1 collected general demographic information (e.g., household size and person age) and established information to facilitate Part 2 (e.g., home/school/work addresses and number of vehicles). Part 2 collected all trip and travel day information and any person-level information (e.g., how often the participant uses transit).

## Proxy Reporting for Child Trips

Among rMove households, only adults related to the main respondent were required to use the app on their smartphones. If a child in an rMove household was reported as a travel party member on an adult's trips, the trip was copied to the child's record. One rMove adult in each household was also designated to proxy report travel information for all children (under 18) in the household on a single travel day. This adult was asked to add trips to a child's roster if the child made an independent trip (e.g., riding the bus to school) or made a trip with someone outside of the household (e.g., getting a ride with a friend's parents).

Among online households, one adult (unassigned) was required to complete a full one-day travel diary for the children of the household. Like rMove, adult proxy reporters could copy children's trips from other adults and report new trips that the children made on their own.

## Language Options

The invitation materials for the study were printed in English, Spanish, Russian, Chinese, and Vietnamese. While the surveys themselves were available only in English, respondents could call the study call center to participate (or ask questions) in Spanish, Russian, Chinese, and Vietnamese.

## Survey Incentives

RSG offered $10–$30 gift card incentives—as communicated on the survey mailed materials—to all households that completed the study. Travel surveys offer incentives to boost response rates and the quality of respondent data, and to decrease the overall study cost by reducing the number of mailed invitations. Without incentives, the number of required households to invite increases, and this increased mailing cost is greater than the cost of providing incentives. rMove app households were offered one $20-$30 Visa gift card per adult after all related adults had completed the survey. Online households were offered one $10-$20 Visa gift card per household. Households could also choose to receive no gift card. The gift card amount was dependent on the sampling segment and reported demographic information. Households with incomes below $15,000 or persons reporting non-White race as well as households in the hard-to-reach sampling segment were offered a higher incentive upfront to encourage participation. These populations are often underrepresented in surveys (and thus required additional attention).

# 4.0 STUDY BRANDING, COMMUNICATION, AND ADMINISTRATION

## 4.1 STUDY BRANDING

RSG developed the study branding collaboratively with SRTC to ensure that the design fit the study region. The complete branding package included the study name, logo, color scheme, and font selections. The final 2022 survey logo is shown in Figure 2.

**FIGURE 2: 2022 SURVEY LOGO**

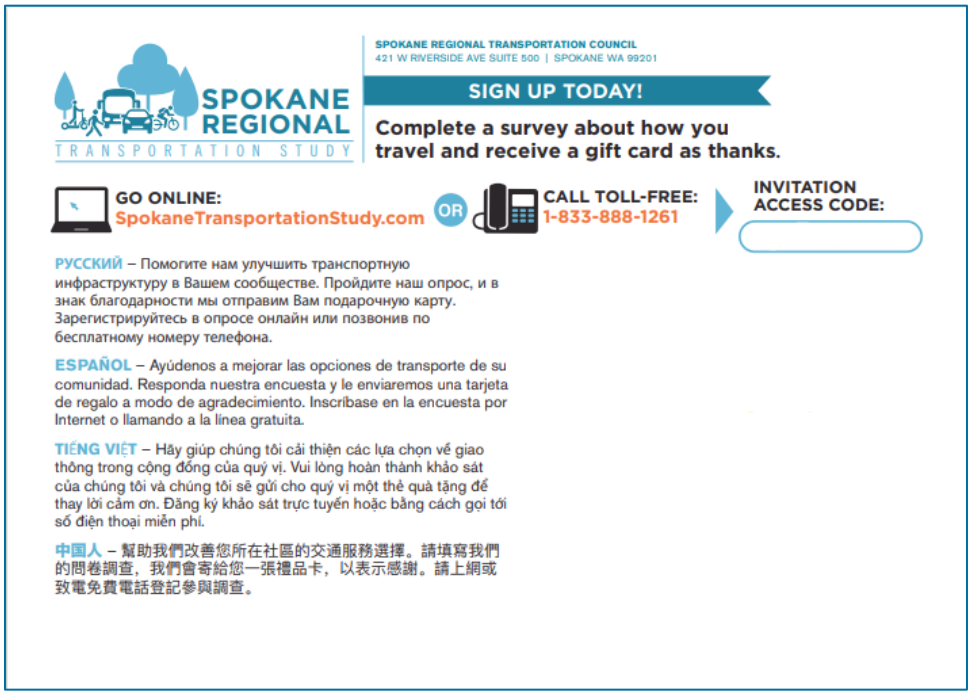

## 4.2 STUDY INVITATION MATERIALS

Each invited household received two mailings:

- **Invitation Packet**: The cover letter explained the survey purpose and described the steps necessary to complete the study. The invitation packet also included a frequently asked questions sheet.
- **Reminder Postcard**: The reminder postcard arrived at each household approximately 4 – 12 days after the invitation packet. These cards included the study phone number, website address, and participant login information.

Figure 3 below shows the postcard invitations.

**FIGURE 3: 2022 STUDY POSTCARDS (FRONT AND BACK)**

## 4.3 STUDY WEBSITE

RSG developed a website to describe the study and facilitate participation. This site was simple, intuitive, and easy to navigate on desktop computers and mobile devices.

Participants could access the survey by entering their access code on the website's home page. Figure 4 shows a screenshot from the study website.

**FIGURE 4: STUDY WEBSITE HOME PAGE**

# 5.0 PARTICIPANT SUPPORT

This study utilized both inbound and outbound participant support. “Inbound” refers to communications that participants initiated, and “outbound” refers to communications that RSG initiated.

## Outbound Participant Support

RSG used several types of outbound participant support (beyond the previously mentioned website and invitation materials) to aid study administration. The primary sources of outbound support were automated email reminders, reminder phone calls, and in-app reminders or notifications (rMove participants only).

### *Email Reminders and Phone Calls*

RSG required all rMove participants to provide email addresses. Online participants could provide both an email address (required for most households, unless participating through the call center) and an optional phone number. Any household that provided an email address received email reminders, while households that only provided a phone number were reminded by phone.

The study call center conducted all phone reminders. These reminders occurred on the following schedule:

- One day before each household’s travel date.
- One day after each household’s travel date.
- Three to five days after each household’s travel date (if the household had not yet completed the survey).

Reminder emails occurred on a similar schedule, although more frequently. RSG sent email reminders/notifications throughout the travel period to all households that provided an email address during Part 1 of the survey. Households received emails within an hour of completing Part 1, prior to the rMove travel periods (reminding participants to activate the app), the day before the travel period began, the day after each travel period ended, and 3–5 days after the end of the travel period if the household had not yet completed the survey.

### *In-App Reminders (rMove)*

rMove participants also had in-app reminders to encourage them to complete all surveys during their travel periods. Participants received notifications as soon as a new survey was available—either several minutes after the end of a trip or the morning after a travel day. rMove participants reporting their children’s trips by proxy also received reminders to review and add to their children’s trip rosters.

## Inbound Participant Support

In addition to all outbound participant support, RSG provided three primary means through which participants could contact survey administrators. All participants could call a toll-free

number to reach the survey call center or submit questions through the contact form on the website. rMove participants also had the option to submit feedback directly through the app. In total, the support team received 874 email/rMove feedback messages and 795 total  phone calls throughout the study, including 176 outbound priority calls and 619 voicemails that were returned by the study call center.

# 6.0 DATASET PREPARATION

Throughout the study, RSG implemented strict dataset preparation and quality control checks to ensure data was properly collected, stored, and analyzed. Before study fielding, survey instrument testing confirmed that study responses were recorded correctly. During data collection, all survey instruments employed real-time validations and logic checks to ensure consistent coding and logical response combinations and to prevent skipped questions. After the data collection period ended, additional time was spent reviewing, cleaning, and processing the raw data to prepare the unweighted dataset for analysis (described further below). The full steps and details of data processing are provided in the separate dataset guide.

## *Initial Data Review*

Before reviewing the data for completion, RSG removed households from the dataset that met the following exclusion criteria:

1. Household reported a home location outside Spokane County. Most households dropped during initial review were excluded for this reason.
2. Household reported contact information that matches other households (indicating duplicates). In these cases, RSG kept the first "household" that reported a full travel diary and removed the subsequent records.

### *Completion and Exclusion Criteria*

Following the initial data review, households were then further reviewed for survey completion. Households were considered complete if they met the following conditions:

1. The household completed the recruit survey by answering all required questions.
2. The household completed a travel diary for all participating household members on at least one concurrent weekday.

In total, 48 households that completed the survey were deemed "incomplete" during cleaning for one or more of the reasons above.

All online households had a single complete travel day. rMove households had at least one complete travel day (where all surveys are completed on the same day by all household adults) but may have up to seven completed travel days. Partially complete rMove travel days were included in the final dataset but flagged accordingly (and were only weighted on complete days).

Additional notes about data cleaning are included in the study dataset user's guide (provided separately).

# 7.0 EXPANSION AND WEIGHTING

Household travel surveys cover a fraction of the population, yet the resulting datasets help analyze and make inferences about the population at large. Weighting is the process of comparing selected demographics in the survey to external control data, like the census or the ACS, and adjusting the profile of the survey dataset to improve the representativeness of the population in the survey area.

RSG provided household, person, day, and trip weights for analysis. Note that RSG did not weight travel data for Monday, Friday, Saturday, or Sunday because (a) data was only collected from smartphone-participating households on those days, (b) the travel behavior for those days is not assumed to be interchangeable with the behavior for Tuesday-Thursday, and (c) the data is used primarily to analyze and model typical weekday travel (for example, as part of the region's travel demand model, which requires data on typical weekdays).

The full weighting memo provided to SRTC contains the detailed description of the weighting process. The targets used for weighting are summarized in Figure 5.

**FIGURE 5: WEIGHTING TARGETS**

| **Household-level:** | **Person-level:** |
|---|---|
| • Total households<br>• Household size<br>• Number of household workers<br>• Household income<br>• Number of household vehicles<br>• Age of head of household<br>• Presence of children | • Total persons<br>• Gender<br>• Age<br>• Worker status<br>• Race<br>• University student status |

*The full weighting process is delineated in a separate weighting memo provided with the final dataset delivery.*

## Notes for Data Users

Although household travel survey (HTS) data provides opportunities for many types of analysis, data users should always consider the context when applying the data. The 2022 Spokane Regional Transportation Study was designed to collect typical weekday data from residents in Spokane County. Therefore, the HTS dataset is not ideal for understanding weekend or visitor analysis (for example).

Data users should always use weighted data in any analysis intended to draw conclusions about the region (as opposed to survey takers). Note that only Tuesday, Wednesday, and Thursday days were weighted in this study, so any weighted analyses do not represent travel on other days.

Finally, data users should ensure sufficient sample size (and acknowledge margins of error) in any analysis. The smaller the sample size, the larger the margin of error. Sample sizes and

margins of error are a complicated topic, but a typical rule of thumb is to ensure at least 30 observations of a behavior to draw reasonable conclusions.

## Error Margins and Confidence Intervals

While there is underlying error in estimates produced from survey datasets (whether weighted or unweighted), part of the error is sampling error – e.g., biases introduced from the way respondents were recruited into the study. For practical decision-making purposes, HTS estimates may still be the best available data source even if error is present. As noted above, larger sample sizes generally reduce the error margins. Using 30 or more observations in any analysis is a typical rule of thumb to have reasonable confidence in the results.

Data users who would like to calculate error margins or confidence intervals can use the following tools (among others):

- The **survey** package in R
- The **SAMPLICS** package in Python
- Standard functions available in **SAS** and **SPSS**

# 8.0 SURVEY RESULTS

## 8.1 RESULTS OVERVIEW

The Spokane Regional Transportation Study collected a rich set of demographic and travel behavior data from a representative sample of 1,953 households in the SRTC planning area. The study collected data from 3,879 persons, representing 34,627 trips across 9,397 complete person-days from February 10 to April 5, 2022.

**TABLE 5: RESULTS OVERVIEW**

| | | |
|---|---|---|
| | Households Surveyed<br>**1,953** | Weighted Households<br>**202,850** |
| | Persons Surveyed<br>**3,879** | Weighted Persons<br>**494,540** |
| | Complete Person-Days<br>**9,397** | Weighted Person-Days<br>**462,931** |

### *Comparison to the 2005 HTS*

While the weighted households and persons have increased since the 2005 HTS[5], which represented 182,816 households and 397,437 persons, many of the characteristics have remained similar. For instance, the number of persons per household has remained 2.43. The number of workers per household has decreased slightly from 1.21 in 2005 to 1.16 in 2022. The number of vehicles per household has also decreased slightly from 2.09 in 2005 to 1.97 in 2022. Additional comparisons to the 2005 survey are included throughout the remainder of the report where comparable data is available in the 2005 survey report.

The following sections also evaluate the success of the sampling plan and provide descriptive statistics for key questions in the study and key travel behaviors from the travel diaries. Throughout the presentation of summary data, values may total to less than 100% due to rounding, or more than 100%, if respondents were given the option to select more than one response to a question.

## 8.2 SAMPLE PLAN EVALUATION

This section evaluates the performance of the sample plan. Overall, this study targeted 1,500 households with complete travel surveys and obtained 1,953 households, which is approximately 30% more households than expected.

[5] Zmud, Johanna. 2005. *Spokane and Kootenai County Regional Travel Survey, Final Report.*

Table 6 shows the expected and actual response rate and sample rate by sampling segment.[6] The actual response rate exceeded expectations across all segments and especially with the hard-to-survey segment. The higher-than-expected response rate led to exceeding the overall sample target.

**TABLE 6: EXPECTED AND ACTUAL RESPONSE BY SAMPLING SEGMENT**

| | | *Expected* | | | *Actual* | | |
|---|---|---|---|---|---|---|---|
| **Segment** | **Invitations[7]** | **Response Rate** | **Complete Households** | **Sample Rate** | **Response Rate** | **Complete Households** | **Sample Rate** |
| Walk/Bike/ Transit | 10,645 | 1.9% | 202 | 1.1% | 2.5% | 267 | 1.5% |
| Hard-to-survey | 3,865 | 1.4% | 54 | 0.7% | 3.0% | 115 | 1.6% |
| General | 65,490 | 1.9% | 1,244 | 0.7% | 2.4% | 1,571 | 0.9% |
| **TOTAL** | **80,000** | **1.8%** | **1,500** | **0.7%** | **2.4%** | **1,953** | **1.0%** |

## 8.3 DEMOGRAPHIC SUMMARY

This section analyzes the demographic composition of the final, weighted dataset. Unless otherwise noted, all analyses use weighted data. Weighted data means that the individual sample records have been assigned multipliers (weighting factors) so that, cumulatively, the variation in subgroup sample sizes is adjusted to align with the actual subgroup population sizes observed in the ACS data for the region. For an evaluation of how closely the *unweighted* dataset matched the ACS data for the region, please see the memo on the data weighting approach, included in Appendix A.

### Household Characteristics

Figure 6 through Figure 8 show the distribution of household characteristics by diary mode (online / call center vs. smartphone app). These figures include both total distributions and distributions by diary type because there are sometimes response biases associated with the different methods, which are then adjusted for during the weighting process. For example, in many regions smartphone participants have higher incomes on average. While there were slight

[6] Sample rate = Complete households / households in the region
Response rate = Complete households / invited households

[7] These figures represent the total number of invitations (letters and postcards) sent during the study. As of September 2022, 2,001 letters and 825 postcards were returned to SRTC. Typical mail return rates on travel studies can be as high as 5-10% depending on the regional composition. The 2.5% return rate observed during the 2022 HTS was well within the typical range.

variations by income, the two diary modes were comparable overall. Households with one worker were more likely to respond via smartphone (Figure 10). Call center respondents were somewhat more likely to have three or more vehicles (Figure 8) and more workers in their households (Figure 10). Rates of households with students were similar across response modes (Figure 9).

**FIGURE 6: HOUSEHOLD SIZE BY DIARY MODE (WEIGHTED)**

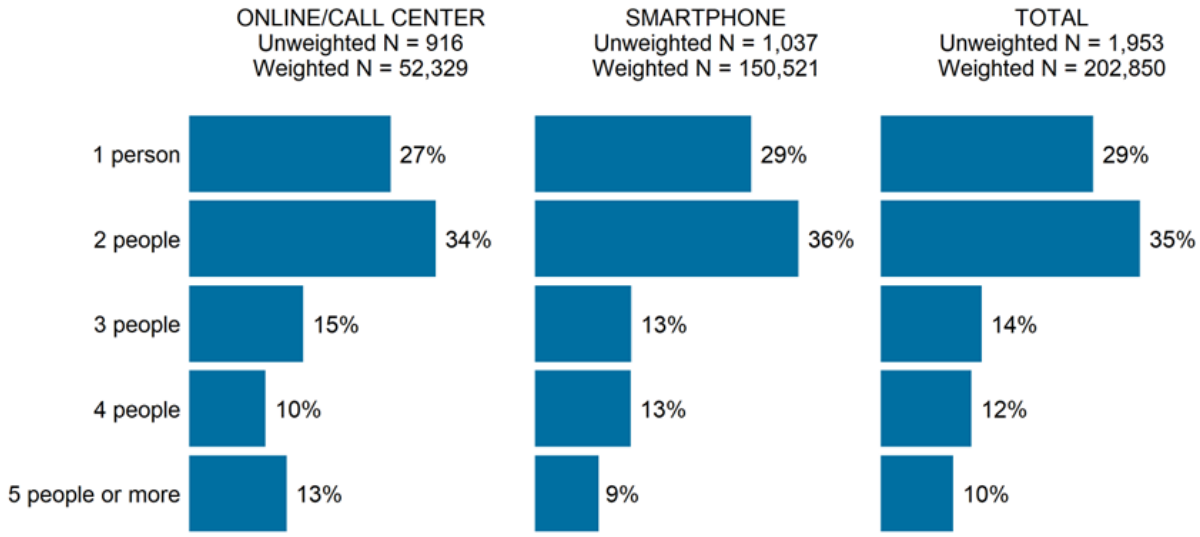



**FIGURE 7: HOUSEHOLD INCOME BY DIARY MODE (WEIGHTED)**

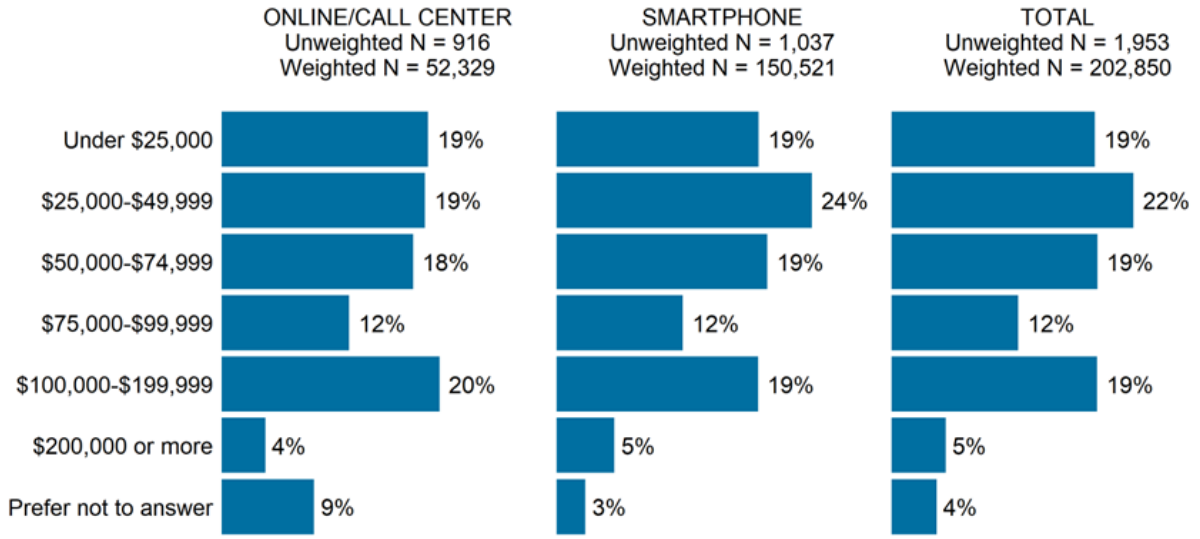


**FIGURE 8: HOUSEHOLD VEHICLES BY DIARY MODE (WEIGHTED)**

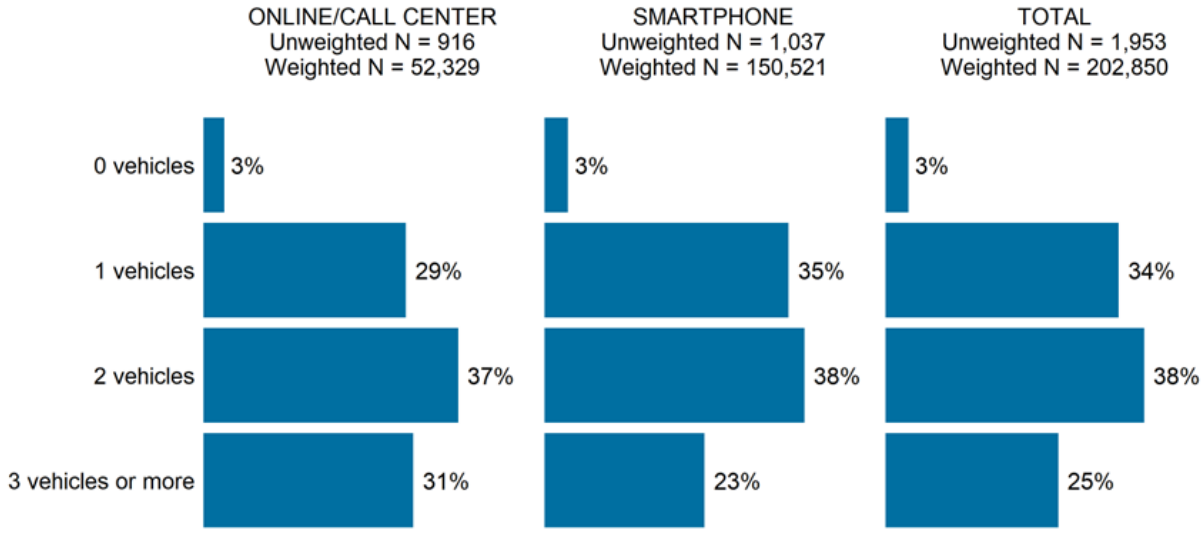



**FIGURE 9: HOUSEHOLD STUDENTS BY DIARY MODE (WEIGHTED)**

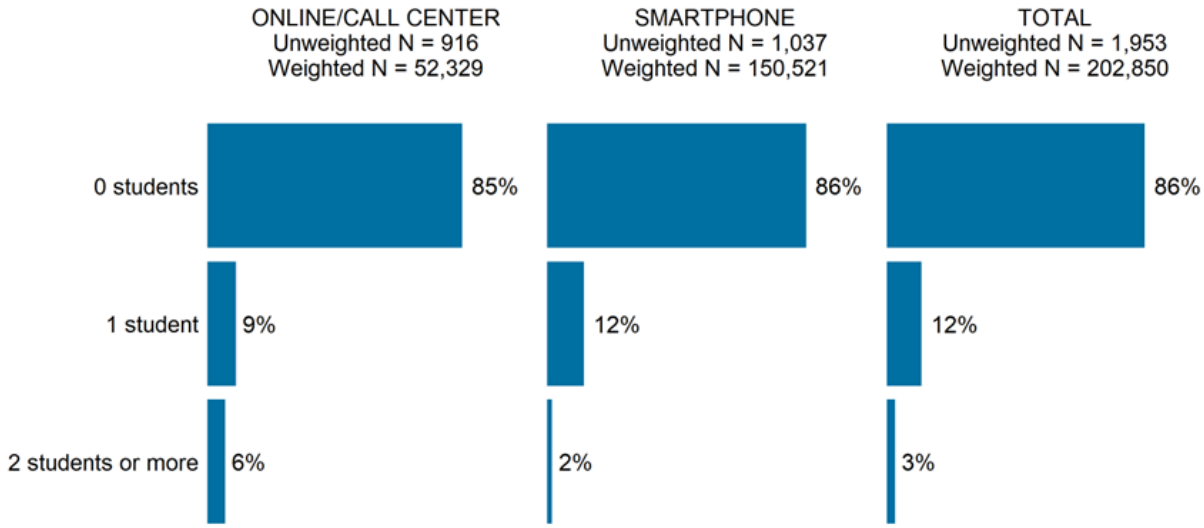
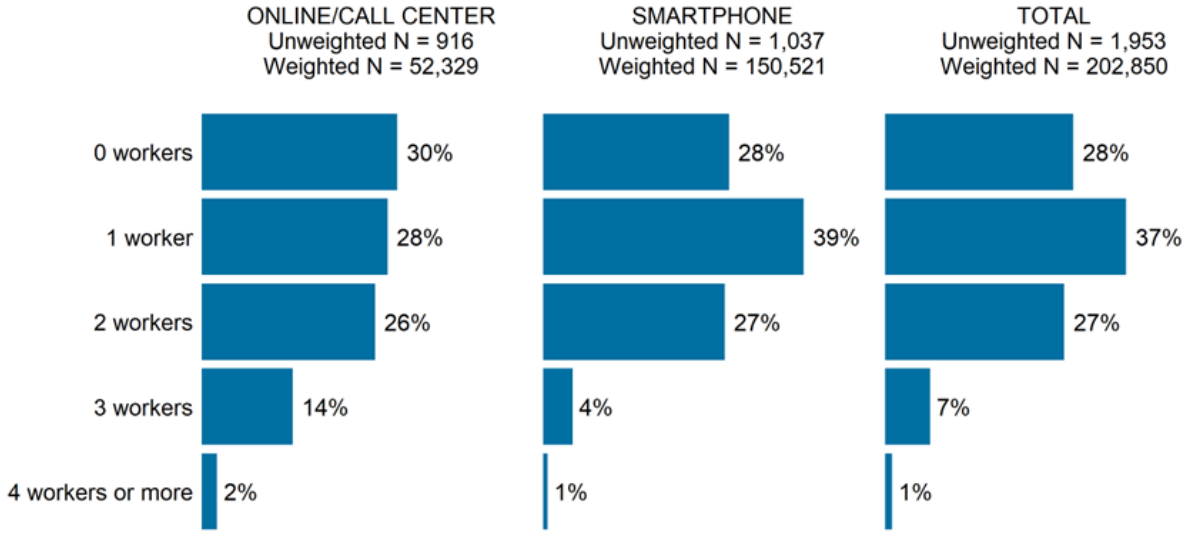


**FIGURE 10: HOUSEHOLD WORKERS BY DIARY MODE (WEIGHTED)**




## Person Characteristics

Unlike household characteristics, person-level characteristics varied more by diary mode (Figure 11). Overall, online and call center households were more likely to be older while smartphone participants were more likely to have children (Figure 11). Households with “White” respondents were more likely to participate via smartphone, and online and call center participants had higher shares of respondents reporting “prefer not to answer” for race and ethnicity (Figure 12 and Figure 13). Among those who did report their race, online and call center participants were more likely to report their race as “African American or Black.”

Females were slightly more likely to respond by smartphone, and online and call center respondents were more likely to select “prefer not to answer” (Figure 14). Person employment status did not vary greatly by diary mode with the greatest difference in the share of respondents who reported part-time employment (16% of online / call center respondents compared to 11% of smartphone respondents) (Figure 15).

**FIGURE 11: PERSON AGE BY DIARY MODE (WEIGHTED)**

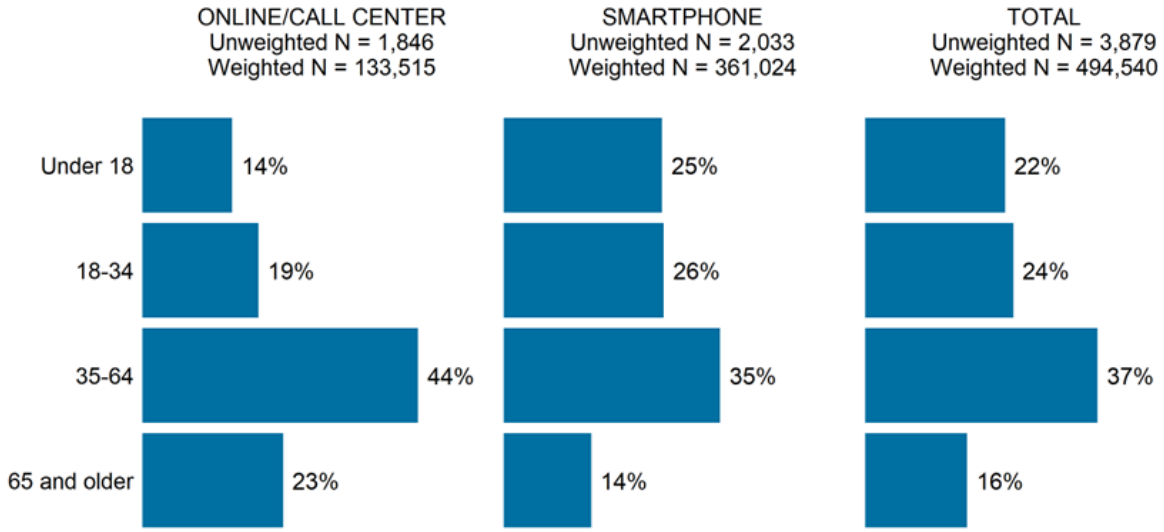



**FIGURE 12: PERSON RACE BY DIARY MODE (WEIGHTED)**

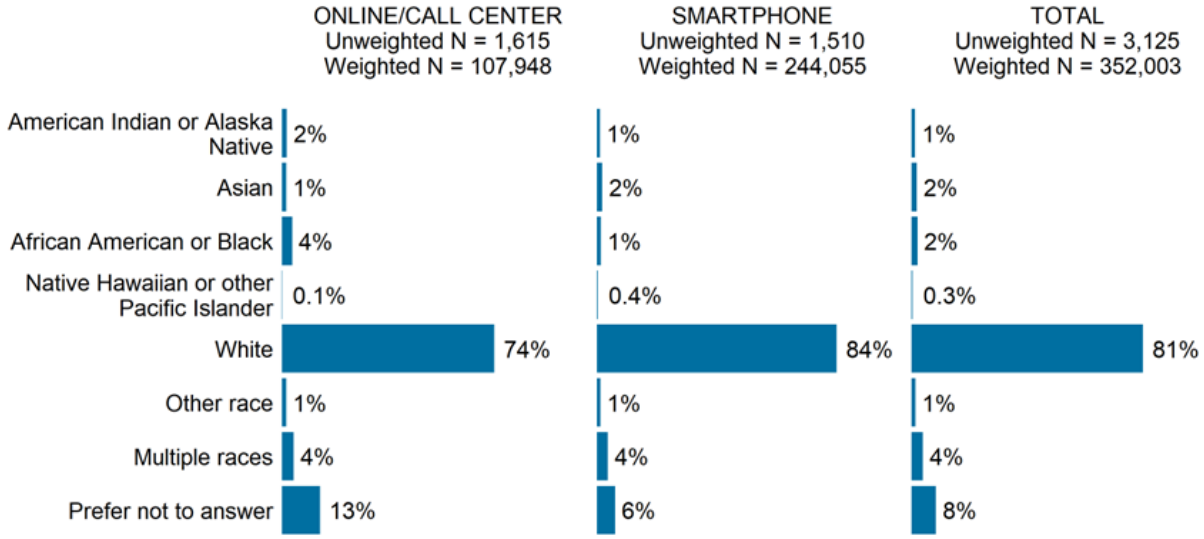


**FIGURE 13: PERSON ETHNICITY BY DIARY MODE (WEIGHTED)**

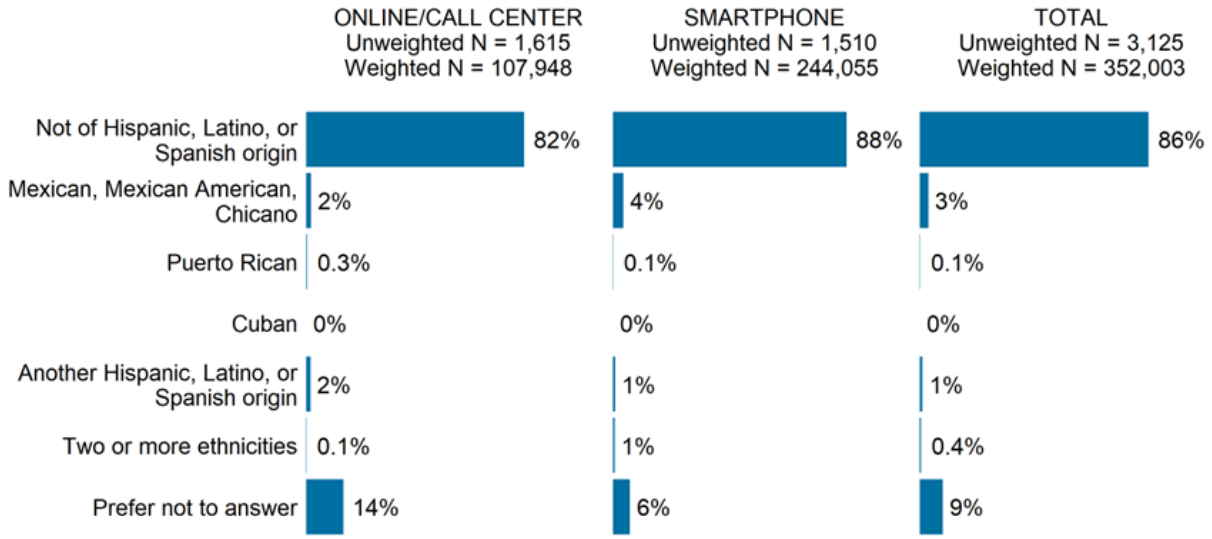



**FIGURE 14: PERSON GENDER BY DIARY MODE (WEIGHTED)**

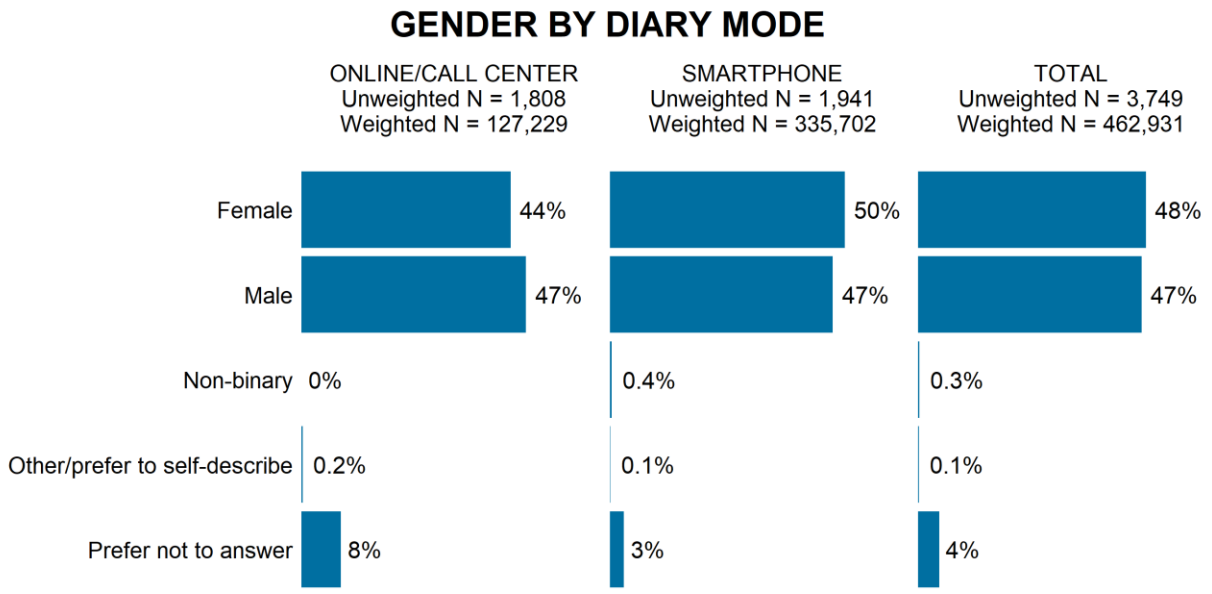
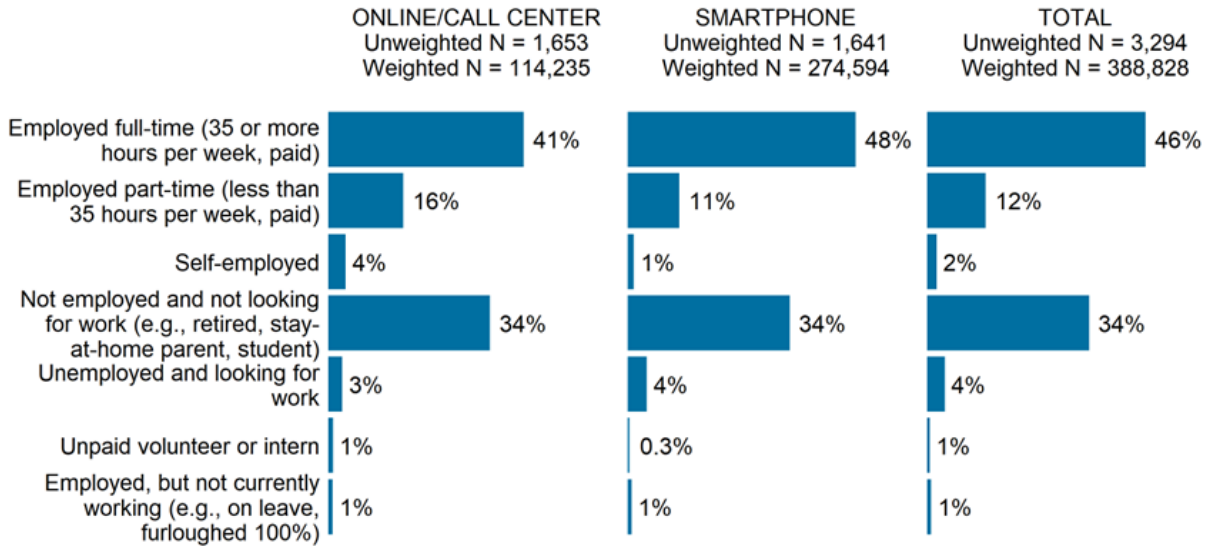


**FIGURE 15: PERSON EMPLOYMENT STATUS BY DIARY MODE (WEIGHTED)**




# 8.4 OVERALL TRIP ANALYSIS

This section describes the travel data collected during the survey using distributions and trip rates. In some cases, these metrics are segmented by important variables, such as household income, age, or time of day.

## Trip Rates

The total weighted trip rate was 3.83 person trips per day. This is somewhat lower than the trip rate documented in 2005, trip rates of 4.41 trips per person and 4.57 trips per adult, though the 2005 reported trip rates did not include those under age 16.[8] For those 16 years and older, the trip rate in 2022 was 4.4 trips, matching the trip rate reported in 2005. In reviewing trip rates by age, those under age 18 make the fewest trips (1.9 trips per day on average) while those of age 35-64 make the most trips (4.7 trips per day on average) (Figure 16). While the study team took several measures to collect thorough data from respondents under age 18, data users should note that children's travel is often underreported in travel surveys due to a combination of increasing privacy concerns over time and parents not being present for children's trips (particularly among those age 16-17).

All income groups have similar trip rates though those with incomes below $25,000 and within $50,000 - $74,999 have the highest trip rates at 4.1 and 4.3 trips per day, respectively (Figure 17). In 2005, trip rates generally increased with higher reported incomes, with the lowest trip rates reported for those reporting household incomes less than $49,999[9].

[8] NuStats. 2005. *Spokane and Kootenai County Regional Travel Survey, Final Report.*
[9] NuStats. 2005. *Spokane and Kootenai County Regional Travel Survey, Final Report.*

**FIGURE 16: PERSON TRIP RATE BY AGE (WEIGHTED)**

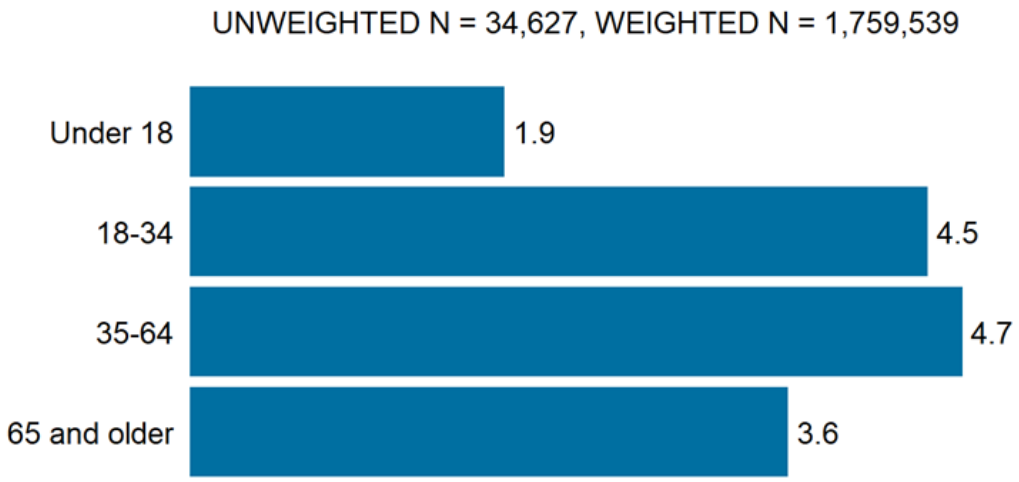
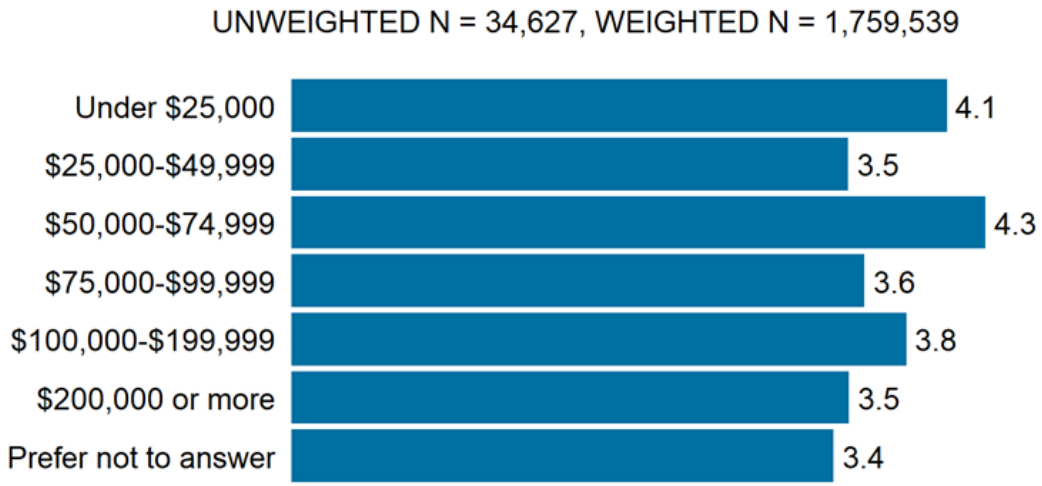



**FIGURE 17: PERSON TRIP RATE BY INCOME (WEIGHTED)**




In looking at trip rates by mode, respondents took 3.3 trips per day by car[10] and 0.36 trips per day walking. All other modes had trip rates below 0.1 trips per day (Figure 18). On average, respondents took 1.28 trips home each day, 0.44 shopping trips each day and 0.29 work trips each day (Figure 19).

[10] Car mode includes taxis, transportation network companies (Uber, Lyft, etc.), car, and carshare.

**FIGURE 18: PERSON TRIP RATE BY TRIP MODE (WEIGHTED)**

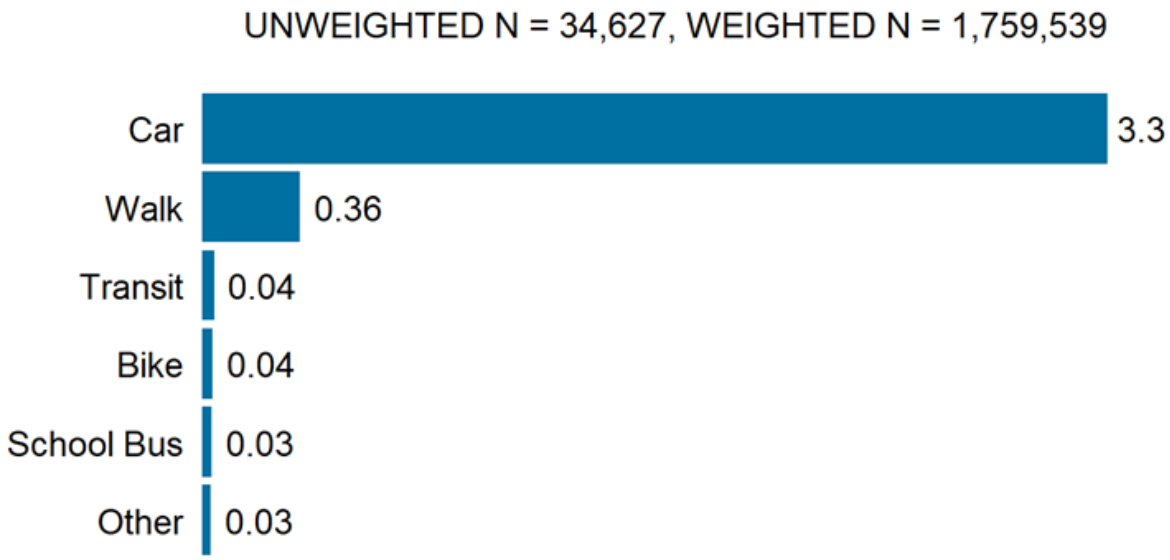
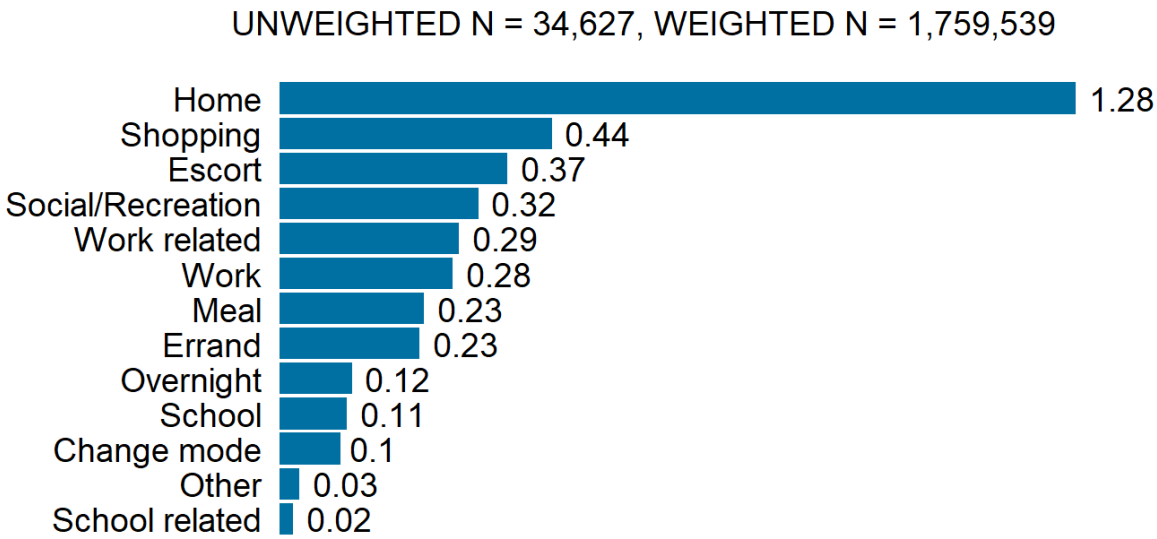



**FIGURE 19: PERSON TRIP RATE BY TRIP PURPOSE (WEIGHTED)**




## Trip Distances and Durations

This section shows trip distances and durations by mode and purpose categories. All tables are shown as medians to remove the effect of extreme outliers. These tables also include unweighted sample sizes to provide context for values. Note that some trips do not have derived distances available if they occurred over water where there is no Google distance information available.

In looking at trip distance and duration by mode (Figure 20), most trip types have a median between 2-3 miles, excluding walk, bike, and school bus trips. These are expected given that walking trips tend to be shorter and school bus trips tend to be indirect. Travel times for most modes are under 20 minutes, excluding school bus trips, which are expectedly longer given their routes (Figure 21).

The longest trips, in miles, are work trips, overnight trips, and those classified as “other” (Figure 22), while the shortest trips are school related trips. Median trip duration in minutes ranges from 9 minutes to 16.5 minutes, with the shortest trips (in minutes) include change mode trips, meals, and school related trips (Figure 21).

**FIGURE 20: MEDIAN TRIP DISTANCE (MILES) BY TRIP MODE (WEIGHTED)**

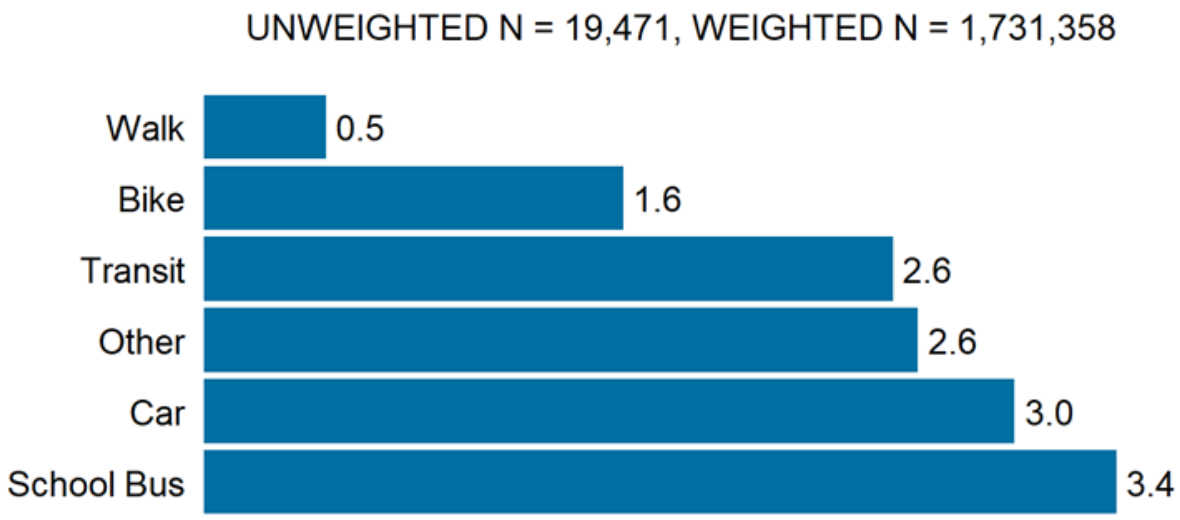


**FIGURE 21: MEDIAN TRIP DURATION (MINUTES) BY TRIP MODE (WEIGHTED)**

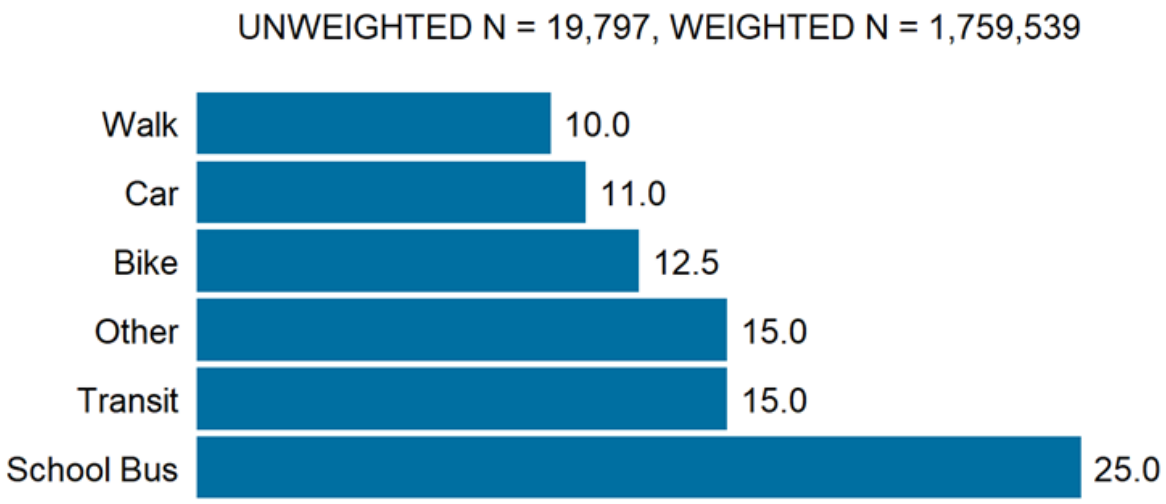



**FIGURE 22: MEDIAN TRIP DISTANCE (MILES) BY TRIP PURPOSE**

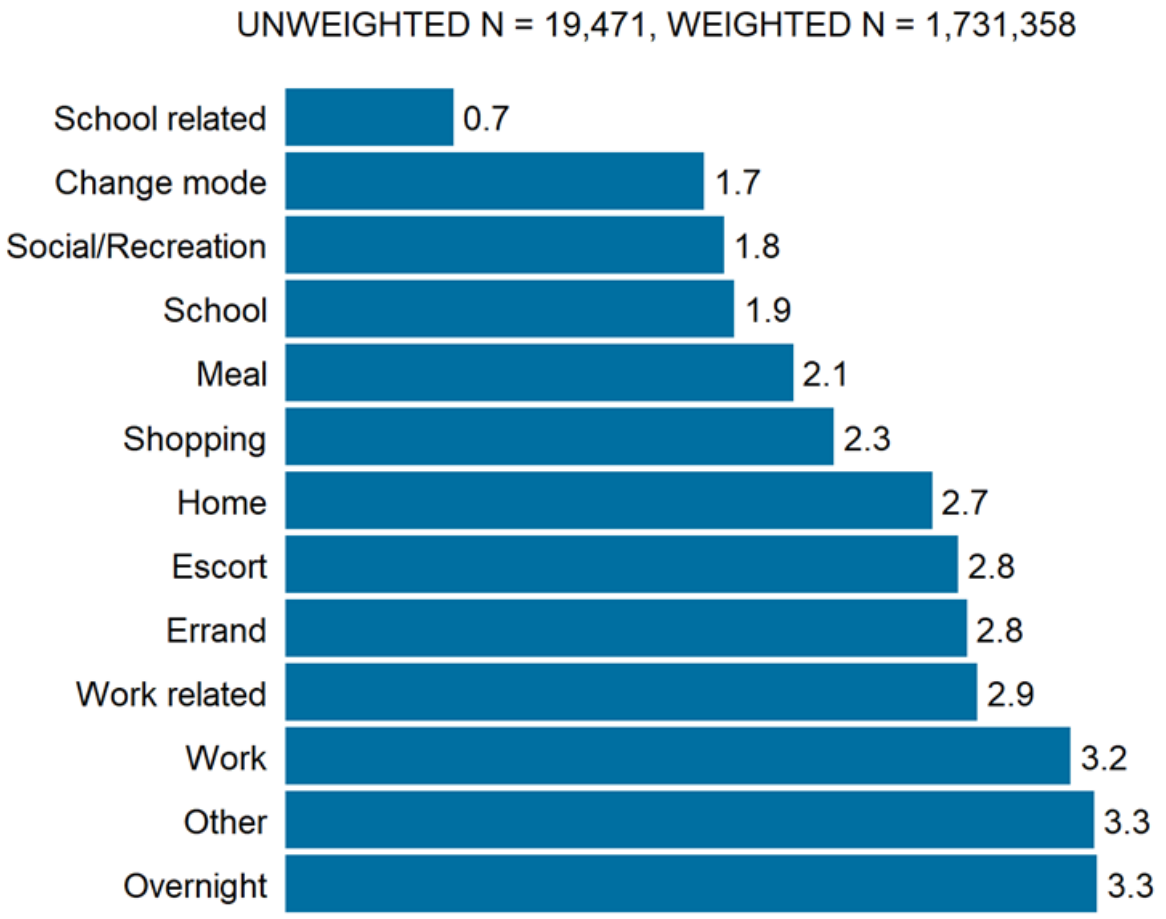
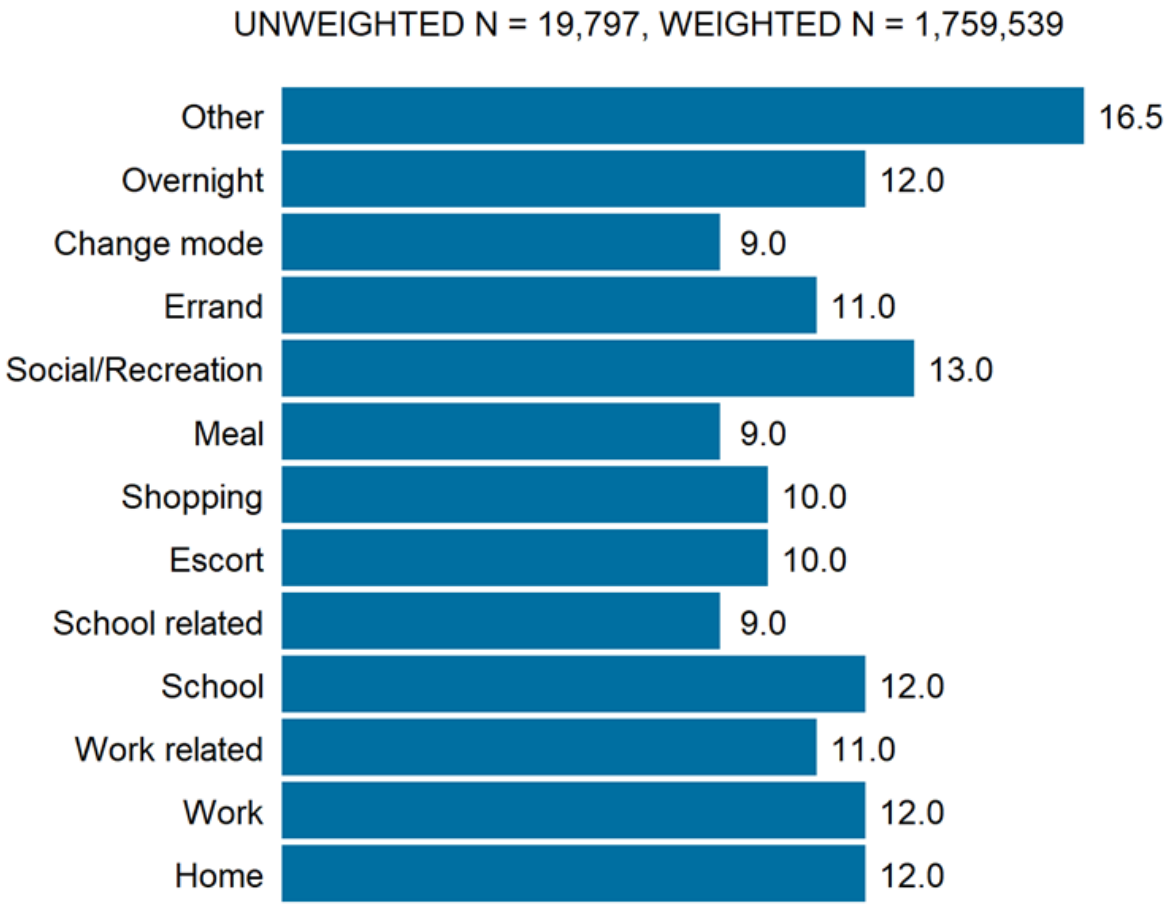


**FIGURE 23: MEDIAN TRIP DURATION (MINUTES) BY TRIP PURPOSE**




# 8.5 TRIP MODE ANALYSIS

## Trip Modes

Figure 24 and Figure 25 show distributions of travel modes by income and age. The total sample distributions are also included in the bottom left corner of each figure. In most cases, the predominate mode used is “car,” representing 87% of all weighted trips.

Mode choice varies little by income above $25,000. Those with incomes under $25,000 had the lowest share of car trips (79%) while those with incomes between $50,000 and $74,999 had the highest share of car trips (90%). 87% of trips among those reporting “prefer not to answer” income were car trips (Figure 24).

Mode choice also varies little by age except for those 18-34, who reported more walk and transit trips compared with other adults. (Figure 25). In contrast, trip mode does vary by gender. Females are more likely to make trips by car (51%) than males (46%), and males are more likely to walk, use transit, bike, or use ‘other’ forms of transportation (Figure 26).

**FIGURE 24: TRIP MODE BY INCOME (WEIGHTED)**

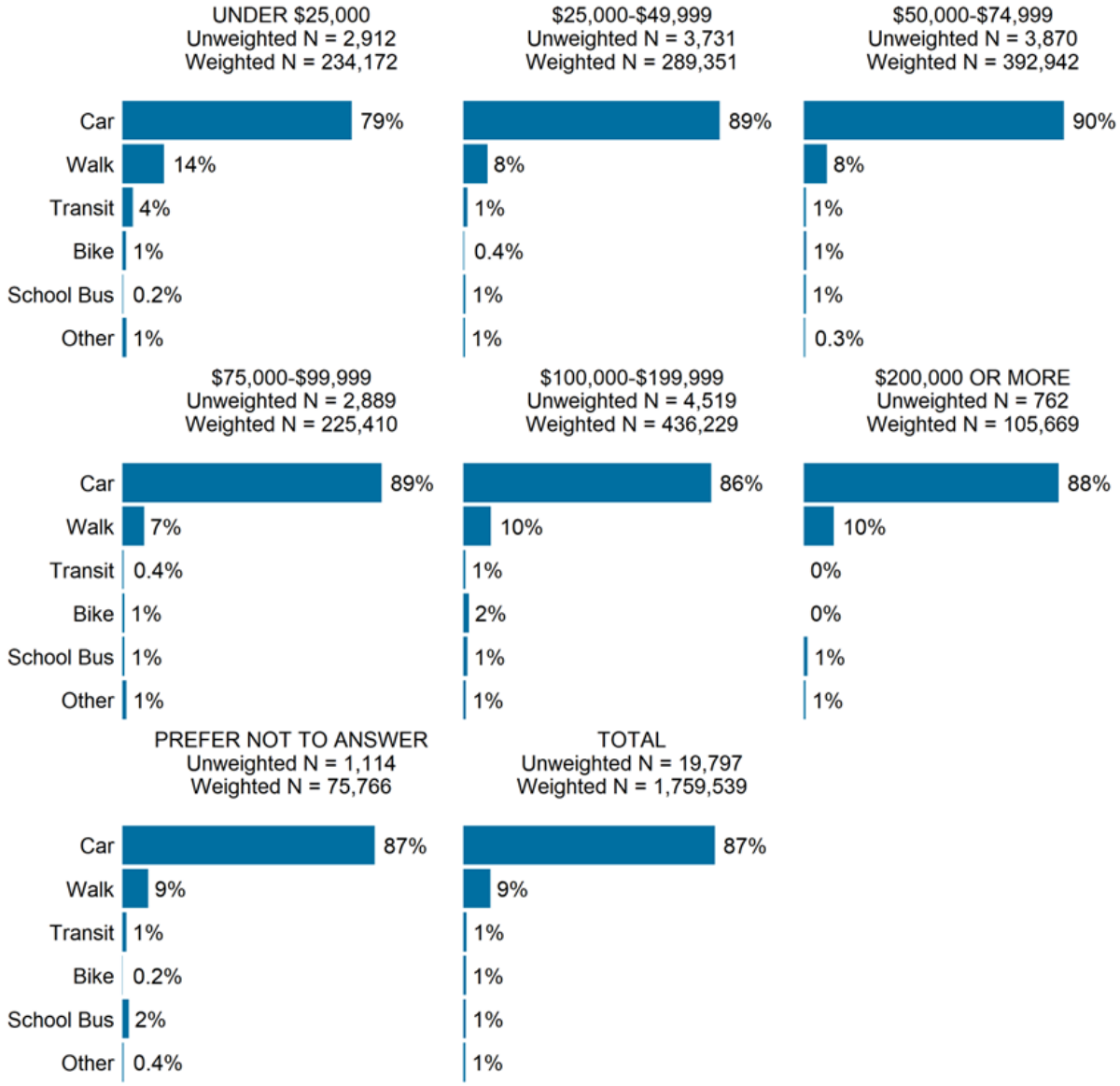


**FIGURE 25: TRIP MODE BY AGE (WEIGHTED)**

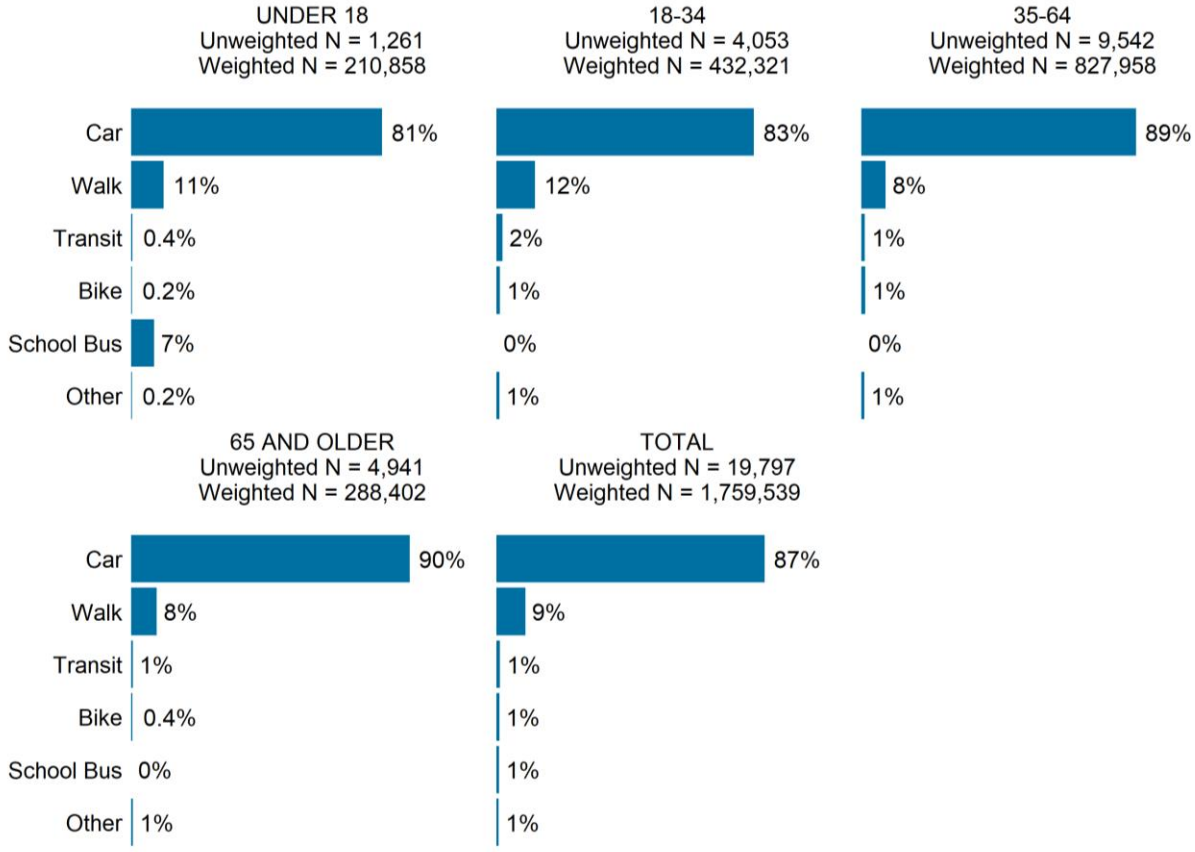
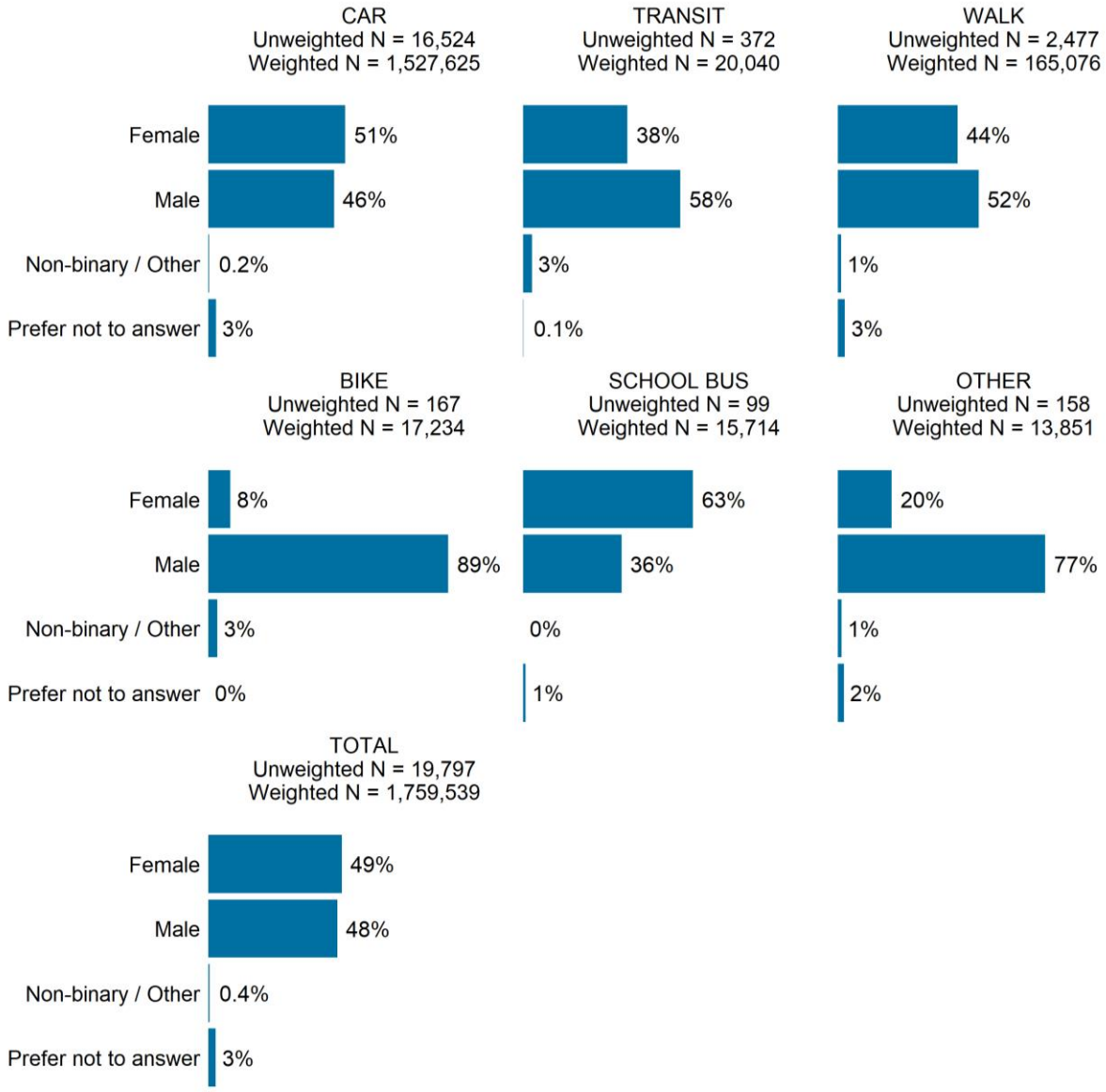


**FIGURE 26: TRIP MODE BY GENDER (WEIGHTED)**




## 8.6 TRIP PURPOSE ANALYSIS

Around one-third of all trip purposes is to home, with little variation in income and age (Figure 27 and Figure 28). Reported income did not have a substantive impact on trip purpose. Respondents 65 and older had fewer school trips and work trips, and slightly more social and recreational trips, while more than half of all trips for those under 18 were related to home or school (Figure 28). Walk and bike trips follow a slightly different pattern by purpose than car trips (Table 7). The majority of walk and bike trips were home trips (25% and 40%, respectively), similar to car trips. However, walk and bike trips were more likely to be social/recreational (26% for walk, and 18% for bike trips) than car trips. Twenty-percent of bike trips were work trips and 11% of walk trips were change mode trips.

## FIGURE 27: TRIP PURPOSE BY INCOME (WEIGHTED)

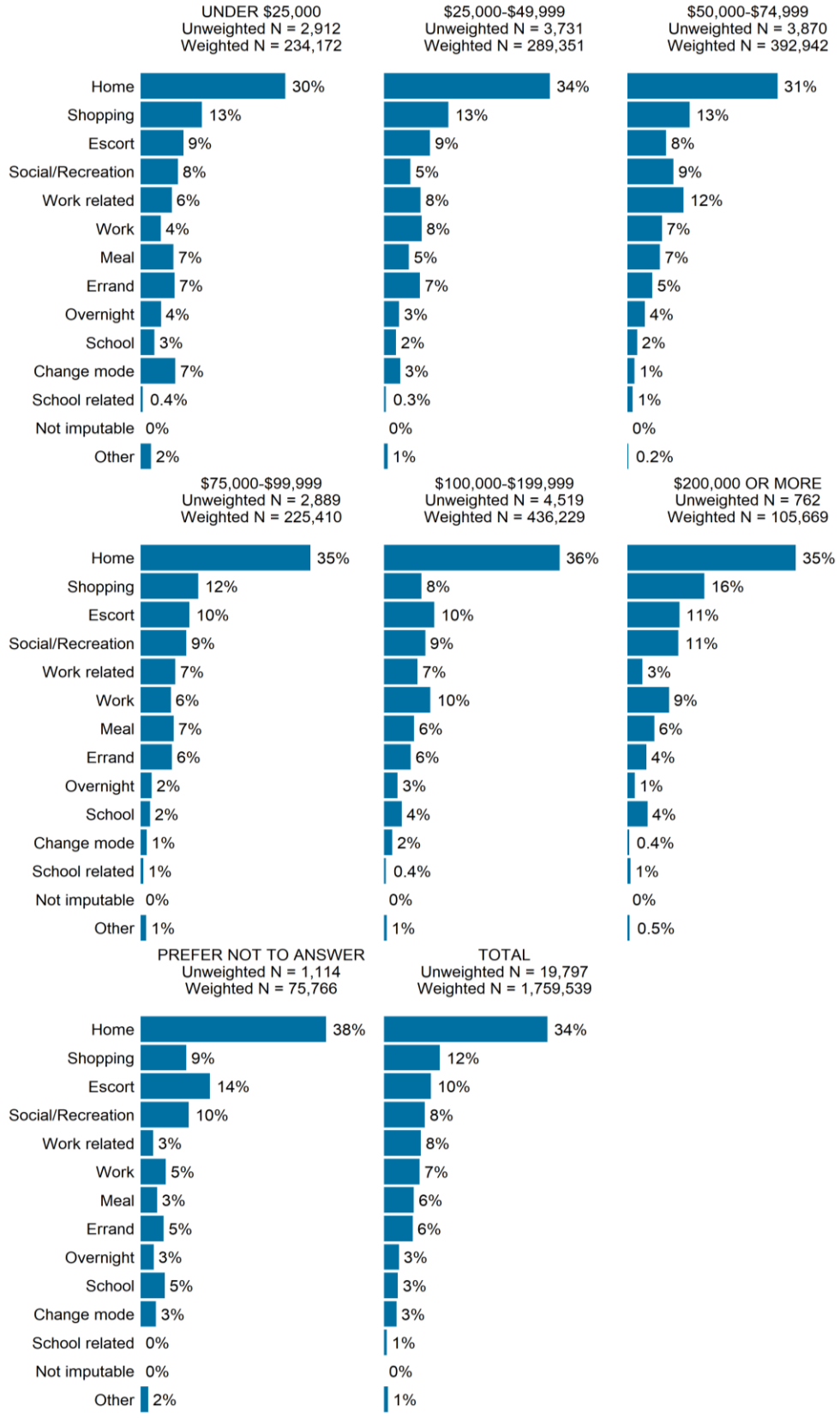


**FIGURE 28: TRIP PURPOSE BY AGE (WEIGHTED)**

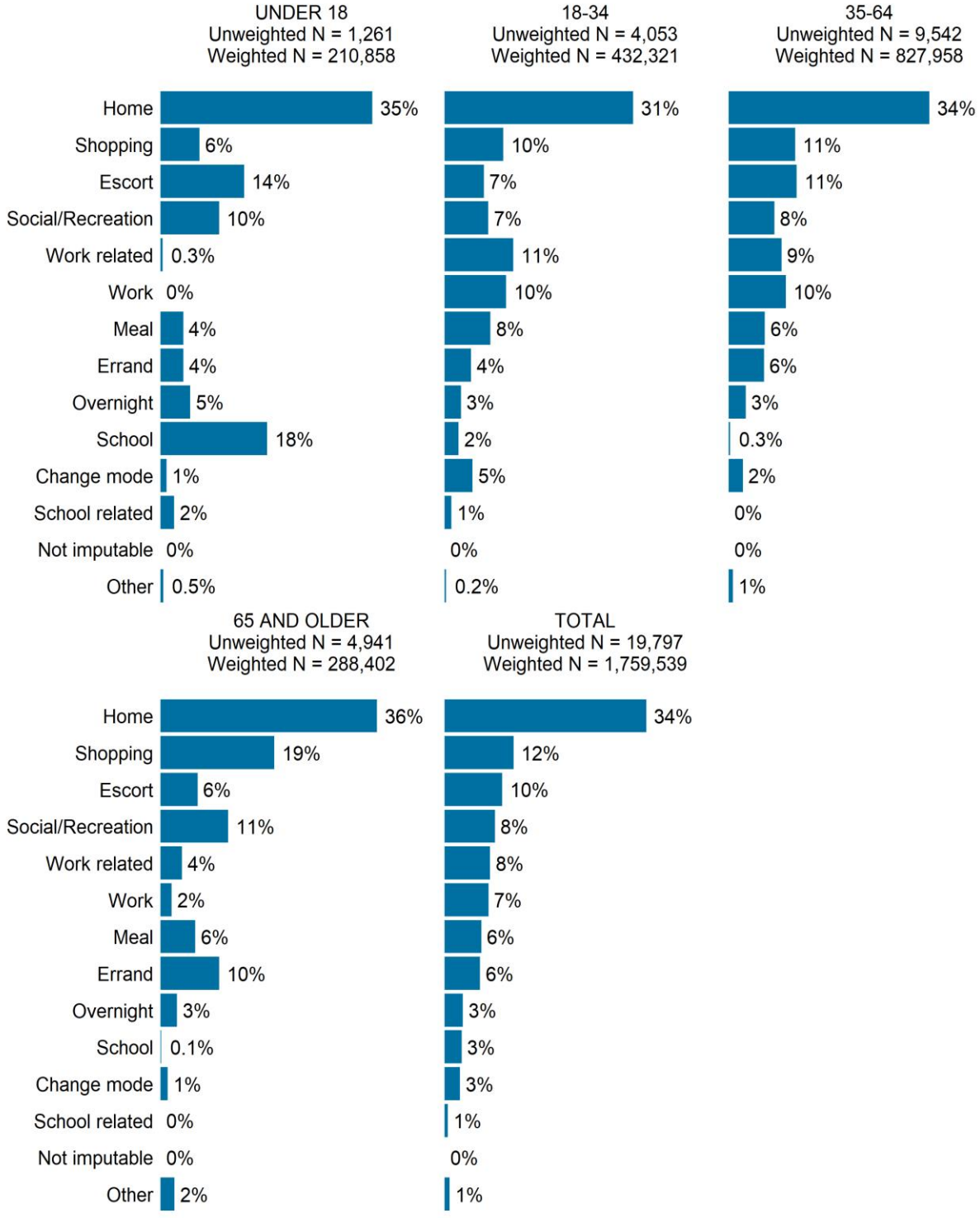


**TABLE 7: TRIP PURPOSE BY TRIP MODE FOR WALK AND BIKE MODES ONLY**

| TRIP PURPOSE | WALK (UNWEIGHTED N = 2,477; WEIGHTED N=165,076) | BIKE (UNWEIGHTED N=167; WEIGHTED N=17,234) | TOTAL UNWEIGHTED N=2,644; UNWEIGHTED N=182,310) |
|---|---|---|---|
| Home | 35% | 40% | 35% |
| Social/Recreation | 26% | 18% | 25% |
| Change Mode | 11% | <1% | 10% |
| Work | 5% | 20% | 7% |
| Shopping | 5% | 4% | 5% |
| Escort | 4% | 1% | 3% |
| School | 4% | <1% | 3% |
| Other | 10% | 16% | 12% |

## 8.7 EMPLOYMENT ANALYSIS

To better understand how employment-related behaviors changed from before March 2020 to spring 2022, the survey asked employed respondents to report their typical commute modes during the two periods (if they travel to a workplace outside the home) and their typical teleworking frequency. Among those who travel to workplaces, the distribution of commute modes changed very little across the two periods, with only a slight drop in the percentage of people who commute using transit (Figure 29 and Figure 30).

Despite seeing little change in the distribution of modes used to commute to work among those who travel to a workplace, there was an increase in the frequency of teleworking (Figure 31 and Figure 32). In 2005, fewer than 10% of respondents worked from home[11], compared to 23% of respondents who work at home four or more days a week in 2022. This is mirrored in the typical employment locations reported in the survey. 27% of employed respondents reported working all or partially from home in 2022 compared to 15% before March 15, 2020. More workers report working in healthcare (18%) than any other single industry, followed by education (14%) (Figure 33).

[11] NuStats. 2005. *Spokane and Kootenai County Regional Travel Survey, Final Report.* p. 81.

**FIGURE 29: WORK COMMUTE MODE, SPRING 2022 (WEIGHTED)**

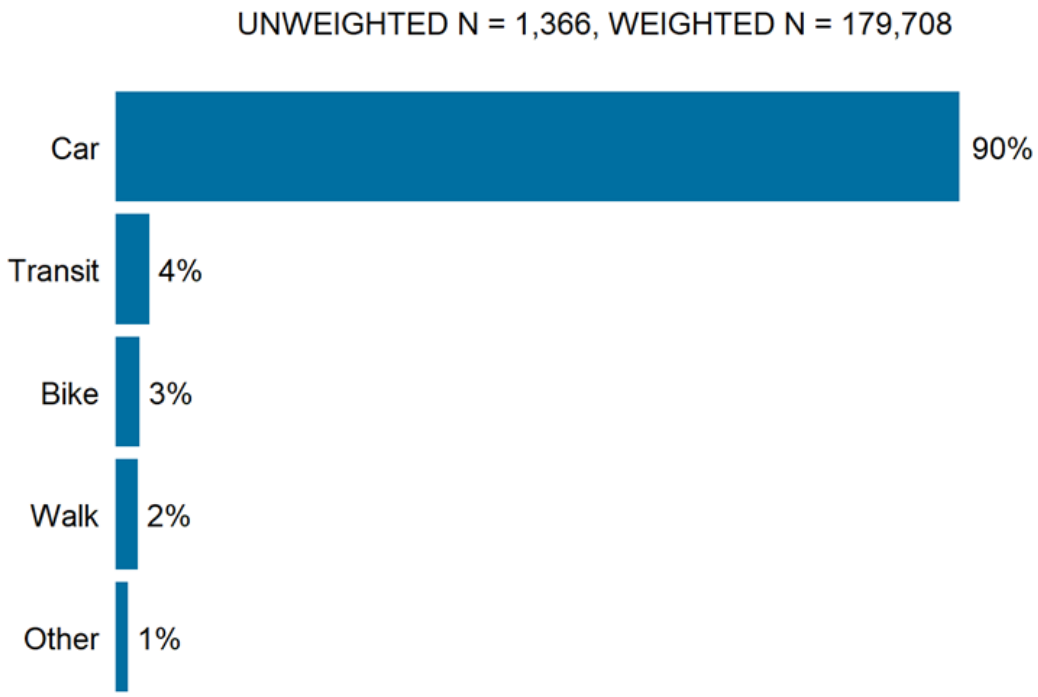



**FIGURE 30: WORK COMMUTE MODE BEFORE COVID-19, FALL 2019 (WEIGHTED)**

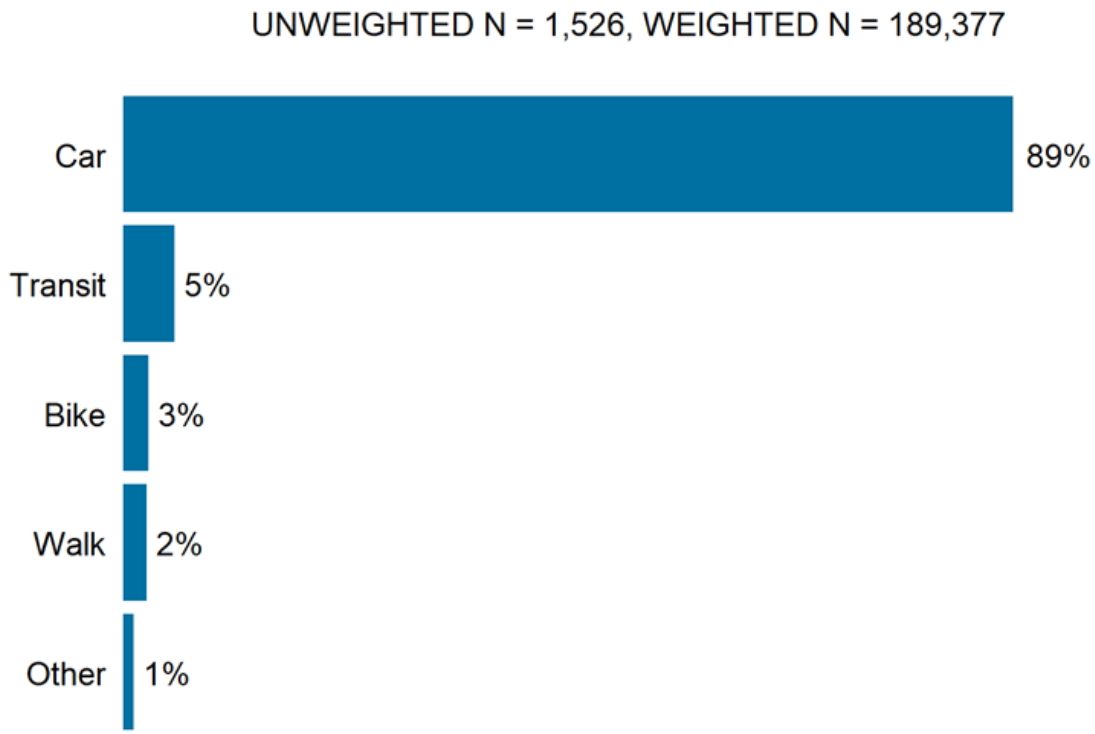


**FIGURE 31: TELEWORK FREQUENCY, SPRING 2022 (WEIGHTED)**

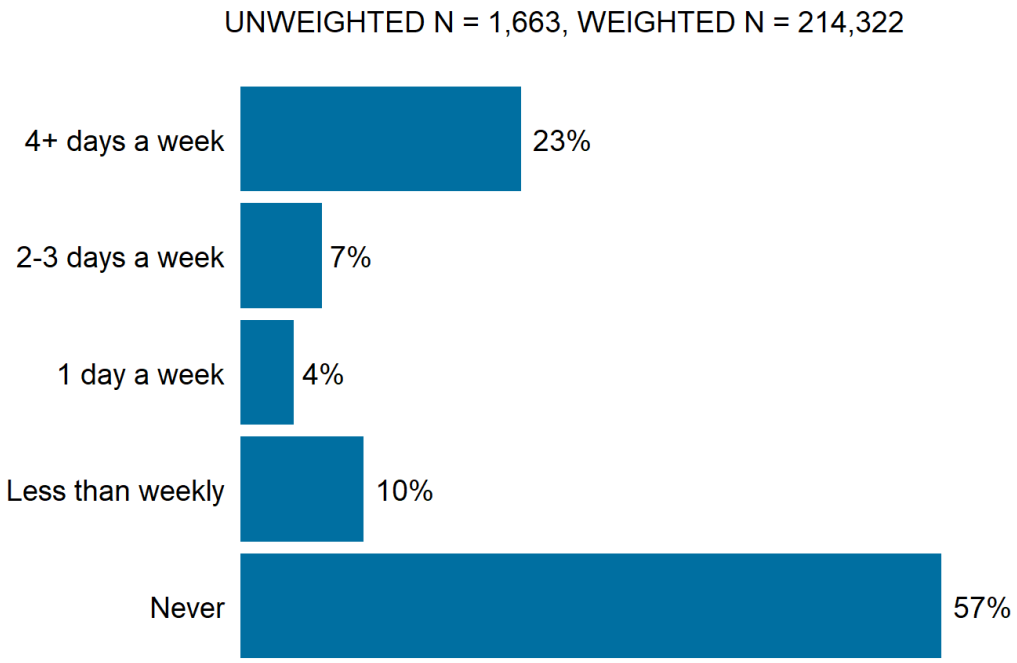



**FIGURE 32: TELEWORK FREQUENCY BEFORE COVID-19, FALL 2019 (WEIGHTED)**

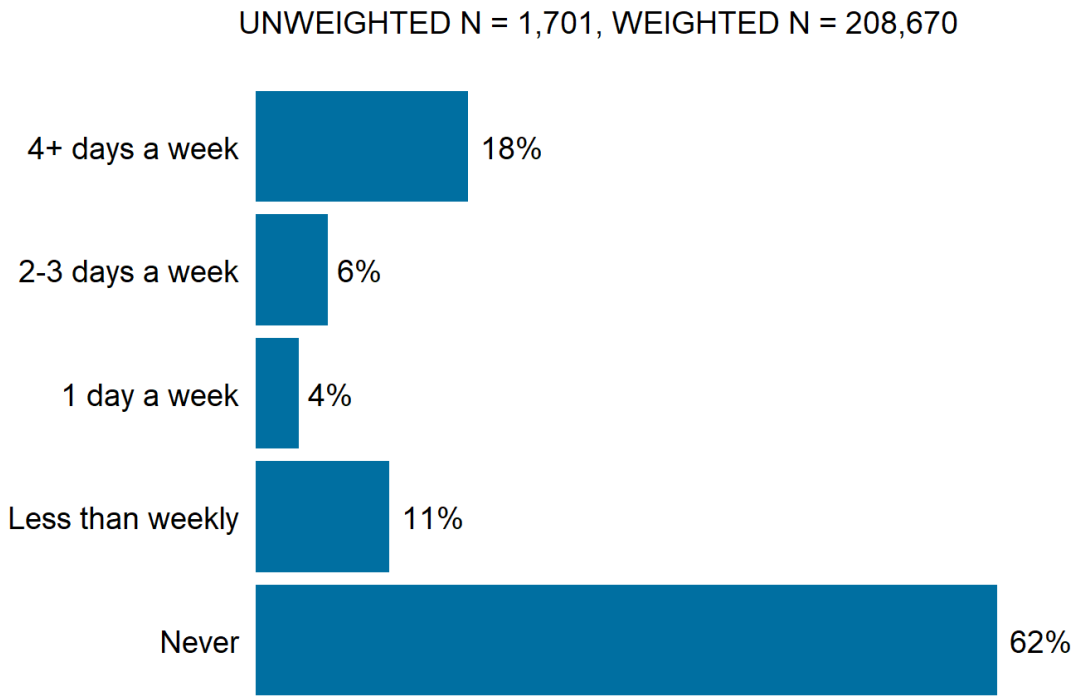
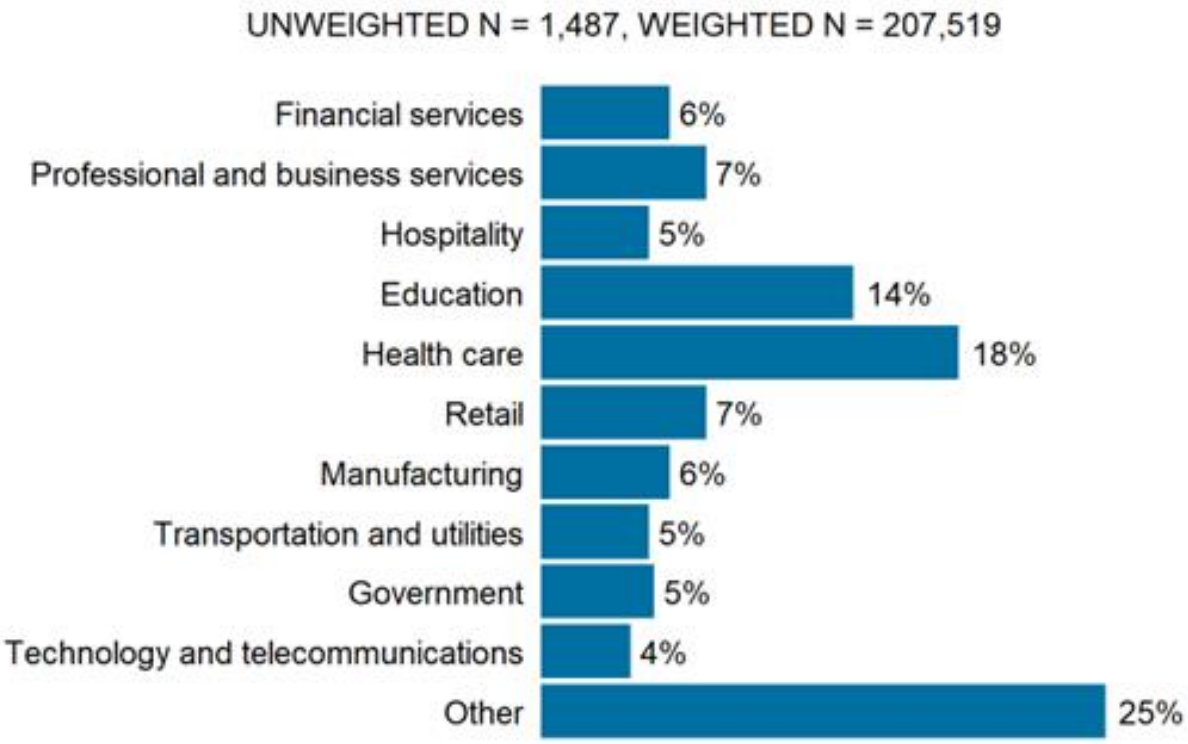


**FIGURE 33: INDUSTRY DISTRIBUTION OF WORKERS (WEIGHTED)[12]**




## 8.8 TRAVEL DAY ANALYSIS

After each travel day, respondents were asked a handful of day-level questions to better understand their travel replacement activities. These included asking about their reasons for not traveling (if applicable), deliveries received on their travel day, and time spent telecommuting (if employed).

Twenty-two percent (22%) of respondents did not make any trips on travel day, compared to the 78% of respondents who made at least one trip on a travel day. Among those who did not travel on their travel day, the most common reason was hanging out around home (60%) followed by working at home (19%). Seven percent of respondents answered that they had no available transportation on the travel day (Figure 34).

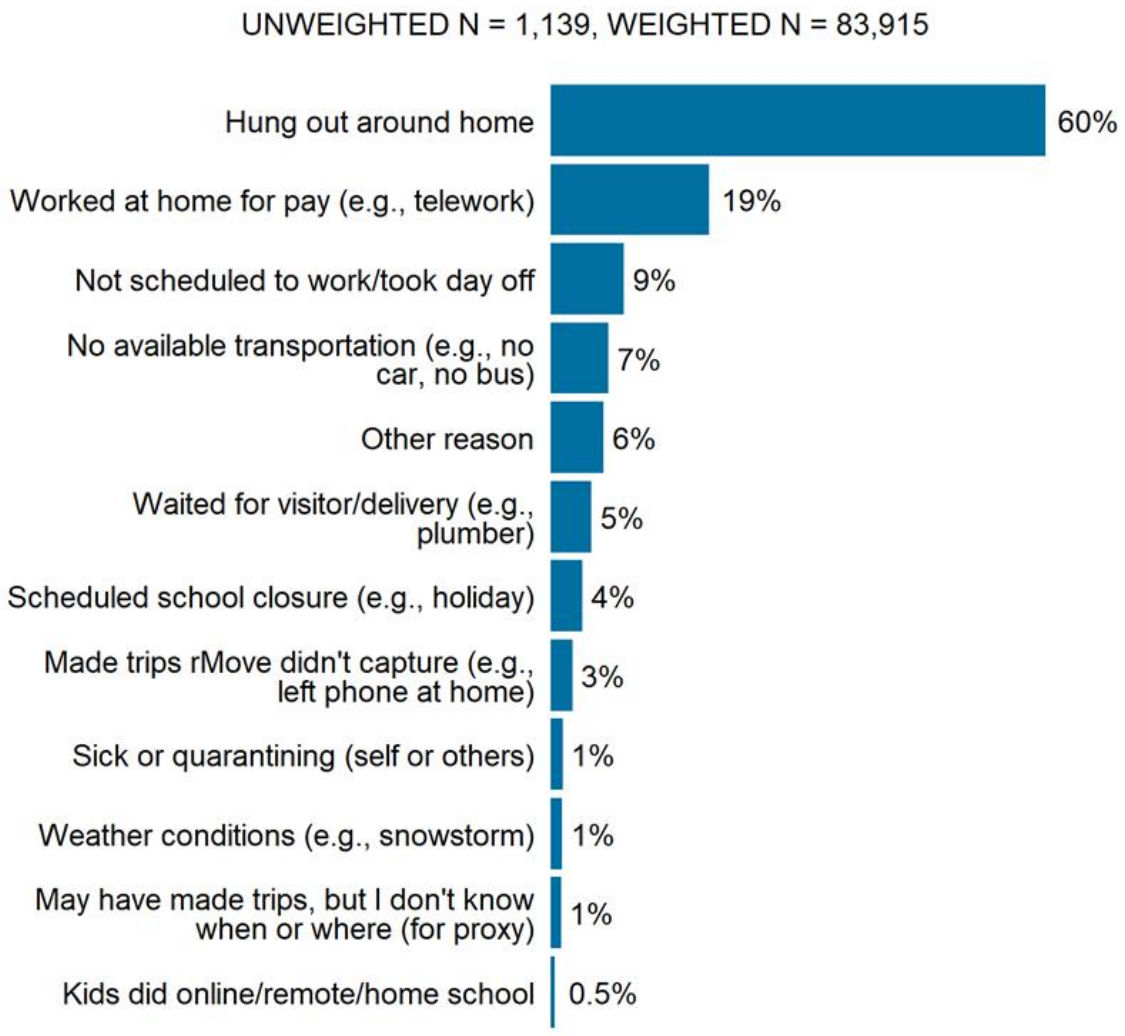
Most respondents (72%) received no deliveries on their travel day, and 24% received packages at home (Figure 35). It may be worth noting that the share of respondents who have reported receiving deliveries has increased in the past several years. For example, fewer than 15% of respondents in the 2018 WCOG HTS reported receiving deliveries on their travel day. This trend has also been observed in the recurrent PSRC HTS between 2019 and 2021. While household

[12] Note that this question in the survey included additional categories not included in this figure. All categories with fewer than 3% of the sample were combined into the "Other" category for readability.

travel surveys are not suitable for fully quantifying the effect of freight travel, this trend may hint at regional transportation changes.

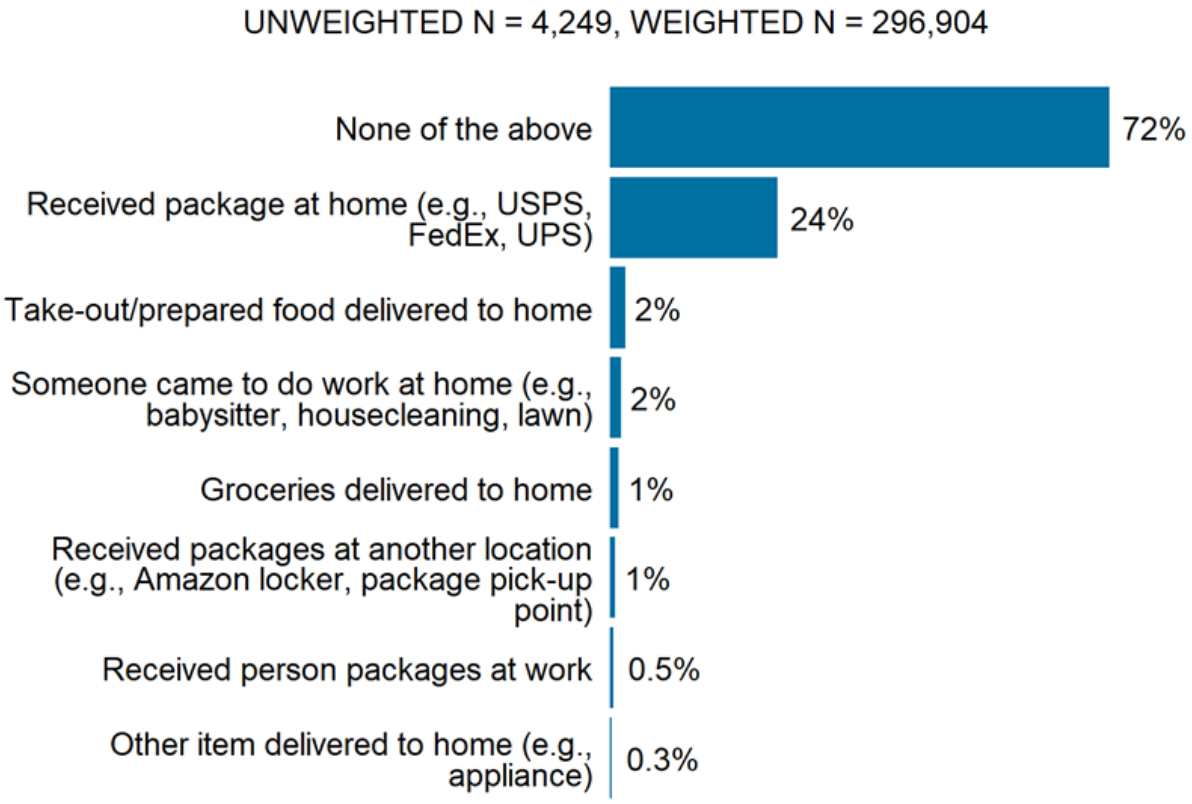
Lastly, employed respondents were asked how much time they spent teleworking at home on their travel day. Nearly two-thirds of employed respondents spent no time teleworking on their travel day, and about one-quarter of respondents teleworked 6 or more hours on their travel day (Figure 36).

**FIGURE 34: REASONS FOR NOT TRAVELING ON TRAVEL DAY (WEIGHTED)**



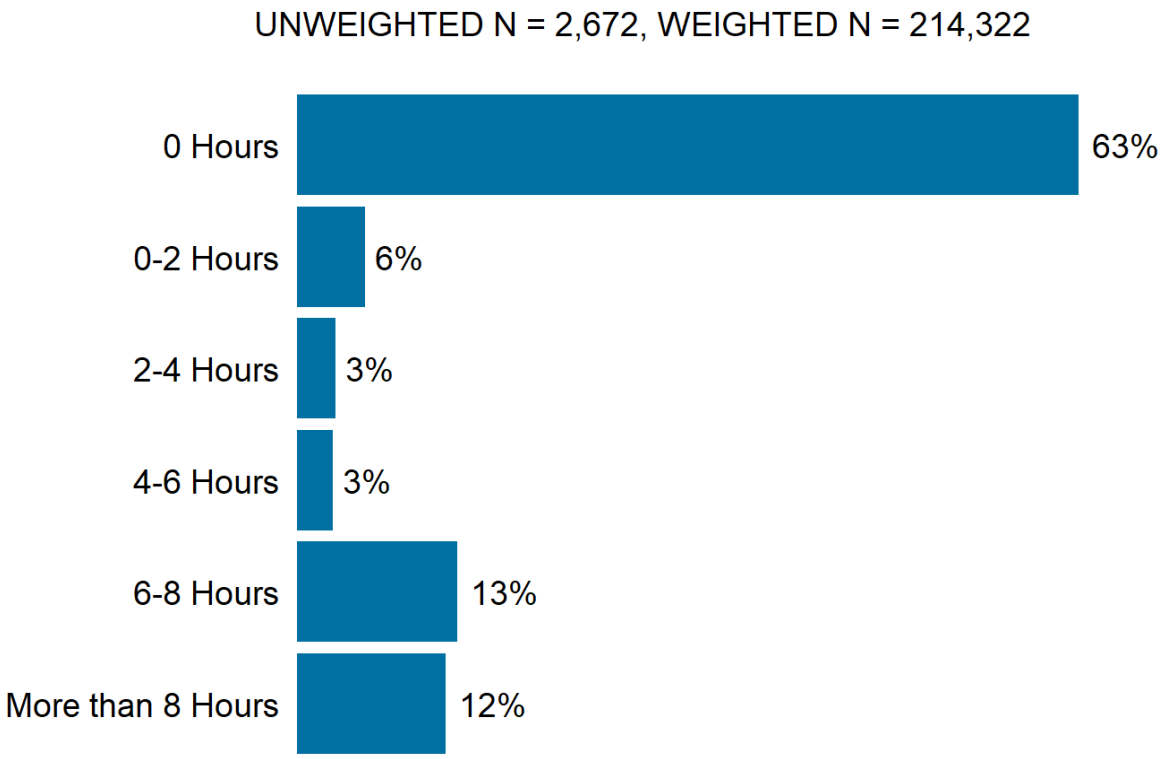

*Note: Respondents could select more than one answer to this question.*

**FIGURE 35: DELIVERIES RECEIVED ON TRAVEL DAY (WEIGHTED)**




*Note: Respondents could select more than one answer to this question.*

**FIGURE 36: TELEWORK TIME ON TRAVEL DAY (WEIGHTED AND UNWEIGHTED)**




## 8.9 REGIONAL QUESTION ANALYSIS

SRTC wanted to understand STA bus travel from responding households. Most respondents (82%) said they don't use transit or had never ridden an STA bus. About 7% had ridden an STA bus in the past 30 days (Figure 37).

Respondents were also asked which factors were important in choosing where they currently live. Affordability was strongly the most common factor (77%), followed by commuting distance to work (46%), and access to outdoor recreation and local parks (44%) (Figure 38).

**FIGURE 37: "WHEN WAS THE LAST TIME YOU RODE AN STA BUS?" (WEIGHTED)**

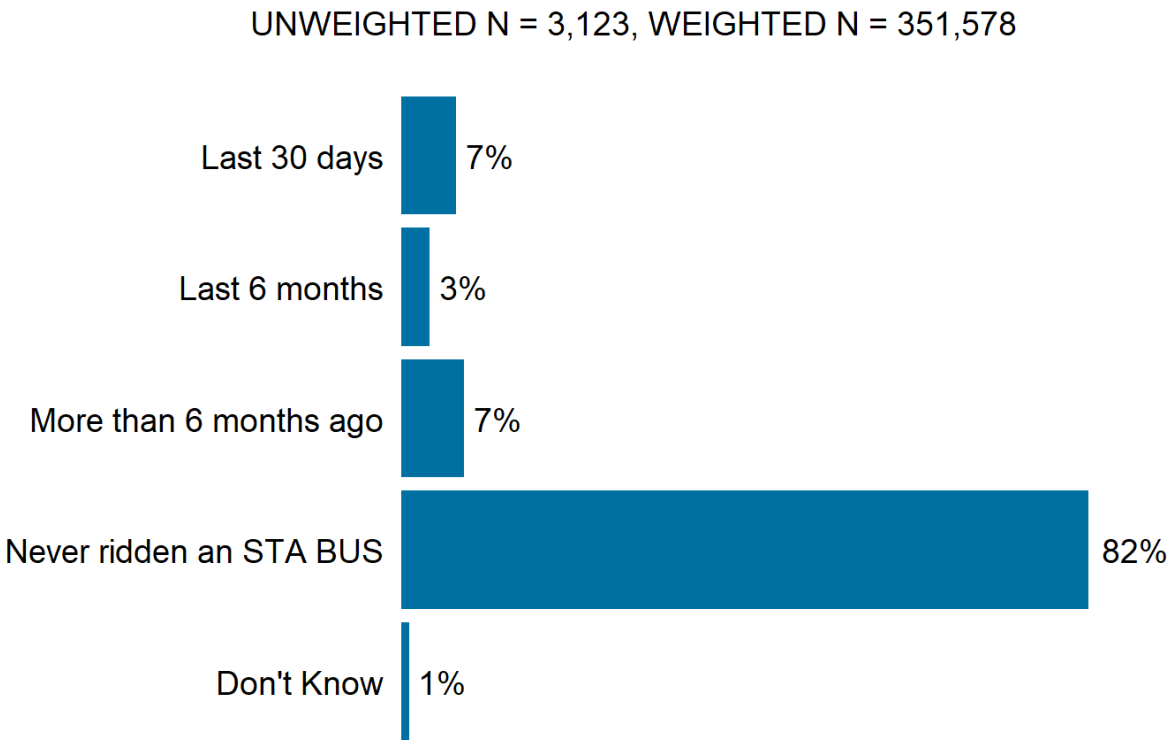
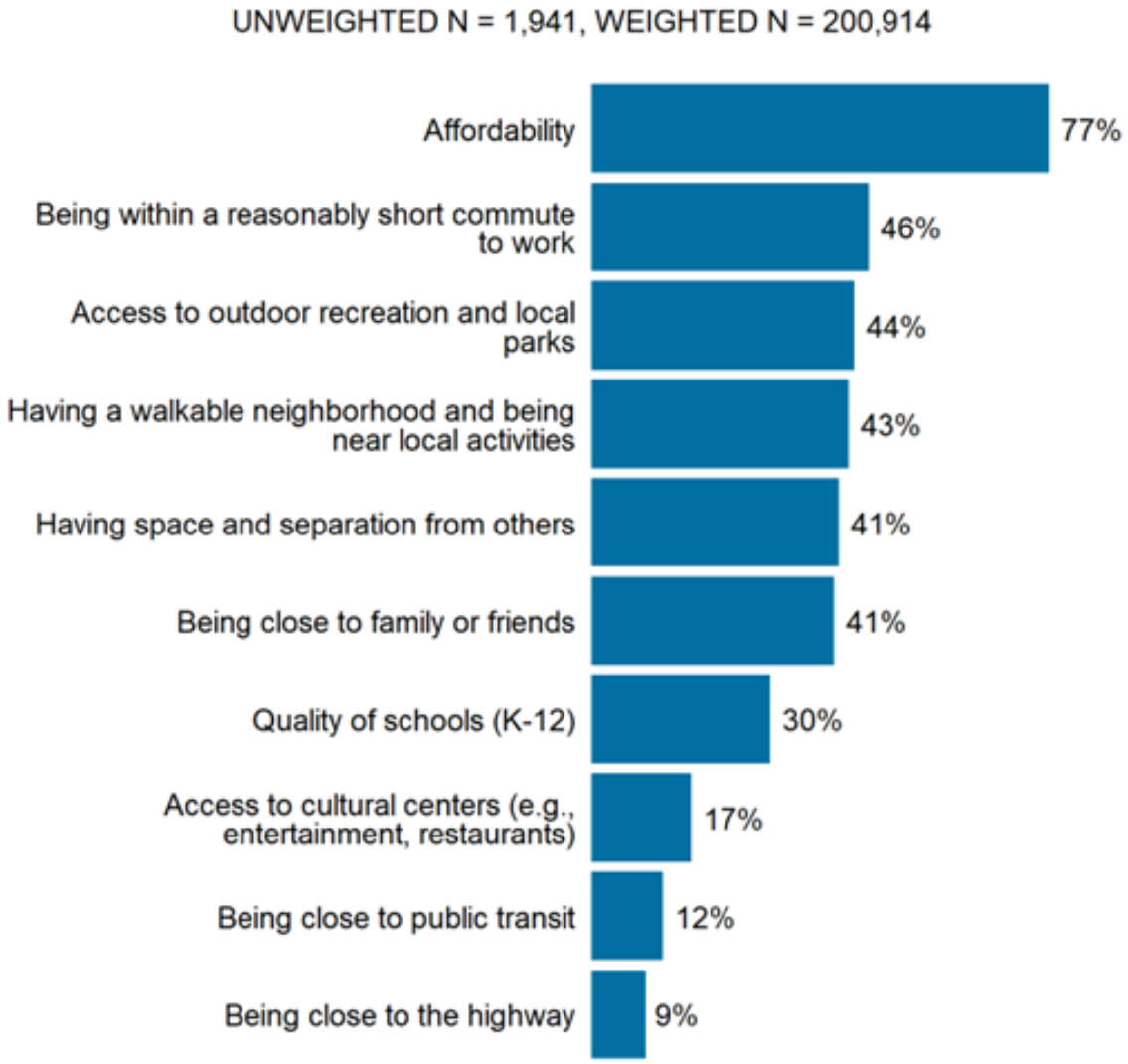


**FIGURE 38: "WHICH FACTORS WERE IMPORTANT IN CHOOSING WHERE YOU LIVE NOW?" (WEIGHTED)**




*Note: Respondents could select more than one answer to this question.*

# 9.0 CONCLUSION

The methods used in the 2022 SRTC provided higher-quality and more versatile data compared to traditional methods. The compensatory and targeted oversampling techniques resulted in a more representative sample than conventional random sampling would have allowed while still maintaining a probability-based sample, which allows for greater confidence in the final weighted data. Coherent, professional study branding and user-friendly survey tools (e.g., Bing Maps API) communicated expectations with participants and maximized the total participation rate. The high proportion of smartphone-collected data allowed for more precise trip rates and greater quantity of trip information captured across multiple days. Overall, the study applied innovative methods to capture higher-quality and higher-quantity data which will lead to greater analytical opportunities in the future.

# APPENDIX A. WEIGHTING MEMO

**TO:** SRTC

**FROM:** RSG

**DATE:** August 25, 2022

**SUBJECT:** 2022 Spokane Regional Transportation Study: Weighting Methodology

## 9.1 INTRODUCTION AND SCOPE

This memo describes the analysis, recommendations, and methodology used to expand[13] the data collected in the 2022 Spokane Regional Transportation Study to the 2019 American Community Survey Public Use Microdata Sample (ACS PUMS)[14] 1-year data[15]. The weighting methodology applied adjusts for survey non-response, survey participation mode, and geographic bias due to oversampling and other factors. In addition, RSG adjusted trip rates between the participation methods offered for the survey: online or smartphone app.

RSG has included a glossary at the end of this memo for key statistical terms used throughout.

**The applied weighting process included four primary steps, each of which are described in the following sections:**

1. **Initial Expansion**: Calculating an "initial weight" based on the probability of selection in the sample design. This essentially "reverses" the sample plan, providing higher initial weights to areas where less sampling occurred.
2. **Reweighting to account for non-response bias**: Performing a fitting routine to match several key household and person dimensions to ensure the weighted data accurately represent the entire survey region (and reduce sampling biases). This routine is performed using the open-source application, PopulationSim[16]. To do this step, missing values for income, gender, and race were imputed using a model-based approach for those who did not provide that information.
3. **Creating day-level weights to account for multi-day survey data:** Adjusting the day-level and trip-level data to account for the fact that smartphone respondents provided multi-day travel diaries, while online respondents provided a single-day travel diary (this is the "multi-day adjustment"). These relatively simple adjustments ensure that travel

[13] For the purposes of this report, the terms expansion, expansion factors, and weights are used interchangeably and are synonymous. They all represent the concept of an expansion weight.
[14] https://www.census.gov/programs-surveys/acs/microdata/access/2019.html
[15] RSG uses 1-year data for weighting because it is the most current available (whereas 5-year data would go back to 2015). Due to the geography size (PUMAs), the confidence in 1-year estimates is sufficiently high. Sampling uses 5-year data because sampling occurs at the block group level. Block groups are much smaller, so 1-year data has a much larger error margin.
[16] https://activitysim.github.io/populationsim/

analyses accurately reflect the entire survey region and do not over-represent smartphone respondents with multiple travel days.

4. **Adjusting for non-response bias in day-pattern and trip rates**: Adjusting the trip-level weights by data collection method (smartphone vs. online) to account for reporting biases that RSG has detected in this survey and prior travel surveys. These adjustments help make the day and trip-level data more consistent and increase the accuracy of trip rates across survey participation methods.

The following sections describe this process and the results in detail. The overall goal is to make the survey sample representative of the entire survey area across several key dimensions related to travel behavior.

## 9.2 INITIAL EXPANSION FACTORS

The purpose of the initial expansion is to expand each complete survey record to the population that was eligible to participate in the survey. The initial expansion weights are based on the relative probabilities each respondent has of being in the sample, as a function of the sampling plan and the number of invitations sent to specific sampling segments.

### Selection of Respondents for Weighting

After data processing was completed and any invalid person-days and household-days were flagged as incomplete, households that had at least one complete and valid weekday travel day were included in the weighting. For this purpose, a complete weekday was any complete Tuesday, Wednesday, or Thursday. The selection of “weekdays” essentially assumes that trip rates and behavior on those days are similar enough to consider them interchangeable, with an average weekday being the average of travel across those days. Only those weekdays were given person-day weights for analysis.

RSG did not weight travel data for Monday, Friday, Saturday, or Sunday because (a) data was only collected from smartphone-participating households on those days, (b) the travel behavior for those days is not assumed to be interchangeable with the behavior for Tuesday-Thursday, and (c) the data is used primarily to analyze and model typical weekday travel.

### Calculation of Initial Expansion Weights

To begin expanding the complete households, separate initial weights were calculated for each sampling segment. To calculate the initial expansion factors for each stratum, the ratio of population household counts to sampled households was calculated.

The initial expansion weights were used as the starting weights for further re-weighting to correct for non-response biases in the data, which is described in the following section. Table 1 provides a summary of the initial expansion factors by sample segment.

**TABLE 1: INITIAL EXPANSION FACTORS**

| SAMPLE SEGMENT[17] | SAMPLED HOUSEHOLDS | ACS HOUSEHOLDS | INITIAL EXPANSION FACTOR |
|---|---|---|---|
| General Population | 1,571 | 177,229 | 112.81 |
| Hard-to-Reach | 115 | 7,354 | 63.95 |
| Walk/Bike/Transit (WBT) | 267 | 18,228 | 68.27 |
| Total | 1,953 | 202,811 | |

## 9.3 REWEIGHTING FOR NONRESPONSE BIAS

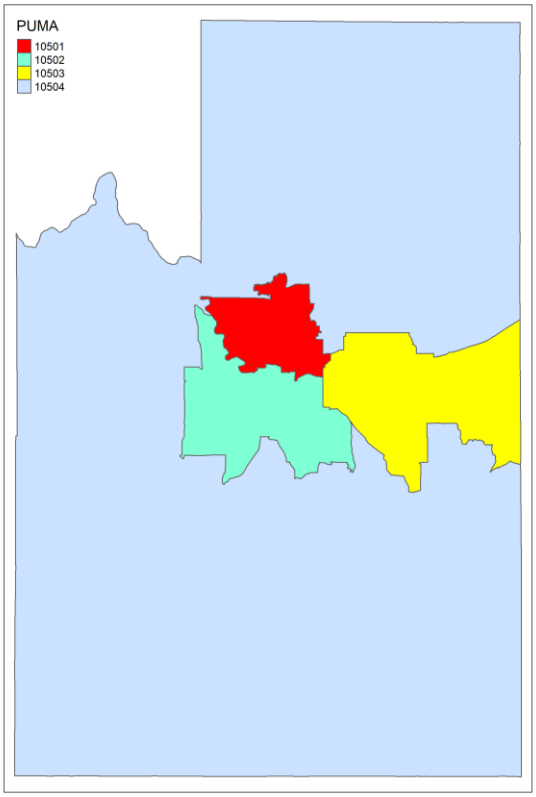
The 2019 American Community Survey Public Use Microdata Sample (ACS PUMS) data served as the target data for weighting this dataset. A fitting routine was used to adjust the initial weights so that the sum of the weights matched various household-level and person-level marginal targets within each of the defined weighting geographies. This routine was seeded with the initial expansion weights. Then, the algorithm was completed in a way to minimize deviation from the initial weights while matching the control targets as closely as possible.

### Weighting Geography

Using ACS PUMS data, weighting controls were generated for the four Public Use Microdata Areas (PUMAs) IDs = 10501, 10502, 10503, 10504) comprising the study area. PUMAs have populations in the range of 100,000–200,000. A map of the PUMAs used for the weighting process is included below in Figure 39.

[17] These sampling segments are defined in the glossary at the end of this memo.

**FIGURE 39: MAP OF PUMAS USED FOR WEIGHTING**




## Household and Person Weighting Targets

There are a variety of person-level and household-level target categories. The person-level targets are designed to identify the person types that are typically used in activity-based modeling software such as CT-RAMP and DaySim. The weighting targets were derived from PUMS data using the person-level weights from ACS. PUMS allows definition of full-time vs. part-time workers in a way consistent with the survey, while ACS tables do not provide consistent information. (For example, in the ACS tables, “part-time” includes people who only worked part of the previous year.) Table 2 and Table 3 provide the household and person-level variables used in the non-response adjustment step.

**TABLE 2: HOUSEHOLD-LEVEL TARGET VARIABLES**

| VARIABLE | CATEGORIES |
|---|---|
| **Household Size** | 1-person<br>2-person<br>3-person<br>4-person<br>5-person or more |
| **Income**<br>***(Imputed if non-response)*** | Under $25,000<br>$25,000 - $49,999<br>$50,000 - $74,999<br>$75,000 - $99,999 |

| | |
|---|---|
| | $100,000 - $199,999<br>$200,000 or more |
| **Workers** | 0 workers<br>1 worker<br>2 workers<br>3 workers or more |
| **Vehicles** | 0 vehicles or 1 vehicle<br>2 vehicles<br>3 vehicles or more |
| **Age of Head of Household** | Under 35 years<br>35 – 64 years<br>65 years or older |
| **Presence of Kids** | 0 kids<br>1 or more kids |
| **Total Households** | Not applicable |

**TABLE 3: PERSON-LEVEL TARGET VARIABLES**

| VARIABLE | CATEGORIES |
|---|---|
| **Gender**<br>***(Imputed if non-response)*** | Male<br>Female |
| **Age** | Under 5<br>5 – 17 years<br>18 – 34 years<br>35 – 64 years<br>65 years or older |
| **Worker Status** | Worker<br>Non-worker |
| **University Student Status** | University student<br>Non-university student |
| **Race**<br>***(Imputed if non-response)*** | White<br>Black or African American<br>Asian<br>Other<br>Multiple races |
| **Total Persons** | Not applicable |

## 9.4 IMPUTATION OF MISSING VALUES

The income, gender, and race questions in the survey allowed participants to respond with "prefer not to answer." To facilitate data weighting, missing values were imputed for these variables when a participant selected "prefer not to answer."

### Income

Survey respondents had the option to select "prefer not to answer" when answering the income question in the survey. Therefore, income was imputed using a model-based approach where missing income was predicted based on a set of independent variables including:

- Income distribution of the block group
- Number of non-working adults in the household
- Educational attainment of the household
- Age of the primary survey respondent
- Homeownership
- Single-family home residence type

This model has been tested across many travel survey projects and adequately matches the income values that were reported, indicating it is reliable to predict the missing income values. An assignment of imputed income was made based on the predicted probabilities generated by the imputation model. Model specification and coefficients are shown in Table 4. Positive coefficients (or estimates) indicate higher likelihood of high income while negative coefficients indicate higher likelihood of low income.

**TABLE 4: INCOME IMPUTATION MODEL SUMMARY**

| PARAMETER | DESCRIPTION | ESTIMATE | STD ERROR | T-STATISTIC |
|---|---|---|---|---|
| finc_0k_25k | Fraction of people in block group with incomes under 25k | -0.9091 | 0.669 | -1.36 |
| finc_25k_50k | Fraction of people in block group with incomes 25k-50k | -0.7771 | 0.749 | -1.04 |
| finc_50k_75k | Fraction of people in block group with incomes 50k-75k | -0.8759 | 0.814 | -1.08 |
| finc_100k_150k | Fraction of people in block group with incomes 100k-150k | 1.9919 | 0.890 | 2.24 |
| finc_150k_plus | Fraction of people in block group with incomes more than 150k | 2.8114 | 0.826 | 3.40 |
| nonworking_adult_n | Number of non-working adults in household | 0.3670 | 0.075 | 4.88 |
| child_n | Number of children in household | -0.0133 | 0.060 | -0.22 |
| full_time_graduate_degree_n | Number of full- time workers with graduate degrees in household | 2.5833 | 0.145 | 17.85 |
| part_time_graduate_degree_n | Number of part- time workers with graduate degrees in household | 0.8987 | 0.296 | 3.04 |
| full_time_bachelor_degree_n | Number of full- time workers with bachelor's degrees in household | 2.2071 | 0.133 | 16.64 |
| part_time_bachelor_degree_n | Number of part- time workers with bachelor's degrees in household | 0.7282 | 0.247 | 2.95 |
| full_time_low_education_n | Number of full-time workers with no advanced degrees in household | 1.3937 | 0.109 | 12.77 |
| part_time_low_education_n | Number of part time workers with no advanced degrees in household | 0.5123 | 0.159 | 3.23 |
| head_under_35_n | Head of household under 35 years | -0.3901 | 0.126 | -3.09 |
| head_over_65_n | Head of household over 65 years | 0.3992 | 0.122 | 3.28 |
| own_home | Household owns home | 1.0074 | 0.140 | 7.17 |
| single_family_home | Household lives in single family home | 0.3497 | 0.143 | 2.45 |

*McFadden's rho-squared: 0.189*

## Gender

Missing gender was probabilistically assigned based on the sample data's gender distribution within the respondent's age category.

## Race

Missing race was probabilistically assigned based on the ACS data's racial distribution within the respondent's home block group.

## 9.5 EXPANSION OF HOUSEHOLD AND PERSON DATA

Table 5 provides the distribution of weights that were calculated for each weighting geography in the sample and summarizes the ratio of the final weight against the initial expansion factor (the weight derived based on the probability of being sampled). In the weighting process, the ratio of the final weight to the initial weight was constrained to be in the range of 0.1 to 6.25[18] for each household. Allowing the weights to be outside this range would enable the process to match the ACS PUMS targets more exactly, but at the cost of having more extremely high or low weights and the introduction of more variance. Considering that the PUMS targets are themselves estimates based on census survey data, it is not good practice to try to match the targets too precisely by allowing the survey weights to vary widely. The range of 0.1 to 6.25 was arrived at after testing alternative limits and judging the best trade-off between accuracy and variability. “N” in the tables refer to the number of samples in each PUMA. The remaining statistics indicate the minimum, average (or mean), median, and maximum weight values in each PUMA.

**TABLE 5: SUMMARY STATISTICS OF THE FINAL WEIGHTS**

| PUMA ID | N | MIN | MEAN | MEDIAN | MAX |
|---|---|---|---|---|---|
| 10501 | 532 | 6.67 | 99.86 | 53.04 | 547.27 |
| 10502 | 678 | 5.15 | 77.81 | 50.43 | 450.78 |
| 10503 | 403 | 8.10 | 137.98 | 75.62 | 703.84 |
| 10504 | 340 | 7.53 | 121.66 | 72.55 | 620.09 |

**TABLE 6: SUMMARY STATISTICS FOR THE RATIO OF FINAL TO INITIAL WEIGHTS**

| PUMA ID | N | MIN | MEAN | MEDIAN | MAX |
|---|---|---|---|---|---|
| 10501 | 532 | 0.10 | 0.99 | 0.53 | 4.85 |
| 10502 | 678 | 0.08 | 0.82 | 0.56 | 4.00 |
| 10503 | 403 | 0.13 | 1.24 | 0.69 | 6.24 |
| 10504 | 340 | 0.11 | 1.10 | 0.67 | 5.50 |

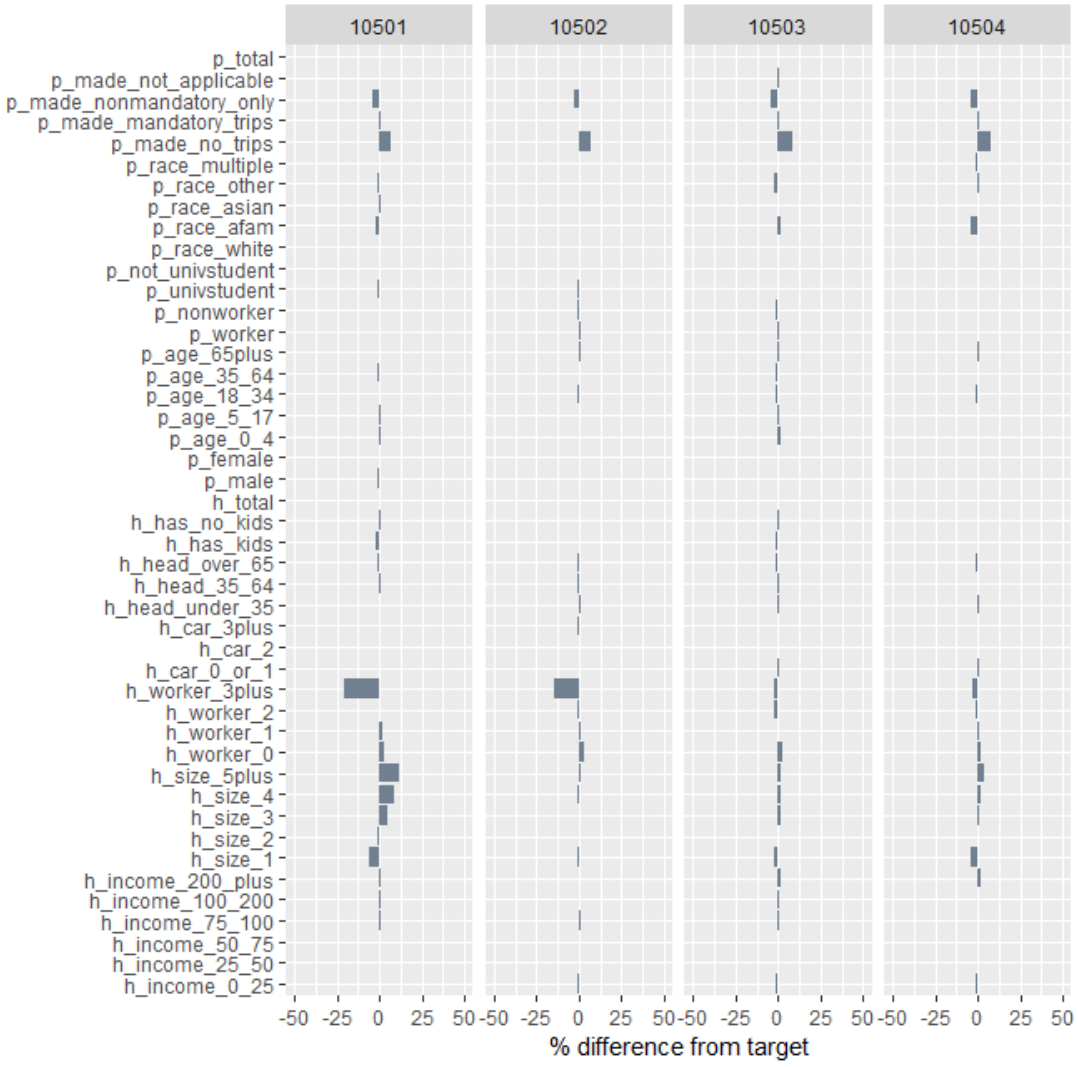
[18] In PopulationSim, the minimum and maximum expansion factors were set to 0.1 and 6.25 respectively. These values are used to set the lower and upper bounds on the ratio of final weights to initial weights as follows (max. is used as the example, but min. are calculated the same way): max weight = initial weight * max expansion factor * number of households / sum of initial weights

## Final Household and Person Weights

The final weights are effective in facilitating close matches to the regional totals for people, households, persons-in-households, and vehicles-in-households when using this dataset. The expanded and weighted survey values match the targets well (Figure 40), with all household and person categories within 10% of the ACS values, except for the household target for 3 or more workers. This target typically has very low sample sizes, and in this case all PUMAs have 10 or fewer households in that category.

As mentioned previously, matching the survey data to the target data even more closely can be achieved by relaxing the constraints on the ratio of the final to initial weights. However, this introduces more variance in the final weights and thereby increases the statistical error in any estimates. Allowing for more extreme weights also increases the likelihood of travel behavior analyses being impacted by extreme or outlier weights, which could unknowingly bias an estimate.

**FIGURE 40: COMPARISON OF WEIGHTED COUNTS TO TARGETS FOR EACH PUMA**




## 9.6 CREATING DAY WEIGHTS

With the shift to data collection using smartphone applications such as RSG's rMove™, it has become cost effective to capture multiple days of data for each respondent. The question then is how to combine the multi-day smartphone-based data with the single-day data from online and call center participants using a consistent weighting method. RSG's usual approach to create an "average weekday" day-level weight for multi-day smartphone data has been as follows:

- Weight to regional targets to obtain the household- and person-level weights for the included respondents.
- Define weekdays as Tuesday through Thursday as discussed previously.

- For each respondent, count the number of weekdays (N) for which the respondent provided complete and valid data. Set the person-day level weight equal to the person-level weight divided by N. In this way, when the data is weighted and aggregated, the sum of the person-day weights across days for each person is equal to the person weight, and the weighted results will reflect an average day for each respondent.

This method results in an “average weekday” for each respondent regardless of the number of days of data provided making the multi-day smartphone-based data compatible with the single-day online and call center-based data.

## 9.7 ADJUSTING FOR DAY-PATTERN AND TRIP RATES

It has been found in previous surveys that the trip rates from the smartphone-based survey data are 15–20% higher than those from online survey data. There are three main reasons for this:

- Smartphone-owning households have different socio-demographic characteristics than non-smartphone households and tend to make more trips.
- There are about twice as many “stay at home” days with no reported trips in the online and call center-based data in comparison to the smartphone-based data.
- Even on days with one or more reported trips, there are more trips per day reported on average in the smartphone-based data than in the online and call center-based data.

All three of these factors are interrelated and need to be isolated from each other through careful analysis and a series of weighting adjustments, as described in the sections below.

A typical method for adjusting the trip rates for online and call center-based data to match smartphone-based data is to adjust the weights at the trip-level. However, RSG employs a two-stage approach, first adjusting weights at the person-day level to adjust for biases in day-pattern types, and then a second stage to adjust weights at the trip-level. There are two key reasons for this:

1. First, as noted above, one of the key reasons that trip rates are different between the methods is the higher proportion of “stay at home” days with no trips reported in the online and call center-based data. While some of this difference is likely legitimate due to differences in demographics, some of it is also likely due to so-called “soft refusal,” whereby it is easy for respondents using the online or call center diary recall method to state that they did not make any trips when in fact they did. It is important to identify the extent of such bias and correct for it at the person-day level, because the “stay at home” cases have no trip records in the data, so the correction cannot be made by factoring weights at the trip-level.
2. Second, most activity-based models include a model component to predict the day-pattern type, such as stay at home, make mandatory (work or school) trips (and possibly other trips), or make non-mandatory trips only. While SRTC currently uses a four-step travel demand model, if the data is used to calibrate an activity-based model at the

person-day and household-day levels later, it is important to correct any biases that distort the day-pattern types in the data.

## Day-Pattern Adjustments

RSG has developed a method for identifying biases in day-patterns and adjusting for them in the weighting process. The following steps were taken to adjust for biases in day-patterns:

1. A multinomial choice model was estimated at the person-day level. There were three day-pattern choices that were modeled: (1) participant made no trips, (2) participant made mandatory (work or school) trips (and possibly other trips), and (3) participant made non-mandatory trips only. The model included the following variables as independent variables:
    - Income
    - Presence of vehicles in the household
    - Worker status
    - Student status
    - Age
2. The model also included additional bias variables for smartphone ownership and for adults whose travel was proxy reported either online or through the call center, which capture the trip reporting bias after accounting for the variables listed above. The day pattern model specification and coefficients are shown in Table 7.
3. The estimated model was applied to each person-day to calculate the probabilities of each of the three-day-pattern alternatives. Then the weighted probabilities were added across the sample within the categories of person-days—(a) those provided by respondents' own smartphones, and (b) those provided by online and call center-diary. The aggregate choice shares from applying the model should match the actual choice shares in the data. This provides a check that the model is being applied correctly to the data.
4. Step 2 was repeated, but this time, any bias coefficients in the model were set to 0. None of the bias coefficients apply to smartphone respondents, so the results for this category were unchanged. For the last two categories (online and proxied participants) the new predictions were what the choice shares would be if any biases did not exist (but all socio-demographic factors still apply. Table 8 shows the percent of weighted days in each category before and after removing the bias, by household group type and smartphone participation status
5. The modified aggregate choice predictions (segmented by weighting geography) were added as a new set of targets in the household/person weighting process described in previous sections. Then the number of person-days for each day-pattern type for each person were counted and used as the corresponding input for weighting at the person-level.

6. The non-response weighting procedure was then rerun with this new added target. The result was that the online/call center households with no trips tended to have their weights reduced, while those with trips (and particularly with non-mandatory trips only) tended to have their weights increased to match the adjusted targets. The weights for smartphone respondents remained essentially unchanged. The advantage of adding these new targets into the household- and person-level weighting process and using all the targets simultaneously is that all the household- and person- level weighting targets were still matched as well, which would not be the case if the adjustment was made to the new day-pattern targets in isolation.

**TABLE 7: DAY PATTERN MODEL SUMMARY**

| ALTERNATIVE[19] | PARAMETER | DESCRIPTION | ESTIMATE | STD ERROR | T-STATISTIC |
|---|---|---|---|---|---|
| Makes mandatory trips | (Intercept) | | -2.8323 | 0.234 | -12.13 |
| | online_data | Online diary data | -0.0549 | 0.112 | -0.49 |
| | call_center_data | Call center diary data | -1.2862 | 0.417 | -3.09 |
| | zero_vehicle | No vehicles in household | -0.1157 | 0.277 | -0.42 |
| | income_aggregate2 | Income 25k-50k | 0.3991 | 0.180 | 2.21 |
| | income_aggregate3 | Income 50k-75k | 0.7669 | 0.182 | 4.21 |
| | income_aggregate4 | Income 75k-100k | 0.5016 | 0.197 | 2.55 |
| | income_aggregate5 | Income 100k-200k | 0.1860 | 0.173 | 1.07 |
| | income_aggregate6 | Income over 200k | 0.2914 | 0.250 | 1.17 |
| | income_aggregate999 | Prefer not to answer income | -0.2918 | 0.202 | -1.44 |
| | age_under_35 | Age < 35 years | 0.4272 | 0.205 | 2.09 |
| | age_35_65 | Age between 35-65 years | 0.4466 | 0.163 | 2.73 |
| | employed | Employed full/part/self | 3.5957 | 0.159 | 22.56 |
| | is_student | Full or part-time student | 2.5583 | 0.265 | 9.66 |
| | online_data:age_under_35 | Online/call center diary data x Age | -0.1190 | 0.202 | -0.59 |
| Makes non-mandatory trips only | (Intercept) | | 1.2697 | 0.137 | 9.27 |
| | online_data | Online diary data | -0.4279 | 0.097 | -4.43 |
| | call_center_data | Call center diary data | -0.8445 | 0.195 | -4.32 |

[19] The no-travel day alternative was used as the base alternative in this model.

| ALTERNATIVE[19] | PARAMETER | DESCRIPTION | ESTIMATE | STD ERROR | T-STATISTIC |
|---|---|---|---|---|---|
| | zero_vehicle | No vehicles in household | -0.2510 | 0.195 | -1.29 |
| | income_aggregate2 | Income 25k-50k | -0.0025 | 0.136 | -0.02 |
| | income_aggregate3 | Income 50k-75k | -0.0145 | 0.145 | -0.10 |
| | income_aggregate4 | Income 75k-100k | 0.1150 | 0.159 | 0.72 |
| | income_aggregate5 | Income 100k-200k | -0.1258 | 0.141 | -0.89 |
| | income_aggregate6 | Income over 200k | 0.3794 | 0.222 | 1.71 |
| | income_aggregate999 | Prefer not to answer income | -0.2126 | 0.157 | -1.36 |
| | age_under_35 | Age < 35 years | -0.2212 | 0.155 | -1.43 |
| | age_35_65 | Age between 35-65 years | -0.2404 | 0.103 | -2.33 |
| | employed | Employed full/part/self | -0.0349 | 0.094 | -0.37 |
| | is_student | Full or part-time student | -0.7848 | 0.283 | -2.77 |
| | online_data:age_under_35 | Online/call center diary data x Age | -0.4405 | 0.196 | -2.25 |

*McFadden's rho-squared: 0.214*

**TABLE 8: DAY CATEGORY BY HOUSEHOLD GROUP & SMARTPHONE PARTICIPATION, WITH AND WITHOUT BIAS REMOVED**

| DAY TYPE | ONLINE - RAW | ONLINE - ADJ | CALL CENTER – RAW | CALL CENTER – ADJ | rMOVE |
|---|---|---|---|---|---|
| No-travel days | 22% | 17% | 40% | 22% | 16% |
| Mandatory trip days | 39% | 35% | 7% | 10% | 40% |
| Non-mandatory trip days | 39% | 48% | 53% | 67% | 44% |
| **TOTAL** | 100% | 100% | 100% | 100% | 100% |

## Trip-Rate Adjustments

After the first stage of adjustment described above, the new person-day weights were applied to compare the trip rates for the different survey participation methods. Adjusting the weights for day-pattern biases reduced the discrepancy in trip rates between methods, but it did not eliminate it altogether. In practice, the difference in trip rates tends to be higher for non-mandatory trips than for mandatory trips, as respondents are less likely to omit their work and school trips in recall-based diary methods. The differences can also be large for non-home-based trips, since online/call center and by-proxy respondents often tend to omit intermediate stops on multi-stop tours. The process for adjusting the trip-level weights was relatively analogous to that described above for day-pattern types but was somewhat simpler. The starting point for the two-stage trip-rate bias correction was the person-day weights. The following steps were then taken to adjust trip rates:

1. Trips were segmented into the following four trip types that have different levels of underreporting. Then for each person-day in the sample, the number of trips were counted by type.
    a. Home-based work/school trips
    b. Home-based other trips
    c. Non-home-based work/school trips
    d. Non-home-based other trips
2. For each trip type, a Poisson regression model was estimated where the dependent variable was the number of trips of that type for the person-day. The independent variables were the same set of household and person variables listed above for the day-pattern models, plus dummy variables for online and call center-based person-days.

For each person-day and for each trip type, the estimated regression model was applied with and without the bias coefficients. The ratio of the two estimates resulted in a factor to apply to the trip weight for that person-day. For example, if the model predicted 1.10 trips with the estimated model and 1.32 trips with the bias parameters set to 0 for an online or call center-based person-day, then a factor of 1.32/1.10 = 1.2 was used to multiply the person-day weight to get an adjusted trip weight. For smartphone respondents, the bias coefficients do not apply, so the factor was always 1.0 and the trip weight equaled the person-day weight. A lower bound of 1.0 and an upper bound of 2.0 were placed on ratios to avoid extreme adjustment to the weights. The specifications for each of the four regression models are shown in Table 9, Table 10, Table 11, and Table 12. The resulting trip adjustment factors by each of the three diary methods and trip type are shown in Table 13. Non-home-based trips have rather high adjustment factors for online and call center-based diary participants, which is likely due to poor recall of intermediate stops between home and another location. As smartphone ownership

increases among adults, the need to assign adults to proxy for other adults via smartphone will decrease.

**TABLE 9: HOME-BASED WORK TRIP MODEL**

| PARAMETER | DESCRIPTION | ESTIMATE | STD ERROR | T-STATISTIC |
|---|---|---|---|---|
| (Intercept) | | -2.9539 | 0.147 | -20.03 |
| online_data | Online diary data | -0.6116 | 0.054 | -11.32 |
| call_center_data | Call center diary data | -0.7540 | 0.533 | -1.41 |
| age_under_25 | Under age 25 | 0.8982 | 0.128 | 7.02 |
| age_25_45 | Age 25 to 45 | 0.4976 | 0.119 | 4.19 |
| age_45_65 | Age 45 to 65 | 0.4432 | 0.120 | 3.68 |
| employed_ft | Employed full-time | 2.5396 | 0.113 | 22.54 |
| employed_pt | Employed part-time | 2.4682 | 0.119 | 20.67 |
| employed_self | Self-employed | 2.1184 | 0.198 | 10.70 |
| bachelors | Has bachelor's degree | -0.1631 | 0.050 | -3.28 |
| graduate_degree | Has masters/PhD | 0.0050 | 0.056 | 0.09 |
| is_student | Is student | -0.2744 | 0.070 | -3.94 |
| work_loc_varies | Work location varies | -0.2387 | 0.073 | -3.27 |
| two_plus_jobs | Works 2+ Jobs | 0.1772 | 0.072 | 2.47 |
| sf_home | Lives in single family home | 0.0962 | 0.051 | 1.89 |

*McFadden's rho-squared: 0.200*

**TABLE 10: HOME-BASED OTHER TRIP MODEL**

| PARAMETER | DESCRIPTION | ESTIMATE | STD ERROR | T-STATISTIC |
|---|---|---|---|---|
| (Intercept) | | 0.4212 | 0.056 | 7.46 |
| online_data | Online diary data | -0.7482 | 0.030 | -24.80 |
| call_center_data | Call center diary data | -1.1028 | 0.206 | -5.34 |
| age_under_25 | Under age 25 | 0.0821 | 0.056 | 1.48 |
| age_25_45 | Age 25 to 45 | 0.2890 | 0.034 | 8.54 |
| age_45_65 | Age 45 to 65 | 0.2140 | 0.034 | 6.29 |

| | | | | |
|---|---|---|---|---|
| employed_ft | Employed full-time | -0.4787 | 0.029 | -16.79 |
| employed_pt | Employed part-time | -0.1752 | 0.039 | -4.44 |
| employed_self | Self-employed | -0.2514 | 0.087 | -2.88 |
| bachelors | Has bachelor's degree | 0.2057 | 0.026 | 7.89 |
| graduate_degree | Has masters/PhD | 0.2287 | 0.030 | 7.63 |
| is_student | Is student | 0.1477 | 0.047 | 3.14 |
| work_loc_varies | Work location varies | 0.1155 | 0.044 | 2.61 |
| two_plus_jobs | Works 2+ Jobs | 0.0337 | 0.049 | 0.69 |
| sf_home | Lives in single family home | 0.0857 | 0.026 | 3.23 |

*McFadden's rho-squared: 0.064*

**TABLE 11: NON-HOME-BASED WORK TRIP MODEL**

| PARAMETER | DESCRIPTION | ESTIMATE | STD ERROR | T-STATISTIC |
|---|---|---|---|---|
| (Intercept) | | -2.1719 | 0.126 | -17.24 |
| online_data | Online diary data | -0.2688 | 0.039 | -6.84 |
| call_center_data | Call center diary data | -0.9310 | 0.423 | -2.20 |
| age_under_25 | Under age 25 | -0.2518 | 0.091 | -2.76 |
| age_25_45 | Age 25 to 45 | -0.4132 | 0.080 | -5.16 |
| age_45_65 | Age 45 to 65 | -0.2459 | 0.081 | -3.05 |
| employed_ft | Employed full-time | 3.4964 | 0.112 | 31.19 |
| employed_pt | Employed part-time | 2.8344 | 0.119 | 23.91 |
| employed_self | Self-employed | 2.4311 | 0.181 | 13.46 |
| bachelors | Has bachelor's degree | -0.5844 | 0.042 | -13.83 |
| graduate_degree | Has masters/PhD | -0.4953 | 0.047 | -10.43 |
| is_student | Is student | -0.3278 | 0.058 | -5.61 |
| work_loc_varies | Work location varies | 0.1729 | 0.050 | 3.47 |
| two_plus_jobs | Works 2+ Jobs | 0.3885 | 0.052 | 7.47 |

| | | | | |
|---|---|---|---|---|
| sf_home | Lives in single family home | -0.2322 | 0.038 | -6.11 |

*McFadden's rho-squared:0.226*

**TABLE 12: NON-HOME-BASED OTHER TRIP MODEL**

| PARAMETER | DESCRIPTION | ESTIMATE | STD ERROR | T-STATISTIC |
|---|---|---|---|---|
| (Intercept) | | 0.1112 | 0.071 | 1.57 |
| online_data | Online diary data | -0.0037 | 0.030 | -0.12 |
| call_center_data | Call center diary data | 0.0373 | 0.148 | 0.25 |
| age_under_25 | Under age 25 | 0.0659 | 0.067 | 0.98 |
| age_25_45 | Age 25 to 45 | 0.1508 | 0.041 | 3.71 |
| age_45_65 | Age 45 to 65 | 0.1064 | 0.040 | 2.67 |
| employed_ft | Employed full-time | -0.6473 | 0.036 | -18.08 |
| employed_pt | Employed part-time | -0.3250 | 0.049 | -6.66 |
| employed_self | Self-employed | -0.1376 | 0.091 | -1.52 |
| bachelors | Has bachelor's degree | 0.1363 | 0.032 | 4.20 |
| graduate_degree | Has masters/PhD | 0.0907 | 0.038 | 2.40 |
| is_student | Is student | 0.2777 | 0.061 | 4.58 |
| work_loc_varies | Work location varies | 0.2414 | 0.053 | 4.52 |
| two_plus_jobs | Works 2+ Jobs | 0.2521 | 0.058 | 4.37 |
| sf_home | Lives in single family home | -0.1929 | 0.031 | -6.32 |

*McFadden's rho-squared: 0.027*

**TABLE 13: TRIP ADJUSTMENT FACTORS**

| TRIP TYPE | RMOVE DIARY | CALL CENTER DIARY | ONLINE DIARY |
|---|---|---|---|
| Home-based work | 1 | 2 | 1.843 |
| Home-based other | 1 | 2 | 2.000 |
| Non-home-based work | 1 | 2 | 1.308 |
| Non-home_based other | 1 | 1 | 1.004 |

## 9.8 FINAL WEIGHTS AND RECOMMENDED USE

The final weights provided with the dataset are described below:

**hh_weight**: The resulting weights from expanding to the PUMS data. The sum of the hh_weight in the household table reflects the total number of households in the survey region. *This weight should be used for household-level and vehicle-level analyses.*

**person_weight**: The resulting weights from expanding to the PUMS data. The sum of the person_weight in the person table reflects the total number of persons in the survey region. *This weight should be used for person-level analyses.*

**day_weight**: The adjusted day-level weights, which are the hh_weight divided by the number of complete days and adjusted based on the day category (no trips, mandatory trips, or non-mandatory trips only). *This weight should be used for day-level analyses.*

**trip_weight**: The adjusted trip-level weights, which are the trip factor multiplied by the day_weight. The sum of trip_weight in the trip table equals the number of trips taken by residents of the survey region on a "typical day," as estimated by this survey and weighting approach. *This weight should be used for trip-level analyses.*

## 9.9 GLOSSARY OF KEY TERMS

- **Estimate:** The estimated coefficients produced by a model.
- **Expansion factor:** The factor used to adjust responses up to an estimate for the entire population, with one respondent representing a certain number (x) of people in the population, where x is the expansion factor.
- **McFadden's rho-squared:** A measure of the goodness of fit of a model, ranging from 0 to 1. A larger rho-squared indicates a better fit.
- **Multinomial choice model:** A model used to choose between several possible distinct options.
- **Poisson regression model:** A type of regression model used to model count variables.
- **Reporting bias:** A bias during data collection that occurs when respondents choose to report data in a certain way, causing a skew in the data.
- **Sampling bias:** A bias resulting from the sampling methods that causes some members of the intended population to have a lower or higher probability of being sampled compared to others in the population.

- **Sampling segments:**
    - **Hard-to-Reach population:** Comprised of the BGs in the sample frame with at least 50% of households earning less than $25,000 per year (“low income“) and / or at least 40% of the households identified as Hispanic and/or Black, Indigenous, or Persons of Color (BIPOC).
    - **Walk/Bike/Transit population:** Comprised of BGs in the sample frame which have at least 15% households reporting walk, bicycle, or public transportation as the means of transportation to work.
    - **General population:** Comprised of block groups in the study region that do not qualify for oversampling segments above.
- **Standard Error (Std Error):** The amount of variation of an observation or estimate from a model due to sampling.
- **T-Statistic:** The ratio between the estimate and the standard error. A higher t-statistic in absolute value indicates higher statistical confidence in the estimate.