

City of Seattle & Puget Sound Regional Council

INTRODUCTORY GUIDE TO HOUSEHOLD TRAVEL SURVEY DATA

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1.0 WHAT IS A HOUSEHOLD TRAVEL SURVEY?

Regional and state transportation planners rely on detailed travel data to inform their planning. This data includes **who** is traveling, **when** they travel, **where** they are going, **why** they go there, and **how** they get there. A household travel survey (HTS) helps collect this data, which planners can then use to better understand travel behavior in the survey geography. In some cases, planners use travel demand models to inform their plans. HTS data is one source often used to develop and calibrate these models, but planners can also use the data outside of these models to create descriptive statistics on regional travel and to analyze trends over time.

1.1 WHAT TYPE OF DATA DOES AN HTS INCLUDE (AND NOT INCLUDE)?

The Puget Sound Regional Travel Studies seek to capture quality, regionally representative data for residents' travel behavior on a typical weekday. This data includes household and person demographics, household vehicle information, and information about daily travel patterns (e.g., locations, travel times, travel modes) (Figure 1).

HTS data, by design, captures nearly all regional household travel. But some travel markets—like transit, air travel and airport ground access, emerging travel modes (e.g., e-scooters, ride-hailing services like Uber or Lyft), and seasonal travel—often require additional data and research to more fully understand. Other travel markets, like visitor travel, external/pass-through trips, or commercial travel, are not captured in an HTS. Table 1 lists examples of planning and policy questions that an HTS can and cannot answer.

FIGURE 1: EXAMPLE HTS TRAVEL DATA

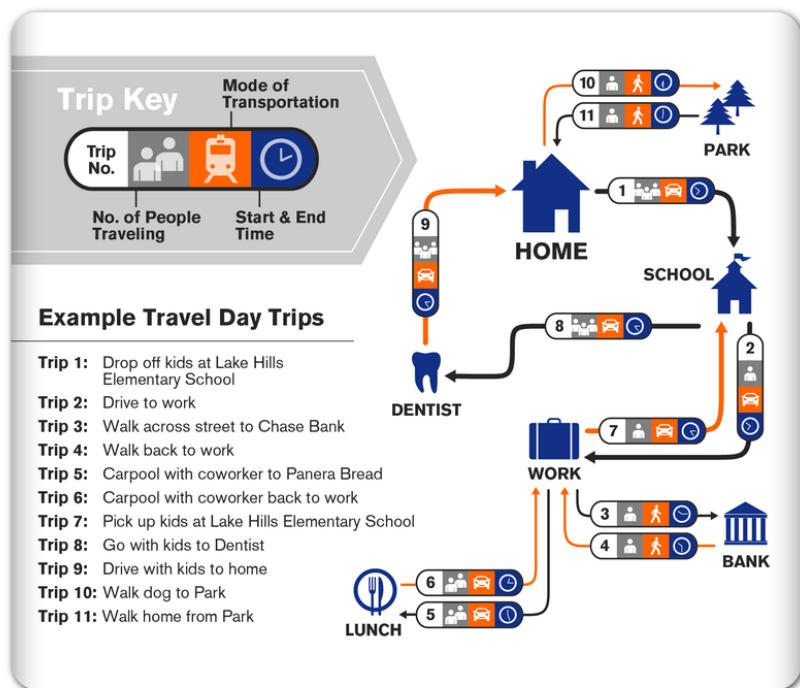


TABLE 1: PLANNING AND POLICY QUESTIONS THAT AN HTS CAN AND CANNOT ANSWER

HTS CAN HELP ANSWER:	ADDITIONAL DATA IS NEEDED TO FULLY ANSWER:
<ul style="list-style-type: none"> • How many car trips does the average resident make on a typical weekday? • How does transit use vary by income? • What are the peak travel hours, by trip purpose, throughout the day? • How often do employed persons typically telecommute (vs. commuting to work)? 	<ul style="list-style-type: none"> • Where do visitors go when they travel to the region? • How many miles do ride-hail drivers (e.g., Uber, Lyft) travel without passengers in their vehicles? • How many airplane trips does the average resident make each year? • Where does freight travel around the region?

1.2 WHAT TYPE OF ANALYSES CAN HTS DATA SUPPORT?

HTS data users can derive many key figures from HTS data, including household and person-trip rates, travel mode shares, vehicle occupancy factors, geographic travel patterns (including origin-destination trip tables), and more—all with rich demographic detail. Data completeness is one of HTS data’s greatest strengths compared to passively collected “big data sources. HTS datasets are smaller in volume but extremely rich as a data source; these datasets uniquely provide detailed household- and person-level data and regionally representative statistics. HTS data is currently viewed as a gold standard for travel behavior data, within the limits of the associated study designs (e.g., not capturing visitors, focusing on weekdays) and statistical margins of error. HTS also has great potential to complement big data to leverage the unique strengths of each data source.

Beyond the traditional HTS uses, the Puget Sound travel survey program is also somewhat unique in its recurrent nature, collecting data approximately every two years using highly consistent methods. This allows for trend analysis over time, which is often not feasible when collection occurs less frequently or with different methods.



2.0 HTS DATA COLLECTION METHODS

The Puget Sound Regional Travel Studies collect data across King, Kitsap, Pierce, and Snohomish counties using an online and GPS smartphone app-based survey data approach. . The household travel survey program is currently scheduled to include three waves between 2017-2021 with data collection every other year (2017, 2019, 2021). Additional details about the program are available at <https://www.psrc.org/household-travel-survey-program>.

Study participants were invited using address-based sampling (ABS)¹ and mailed letter and postcard invitations. The study oversampled block groups that included high proportions of household and travel characteristics that are particularly important for transportation planning, such as low-income households, zero-vehicle households, non-auto (e.g., walk, bike, transit) commuters, and young households.

Participants could complete the survey online for a one-day travel period or by smartphone app (rMove™) for a seven-day travel period. The study required that all household members over age five report their travel information during their travel period. Adults provided information on behalf of children between the ages of 5 and 17. Households that completed the entire study were eligible to receive a gift card incentive. Offering incentives helps improve response rates (thereby reducing the overall cost of the survey) and improve data quality.

Following data collection, the survey data was weighted to match the regional population across key sociodemographic dimensions. Weights correct any bias that may be present in the sample of people who completed the survey (e.g., from surveying too many persons of a particular profile or from a particular area). This ensures the survey is representative and aligns with census totals for those demographics. The weighting process results in a new variable that reflects how many households (or persons, days, or trips) that survey record represents in the region. For example, a household weight of 250 implies the survey record represents 250 similar households in the region.

¹ Address-based sampling (ABS) is a sampling method that typically relies on USPS residential address data to sample and invite survey participants. This approach provides the most complete and reliable data frame for household-level surveys (compared to other methods, such as random digit dialing).

3.0 PUGET SOUND STUDY DATA ELEMENTS

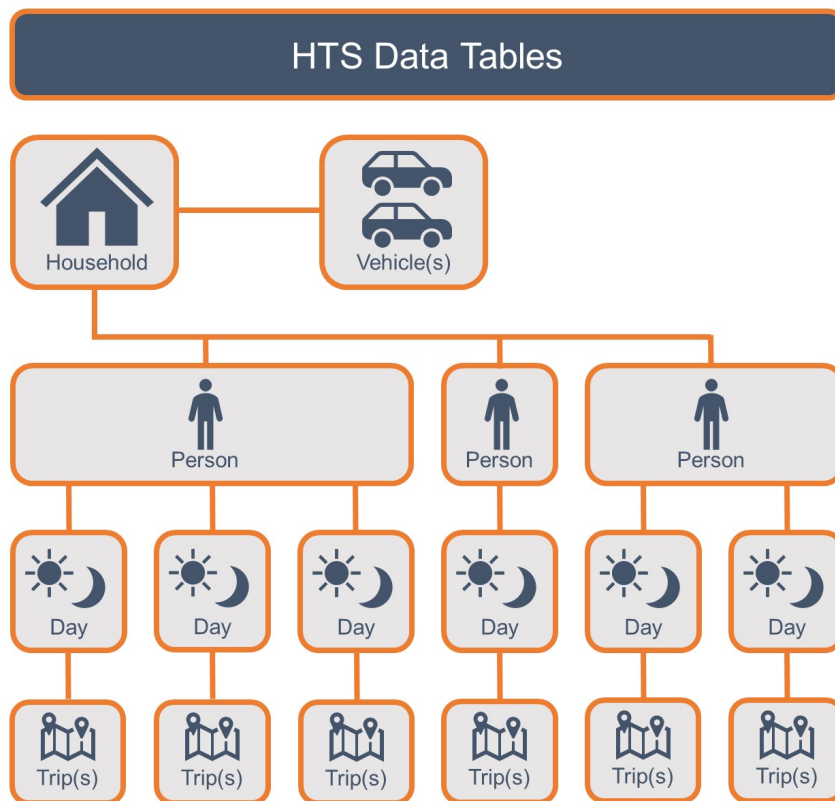
The 2019 Puget Sound Regional Travel Study dataset includes several different data tables, often referred to as their own “level” of data (shown in Table 2 below).

TABLE 2: HTS DATA TABLE OVERVIEW

DATA TABLE	RECORDS
Household	One record per household that completed the study
Vehicle	Zero or more records per household
Person	One or more records per household
Day	One to seven records per person
Trip	Zero or more records per person-day

Figure 2 shows the basic relationship between the different tables of survey data.

FIGURE 2: HTS DATA TABLE RELATIONSHIPS



Each data table captures several data elements. Table 3 synthesizes the primary elements at each level (or data table). This list does not include administrative/metadata fields (e.g., household ID, time to complete). The appended survey questionnaire has full variable details.

TABLE 3: SELECT/EXAMPLE DATA ELEMENTS BY DATA TABLE

DATA LEVEL		SELECT/EXAMPLE DATA ELEMENTS	
Demographics/Household Composition	Household	<ul style="list-style-type: none"> • Carshare program use • Home location (primary & previous) • Home ownership • Household income • Household size 	<ul style="list-style-type: none"> • Household vehicle count • Reasons for home relocation • Residence type and duration • Seasonal residency
	Vehicle	<ul style="list-style-type: none"> • Disability pass status • Fuel type 	<ul style="list-style-type: none"> • Make, model, and model year • Purchase year
	Person	<ul style="list-style-type: none"> • Age category • Autonomous vehicle use (concerns, interest) • Commute benefits • Commute mode (typical) • Commute frequency (typical) • Driver's license type • Educational attainment • Employment status • Factors to influence more bike travel • Factors to influence more transit travel 	<ul style="list-style-type: none"> • Gender • Job count • Job location (current & previous) • Parking at work • Race/ethnicity • Relationship to primary householder • School type, location, travel mode • Student status • Transit payment methods • Vehicle driven most often • Walk/bike/transit/ride hailing frequency
Travel/Location Information	Day	<ul style="list-style-type: none"> • Diary reporter (i.e., self-reported or assisted) • Date/day of week • Day trip count • Home deliveries on travel day 	<ul style="list-style-type: none"> • If used toll roads on travel day • If paid for parking on travel day • Online shop time on travel day • Reasons for not traveling (if applicable) • Telecommute time on travel day
	Trip	<ul style="list-style-type: none"> • Carpool start and end location • Date/day of week • Parking costs • Parking location type • Persons in travel party • Taxi/bus/ferry/air fares 	<ul style="list-style-type: none"> • Toll road fares • Transit lines used • Travel modes • Travel times/trip durations • Trip purpose • Vehicle driver

4.0 TYPICAL USES OF HTS DATA

4.1 OVERVIEW OF POSSIBLE DATA USES

Travel demand modeling (either trip-based or activity-based) is one of the fundamental uses of HTS data. Effective transportation planning requires current data when updating these models. Outside of modeling, planners can also use HTS data for generating descriptive statistics, general transportation planning (e.g., developing demographic profiles of cyclists), and trend analysis of these metrics over time, among other uses. Some common metrics when using HTS data, or any survey data, are listed in Table 4.

TABLE 4: COMMON METRICS WHEN USING HTS DATA (OR ANY SURVEY DATA)

COMMON METRICS FOR HTS DATA	EXAMPLE
<ul style="list-style-type: none"> • Counts and distributions 	<ul style="list-style-type: none"> • 81% of households own one or more personal vehicles
<ul style="list-style-type: none"> • Person and vehicle trip rates 	<ul style="list-style-type: none"> • The average person makes 4.5 trips per day
<ul style="list-style-type: none"> • Person-miles traveled and vehicle-miles traveled 	<ul style="list-style-type: none"> • The average person travels 29 miles per day. The average car travels 22 miles per day
<ul style="list-style-type: none"> • Vehicle occupancy factors 	<ul style="list-style-type: none"> • The average personal vehicle traveling on the road has 1.9 people in it
<ul style="list-style-type: none"> • Person-time use and vehicle-time use 	<ul style="list-style-type: none"> • The average personal vehicle is used for 65 minutes per day
<ul style="list-style-type: none"> • Top box or top two box 	<ul style="list-style-type: none"> • “28% of people are very or somewhat interested in using an autonomous car in the future.”
<ul style="list-style-type: none"> • Elasticity or shares 	<ul style="list-style-type: none"> • “On average, people value their time at \$25/hour while traveling”



4.2 EXAMPLE DATA METRICS

Figure 3, Figure 4, and Figure 5 below visualize analyses using the types of metrics described in Table 4.

FIGURE 3: MODE CHOICE AND GENDER

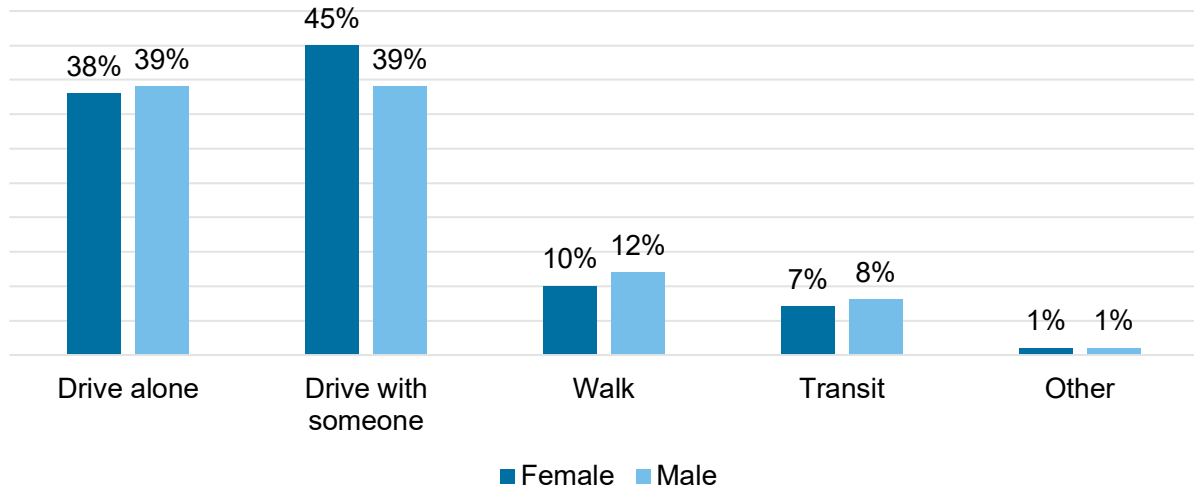


FIGURE 4: HOW TRANSIT RIDERS ACCESS TRANSIT

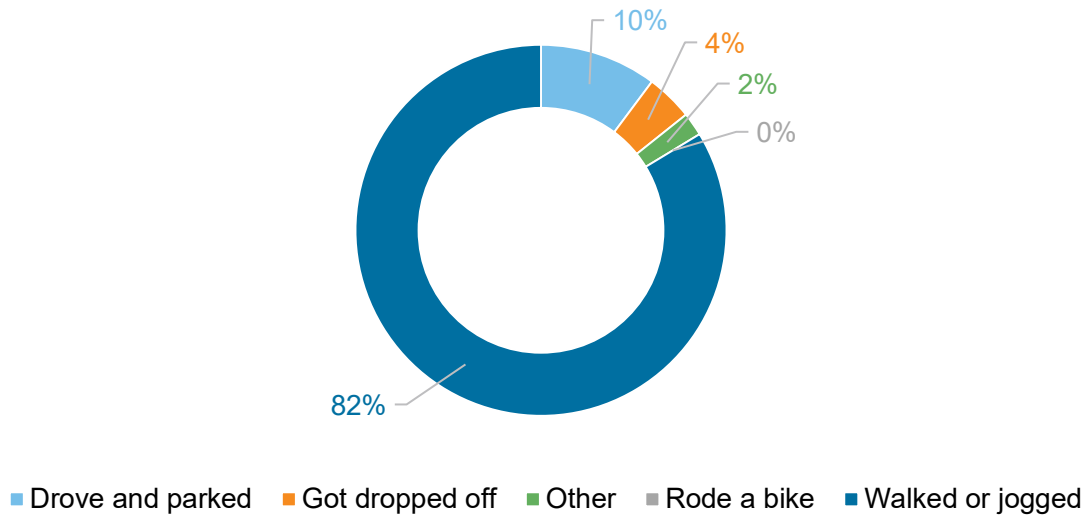
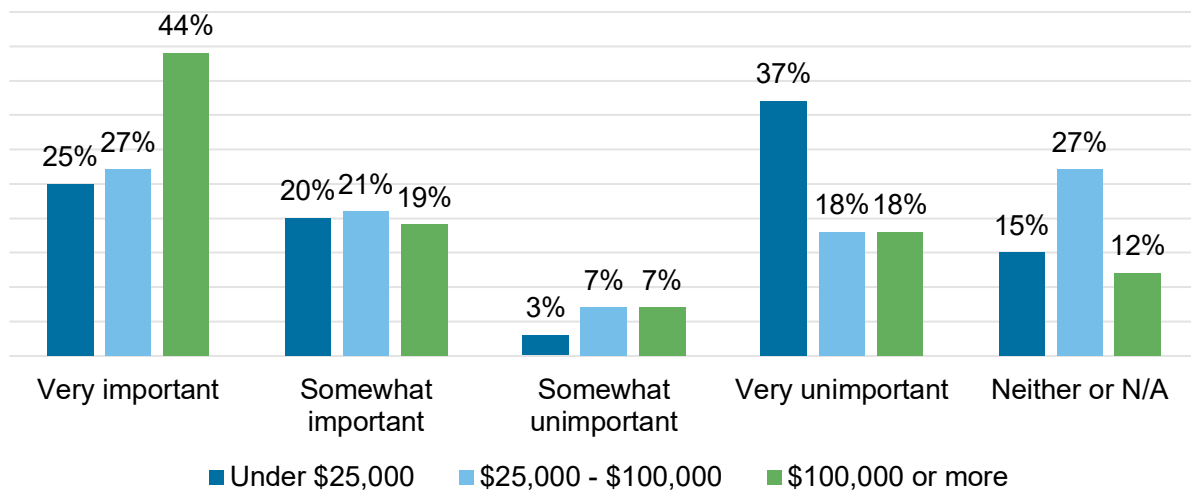


FIGURE 5: HOW IMPORTANT IS QUALITY OF SCHOOLS (K-12) TO HOME CHOICE



4.3 REMINDERS FOR DATA USERS

Although HTS data provides many opportunities for interesting analysis, data users should consider the context and best applications of the data. Data users should **keep the universe of data collection in mind** to ensure the analysis is logical for the data source. The 2019 Puget Sound Regional Travel Study was designed to survey regional residents on a typical weekday. Therefore, this HTS dataset is not ideal for generating analyses of weekend for example.

Second, data users should **use the weighted survey data** in any analysis wishing to draw conclusions about the region as a whole (as opposed to the survey takers). Applying weights ensures that the final analysis is regionally representative.

Finally, data users should **ensure a sufficient sample size (and acknowledge margins of error)** in any analysis. The smaller the sample size, the larger the margin of error. For example, HTS data users can generally draw reasonable conclusions about trip rates by mode on an average weekday. Sample sizes and margins of error are a complicated topic, but a common rule of thumb is that you need at least 30 observations of a behavior to draw reasonable conclusions. The PSRC crosstab generator tool, described below, can help users with all of these tasks. This and other tools to analyze (weighted) survey data and work with relational databases are described next in Section 5.0.

5.0 PRACTICAL TIPS FOR DATA ANALYSIS

5.1 COMMON TOOLS FOR ANALYSIS

Many ways exist to view, join, summarize, and map HTS data. To achieve the full data benefits, data users may need multiple tools. Common analysis tools for working with relational databases and location data include the following:

1. SQL, R, Python, SPSS, Stata, and other code-driven environments.
2. Microsoft Access, ArcGIS, Tableau, and other point-and-click environments.
3. PSRC has also created a Travel Survey Data Explorer tool for the 2017 and 2019 Household Travel Surveys in the Puget Sound region. The Travel Survey Data Explorer can be found at <http://dataviz.psrc.org/travel-study-stories/>. The app is open source, and its code is on GitHub at: <https://github.com/psrc/travel-study-stories>

5.2 DATA ANALYSIS MECHANICS

Using the Travel Survey Data Explorer

The travel survey data explorer app found at <http://dataviz.psrc.org/travel-study-stories/> allows for the creation of a one-way (single dimension table) or a two-way table with a tab selection.

One-way table creation and data visualization

If a one-way table is selected, the user can choose from a category of data and then a specific variable to analyze. The app then returns a table that displays survey estimates for the selected variable, as shown in Figure 6. The user then can select how to visualize the data with a bar chart by using a radio button, as shown in Figure 7. The user can download the data to an Excel file, by selecting the download data button.

The app guides the user to consider the sample sizes and margins of error for all the estimates. Many planners have expressed confusion over when it is appropriate to report the data, and when the data should be suppressed. The app is designed to alleviate some of the confusion by linking them to information about margins of errors and graying out any cells in which the number of samples is less than 30.

FIGURE 6. ONE-WAY TABLE SELECTION

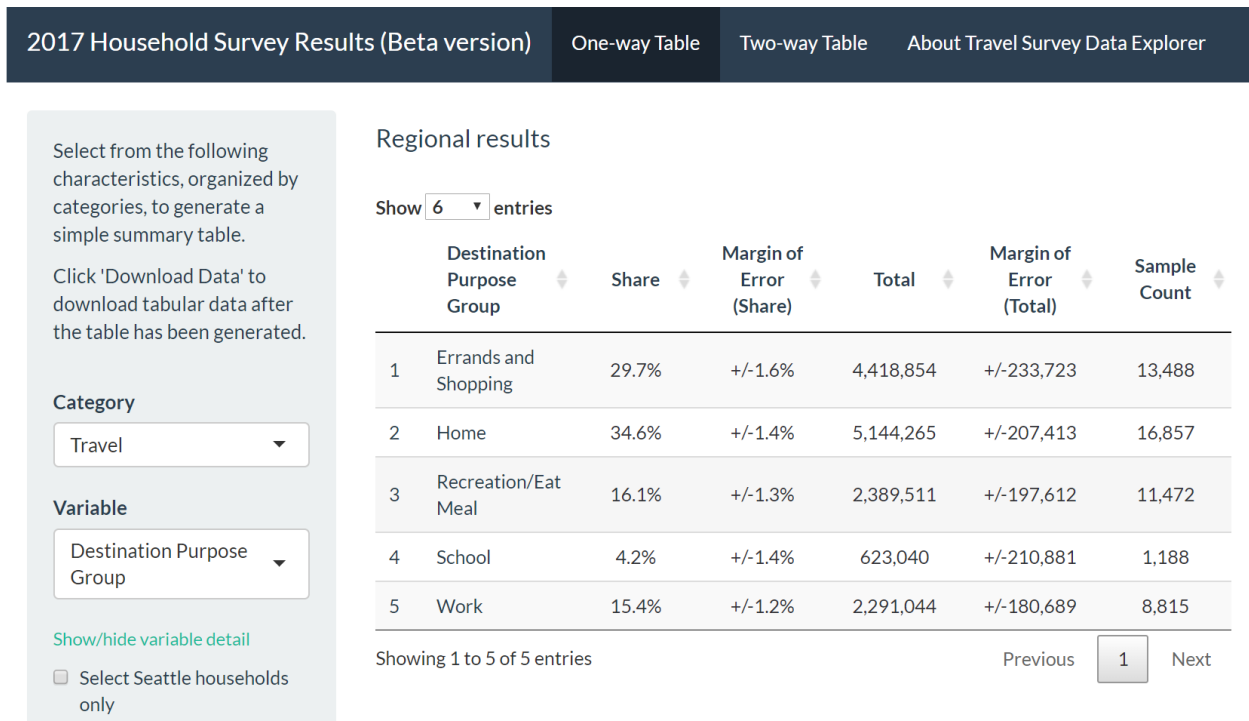
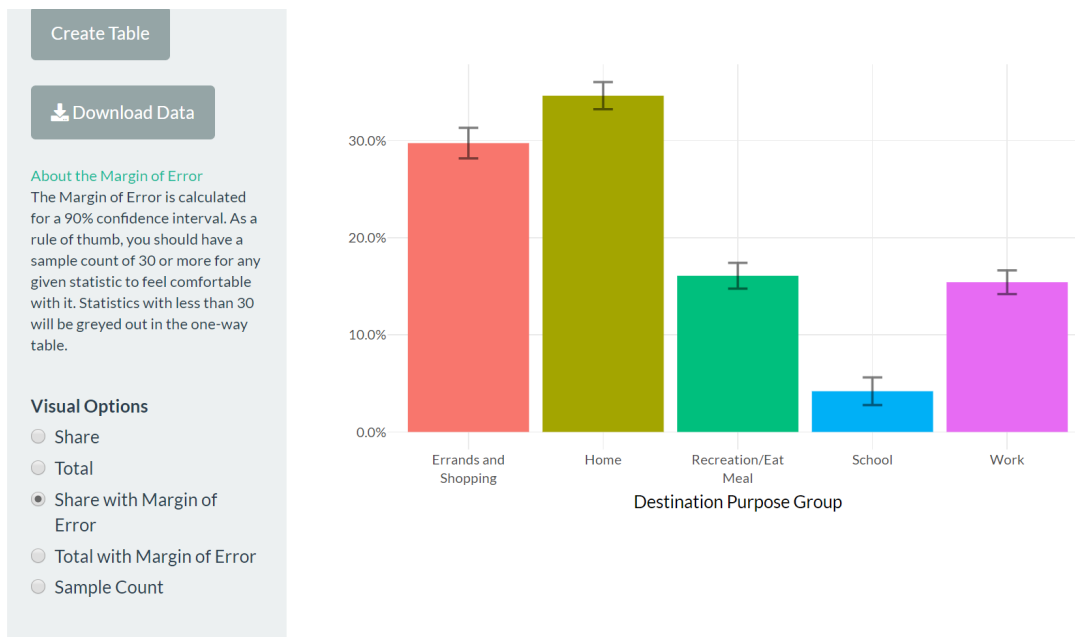


FIGURE 7. BAR CHART SHOWING TRIP DESTINATION PURPOSES



Two-way table creation and data visualization

The two-way table tab allows the user to select two variables to create a crosstab to show the data across two dimensions, as shown in Figure 8. Then the user can select to either see the data as a bar chart or a table. As with the one-dimensional table, information about margins of error is provided and the data can be downloaded to an Excel file.

FIGURE 8. TWO WAY TABLE SELECTION

2017 Household Survey Results (Beta version)
One-way Table
Two-way Table
About Travel Survey Data Explorer

Select from the following characteristics, organized by categories, to generate two-way tables.

Tables may be summarized by sample counts, or by share or weighted totals, with and without margins of error.

Click 'Download Data' to download tabular data for all summary types after the cross-tabulation has been generated.

First Variable (Crosstab rows)

Category: Person

Variable: Gender

[Show/hide variable detail](#)

Second Variable (Crosstab columns)

Category: Travel

Variable: Destination Purpose Group

[Show/hide variable detail](#)

☐ Select Seattle households only

Create Crosstab
Download Data

About the Margin of Error

The Margin of Error is calculated for a 90% confidence interval. As a rule of thumb, you should have a sample count of 30 or more for any given statistic to feel comfortable with it. Statistics with less than 30 will be greyed out in the two-way tables.

FIGURE 9. TWO-WAY TABLE SHOWING GENDER BY PURPOSE

Regional results
Table
Visual

Summary Types

- Share
- Total
- Share with Margin of Error
- Total with Margin of Error
- Sample Count

Shares are based on rowwise totals.

Show 10 entries

Gender	Destination Purpose Group				
	Errands and Shopping	Home	Recreation/Eat Meal	School	Work
Male	25.4%	34.6%	17.4%	4.4%	18.2%
Female	32.7%	34.3%	15.6%	4.1%	13.3%
Another	4.4%	46.9%	19.7%	7.5%	21.5%
Prefer not to answer	40.3%	38.5%	7.0%	2.6%	11.5%

Showing 1 to 4 of 4 entries
Previous
1
Next

Advanced Mechanics : Joining, Weighting, and Trip Weights

When not using the travel survey data exploring app, the user will need to apply some advanced techniques described in this section. Data users can apply three key data analysis mechanics, covered below, to make the most of their analyses:

- Joining tables on unique IDs
- Applying and interpreting weights
- Generating trip rates

Joining Tables on Unique IDs

Many crosstab analyses require joining one or more tables of data together. The 2019 Puget Sound Regional Travel Study tables can be joined using the unique IDs listed in Table 5. Some unique IDs are a combination of two variables. In these cases, joining on only one of the variables will create duplicate records. Data users can read more about relational databases and joining data in SQL here: https://www.w3schools.com/sql/sql_join.asp

TABLE 5: UNIQUE IDS FOR JOINING TABLES

	HOUSEHOLD	PERSON	VEHICLE	DAY	TRIP	LOCATION
Household	--	hhid	hhid	hhid	hhid	hhid
Person	hhid	--	--	personid	personid	personid
Vehicle	hhid	--	--	--	--	--
Day	hhid	personid	--	--	personid daynum	--
Trip	hhid	personid	--	personid daynum	--	tripid

The example syntax below shows two methods to join data and create simple analyses. Both code snippets join the household and person tables to create a crosstab of typical commute to work mode by reported household income.

TABLE 6: CREATING A CROSSTAB WITH JOINED DATA (COMMUTE MODE, BY HOUSEHOLD INCOME)

TOOL	EXAMPLE SYNTAX
SQL	<pre>select hhincome_broad, commute_mode, count(*) as n_persons from PERSON p inner join HOUSEHOLD h on h.hhid = p.hhid group by hhincome_broad, commute_mode order by hhincome_broad, commute_mode;</pre>
R	<pre>Household %>% dplyr::left_join(Person, by = "hhid") %>% dplyr::group_by(hhincome_broad, commute_mode) %>% dplyr::summarise(n_persons = n())</pre>

Applying and Interpreting Weights

As mentioned in Section 4.0, analyses designed to draw conclusions about travel behavior in the region (as opposed to just the survey respondents) should use weighted data. When applied, the weights make the dataset representative of personal travel in households within the study region for the time period studied (weekdays in spring 2019). This means it does not include commercial vehicle travel, travel for persons residing in group quarters outside of the ABS frame (e.g., college dorms, institutional housing), travel from nonresidents (i.e., visitors to the region), or seasonal/holiday travel outside of the survey fielding period.

Using weighted data generally involves summing the weights for the groups of interest. The sum of weights in each table is outlined in Table 7 below.

TABLE 7: GROUPS REPRESENTED BY SUMMED WEIGHTS

WEIGHT NAME		GROUP REPRESENTED BY SUMMED WEIGHTS
Household	hh_weight	Total number of households within the study region
Person	hh_weight	Total number of persons within the study region
Vehicle	hh_weight	Total number of personal vehicles within households in the study region
Day	hh_day_weight	One weekday for all persons within households in the study region. (In this study, also equal to the number of persons in the region)
Trip	trip_weight	Total number of trips all persons within households in the study region make on a typical weekday.*

*Note that this differs from the number of trips made *in the study region* on a typical weekday, given that some residents make trips outside the region.

To calculate weighted crosstabs or descriptive statistics, sum the weights for that table. Grouping variables (e.g., “GROUP BY” operators in SQL and many other software programs) or filters will provide weighted totals for specific subgroups, like two-person households, or by age group. Keep in mind the following when creating weighted statistics and summaries from HTS data:

- 1. Filter to the data relevant to your analysis (e.g., complete travel days).**
 - For example, focusing on travel days with complete survey information (i.e., no unanswered survey questions) is best. Also note that not all people are asked every question, so understanding the ‘missing value’ codes can be important.
- 2. Remember the study design when using and interpreting weighted values.**
 - For example, the study design for the 2019 Puget Sound Regional Travel Study included both one-day online participation (on a Tuesday, Wednesday, or



Thursday) and seven-day smartphone app participation. Therefore, it is best to avoid filtering by day of week since not all people traveled on all days.

3. Be sure to use the appropriate weight for the intended analysis.

- Table 7 above includes the primary weight for each table, but some tables include more than one weight (e.g., the trip table includes both the hh_day_weight and trip_weight). In general, hh_weight should be used for household- and person-level analyses, hh_weight_day should be used for household-day and person-day analyses, and trip_weight should be used for trip-level analyses.

Similar to Table 6 above, the example syntax below shows two methods to join data and create simple analyses (in these cases, weighted). Both code snippets join the household and person tables and use the sum of household weights to create a representative crosstab of typical commute to work mode by reported household income in the region.

TABLE 8: CREATING A CROSSTAB WITH WEIGHTED JOINED DATA (COMMUTE MODE, BY HOUSEHOLD INCOME)

TOOL	EXAMPLE SYNTAX
SQL	<pre>select hhincome_broad, commute_mode, sum(hh_weight) as n_persons from PERSON p inner join HOUSEHOLD h on h.hhid = p.hhid group by hhincome_broad, commute_mode order by hhincome_broad, commute_mode;</pre>
R	<pre>Household %>% dplyr::left_join(Person, by = "hhid") %>% dplyr::group_by(hhincome_broad, commute_mode) %>% dplyr::summarise(n_persons = sum(hh_weight))</pre>

Generating Trip Rates

Trip rates—or the number of trips per day among groups—are useful for comparing several travel behaviors (e.g., travel by mode, travel by age group). Trip rates can be weighted or unweighted, but this section focuses on the former.

To calculate a weighted trip rate, data users must divide the number of weighted trips by the number of weighted travel days. For example, if there are 300,000 weighted person-trips across 75,000 person-days, then the average person-trip rate is 4.0 per day. If there are 225,000 person-trips by car across 75,000 person-days, then the person-trip rate for car trips is 3.0. This is different than calculating vehicle trip rates, which would require calculating the weighted vehicle trips taking place (in this example, if the average vehicle occupancy is two people, then the vehicle trip rate would be 1.5).

Data users should always calculate the number of weighted travel days using the day table rather than the trip table given that persons with zero-trip travel days do not have any records in the trip tables for those days.

5.3 EXAMPLES

The range of possible HTS data analyses is broad. To help data users begin their analyses and build on the examples included above, this section includes additional examples for data visualization.

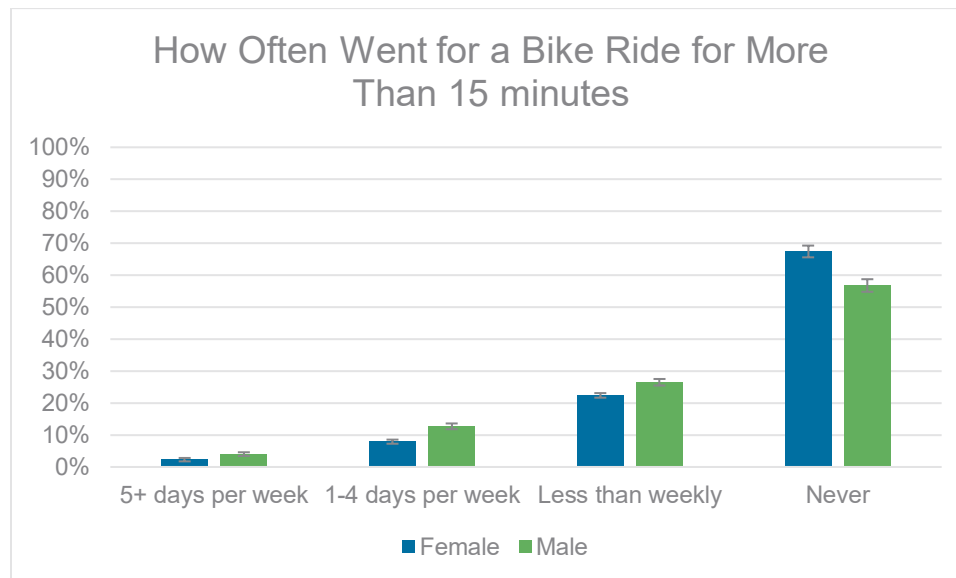
Travel survey data explorer examples

The following are examples of simple data from the travel survey app that is valuable to planning:

- A large majority of workers (82%) reported having free parking at work.
- Older adults are in cars on about 85% of their trips.
- Households making less than \$25,000 a year are three times as likely to use transit on each trip, and twice as likely to walk than households making \$25,000-\$100,000 a year.

Another example of simple table data that is useful to planning is displayed in Figure 10 below. Figure 10 shows how much more frequently men go for bike rides than women.

FIGURE 10. BIKE RIDING RATES BY GENDER

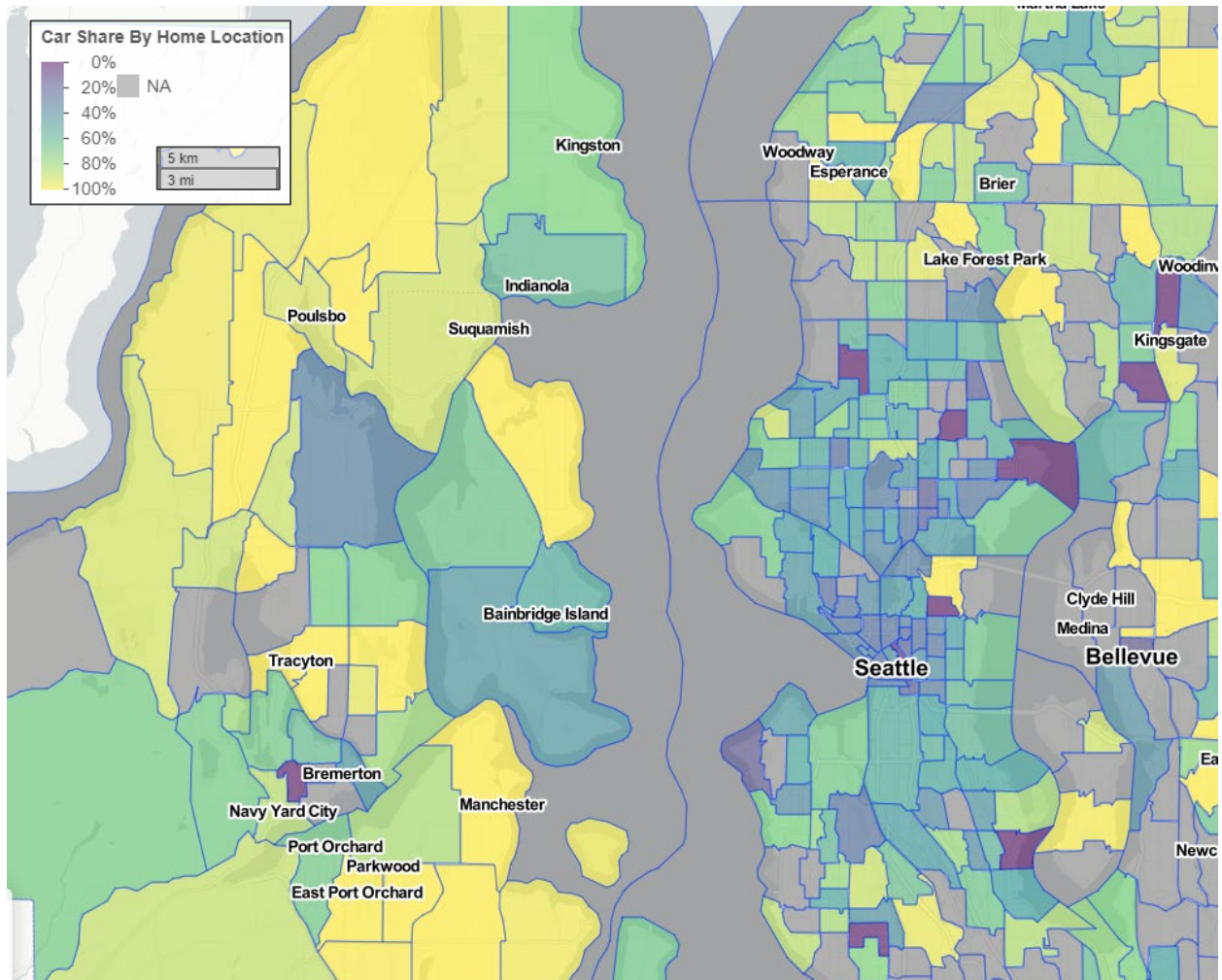


Mapping Home Locations

Figure 6 shows one of the many types of maps data users can create with HTS data. This map (which uses unweighted data) shows the average car/personal vehicle mode share of the households living within regional census tracts. Tracts with high average car mode shares are yellow, and tracts with low average car mode shares are purple. (Note that “NA” tracts do not

have any household data in this example.) This type of analysis—if created with weighted data—can be useful for summarizing where frequent car travelers live in the region.

FIGURE 11: AVERAGE CAR/PERSONAL VEHICAL MODE SHARE BY HOME LOCATION TRACT





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