NHTS NextGen Study
2022 NHTS
Address-Based Sample Weighting Plan

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NHTS NextGen Study: 2022 NHTS ABS Weighting Plan

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Overview

The National Household Travel Survey (NHTS) is the U.S. Department of Transportation's (USDOT's) nationally representative data source for daily local and long-distance passenger travel. This inventory of travel behavior has been conducted every five to eight years since 1969 to capture travel mode (private vehicle, public transportation, pedestrian, and cycling) and trip purpose (travel to work, school, recreation, and personal/family trips), as well as other travel statistics among U.S. household residents. Survey results are used by Federal, State, and Local agencies to monitor the performance and adequacy of current transportation facilities and infrastructure and to plan for future needs. Data from the NHTS are also included in biennial reports to Congress on the Nation's surface transportation system performance.

The 2022 NextGen NHTS Study is comprised of a national statistical sample randomly selected from an Address-Based Sample (ABS) frame derived from the United States Postal Service (USPS) Delivery Sequence File (DSF) of all residential addresses administered via a single-stage stratified 'push-to-web' approach. The NHTS utilized a probability-based sampling plan to select households representative of the entire United States from a sampling frame derived from the USPS DSF maintained by Marketing Systems Group.

The 2022 NextGen NHTS Study also consists of three localized add-on studies for the Virginia Department of Transportation (VDOT), the Tennessee Department of Transportation (TDOT), and the Oahu Metropolitan Planning Organization (OMPO). These three add-on studies used the same sampling frame and field protocols as the NHTS.

Figure 1 briefly summarizes the steps taken for weighting the NHTS, and address how certain hard-to-reach populations were accounted for in the weighting. Further details on each step are included in the remainder of this report.

Figure 1. Summary of NHTS Weighting Methodology

Weighting steps	Description	Methods
1. Design weights	• Adjust for the probability of selection to project to national household population. • Adjust such that weights distribute evenly across 12 months and 7 days of week.	• Calculate probability of selection using average frame size across 12 months. • Adjust weights so sum is proportionate to number of days in the month and sum of weights are equal for each day of week.
2. Nonresponse bias analysis	• Identify characteristics that differ between respondents and nonrespondents. • Such differences could introduce bias into the estimates.	• Identify characteristics where differences for responding and non-responding households ○ Univariate analyses of Census block group's measures ○ CART analyses of modeled sample frame data ○ Analysis of univariate estimates using design weights compared to national benchmarks
3. Adjust the weights for nonresponse	• Adjust weights of respondents based on characteristics found in nonresponse bias analyses to reduce any potential bias due to nonresponse.	• Iterative proportional fitting (raking) to population totals on key characteristics by applying adjustments in multiple stages until weighted distribution matches population distributions of key characteristics.
4. Trimming of weights	• Control influence of large weights for small groups of respondents on estimates.	• Cap weights at three times the inter-quartile range.
5. Post-stratify the weights	• Readjust weights to match month and day of week distributions and stratum population totals.	• Rake the trimmed weights to the month, day, and stratum marginal distributions.

Impact on Hard-to-Reach (HTR) Populations in the ABS sample:

- Sampling - The key HTR populations including large households, low-income households, and Hispanic- or young adult-headed households were randomly sampled in proportion to their prevalence in the population.
- Nonresponse Bias Analysis – Nonresponse among each HTR these subgroups were examined in the nonresponse bias analyses.
- Adjustments to the Weights–Each HTR subgroup had a factor to account for differential response rate in the weighting adjustment, bringing their weighted distribution back in line with the population distribution.
- Trimming of Weights – Large weights were trimmed using the overall interquartile range, with about 3 percent of all weights trimmed. The HTR subgroups had higher relative numbers of weights trimmed indicating larger weighting adjustments were needed on average than for other groups.

The weighting both corrected for the HTR response rates and controlled for the influence of large weights. The impact is that the HTR subgroups are slightly under-represented in weighted household analyses. See tables 23 and 25 for demographic distributions.

Reporting and Sampling Requirements for the NHTS

USDOT utilizes the NHTS data for reporting on various subdomains. In addition to reporting at an overall total level (i.e., all trips, regardless of day of week or time of year, etc.), the NHTS requires reporting of incidences and types of trips for day-of-week, weekday travel, and weekend travel. These also include estimates of numbers of trips, estimates for US Census Divisions, for urban or rural areas of the country, and for key demographic groups.[1] To ensure this level of representativeness, the sampling plans for the national NHTS were stratified by US Census Divisions and urban/rural designations. The sampling plan called for 7,500 annual completes collected proportionately across the strata.

The **NHTS Sampling Plan** stratified the ABS frame into 18 strata defined by the nine U.S. Census Divisions split by urban and rural. The sampling plan defined Urban and Rural using the 2010 Decennial Census designation of urban and non-urban areas as the 2020 reclassification of urban areas was not available at the time of sampling.[2] This provided representation according to Census region and Census division, as well as by urban or rural geographies. The sampling plan also incorporated an adaptive sampling algorithm to target 71% of the responses for weekday travel and 29% of the responses for weekend travel. The sampling plan released national replicates daily across each month. This release was designed to capture travel patterns across the entire year. The plan for releasing sample was intended to account for mail transit-time and the time people hold onto their mail before reading. Once a recipient opened their survey invitations, they were directed to a website to register and begin the survey process. During this time, they and their household members were directed to complete travel diaries for the day preceding their initial contact.

The sampling plan assumed that survey invitations that are sent on a Monday will have a different pattern of travel day completions than those sent out on Tuesday, and so on, for each day of the week. Accordingly, as part of the sampling plan, the mailout rates by day-of-the-week were assessed monthly by examining the diary completion yield rates for the travel day-of-the-week.

The resulting adaptive sample allocation algorithm used an optimization model to determine the sample allocation to be released for a given day-of-the-week for mailout. The optimization model minimized the number of invitations mailed out on Monday, Tuesday, etc., through Saturday for the next month, using the most recent yield rate estimates. The optimization model was subject to constraints that:

1. Set a lower limit for the number of completed diaries for each day of the week. For example, if we expect 350 completes across the 7 days, the average would be 50 completes per day. We would set a 90 percent lower limit (or bottom rate), so the model would target a minimum of 45 completes per day.
2. Set a fixed proportion of the completes to come from weekdays versus weekends. The NextGen NHTS has the target of 71% of the diaries to be weekdays.

[1] The Pacific Census Division's Urban and Rural strata were split into two (an Alaska and Hawaii substrata and a "remainder of the Pacific Division" substrata) to help track potentially different mail transit time to Alaska and Hawaii.

[2] https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural.html

3. Set the number of completes for a given month to be proportionate to the number of days in that month.

A separate optimization model was run for each stratum in the study design across the ABS protocol. There were 18 strata plus the Alaska and Hawaii substrata in the NextGen NHTS. The optimization models were subject to adjustment as needed. A National summary is given in Table 1, below. The total number of household responses, 7,893, exceeded the targeted count of 7,500 households.

Table 1: National Summary

Stratum	Stratum Description	Response count	Weekday/Weekend Split	Population Total
1021	New England - Urban	368	71.20%	4,884,038
1022	New England - Rural	71	64.79%	1,155,278
1023	Mid-Atlantic - Urban	797	72.27%	14,209,554
1024	Mid-Atlantic - Rural	127	74.02%	2,170,013
1025	East North Central - Urban	993	70.49%	14,977,514
1026	East North Central - Rural	300	75.33%	4,029,511
1027	West North Central - Urban	357	73.95%	6,154,056
1028	West North Central - Rural	212	69.34%	2,520,576
1029	South Atlantic - Urban	1,271	71.68%	20,453,340
1030	South Atlantic - Rural	313	73.16%	5,467,237
1031	East South Central - Urban	295	68.47%	4,696,652
1032	East South Central - Rural	152	78.29%	2,956,595
1033	West South Central - Urban	695	71.94%	11,901,302
1034	West South Central - Rural	187	69.52%	3,410,511
1035	Mountain - Urban	492	69.92%	8,068,369
1036	Mountain - Rural	129	73.64%	1,574,876
1037	Pacific – Urban	1,033	71.44%	17,266,424
1038	Pacific - Rural	101	78.22%	1,648,884
Total		**7,893**	**71.73%**	**127,544,730**

The NHTS Weighting Plan and Structure of Remainder of Report

This section presents the NHTS weighting procedures. The structure of the remainder of this report consists of:

- Description of household design weights
- Summary of Nonresponse Bias Analysis (NRBA) study
- Description of the nonresponse-adjusted household weights, nonresponse-adjusted person weights, and trip weights. Each file includes 3 sets of weights: 7-day, 5-day (non-holiday

weekdays), and 2-day (weekend) periods. Table 2 summarizes the weights included in the data files.

Table 2: Summary of NHTS Final Weights' Names and Purpose

Weight	Purpose
WTHHFIN	Household-level analysis for all 7 days of week
WTHHFIN5D	Household-level analysis for Monday – Friday
WTHHFIN2D	Household-level analysis for weekends
WTPERFIN	Person-level analysis for all 7 days of week
WTPERFIN5D	Person-level analysis for Monday – Friday
WTPERFIN2D	Person-level analysis for weekends
WTTRDFIN	Trip-level analysis for all 7 days of week
WTTRDFIN5D	Trip-level analysis for Monday – Friday
WTTRDFIN2D	Trip-level analysis for weekends

Household Design Weights

The NHTS is a non-overlapping, independently drawn sample using distinct sample design. Therefore, all stages of weighting, from the calculation of design weights, adjustments for nonresponse, trimming, and final evaluation of the weights, were done separately. This includes estimation of nonresponse patterns via Classification and Regression Trees (CART) analyses, the calculation and application of adjustments for nonresponse, post-stratification adjustments, and trimming cutoffs. All results are also reported separately in the following sections.

As indicated above, the key elements of the NHTS study are the following:

- Sample each month to be a projectable stratified sample of the corresponding study's population
- Release of random replicates across day of week and weeks within a month
- Adjust the number released per day to smooth out expected variation in day-of-week responses
- Allow for responses to be completed in month or months following sample release
- Proportional representation for each month by number of days in the month and planned representation for each weekday

The household design weights capture these attributes of the sampling plans. Underlying the sampling plan is an information array for each household, structured as follows:

$$\{i, m, m^{(R)}, L, N_L, M_{L,m}, d', d, n'_{L,d'}(i), n_{L,d}(i)\}$$

Where:

i - Household

m - Month of sample selection

$m^{(R)}$ - Month of report (Travel Date)

L - Stratum

N_L - Strata population size (number of households)

$M_{L,m}$ - Strata frame size at time of selection (monthly)

d' - Day-of-Week assignment for outgo mailout

d - Day-of-Travel completion

$n'_{L,d'}(i)$ -Sample size selected for Day-of-Week in stratum *L* on day *d'* across months for household *i*

$n_{L,d}(i)$ -Number of responses for Day-of-Week in stratum *L* on day *d* across months for household *i*

This array contains information necessary to determine a design weight accounting for the stratified random selection, month, and day of responses. It also contains the information required to smooth out the statistical representation of the data through design weights and provide equal representation for month and day-of-week.

The samples' design weights include four main steps as follows:

1) Probability of selection for household i and weight associated with the probability of selection,
2) Weight for Day-of-Travel completion in reporting month for household i,
3) Adjustment for Strata Size, and
4) Adjustment of weight to balance the number of responses for month and Day-of-Travel completion.

Step 1 - Probability of Selection for household i for Day-of-Week

The probability of selection for a household reflects the number of households in a stratum selected from the size of its frame. The probability of selection is:

$p'_i = \frac{n'_{L,d'}(i)}{\bar{M}_L}$ **,** Number selected for Day-of-Week divided by the average frame size for stratum *L.*

The value $\bar{M}_L = \frac{1}{K}\sum_{m=1}^{K} \bar{M}_{L,m}$ is the average frame size across the *K* number of months in the study.[3]

Step 1a -Weight for household *i* for Day-of-Week

The weight for a household is the inverse of its probability of selection,

$$w'_i = \frac{1}{p'_i} = \frac{\bar{M}_L}{n'_{L,d'}(i)}.$$

[3] The weights are being computed using the complete sample across the months. The number of responses for within-month calculations of the weights often have very few or zero numbers of completes.

Step 2 - Adjustment to design weights for Day-of-Travel Completion in reporting month for household i

This stage adjusts the Step 1a weight to account for the Day-of-Travel completion:

$$w_i = n_{L,d}(i) \times \frac{\frac{n'_{L,d'}(i)}{M_{L,m}}}{\sum_{j \in d} \frac{n'_{L,d'}(j)}{M_{L,m}}} = n_{L,d}(i) \times \frac{w'_i}{\sum_{j \in d} w'_j},$$

where j ϵ d designates all cases across mailout days *d'* found for day *d* in reporting month $m^{(R)}$.

Step 3 – Adjustment for Strata Size within a Month

The weights in Step 2 do not necessarily project to their corresponding population size for a given month. Step 3 adjusts the weights in each month to project to the number of households in a stratum, *N*. The adjusted weight is:

$$w_i^{(L,m^{(R)})} = w_i \times \frac{N_L}{\sum_{i \in L \text{ for Month } m} w_i}.$$

Step 4 – Adjustment of weights to balance the weighted number of responses for month and Day-of-Travel completion

The Step 3 weight ensures that the stratum weighted total reflects each stratum's size. Step 4 smooths the weighted representation for Day-of-Travel and month. The Step 4 weight adjusts the Step 3 weights to reflect each month and Day-of-Travel within a week to meet the plan's goal. The Step 4 weight is:

$$w_i^{(L,m^{(R)},d)} = w_i^{(L,m^{(R)})} \times \frac{P_{L,m,d}}{\frac{\sum_{i \in m^{(R)},d,L} w_i^{(L,m^{(R)})}}{\sum_{1=1}^{n} w_i^{(L,m)}}}.$$

The components of this weight are:

- $P_{L,m,d}$ is the proportion of the sample that should fall in Day-of-Travel completion for month m. E.g., if each month has equal weight (1/12th) and there are 7 days being reported on with equal weight, then $P_{L,m,d}$ = 1.1905%, and
- $i \in m^{(R)}, d,\ L$ to be the sum of all households in reporting month *R* for Day-of-Travel *d* in stratum *L*.

The distributions of the weights for the NHTS are given in Table 3.

Table 3: Design Weights Distribution for NHTS Data

Stratum	Household completes (n)	Design Weights						
		Sum	Mean	Min	Max	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1021	368	4,974,502	13,517.67	4,345.05	45,288.99	8,163.64	60.39	1.3647
1022	71	1,144,925	16,125.70	5,442.94	83,198.19	14,722.71	91.30	1.8336
1023	797	14,239,183	17,865.98	7,080.10	72,684.18	10,981.59	61.47	1.3778
1024	127	2,184,570	17,201.34	5,670.24	43,365.75	8,549.48	49.70	1.2470
1025	993	15,410,428	15,519.06	5,142.46	58,291.16	8,810.51	56.77	1.3223
1026	300	4,119,098	13,730.33	4,060.58	42,375.69	7,459.96	54.33	1.2952
1027	357	6,422,108	17,989.10	6,878.68	97,765.50	11,450.19	63.65	1.4051
1028	212	2,474,091	11,670.24	4,494.22	32,489.14	5,623.62	48.19	1.2322
1029	1,271	21,411,414	16,846.12	7,008.93	88,018.40	7,888.64	46.83	1.2193
1030	313	5,935,186	18,962.26	4,904.71	49,309.47	8,900.33	46.94	1.2203
1031	295	5,000,822	16,951.94	4,750.23	50,013.49	9,155.94	54.01	1.2917
1032	152	3,263,694	21,471.67	5,855.57	76,291.43	12,953.62	60.33	1.3640
1033	695	12,620,496	18,158.99	8,495.65	76,166.87	8,836.66	48.66	1.2368
1034	187	3,605,856	19,282.65	4,728.53	63,243.36	11,507.82	59.68	1.3562
1035	492	8,132,916	16,530.32	5,813.32	64,822.75	9,449.87	57.17	1.3268
1036	129	1,408,126	10,915.71	3,206.24	28,761.70	5,662.66	51.88	1.2691
1037	1,033	17,713,438	17,147.57	294.59	91,635.14	11,309.20	65.95	1.4350
1038	101	1,539,727	15,244.82	384.28	48,747.89	8,818.06	57.84	1.3346
Total	**7,893**	**131,600,579**	**16,673.07**	**294.59**	**97,765.50**	**9,680.22**	**58.06**	**1.3371**

Nonresponse Bias Analysis (NRBA)

The NHTS selected a random sample and mailed invitations to addresses nationwide, stratified by Census division and Urban/Rural status. Due to the random probabilistic selection, this sample is unbiased in expectation. However, differential nonresponse to the survey can result in biased estimates if the nonresponse pattern is correlated with the survey measures, contributing to the total survey error. If such nonrandom nonresponse exists, often correcting for differential nonresponse by using weighting adjustments can mitigate bias in the estimates.

The first step in a nonresponse bias analysis is to examine responding and nonresponding portions of the sample and identify attributes of respondents and nonrespondents that differentiate them from one another. For example, men with less than a high school education may have been less likely to respond to a survey than men with a high school diploma or higher and women at any level of education. In this example, the lower response rate among men with less than a high school education constitutes a potential source of nonresponse bias if these men respond differently to the survey metrics.

Generally, it is not possible to demonstrate whether differing propensities to respond result in creating biased survey estimates. Since survey responses are not measured for nonrespondents, a nonresponse bias analysis looks for items that may contribute to biased results given what is known about the survey metrics of interest. Key demographic information, such as age, sex, and education of respondents for person level nonresponse or household size, household income, and home ownership for households are often seen as differentiators between respondents and nonrespondents and related to many common study metrics. A nonresponse study can also include characteristics more specifically related to the survey topic. For example, the occupation of household members may have an influence on the survey response, since commuting demands may vary by type of occupation. Thus, lower response rates among individuals with certain types of occupations could result in biased estimates of commuting measures.

The nonresponse analysis lacks data that are directly related to measures for the nonresponding households and their members, as the sample frame included very little data directly measured for the households. Therefore, the analysis focuses on two different sources of information that provide aggregate or proxy metrics on households but are not direct measures for the households themselves. The data are:

- Census Block Group Data - Census Block Group (CBG) Data are data about the neighborhood where a household is located – Information about demographic structure and other characteristics from the ACS and the Environmental Protection Agency (EPA)'s National Walkability Index along with its other metrics were collated CBGs and attached to responders' and non-responders' sample records.
- Modeled Frame Data - Modeled Frame Data are data provided with sample information from the ABS database – Marketing Systems Group, the developer of the ABS database has data for many attributes based on models developed for commercial purposes to predict demographic and other attributes about households.

An additional step in the NRBA is to compare estimates from the studies' responses and design weights to reliable national benchmarks.

- Comparison of Study's Demographic Estimates to Census Benchmarks – This analysis looks at the demographic distribution of the studies under their design weights. When non-responding households are considered to be missing at random, then estimates based on design weights among just the respondents for demographic variables should be similar to relevant benchmarks. The comparisons here identified other adjustment variables to include in the non-response weighting adjustments.

Univariate Analysis in the NHTS

CBG metrics were attached to each survey record for the NHTS ABS study. The attached metrics range from composition of household, race/ethnicity, employment, commuting choices, Internet penetration,

and the National Walkability Index.[4] Modeled data are household attributes based on modeled (or "predicted") household characteristics included in the ABS sample frame. These modeled values include race, age, income, home ownership, and others. Some of the measures apply to an individual and not the household. In those cases, the measures such as age or race are those of the householder, the elder of the household. The modeled characteristics differ from the CBG characteristics since the modeled characteristics pertain to the individual household with specific scores and not just an aggregate measure corresponding to the locale in which the household resides. Ultimately, the modeled data values are just predicted values that could be correct, incorrect, or inconclusive; however, the analysis uses these measures to provide understanding about the impact of these variables on the likelihood a person responds to the survey. Table 4 presents results for the univariate analyses examining the relationship between response rates for different levels. The analyses followed these steps:

- Attach CBG metrics to each data record based on their household address
- Calculate quintiles for each CBG measure and continuous modeled data point, yielding five ordered categories based on the measures' values from lowest to highest
- Tabulate Respondent/Nonrespondent category versus the five categories plus an additional category for missing values[5]
- Record Chi-square score and the Probability of Test (P-Value) for Chi-Square Test of Independence
- Rank Chi-square across the 65 tests and record direction of trend across the quintiles

Using the Chi-square as an impact score across the metrics, 7 of the top 10 metrics are based on predicted characteristics of the householder (occupation, education, home ownership, age, and rate ethnicity) or the predicted household income or number of adults in the household. The other three pertain to the Race/Ethnicity composition of the CBGs or household size in the CBG. Modes of commuting, components of the National Walkability Index, and some other CBG characteristics had low impacts. The P-Value for the Chi-Square test helps assess possible non-response bias, although since the analysis is based on over 60,000 cases in the sample file, the value of a significant Chi-square test is limited.[6]

[4] The National Walkability Index includes several measures including proximity to transit stops, intersection density, employment mix, and employment and household mix. The National Walkability Index was included in the analysis instead of the proximity to mass transit alone.

[5] Individual Census Block Groups may have missing data for the ACS, EPA, and other sources due reporting suppression rules.

[6] Other statistical tests would be similarly overpowered given the large sample size.

Table 4: Results of NHTS ABS Univariate Nonresponse Bias Analysis

Category	Characteristic Percent of CBG or Predicted Characteristics	Chi-Square Measure	P-Value	Rank of Chi-Square
Race/Ethnicity	White	295.1	0.0000	2
	Black	137.0	0.0000	12
	Hispanic	151.1	0.0000	9
Household size and residence	Households with 1 Person	0.7	0.9812	65
	Households with 2 Persons	148.2	0.0000	10
	Households with 3 or more Persons	26.3	0.0001	48
	Households with 4 or more Persons	40.2	0.0000	36
	Predicted Number of Adults in Household	336.9	0.0000	1
	Predicted Number of Children in Household	2.8	0.2475	62
	Predicted Number of Units in Dwelling	96.4	0.0000	17
	Predicted Length of Residence	89.8	0.0000	19
Vehicle ownership	Households with no Vehicles	94.2	0.0000	18
	Households with 1 Vehicle	21.0	0.0008	52
	Households with 2 Vehicles	101.1	0.0000	16
	Households with 3 or More Vehicles	18.0	0.0029	55
Employment	Household Head Work From Home	133.8	0.0000	13
	Households with Zero Workers	11.3	0.0450	57
	Households with One Worker	33.7	0.0000	42
	Households with Two Workers	70.3	0.0000	28
	Households with Three or More Workers	18.2	0.0028	54
Income	Median Household Income	145.3	0.0000	11
	Households with Low Wage Earner	71.9	0.0000	27
	Predicted household income	232.2	0.0000	5
Commuting	Commuting Mode - Drive Alone	17.8	0.0032	56
	Commuting Mode - Carpool	56.3	0.0000	31
	Commuting Mode - Public Transportation	42.6	0.0000	35
	Commuting Mode - Walk	1.4	0.9290	63
	Commuting Mode - Bicycle	21.4	0.0001	51
Home Ownership	Housing Unit Ownership Rate	73.2	0.0000	25
	Housing Unit Renter Rate	73.2	0.0000	26
	Housing Unit Occupancy Rate	38.5	0.0000	37
	Housing Unit Vacancy Rate	38.5	0.0000	38
	Predicted homeownership	213.5	0.0000	6
	Households with Internet	128.1	0.0000	14

Category	Characteristic Percent of CBG or Predicted Characteristics	Chi-Square Measure	P-Value	Rank of Chi-Square
Internet Penetration	Households without Internet	128.1	0.0000	15
Community	Urban	0.7	0.3917	64
	National Walkability Index	23.2	0.0001	50
	Street Intersection Density	6.9	0.1394	61
	Jobs within 45 minutes Auto Travel Time	34.9	0.0000	41
	Proportional Accessibility of Regional Destinations - Transit: Working age population accessibility	29.3	0.0000	46
	Total road network density	7.8	0.1681	59
	Proportional Accessibility to Regional Destinations - Auto: Employment Accessibility	76.2	0.0000	24
	Proportional Accessibility of Regional Destinations - Transit: Employment Accessibility	7.7	0.1744	60
	Proportional Accessibility to Regional Destinations - Auto: Working Age Population Accessibility	9.7	0.0836	58
	Regional Centrality Index – Auto: CBG Employment Accessibility Score Relative to Max CBSA Score	58.7	0.0000	30
	Aggregate Frequency of Transit Service per Square Mile	37.6	0.0000	40
	Network Density in Terms of Facility Miles of Pedestrian Oriented Links per Square Mile 2018	51.9	0.0000	33
	Network Density in Terms of Facility Miles of Multi-Modal Links per Square Mile 2018	51.3	0.0000	34
	Regional Centrality Index – Auto: CBG Working Age Population Accessibility Score Relative to Max CBSA Score	65.7	0.0000	29
	Distance from Centroid to Nearest Transit Stop	53.9	0.0000	32
	Transit Service per Capita	19.2	0.0007	53
	Jobs within 45-Minute Transit Commute	31.1	0.0000	45
	Regional Centrality Index – Transit: CBG Working Age Population Accessibility Score Relative to Max CBSA Score	33.7	0.0000	43
	Network Density in Terms of Facility Miles of Auto-Oriented Links per Square Mile 2018	25.5	0.0000	49

Category	Characteristic Percent of CBG or Predicted Characteristics	Chi-Square Measure	P-Value	Rank of Chi-Square
	Regional Centrality Index – Transit: CBG Employment Accessibility Score Relative to Max CBSA	33.1	0.0000	44
	Aggregate Frequency of Transit Service within 0.25 Miles of CBG Boundary per Hour During Evening	28.9	0.0000	47
Mobile electronic ownership	Percent of CBG with mobile electronic ownership	79.0	0.0000	22
	Percent of CBG with no mobile electronic ownership	79.0	0.0000	23
Predicted householder characteristics	Household Member Age	194.1	0.0000	7
	Household Member Ethnicity	180.4	0.0000	8
	Household Member Gender	79.9	0.0000	21
	Household Member Education	245.1	0.0000	4
	Household Member Occupation	246.7	0.0000	3

* Vehicles include cars and all other motorized transportation, such as motorcycles.

Note: Unit of analysis is the household.

Multivariate Data Analysis

The second stage of our nonresponse bias analysis involved fitting a classification and regression tree (CART) using the characteristics most highly associated with response based upon the univariate analysis. The purpose of this second stage of analysis was to further limit the selection of factors to those most related to response and to account for the multivariate relationship between these factors and response, which the univariate analysis would miss.

Classification and Regression Trees (CART) were applied to the CBG quantile and modeled household characteristic data using the SAS procedure HPSLIT to assess impacts of attributes on response rates, and thus identify potential sources of nonresponse bias. The dependent variable in these analyses was survey response status (respond/not respond). CART iteratively performs a series of statistical tests across each variable in a set of candidate predictor variables, searching for statistically significant differences in response percentages between the two groups defined by different values (or "splits") for each predictor variable. Accordingly, once the optimal predictor and predictor split associated with the first iteration is identified, the sample is parsed into one of the groups based on their values of the optimal predictor. The procedure is then repeated iteratively among the remaining predictor variables for each branch of the resulting tree, until no further differences are found, or a predetermined tree depth is reached. The CART algorithm therefore not only determines the optimal candidate variables to predict the response value, it also determines the optimal split values for each of these variables. Classification trees are especially useful in identifying interactions between independent variables, identified via nested splits within individual branches of the tree.

Table 5 presents the independent variables included in the classification tree analysis. These were selected from the set of characteristics with the largest chi-square test statistics from the univariate analysis, except those not measured in any way on the survey, as we would be unable to adjust the weights for those characteristics.

Table 5: Variables Included in Classification Tree Analysis

Characteristic	Data source	Categories
Household income	ABS Sample Frame (reported in $5,000 increments)	$0 - $40,000 $45,000 - $75,000 $80,000 or more (Missing)
Home is owned or rented	ABS Sample Frame	Own Rent (Missing)
Number of adults in household	ABS Sample Frame	1 2 3 or more (Missing)
Length of residence	ABS Sample Frame	Less than 1 year 1 – 5 years 6 – 10 years More than 10 years (Missing)
Size of residence	ABS Sample Frame	1 unit More than 1 unit (Missing)
Age of Household Respondent	ABS Sample Frame	17 – 34 years 35 – 49 years 50 – 64 years 65 or older (Missing)
Education of Household Respondent	ABS Sample Frame	High school diploma or less Some college Bachelor's degree or higher (Missing)
Race/ethnicity of Household Respondent	ABS Sample Frame	African descent/African American Western European descent Hispanic Other (Missing)
Occupation type of Household Respondent	ABS Sample Frame	Management/sales/office work Technical/professional Blue collar/farm Other/retired (Missing)
Gender of Household Respondent	ABS Sample Frame	Female Male (Missing)
Division	US Census Bureau	East North Central

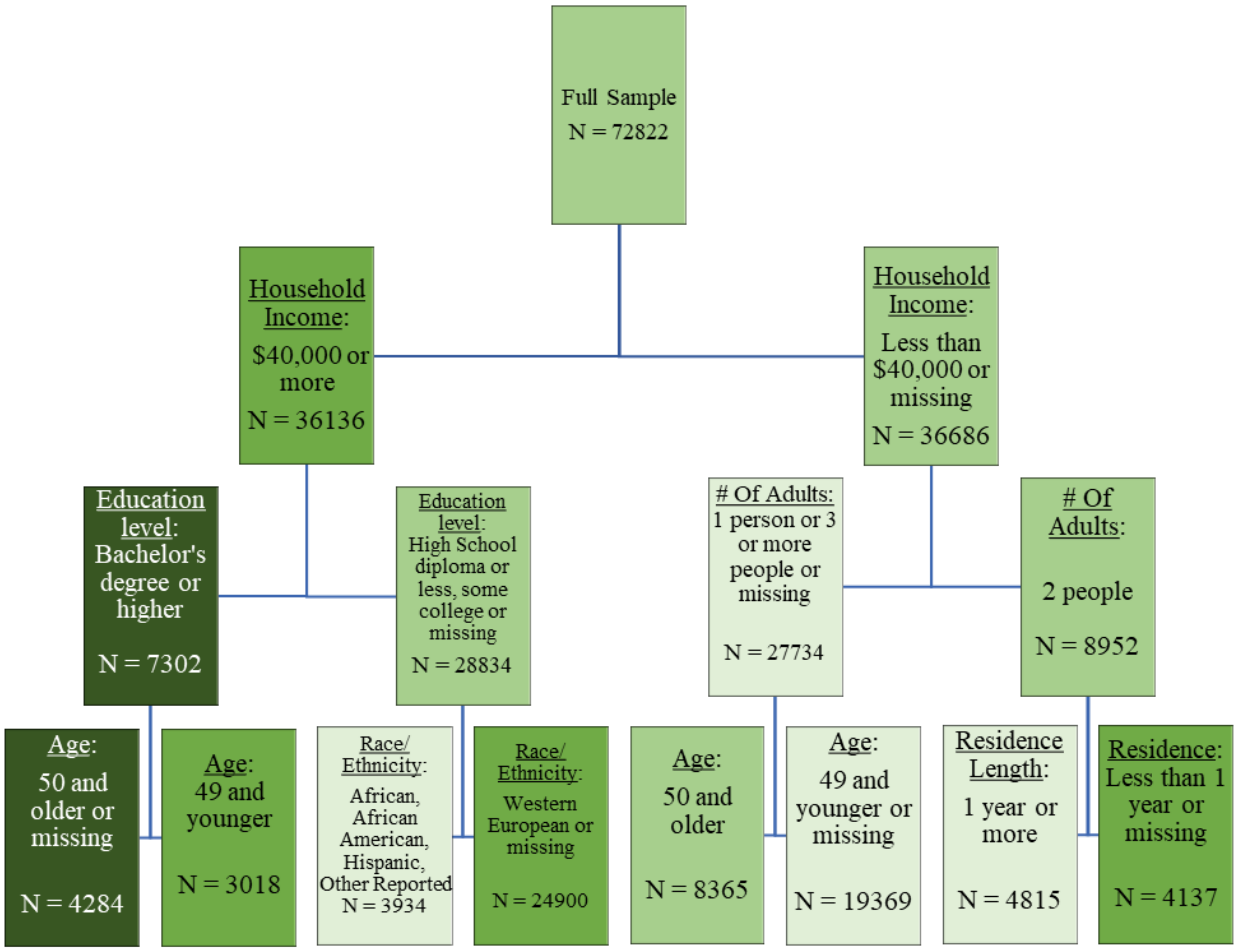
Table 5: Variables Included in Classification Tree Analysis

Characteristic	Data source	Categories
		East South Central Mid-Atlantic Mountain New England Pacific South Atlantic West North Central West South Central
Urbanicity	US Census Bureau	Rural Urban
Percent in CBG who work from home	US Census Bureau	0%-2.5% 2.5%-4.7% 4.7%-7.1% 7.1%-10.8% 10.8%-62.2% (Missing)
Percent in CBG with no vehicles	US Census Bureau	0% <0.1%-2.6% 2.6%-5.7% 5.7%-12.7% 12.7%-100.0% (Missing)
Percent in CBG with two vehicles	US Census Bureau	0%-28.7% 28.7%-35.3% 35.3%-40.0% 40.0%-45.4% 45.4%-80.6% (Missing)

† - The ABS database included geographic and modeled information for households as part of the sample frame

The CART analyses were performed at the household-response level, using the responses included in the final delivery file (there were 7,894 responses and 64,928 nonresponses). We allowed a maximum tree depth of 3 to avoid overfitting the data. The resulting tree included six variables: household income, predicted education, age, and race/ethnicity of householder, number of adults in the household, and the length of residence in the housing unit. Figure 2 shows the visual representation of the resulting classification tree. The CART analysis indicates response rates for each grouping by the shade of the box.

Figure 2. Response/ Nonresponse Classification tree for NHTS ABS study



Comparison of NHTS Respondents' Demographic Statistics to Population Benchmarks

In this analysis, distributions for Age, Education, and Race of the responding adult are compared to the responding head of household statistics derived from the 2021 1-year ACS PUMS. We limited the data to the population aged 5+ in occupied housing units, and to exclude populations living in group quarters or institutionalized (table B25002). In addition, respondent distributions are examined for household size, household income, and home ownership/ renter status. The statistics are weighted by the study's design weights.

Table 6 compares the demographic characteristics of the head of household for the NHTS compared to the 2021 1-year ACS PUMS distributions.[7] There are sufficient differences between the design weighted respondent distribution and ACS targets to adjust the weights for Age, Education, and Race/Ethnicity. The CBG and Modeled data analyses also noted Race/ Ethnicity in their results.[8]

[7] American Community Survey 2021 1-year Public Use Microdata. Sample limited to 5 years and older and occupied housing units and excludes group quarters.

Table 6: Distribution Under Design Weights for Household Respondents' Demographics

Gender	Respondents	Target	Age	Respondents	Target	Education	Respondents	Target	Race*	Respondents	Targe
Male	52.12	48.71	**18-29**	9.04	10.52	High school grad or less	14.38	32.18	White	79.08	64.4
Female	47.88	51.29	**30-44**	23.13	26.10	Some college†	30.39	29.91	Black	7.09	11.7
Total	100.0	100.0	**45-59**	24.30	26.66	Bachelor's or *higher*	55.23	37.91	Other non-Hispanic	6.29	9.4
			60+	43.53	36.73	Total	100.0	100.0	Hispanic	7.54	14.3
			Total	100.0	100.0				Total		100

† Some college - Some college, Associates degree/Trade school certificate

* Categories: White non-Hispanic, Black/African American non-Hispanic, Other non-Hispanic, Hispanic, 2 plus Races non-Hispanic

Target Source: ACS 2021 1-year estimate public use microdata

Table 7 presents the respondent distributions of household demographics including household size, household income, and home ownership. Differences between the respondent distribution under the design weights also occur for each of these measures. The nonresponse bias analysis found each of these as factors in nonresponse. Table 7 also includes the distribution by stratum, which was included by default in the household adjustments to align the respondents with the population distribution.

Table 7: Respondent Distributions under the Design Weights for Key Household Demographics

Household Size	Respondents	Target	Household Income	Respondents	Target	Home Ownership	Respondents	Target
1 person in household	29.18	28.28	<$10K	3.73	6.12	Own	73.52	67.14
2 persons in household	42.28	34.17	$10K to $25K	8.92	11.42	Rent	26.48	32.86
3 persons in household	12.34	15.42	$25K to $50K	17.74	18.98	Total	100.0	100.0
4 or more people in household	16.19	22.13	$50K to $75K	18.24	16.76			
Total	100.0	100.0	$75K to $100K	14.30	12.76			
			$100K to $150K	19.04	16.06			
			$150K or more	18.02	17.9			
			Total	100.0	100.0			

Stratum	Respondents	**Target**	Stratum	Respondents	Target	Stratum	Respondents	**Target**
1021	3.77	3.83%	1027	4.80	4.83%	1033	9.51	9.33%
1022	0.88	0.91%	1028	1.95	1.98%	1034	2.86	2.67%
1023	10.78	11.14%	1029	15.98	16.04%	1035	6.13	6.33%
1024	1.70	1.70%	1030	4.76	4.29%	1036	1.11	1.23%
1025	11.56	11.74%	1031	3.74	3.68%	1037	13.4	13.54%
1026	3.28	3.16%	1032	2.56	2.32%	1038	1.23	1.29%
Total	**100.0%**							

Target Source: ACS 2021 1-year estimates public use microdata

The comparison of the respondents' demographic statistics to population benchmarks identified differences on nearly all characteristics between household respondents compared to benchmarks as potential sources of non-response biases.

Weighting Plan

The NHTS Weighting Plan accounts for weights to be included in household, person, travel, and trip analyses. This section extends the discussion from the design weights based on the sample design and project specifics to create reliable and efficient:

- Household weights,
- Person weights, and
- Trip weights.

NHTS Household Weighting Plan

The weighting plan to produce analytic weights for the NHTS comprises two primary stages.

- **Household design weight** - In the first stage, design weights are produced to capture all key components of the sample design, fielding, and timing of response, as described above in the design weight section. The design weights are based on the probability of selection from the frame, which is then adjusted for the day-of-travel response, re-adjusted to strata population totals, and smoothed across day-of-travel and month-of-travel responses. The goal of these weights is to capture the sample design and for the weighted distribution of day-of-travel and month-of-travel response to match the intended distribution.
- **Final Household weight** - The second stage will adjust the household weights to account for differential nonresponse, based on the analysis provided in the previous section. Based on the nonresponse bias analysis, the weighting should account for several conditions simultaneously. A raking approach will be used to account for these in the adjustments. The household weights will be adjusted for the following factors:
    - household size,
    - household income,
    - education of the primary respondent,

- age of the primary respondent,
- race/ethnicity of the primary respondent,
- residence length,
- distribution of response by stratum,
- distribution of response by day,
- and distribution of response by month of response.

Two additional steps in the weighting plan are:

- **Imputation of missing values** – Prior to raking, key measures used in the raking process are checked for missing cases, and hot deck imputation is used to impute missing cases.
- **Trimming of extreme weights** – The design weight and raking process may yield large and influential household weights. The NHTS uses trimming to curtail the influence of large weights with proportionate adjustments to achieve the nation's population sizes (Numbers of Households and Total 5+ Population)

Raking of Design Weights

As part of the final household weight process, the resulting adjustment factors will be evaluated to ensure there are no large adjustments for small groups of respondents, which could result in too much influence for a small group of respondents. If needed, we will adjust the benchmark definitions to avoid too large factors, and to accommodate differences in the available data. The final household weights will be formulated to meet the analytic characteristics built into the design weights using the approach described above, while also minimizing the possibility of nonresponse bias.

- The final household weight is a function of the household design weight and the raking process, and it has the form
  - $w_i^{HH} = Rake\left(w_i^{Design\,Weight} | Raking\ marginals\right).$

Imputation of missing values

There are two approaches to deal with these missing values. The first choice is to leave the cases untreated. This would preclude weighting the data for these cases and reduce the size of the analysis database. Research indicates that item response can compromise statistical analyses when two or more items have item nonresponse rates as low as even 5% per item (King 2001 and Graham 2012). In this discussion, we are concerned with missing values for items used in weighting. The missing rates for these measures were less than 5% except for residence length, at about 8%. The second choice is to impute the values. Imputation of these missing values will allow for weights to be calculated for the full data set, and imputation helps minimize and mitigate the impact of item nonresponse on the weights.

Ipsos uses a *Hotdeck* method to impute missing values of all such variables and key outcome measures critical to the computation of travel statistics based on the *Survey Impute* procedure of SAS that relies

on a Sequential *Hotdeck* algorithm[8] . This procedure uses survey data as donors to provide surrogate values for what is missing. The donor selection process will be carried out within imputation classes indexed by cross-classification of key covariates, after which missing values are sequentially replaced within each imputation class. Ipsos uses CART procedures to identify homogeneous imputation classes (Fahimi 2011). Moreover, the imputation process will be hierarchical so that variables with fewer missing values are imputed first and then used in the imputation of other variables.

Trimming Extreme Household Weights

Adjustments by the elements Travel Day and Travel Month for the study design plus the additional adjustment to bring Education, Age, and Income into alignment with external benchmarks caused large and possibly extreme weights. Extreme weights are trimmed to avoid undue influence on survey estimates from a small set of respondents. Instead of using static thresholds for identifying outliers, Ipsos uses an empirical approach that considers the observed distribution of survey weights. The Weighting Plan uses the Interquartile Range Rule to identify such values. The Interquartile Range Rule (IQR) is:

- The interquartile range (IQR) of the weights, which is the difference between the third (Q_3) and first (Q_1) quartiles (75th and 25th percentiles) of the weight distribution, is computed as follows: $IQR = Q_3 - Q_1$
- The upper (U) and lower (L) limits for identifying the so-called mild outliers is computed as follows:
  $L_1 = Q_1 - 1.5 \times IQR$ and $U_1 = Q_3 + 1.5 \times IQR$
- Moreover, the upper and lower limits for identifying extreme outliers is computed as follows:
  $L_3 = Q_1 - 3 \times IQR$ and $U_3 = Q_3 + 3 \times IQR$
- Weights identified as mild outliers are examined and most likely retained to correct for differential nonresponse encountered during the data collection. However, those identified as extreme outliers might be replaced by their corresponding upper and lower limits, L_3 and U_3.
- After the weights are trimmed, the final weights are adjusted such that the sum of the weights again match the population total, but they do not go through another raking process.

When nonresponse is moderate, the above trimming thresholds often correspond to the 1st and 99th percentiles of the weight distribution. Under excessive nonresponse, however, more aggressive trimming thresholds might be necessary to improve the weighting efficiency. Either way, the plan studies the unequal weighting effect (UWE) to ensure high weighting efficiency. With W_i representing the weight of the i^{th} household or person such as w_i^{HH}, UWE can be approximated by the following equation:

$$UWE = 1 + CV_W^2 = 1 + \frac{\sum_i \frac{(W_i - \bar{W})^2}{n-1}}{\bar{W}^2},$$

where CV_W^2 is the coefficient of the variation of the weights, $\bar{W}$ is the average of the weights. The above is the factor by which the effective size of a sample is reduced, reflecting the actual number of

[8] SAS (2016). Survey Data Imputation with PROC SURVEYIMPUTE. SAS3520-2016. https://support.sas.com/resources/papers/proceedings16/SAS3520-2016.pdf.

independent observations from which inferences are made. Under an ideal situation when respondents are self-weighting, this factor would equal one.
The final Household Weight is trimmed using the IQR rule with a final adjustment to household or person population size and day-of-week. The Final Household weight has the form:

$$w_i^{HH\_Final} = Rake\left(w_i^{HH} \mid Trimmed\ and\ Raked\ for\ Population, Day\ of\ Week, and\ Month\right)$$

Computation of NHTS Final Household Weights

A summary of the steps to determine Final NHTS Household Weights is:

1. Rake household design weights to household demographics and behavior attributes associated with household nonresponse found in the NRBA analysis.
2. Trim raked weights to maintain day-of-week, monthly proportions, and population household totals.

Computation of the Household Weights

Including the NRBA Findings

The NRBA found several variables to be differentiators. The analyses were limited due to missing data rates in the ACS CBG results, in the sample frame's auxiliary data, and respondent results under the design weights compared to population benchmarks. The NRBA found differentiation in the likelihood of response for several measures. The following variables were included in the adjustment process:

- Stratum totals
- Day-of-Travel
- Month of Report
- Household size
- Household income
- Education level of the householder
- Race/ Ethnicity of the householder
- Age of the householder
- Residence length

Imputation of Missing Data

The raking-adjusted household weight uses several reported items from the survey. These include the primary household respondent's Age, Education, Race, and Sex, plus the household's Income. Age, Race, and Sex were required responses. If an answer was not provided, households were recontacted to provide an answer. After completing recontact some responses to these variables were still missing, including:

- Household Income – 96 missing cases,
- Education – 123 missing cases,

- Race/ethnicity – 16 missing cases,
- Age – 35 missing cases, and
- Sex – 121 missing cases.

Table 8 shows the distributions of Sex and Household Income before and after imputation. The imputation maintains the distribution of the original data.[9]

Table 8: Response Levels to Sex, Income, Education, Age, and Race/Ethnicity Pre and Post Imputation

Sex					Income				
	Raw		Imputed			Raw		Imputed	
	n	%	n	%	Level	n	%	n	%
Male	4,030	51.06	4,074	51.62	1- <$10K	300	3.8	301	3.81
Female	3,742	47.41	3,819	48.38	2- $10K to $25K	709	8.98	715	9.06
Missing	121	1.53	0	0	3- $25K to $50K	1,376	17.43	1,391	17.62
Total	7,893	100.0	7,893	100.0	4- $50K to $75K	1,392	17.64	1,415	17.93
					5- $75K to $100K	1,120	14.19	1,132	14.34
					6- $100K to $150K	1,501	19.02	1,526	19.33
					7- $150K or more	1,399	17.72	1,413	17.9
					Missing	96	1.22		
					Total	7,893	100.0	7,893	100.0

Education					Age				
	Raw		Imputed			Raw		Imputed	
	n	%	n	%		n	%	n	%
Less than high school	215	2.72	216	2.74	18-29	699	8.86	708	9.0
High school grad	923	11.69	927	11.74	30-44	1,797	22.77	1,809	22.9
Some college	2,384	30.2	2,392	30.31	45-59	1,900	24.07	1,908	24.2
BA degree or higher	4,336	54.93	4,358	55.21	60+	3,462	43.86	3,468	43.9
Missing	35	0.44			Missing	35	0.44	0	0.0
Total	7,893	100.0	7,893	100.0	Total	7,893	100.0	7,893	100.0

Race/ethnicity				
	Raw		Imputed	
	n	%	n	%
White	6,215	78.74	6,245	79.12
African American	549	6.96	550	6.97
Hispanic	597	7.56	598	7.58
Other/2 or more	497	6.30	500	6.33
Missing	35	0.44		
Total	7,893	100.0	7,893	100.0

Note: Table counts are household responses.

[9]Some additional imputations were required for other household members for use in the person-level weights.

The list above includes the variables identified in the CART analysis plus several considered key demographic benchmarks. A final aspect of the weighting are the study design requirements Travel Day-of-Week and Month-of-Travel. Table 9 shows that the design weights met the targets for Travel Day-of-Week, but adjustments are needed for strata and Travel Month.

Table 9: Respondent Distribution Under Design Weights for Strata, Travel Day of Week, and Travel Month

Stratum	Respondents	Target	Day of Week	Respondents	Target	Month	Respondents	Target
1021	3.78%	3.83%	Monday	14.29%	14.29%	January	3.73%	8.49%
1022	0.87%	0.91%	Tuesday	14.29%	14.29%	February	8.70%	7.67%
1023	10.82%	11.14%	Wednesday	14.29%	14.29%	March	9.63%	8.49%
1024	1.66%	1.70%	Thursday	14.29%	14.29%	April	9.32%	8.22%
1025	11.71%	11.74%	Friday	14.29%	14.29%	May	9.63%	8.49%
1026	3.13%	3.16%	Saturday	14.29%	14.29%	June	9.32%	8.22%
1027	4.88%	4.83%	Sunday	14.29%	14.29%	July	9.63%	8.49%
1028	1.88%	1.98%	**Total**	**100%**	**100%**	August	9.63%	8.49%
1029	16.27%	16.04%				September	9.32%	8.22%
1030	4.51%	4.29%				October	9.63%	8.49%
1031	3.80%	3.68%				November	9.32%	8.22%
1032	2.48%	2.32%				December	2.17%	8.49%
1033	9.59%	9.33%				**Total**	**100%**	**100%**
1034	2.74%	2.67%						
1035	6.18%	6.33%						
1036	1.07%	1.23%						
1037	13.46%	13.54%						
1038	1.17%	1.29%						
Total	**100%**	**100%**						

The final household weight process adjusts the Household Design Weights using raking ratio adjustments for the measures in Table 10. The design factors in Table 9 will also be included so as not to lose the sample design requirements for the representation by Strata, Travel Day-of-Week and Travel Month. A final step evaluates the adjusted household for large weights to ensure there are no large adjustments for small groups of respondents, which could result in too much influence for a small group of respondents.

Table 10: Raking Marginal Categories for Household Weights for Nonresponse-Adjustments

Household income	Household Size	Age	Education	Residence length	Race/ Ethnicity	Stratum
<=$10,000	1	18 - 29	Less than High School	12 months or less	White -NH	New England, Urban
$10,000-$24,999	2	30 - 44	High School Grad.	13 – 23 months	Black -NH	New England, Rural
$25,000-$49,999	3	45 – 59	Some College	2 – 4 years	Other - NH	Middle Atlantic, Urban
$50,000-$74,999	4 or more	60 or older	Bachelor's higher	5 – 9 years	Hispanic	Middle Atlantic, Rural
$75,000-$99,999				10 – 19 years		East North Central, Urban
$100,000-$149,999				20 – 29 years		East North Central, Rural
>$150,000				30 years or more		West North Central, Urban
						West North Central, Rural
						South Atlantic, Urban
						South Atlantic, Rural
						East South Central, Urban
						East South Central, Rural
						West South Central, Urban
						West South Central, Rural
						Mountain Division, Urban
						Mountain, Rural
						Pacific Division, Urban
						Pacific, Rural

As part of the final household weight process, the resulting adjustment factors will be evaluated to ensure there are no large adjustments for small groups of respondents, which could result in too much influence for a small group of respondents. After evaluating the distribution of the weights, it was determined that there was no need to adjust the benchmarks used in the weighting adjustments

The final household weight is a function of the household design weight and the raking process, and it has the form

$$w_i^{HH} = Rake(w_i \,|Raking\ marginals).$$

The raking process adjusts design weights such that the weighted distributions of the measures included in the raking reflect the target distributions listed in Table 14. These Target distributions are also referred to as the Raking Marginals. Table 11 shows the respondent distribution under these raking-adjusted weights.

Table 11: Distribution of Raking-Adjusted Household Weights

Stratum	Cases (n)	Raking-Adjusted 7-Day Household Weights						
		Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1021	368	4,867,060	13,225.71	1,726.08	104,176.60	12,580.91	95.12	1.905
1022	71	1,255,086	17,677.27	3,081.25	91,245.22	19,369.39	109.57	2.201
1023	797	14,211,771	17,831.58	2,194.21	198,340.61	19,345.13	108.49	2.177
1024	127	2,113,951	16,645.28	2,667.36	75,698.77	13,337.81	80.13	1.642
1025	993	15,069,093	15,175.32	1,526.05	308,074.70	19,494.53	128.46	2.650
1026	300	3,936,460	13,121.53	1,478.23	108,068.31	12,032.63	91.70	1.841
1027	357	6,279,172	17,588.72	2,736.28	117,475.40	17,178.47	97.67	1.954
1028	212	2,404,823	11,343.50	1,316.91	94,219.51	10,393.51	91.63	1.840
1029	1,271	20,693,165	16,281.01	2,453.48	222,440.59	16,529.24	101.52	2.031
1030	313	5,225,497	16,694.88	1,969.36	171,060.91	17,312.51	103.70	2.075
1031	295	4,778,823	16,199.40	1,881.94	129,159.08	15,268.64	94.25	1.888
1032	152	2,859,952	18,815.47	2,498.60	88,798.29	15,016.64	79.81	1.637
1033	695	11,931,594	17,167.76	2,297.80	158,512.03	16,927.93	98.60	1.972
1034	187	3,345,589	17,890.85	2,082.10	128,837.66	19,035.57	106.40	2.132
1035	492	8,091,502	16,446.14	2,167.60	167,153.46	18,511.72	112.56	2.267
1036	129	1,604,551	12,438.38	1,471.09	45,529.50	9,002.09	72.37	1.524
1037	1,033	17,304,561	16,751.75	103.59	228,890.33	18,307.47	109.29	2.194
1038	101	1,572,056	15,564.91	789.23	125,050.40	15,242.70	97.93	1.959
Total	**7,893**	**127,544,707**	**16,159.22**	**103.59**	**308,074.70**	**17,180.73**	**106.32**	**2.130**

Trimming Extreme Household Weights

Table 12 provides the distribution of the trimmed and re-raked household weights.[10] In comparison to Table 11, the maximum weight has been reduced as well as the standard deviations and the coefficient of variation of the weights. In all, 3% of the cases were trimmed. The UWE is 1.7. The UWE for the raking-adjusted household weights without trimming is 2.1.

[10] The trimmed weights were smoothed across day and month of diary response but were not re-raked to demographic population distributions.

Table 12: Distribution Trimmed and Raking-Adjusted 7-Day Household Weights

Stratum	Cases (n)	Trimmed and Raking-Adjusted 7-Day Household Weights						
		Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1021	368	4,858,297	13,201.89	1,688.31	55,771.02	10831.29	82.0434	1.673
1022	71	1,268,465	17,865.71	3,217.50	72,667.39	17154.15	96.0172	1.922
1023	797	14,216,603	17,837.64	2,162.99	75,507.39	15883.39	89.0442	1.793
1024	127	2,122,222	16,710.41	2,575.66	65,774.10	13396.59	80.1691	1.643
1025	993	15,089,518	15,195.89	1,511.77	60,121.33	12883.46	84.7826	1.719
1026	300	3,942,376	13,141.25	1,446.20	55,624.01	10916.22	83.0683	1.690
1027	357	6,249,409	17,505.35	2,617.61	68,476.48	14861.7	84.8981	1.721
1028	212	2,423,420	11,431.23	1,281.31	43,694.06	8738.62	76.4452	1.584
1029	1,271	20,614,807	16,219.36	2,520.67	62,526.83	12954.6	79.8712	1.638
1030	313	5,246,614	16,762.35	2,030.20	60,060.38	13368.78	79.7548	1.636
1031	295	4,755,133	16,119.10	1,895.59	68,067.57	13207.53	81.9371	1.671
1032	152	2,871,946	18,894.38	2,354.83	76,132.85	14661.33	77.5962	1.602
1033	695	11,876,929	17,089.11	2,205.93	73,616.91	14936.57	87.404	1.764
1034	187	3,392,100	18,139.57	2,148.62	81,832.02	17599.04	97.0201	1.941
1035	492	8,080,890	16,424.57	2,237.13	59,451.11	13534.51	82.404	1.679
1036	129	1,612,449	12,499.61	1,404.50	47,189.22	9198.85	73.5931	1.542
1037	1,033	17,355,406	16,800.97	100.85	64,209.71	14562.95	86.6792	1.751
1038	101	1,568,121	15,525.95	767.55	63,211.46	12192	78.5266	1.617
Total	**7,893**	**127,544,707**	**16,159.22**	**100.85**	**81,832.02**	**13,792.24**	**85.35**	**1.728**

Person Weights

The final household weight is the basis for the person-weight. The final household weight, w_i^{HH}i, will go through a raking process using the person-level response data. The final person weight takes the form:

$$w_i^{Person} = Raking\left(w_i^{HH} \mid Person\ Raking\ Marginals\right).$$

The NHTS reports on attitude and usage over the seven days of the week, the five general commuting weekdays of the week, and the two weekend days of a week. The weights used in constructing estimates for attitudes, usage, and trips for weekly/ seven days have 7-Day reference in their description. Weights to provide commuting estimates for weekdays have a 5-Day reference, and weights for weekend travel have a 2-Day reference. This section focuses on the 7-Day weights.

7-Day Person Weights

The raking marginals for the person-level weights include elements to account for the sample design and nonresponse. They include:

- Gender,
- Age,
- Education,
- Race/Ethnicity,
- Employment status,
- Household income,
- Household size,
- Residence length,
- Household income x zero-trip vs 1+ trip,
- Age x employment x zero-trip vs 1+ trip, and
- Stratum.

In addition, the adjustment includes the Travel Day-of-Week and Month to maintain the study's design requirements. Two of the marginal distributions pertain to whether the person reported any trips on their travel day. Preliminary estimates showed an unusually high rate of zero reported trips for the 2022 NHTS as compared with the 2017 NHTS and other more recent external data sources, the latter measured after the major disruptions due to the COVID19 pandemic. It was not possible to pinpoint the reason for this increase in reported zero-trips, which could result from a combination of the after-effects of COVID, changes in the mode of data collection between 2017 and 2022, or methodological changes in how trips were reported. Whatever the reasons, to correct for this over-reporting of zero-trip days, we used an external data source, the 2021 American Time Use Survey, to provide benchmark estimates for zero-trip days. In our examination of this data, we found zero-trip days varied the most by household income, age, and employment status, thus our choice of marginal distributions for the person weight adjustments.

Table 13 presents the distributions of the 7-Day Person Weights after the household weights have undergone the raking adjustments.

Table 13: Distribution of Raking-Adjusted 7-Day Person Weights

Stratum	Cases (n)	Raking-Adjusted 7-Day Person Weights						
		Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1021	766	11,244,005	14,678.86	885.21	620,516.34	25,952.36	176.80	4.126
1022	151	2,628,461	17,407.02	949.12	283,265.98	27,491.83	157.94	3.494
1023	1,663	33,639,562	20,228.24	696.13	608,333.69	30,089.38	148.75	3.213
1024	292	4,983,339	17,066.23	1,457.51	171,225.86	22,601.87	132.44	2.754
1025	2,079	34,197,984	16,449.25	515.92	204,685.16	18,201.06	110.65	2.224
1026	666	9,288,212	13,946.26	533.05	108,726.95	15,052.66	107.93	2.165
1027	779	14,194,326	18,221.21	1,568.55	151,847.67	19,248.10	105.64	2.116
1028	496	5,689,195	11,470.15	523.90	108,453.70	12,586.20	109.73	2.204
1029	2,707	48,814,191	18,032.58	820.01	491,599.83	27,655.49	153.36	3.352
1030	705	12,718,195	18,039.99	643.66	146,935.32	19,321.17	107.10	2.147
1031	654	10,783,633	16,488.74	945.26	120,119.46	17,355.64	105.26	2.108
1032	324	7,063,965	21,802.36	1,009.51	366,642.21	28,417.27	130.34	2.699
1033	1,531	29,117,707	19,018.75	780.33	226,980.67	22,582.81	118.74	2.410
1034	397	8,472,632	21,341.64	934.10	781,699.97	45,056.36	211.12	5.457
1035	1,081	19,593,222	18,125.09	657.96	552,004.11	26,791.36	147.81	3.185
1036	288	3,814,764	13,245.71	587.89	79,816.70	13,122.96	99.07	1.982
1037	2,193	45,419,985	20,711.35	30.88	673,365.29	29,301.06	141.47	3.0015
1038	225	3,897,548	17,322.44	462.53	138,332.54	15,863.50	91.58	1.839
Total	**16,997**	**305,560,925**	**17,977.34**	**30.88**	**781,699.97**	**25,107.33**	**139.66**	**2.9505**

No trimming was required for the 7-Day Person Weights. These weights are the final person weights for the 7-day estimates. Table 14 compares how the distributions of key demographics compared between the raw data, the final household weights, and the final person weights.

Table 14. Demographics by Weight

Age	NHTS ABS Results			ACS 2021 5-year (%)
	Unweighted (%)	Final HH Weight (Trimmed and Raking Adjusted) (%)	Final Person Weight (Raking-Adjusted) (%)	
0-15	12.90	15.56	15.10	15.10
16-17	2.24	2.68	2.79	2.79
18-24	6.06	7.16	8.83	8.83
25-34	12.25	13.00	14.43	14.43
35-54	24.94	26.76	27.21	27.21
55-64	16.14	14.93	13.81	13.82
65-74	16.86	13.01	10.91	10.91
75+	8.61	6.90	6.92	6.92
Total	**100.0**	**100.0**	**100.0**	**100.0**
Education	**Unweighted**	**Trimmed HH Weight**	**Raking-Adjusted Person Weight**	**ACS 2021 5-year**
High School or less	33.19	45.13	48.68	48.67
Some college	25.34	24.34	24.03	24.03
Bachelor's or higher	41.47	30.52	27.30	27.30
Total	**100.0**	**100.0**	**100.0**	**100.0**
Employment Status	**Unweighted**	**Trimmed HH Weight**	**Raking-Adjusted Person Weight**	**ACS 2021 5-year**
Not Asked (Age 5-15)	12.90	15.56	15.10	15.09
Employed	45.79	44.46	51.71	51.65
Unemployed	41.31	39.98	33.19	33.26
Total	**100.0**	**100.0**	**100.0**	**100.0**
Gender	**Unweighted**	**Trimmed HH Weight**	**Raking-Adjusted Person Weight**	**ACS 2021 5-year**
Male	48.54	48.67	49.12	49.12
Female	51.46	51.33	50.88	50.88
Total	**100.0**	**100.0**	**100.0**	**100.0**
Race	**Unweighted**	**Trimmed HH Weight**	**Raking-Adjusted Person Weight**	**ACS 2021 5-year**
(1) Hispanic	8.83	14.87	17.11	18.56
(2) White	77.79	65.12	60.75	58.79
(3) African American	6.68	10.42	11.40	11.54
(4) Other	6.70	9.59	10.74	11.11
Total	**100.0**	**100.0**	**100.0**	**100.0**

Trip Weights

The projection and analyses of trips is a goal of the NHTS program. This requires a travel-day trip weight based on the final person weight. The final person weight reflects the Day-of-Travel to allow for

estimation of the average and projection or total for a day of the week, month of a year, quarter of a year, and annual statistics, among a few. The functional form of the trip weight is:

$$w_{i\in d}^{Trip} = D \times w_{i\in d}^{Person}.$$

D is the number of annual reference days each weight is designed to represent.

The NHTS requires analyses for 1) all potential travel days combined, 2) typical commuting travel defined as weekday travel, and 3) weekend travel. Trip Weights for these three scenarios for are summarized here:

7-Day Trip Weights

The 7-day Trip Weights are for estimating the number of trips for all potential travel days combined. The previous sections reported on the raking and trimming of the design weights to produce final Household weights, and the sections also described the process to determine person weights from their household' weights using raking and trimming of the final Household weights. Both the household and person weights were adjusted such that the weights each day of the week, Monday through Sunday, had an equal $\left(1/7\right)^{th}$ contribution of the weights' totals, and the weights associated with each month were proportionate relative to the number of days for that month. The final Household weights and the final Person weights described earlier were adjusted to meet the daily $\left(1/7\right)^{th}$ requirement and the monthly proportionate requirement. The final Household weights and the final Person weights are the basis for the 7-day trip weights. The multiplier *D* for the 7-day trip weights is 365 days for the 7-day weights. This is the full number of days in 2022.

5-Day Trip Weights

The 5-day Trip Weights are for analyzing and estimating trips on commuting travel days, which consist of weekdays. As noted in the preceding 7-day Trip weight discussion, the final Household and final Person weights are adjusted to the meet the $\left(1/7\right)^{th}$ requirement and proportionate allocation across the months, and they were the foundational weights in the 7-day Trip Weights. The 5-day weights are adjusted to a $\left(1/5\right)^{th}$ daily requirement as well as the monthly allocation. The weights need to project to the population distributions as did the foundational Household and Person weights in the 7-day Trip process. To meet the requirements, the household and succeeding person weights were calculated under the 5-day rules. This results in an additional set of 5-day Household weights and 5-day Person weights. The process includes:

a. Raking and Trimming Design Weights for weekdays to create a 5-day Household weight
b. Raking and Trimming 5-day Household weights to create a 5-day Person weight
c. Calculate the 5-day Trip weight using 260 for the multiplier *D*, the number of weekdays during the NHTS study period

Formally, the 5-day Trip Weights are:

- 5-Day Household Weight

$$w_i^{HH\_5D} = w_i^{Design\ Weight}, if\ day\ i\ is\ a\ Weekday$$
$$= 0, if\ day\ i\ is\ Weekend\ Day$$

Note that the 5-day Household weight uses the household underlying design weights

- 5-Day Raking-Adjusted Household Weight

$$w_i^{Adjusted\ HH\_5D} = Rake\left(w_i^{HH\_5D} | Raking\ marginals|\right)$$

- 5-Day Trimmed Raking-Adjusted Household Weight

$$w_i^{Trimmed\ Adjusted\ HH\_5D} = Trim\left(w_i^{Adjusted\ HH\_5D}\right)$$

- 5-Day Raking-Adjusted Person Weight

$$w_i^{Person\_5D} = Raking\left(w_i^{Adjusted\ HH\_5D} | Person\ Raking\ Marginals|\right).$$

- 5-Day Trimmed Raking-Adjusted Person Weight

$$w_i^{Trimmed\ Person\_5D} = Trim\left(w_i^{Person\_5D}\right)$$

- 5-Day Trip Weight

$$w_{i\in d}^{Trip\_5D} = 260\ x\ w_{i\in d}^{Trimmed\ Person\_5D}$$

2-Day Trip Weights

Analyses of weekend trips require a 2-day Trip Weight based on only Saturday and Sunday travel diaries. The multiplier D for the 2-day Trips Weights is 105 days. As with the 7-day and 5-day Trips weight, the 2-day Trips follow the same systematic approach to assure the components of the 2-day Trips weights projection to household and population sizes, equalness for Saturday and Sunday, and proper proportions for the study months. The 2-day Trip Weights are:

- 2-Day Household Weight

$$w_i^{HH\_2D} = w_i^{HH\_7D}, if\ day\ i\ is\ a\ Saturday\ or\ Sunday$$
$$= 0, if\ day\ i\ falls\ on\ Monday - Friday$$

- 2-Day Raking-Adjusted Household Weight

$$w_i^{Adjusted\ HH\_2D} = Rake\left(w_i^{HH\_2D} | Raking\ marginals|\right)$$

- 2-Day Trimmed Raking-Adjusted Household Weight

$$w_i^{Trimmed\ Adjusted\ HH\_2D} = Trim\left(w_i^{Adjusted\ HH\_2D}\right)$$

- 2-Day Raking-Adjusted Person Weight

  $$w_i^{Person\_2D} = Raking\left(w_i^{Adjusted\ HH\_2D} \mid Person\ Raking\ Marginals\right).$$

- 2-Day Trimmed Raking-Adjusted Person Weight

  $$w_i^{Trimmed\ Person\_2D} = Trim\left(w_i^{Person\_2D}\right)$$

- 2-Day Trip Weight

  $$w_{i\in d}^{Trip\_2D} = 105\ x\ w_{i\in d}^{Trimmed\ Person\_2D}$$

Table 15 reports the progression of the steps for the 7-day, 5-day, and 2-day weights for the NHTS, examining the distribution for the design, final Household, final person, and the final trip weights for each. Full tables with national and strata distributions are provided in Appendix A.

Table 15: Distribution for Trip Weights
And Their Component Design, Trimmed Household and Trimmed Persons Weights

Weight	Cases (n)	Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
Components for 7-day Trip Weights								
Design	7,893	131,600,579	16,673.07	294.59	97,765.50	9,680.22	58.059	1.337
Final Household	7,893	127,544,707	16,159.22	103.59	30,8074.70	17,180.73	106.32	2.130
Final Person	16,997	305,560,925	17,977.34	30.88	781,699.97	25,107.33	139.66	2.9505
7-day Trip	31,074	231,715,789,629	7,456,902.54	30,118.12	285,320,489.88	9,941,676.96	133.32	2.777
Components for 5-day Trip Weights								
Design	5,662	94,000,414	16,601.98	294.59	97,765.50	9,277.63	55.88	1.312
Final Household	5,662	127,544,707	22,526.44	147.15	468,464.13	23,856.16	105.90	2.122
Final Person	12,186	305,560,925	25,074.75	41.37	972,351.28	34,088.93	135.95	2.848
5-day Trip	23,223	165,128,990,618	7,110,579.62	26,547.56	252,811,333.00	9,513,284.90	133.79	2.790
Components for 2-day Trip Weights								
Design	2,231	37,600,165	16,853.50	317.18	91,635.14	10,633.83	63.10	2,231
Final Household	2,231	127,544,707	57,169.30	567.29	746,881.67	61,288.70	107.21	2.149
Final Person	4,811	305,560,925	63,512.98	363.71	473,081.72	66,200.27	104.23	2.086
2-day Trip	7,851	65,171,659,579	8,301,064.78	89,368.56	49,673,581.05	7,733,280.20	93.16	1.868

Variance Estimation

Survey estimates need to be interpreted in the context of the survey's sample design and adjustments due to nonresponse. Survey weights account for both sample design and the adjustments. Standard variance calculation formulae using weighted data do not properly account for the additional variability in estimation from the weights. This can result in misleading inferences and tests of significance. Two general approaches for variance estimation are the forms of replication variance estimation and the Taylor Series linearization[11].

Ipsos prefers using the Taylor Series linearization (linearization) method for the NHTS and its add-on studies. The linearization method is available in the major software packages such as SAS, SPSS, SUDAAN, Stata, and R. This option requires nothing more than the full analysis weights and properly specifying the sample design parameters, including clustering for person and trip analyses, to produce proper estimates of variances.[12] For both the NHTS, specifying the strata, clustering (for non-household analysis) and the analysis weight is needed for most standard statistical packages.

A simpler option for those without access to the software packages above can approximate sampling variances using the following approach. Sample weights accounting for the sample design and adjustments increase the variability of estimates, and variance inflation due to weighting (specifically UWE) can be incorporated into the calculation of confidence intervals or tests of hypotheses. For example, when estimating a population proportion by $\hat{p}$ one can approximate the adjusted variance of this statistic by:

$$\hat{V}(\hat{p}) \approx V(\hat{p}) \times UWE = \frac{\hat{p}\times(1-\hat{p})}{n-1}\left(\frac{N-n}{N}\right) \times UWE.$$

Here, $\hat{V}(\hat{p})$ is the sample variance, or square of the standard error and $\hat{p}$ is the estimator for the population proportion. N is population size, and n is the number of responses.
Finally, the (100-α) percent confidence interval for *P* would be given by:

$$\hat{p} \pm z_{\alpha/2}\sqrt{\hat{V}(\hat{p})}, \text{ or}$$

$$\hat{p} \pm z_{\alpha/2}\sqrt{\frac{\hat{p}\times(1-\hat{p})}{n-1}\left(\frac{N-n}{N}\right) \times UWE}.$$

$z_{\alpha/2}$ is value under the normal distribution achieving $\left(1-\frac{\alpha}{2}\right)\%$ confidence level.

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[11] Wolter, K. M. (1985). Introduction to Variance Estimation, Springer: New York.

[12] Here is an example in SAS for calculating an estimate and its standard error for a stratified design.

```
PROC Surveymeans data=<DataFile>;
 Weight <Final_Weight>;
 Title "**  Test Code **";
 Strata <Strata Indicator>;
 cluster <Household ID>; /* Include for non-household-level estimates */
 Var <Attribute>;
Run;
```

The entries within "<>" provides the procedure the study's dataset name and location, identifies the variable with the sample weights, specifies the sample design and its stratum flag, and requests statistics for a list of survey measures.

Data Masking

Ipsos recognizes the need to protect the privacy of respondents while still maintaining the meaningfulness of the data. Data anonymization or confidentiality edits have not been applied to the data accompanying this memo, as this data is intended only for internal use. However, when constructing a public-use file, it is essential to evaluate the possibility of disclosure of respondents' identities, and to take steps to minimize this possibility prior to release of the public use data. Disclosure is a risk when one or more data points produce a unique or near-unique profile that can be matched to information known about the respondents. Based on prior PUF layouts, the smallest geography provided was name of the Core Based Statistical Area where the household is located (if applicable), which should limit the ability to uniquely identify respondents even with numerous data points provided on the file. Smaller geographies, such as zip code Census block, would greatly increase the ability to identify respondents. Nonetheless, a cross-tabulation of state, urban/rural, CBSA, homeownership, and household size results in over 1,000 unique combinations for the respondents. Additional combinations could yield even more unique combinations. Such patterns do not necessarily indicate a disclosure risk, as external data would still be required to make a linkage and disclose a respondent's identity. As such, Ipsos recommends a review of available external data sources that could pose a disclosure risk when combined with the NHTS public use data. We also recommend comparing the distribution of certain demographics of household respondents against the census block data for their CBSA. For example, how many households have more than 10 household members, with a family income above $100,000, whose head of household is male and Hispanic, and who own their home in that CBSA? If any combinations result in a small number of cases, that could constitute a disclosure risk, not through the use of Census data, but through other means. If any sources are found, coarsening of the key variables should be considered to reduce the number of unique combinations. The choice of cutpoints for any coarsening can align with common data analysis procedures to not overly limit the use of the data. A more extreme option would be to remove a variable from the public use file, but this would only apply if coarsening could not be performed or is inadequate to reduce the disclosure risk.

To support the possible publication of anonymized and confidentiality-protected public-use files, Ipsos has provided a randomly-generated, non-informative unique survey respondent ID for each respondent and household. These IDs do not contain any information that could be used to identify any survey respondents, but do allow linkage of household, person, and trips data. The use of these IDs, in conjunction with removal of all personally identifiable information (PII) and other applicable data edits to eliminate respondents with unique or near-unique attributes, can allow for public release of data in microform.

Appendices

Appendix A – Supporting NHTS ABS Study Weights Tables

List of tables

Table A1: NHTS ABS Study Distribution of Final 7-Day Trip Weights

Stratum	Cases (n)	7-Day Trimmed and Raking Adjusted Trip Weights						
		Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1021	1,476	8,729,394,756	5,914,224.09	540,135.89	226,488,464.00	9,723,549.16	164.41	3.703
1022	301	2,008,580,943	6,673,026.39	893,462.80	28,730,051.34	6,702,331.36	100.44	2.009
1023	3,002	24,653,431,497	8,212,335.61	731,184.27	222,041,796.00	11,593,582.45	141.17	2.993
1024	519	4,971,065,053	9,578,160.02	854,697.29	62,497,438.77	12,652,418.48	132.10	2.745
1025	3,749	26,519,326,444	7,073,706.71	445,005.97	74,710,084.71	7,379,827.62	104.33	2.088
1026	1,161	6,939,350,209	5,977,045.83	409,160.06	39,685,336.34	6,287,505.48	105.19	2.107
1027	1,505	11,355,383,494	7,545,105.31	848,234.61	55,424,399.63	7,841,031.42	103.92	2.080
1028	872	4,732,070,552	5,426,686.41	851,232.72	39,585,599.14	5,526,848.68	101.85	2.037
1029	5,042	35,510,642,228	7,042,967.52	564,903.64	179,433,938.00	9,936,281.09	141.08	2.990
1030	1,242	9,793,781,442	7,885,492.30	515,660.31	53,631,392.75	8,179,116.84	103.72	2.076
1031	1,171	7,893,440,453	6,740,768.96	506,313.90	43,843,603.16	6,837,033.23	101.43	2.029
1032	465	4,400,949,792	9,464,408.15	703,189.49	133,824,407.00	11,625,225.25	122.83	2.509
1033	2,866	21,470,748,900	7,491,538.35	439,631.24	82,847,944.69	8,836,866.76	117.96	2.391
1034	623	5,612,940,235	9,009,534.89	550,648.53	285,320,490.00	21,234,079.88	235.68	6.555
1035	2,059	14,531,220,710	7,057,416.57	540,015.62	201,481,499.00	10,005,713.20	141.78	3.010
1036	562	3,423,430,269	6,091,512.93	522,242.26	29,133,095.08	5,063,473.19	83.12	1.691
1037	4,058	36,386,034,179	8,966,494.38	30,118.12	245,778,330.00	12,113,199.90	135.09	2.825
1038	401	2,783,998,474	6,942,639.59	378,380.77	50,491,375.52	6,049,118.60	87.13	1.759
Total	31,074	231,715,789,629	7,456,902.54	30,118.12	285,320,490.00	9,941,676.96	133.32	2.777

The following tables summarize the 5-day weights and 2-day weights for NHTS ABS. Therefore, case counts are smaller than in Table A1 above.

Table A2: NHTS ABS Study Distribution of Final 5-Day Trip Weights

Stratum	Cases (n)	5-Day Trimmed and Raking Adjusted Trip Weights						
		Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1021	1,136	6,251,661,879	5,503,223.48	496,595.59	207,364,758.00	9,952,387.66	180.85	4.271
1022	183	1,619,714,903	8,850,901.11	1,519,092.74	30,872,303.54	7,175,657.47	81.07	1.657
1023	2,216	16,415,346,342	7,407,647.27	632,263.28	195,756,518.00	10,479,343.05	141.47	3.001

Table A2: NHTS ABS Study Distribution of Final 5-Day Trip Weights

Stratum	Cases (n)	5-Day Trimmed and Raking Adjusted Trip Weights						
		Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1024	401	3,848,421,120	9,597,060.15	675,434.34	51,718,944.64	12,380,445.36	129.00	2.664
1025	2,686	18,475,939,371	6,878,607.36	410,117.86	60,235,574.71	7,227,605.47	105.07	2.104
1026	960	5,175,377,840	5,391,018.58	316,207.56	36,800,786.54	5,915,935.02	109.74	2.204
1027	1,131	7,856,213,683	6,946,254.36	768,527.76	60,574,285.18	7,847,530.27	112.97	2.276
1028	645	3,233,839,342	5,013,704.41	776,972.15	37,086,154.07	4,724,403.80	94.23	1.888
1029	3,794	26,262,715,910	6,922,170.77	455,906.12	154,191,446.00	9,458,056.63	136.63	2.867
1030	949	7,019,830,867	7,397,082.05	643,236.97	45,351,694.56	6,684,407.56	90.37	1.817
1031	869	5,945,452,826	6,841,717.87	504,541.32	43,871,817.01	7,287,763.22	106.52	2.135
1032	395	3,199,993,253	8,101,248.74	504,263.46	104,367,293.00	9,876,430.28	121.91	2.486
1033	2,130	15,872,567,693	7,451,909.71	380,107.08	72,335,475.43	8,685,737.48	116.56	2.359
1034	466	3,971,932,057	8,523,459.35	459,096.74	252,811,333.00	20,997,496.65	246.35	7.069
1035	1,463	10,302,731,511	7,042,195.15	486,392.76	101,976,846.00	9,198,056.47	130.61	2.706
1036	460	2,420,655,377	5,262,294.30	406,834.10	23,818,988.23	4,285,579.88	81.44	1.663
1037	3,033	25,393,539,472	8,372,416.57	26,547.56	210,409,545.00	11,815,386.29	141.12	2.992
1038	306	1,863,057,173	6,088,422.13	319,245.44	44,886,419.13	5,642,572.97	92.68	1.859
Total	23,223	165,128,990,618	7,110,579.62	26,547.56	252,811,333.00	9,513,284.90	133.79	2.790

Table A3: NHTS ABS Study Distribution of 5-Day Trimmed and Raking Adjusted Person Weights

Stratum	Cases (n)	5-Day Trimmed and Raking Adjusted Person Weights						
		Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1021	554	11,198,347	20,213.62	1,083.89	797,556.76	38,318.92	189.57	4.594
1022	99	2,674,117	27,011.28	2,655.39	118,739.63	23,914.48	88.54	1.784
1023	1,188	33,529,915	28,223.83	1,033.76	752,909.68	41,831.25	148.21	3.197

Table A3: NHTS ABS Study Distribution of 5-Day Trimmed and Raking Adjusted Person Weights

Stratum	Cases (n)	5-Day Trimmed and Raking Adjusted Person Weights						
		Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1024	227	5,092,997	22,436.11	2,597.82	198,919.02	29,470.43	131.35	2.725
1025	1,451	33,846,693	23,326.46	655.79	231,675.29	25,702.36	110.19	2.214
1026	526	9,604,076	18,258.70	743.55	141,541.49	19,899.43	108.99	2.188
1027	547	13,813,938	25,254.00	1,721.51	232,978.02	28,447.99	112.65	2.269
1028	365	6,016,963	16,484.83	690.18	142,639.05	16,047.40	97.35	1.948
1029	1,892	48,121,243	25,434.06	1,108.60	593,044.02	35,736.43	140.51	2.974
1030	548	13,357,628	24,375.23	715.92	174,429.59	24,046.09	98.65	1.973
1031	437	10,705,560	24,497.85	1,072.83	168,737.76	25,916.91	105.79	2.119
1032	262	7,169,756	27,365.48	1,100.25	401,412.66	34,560.94	126.29	2.595
1033	1,062	29,009,826	27,316.22	1,082.31	278,213.37	31,861.13	116.64	2.360
1034	293	8,696,383	29,680.49	1,402.76	972,351.28	63,136.65	212.72	5.525
1035	737	19,446,162	26,385.57	1,009.97	392,218.64	34,061.48	129.09	2.666
1036	222	3,959,805	17,836.96	674.91	91,611.49	15,896.29	89.12	1.794
1037	1,582	45,062,881	28,484.75	41.37	809,267.48	40,757.34	143.08	3.047
1038	194	4,254,635	21,931.11	626.75	172,640.07	19,643.53	89.57	1.802
Total	12,186	305,560,925	25,074.75	41.37	972,351.28	34,088.93	135.95	2.848

Table A4: NHTS ABS Study Distribution of 2-Day Trimmed and Raking Adjusted Household Weights

Stratum	Cases (n)	Trimmed and Raking Adjusted Household Weights, ABS						
		Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1021	105	4,846,699	46,159.04	7,287.27	247,346.00	45,959.73	99.57	1.991
1022	26	1,275,447	49,055.66	6,393.37	164,603.88	48,216.71	98.29	1.966

Table A4: NHTS ABS Study Distribution of 2-Day Trimmed and Raking Adjusted Household Weights

Stratum	Cases (n)	Trimmed and Raking Adjusted Household Weights, ABS						
		Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1023	220	14,157,462	64,352.10	8,406.10	468,380.53	72,201.94	112.20	2.259
1024	34	2,168,260	63,772.35	14,833.35	238,608.12	53,609.84	84.06	1.707
1025	291	14,922,731	51,280.86	7,285.67	674,977.67	59,452.07	115.93	2.344
1026	76	4,081,431	53,703.03	9,302.31	393,028.61	57,425.80	106.93	2.143
1027	93	6,122,146	65,829.53	10,346.81	426,307.71	60,497.49	91.90	1.845
1028	65	2,550,894	39,244.53	6,906.69	242,826.03	40,412.59	102.98	2.060
1029	352	20,407,153	57,974.87	8,649.62	436,727.92	57,692.62	99.51	1.990
1030	92	5,484,422	59,613.29	7,899.36	415,585.97	66,649.28	111.80	2.250
1031	91	4,719,154	51,858.84	7,954.85	331,188.08	48,346.81	93.23	1.869
1032	35	2,933,528	83,815.09	17,381.27	254,554.42	60,854.57	72.61	1.527
1033	193	11,861,658	61,459.37	7,613.97	603,186.84	63,718.78	103.68	2.075
1034	59	3,443,707	58,367.92	7,945.54	317,825.95	60,096.74	102.96	2.060
1035	147	8,035,317	54,662.02	8,167.62	468,679.78	65,964.66	120.68	2.456
1036	35	1,658,081	47,373.75	14,970.37	164,240.54	35,883.55	75.75	1.574
1037	294	17,218,535	58,566.45	567.29	746,881.67	68,786.67	117.45	2.379
1038	23	1,658,081	72,090.49	5,259.20	242,943.73	59,342.85	82.32	1.678
Total	**2,231**	**127,544,707**	**57,169.30**	567.29	746,881.67	61,288.70	107.21	2.149

Table A5: NHTS ABS Study Distribution of 2-Day Trimmed and Raking-Adjusted Person Weights

Stratum	Cases (n)							
		Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1021	205	11,323,479	55,236.48	2,254.13	264,954.59	57,927.44	104.87	2.100
1022	59	2,700,848	45,777.08	1,455.44	205,944.24	53,372.04	116.59	2.359
1023	466	33,461,009	71,804.74	1,844.65	283,704.48	74,813.33	104.19	2.086
1024	74	5,166,970	69,823.92	5,990.30	339,217.48	71,957.47	103.06	2.062
1025	602	33,853,392	56,234.87	1,673.51	253,050.71	57,843.23	102.86	2.058
1026	167	9,749,265	58,378.83	3,230.93	269,416.97	58,012.10	99.37	1.987
1027	213	13,754,194	64,573.68	3,466.83	288,571.92	60,470.88	93.65	1.877
1028	146	6,029,102	41,295.22	3,252.79	152,587.86	39,998.90	96.86	1.938
1029	759	47,548,578	62,646.35	2,413.29	254,871.23	61,738.00	98.55	1.971
1030	209	13,514,733	64,663.79	5,459.15	267,025.96	63,695.62	98.50	1.970

Table A5: NHTS ABS Study Distribution of 2-Day Trimmed and Raking-Adjusted Person Weights

Stratum	Cases (n)	Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1031	209	10,859,069	51,957.27	2,504.28	255,956.20	55,524.77	106.87	2.142
1032	72	7,120,079	98,889.98	6,983.16	473,081.72	99,788.94	100.91	2.018
1033	456	28,468,708	62,431.38	1,908.06	298,705.75	62,136.21	99.53	1.991
1034	123	8,814,485	71,662.48	5,674.05	214,457.74	62,815.87	87.66	1.768
1035	335	19,291,080	57,585.31	2,321.67	196,166.04	47,053.91	81.71	1.668
1036	74	3,846,665	51,981.96	4,761.63	225,626.21	53,050.65	102.06	2.042
1037	590	45,906,268	77,807.23	363.71	374,223.61	88,205.53	113.36	2.285
1038	52	4,153,002	79,865.42	5,037.94	398,506.40	84,698.93	106.05	2.125
Total	4,811	305,560,925	63,512.98	363.71	473,081.72	66,200.27	104.23	2.086

Table A6: NHTS ABS Study Distribution of 2-Day Trimmed and Raking-Adjusted Trip Weights

Stratum	Cases (n)	Sum	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation	UWE (Design Effect)
1021	340	2,277,449,772	6,698,381.68	702,376.56	27,820,231.86	6,023,426.74	89.92	1.809
1022	118	622,190,386	5,272,799.88	582,091.79	21,624,145.22	5,666,081.69	107.46	2.155
1023	786	7,860,974,344	10,001,239.62	767,798.24	29,788,970.78	8,950,722.64	89.50	1.801
1024	118	931,156,660	7,891,158.13	1,427,800.41	35,617,834.89	7,992,106.15	101.28	2.026
1025	1,063	8,064,590,482	7,586,632.63	567,379.53	26,570,324.32	6,739,614.88	88.84	1.789
1026	201	1,765,904,592	8,785,594.98	867,178.59	28,288,781.50	7,600,223.41	86.51	1.748
1027	374	3,373,760,675	9,020,750.47	1,142,431.64	30,300,051.22	6,967,215.11	77.24	1.597
1028	227	1,390,560,618	6,125,817.70	628,378.60	16,021,725.45	4,845,109.99	79.09	1.626
1029	1,248	9,318,753,522	7,466,949.94	588,943.34	26,761,479.14	6,892,389.56	92.31	1.852
1030	293	2,507,129,567	8,556,756.20	573,211.01	28,037,726.03	7,845,609.41	91.69	1.841
1031	302	2,165,769,489	7,171,422.15	523,501.81	26,875,400.92	6,425,649.72	89.60	1.803
1032	70	986,835,579	14,097,651.13	1,340,417.05	49,673,581.05	12,266,005.81	87.01	1.757
1033	736	5,544,360,970	7,533,099.14	700,304.52	31,364,103.74	6,698,725.69	88.92	1.791
1034	157	1,495,497,122	9,525,459.38	990,320.40	22,518,063.03	7,783,419.20	81.71	1.668
1035	596	4,101,525,889	6,881,754.85	733,504.79	20,597,434.70	5,006,871.72	72.76	1.529
1036	102	983,016,410	9,637,415.78	1,093,136.37	23,690,752.03	7,690,154.81	79.79	1.637
1037	1,025	10,780,029,859	10,517,102.30	89,368.56	39,293,478.66	10,408,045.28	98.96	1.979
1038	95	1,002,153,643	10,548,985.72	1,794,598.30	41,843,172.38	9,379,819.98	88.92	1.791
Total	7,851	65,171,659,579	8,301,064.78	89,368.56	49,673,581.05	7,733,280.20	93.16	1.868

Appendix B – Formulae used to summarize weights

Standard Deviation (σ)

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

where μ = average of the weights.

Coefficient of variation (*CV*)

$$CV = \frac{\sigma}{\mu}$$

Unequal weighting effect (UWE)

$$UWE = 1 + CV^2$$