American Community Survey Multiyear Accuracy of the Data (5-year 2017-2021)

INTRODUCTION

This document describes the accuracy of the 2017-2021 American Community Survey (ACS) 5-year estimates.[1] The data contained in these data products are based on the American Community Survey (ACS) samples interviewed from January 1, 2017 through December 31, 2021.

ACS estimates are period estimates that describe the average characteristics of the population and housing over the period of data collection. The 2017-2021 ACS 5-year period is from January 1, 2017 through December 31, 2021. These estimates cannot be used to describe what is going on in any particular year in the period, only what the average value is over the full period.

The ACS sample is selected from all counties and county-equivalents in the United States. In 2006, the ACS began collection of data from sampled persons in group quarters (GQ) – for example, military barracks, college dormitories, nursing homes, and correctional facilities. Persons in group quarters are included with persons in housing units (HUs) in all 2017-2021 ACS 5-year estimates based on the total population.

The ACS, like any statistical activity, is subject to error. The purpose of this document is to provide data users with a basic understanding of the ACS sample design, estimation methodology, and accuracy of the 2017-2021 ACS 5-year estimates. The ACS is sponsored by the U.S. Census Bureau and is part of the Decennial Census Program.

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[1] The Census Bureau has reviewed this data product to ensure appropriate access, use, and disclosure avoidance protection of the confidential source data used to produce this product (Data Management System (DMS) number: P-001-0000001262, Disclosure Review Board (DRB) approval number: CBDRB-FY22-180).

For additional information on the design and methodology of the ACS, including data collection and processing, visit: https://www.census.gov/programs-surveys/acs/methodology/design-and-methodology.html.

To access other accuracy of the data documents, including the 2021 ACS 1-year Accuracy of the Data and the 2017-2021 PRCS Multiyear Accuracy, visit: https://www.census.gov/programs-surveys/acs/technical-documentation/code-lists.html.

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DATA COLLECTION

The ACS employs four modes of data collection:

1. Internet
2. Mailout/Mailback
3. Computer Assisted Telephone Interview (CATI)[2]
4. Computer Assisted Personal Interview (CAPI)

The general timing of data collection is as follows. Note that mail responses are accepted during all three months of data collection:

Month 1:   Mailable addresses in sample are sent an initial mailing package, which contains information for completing the ACS questionnaire via the internet. If a sample address has not responded online within approximately two weeks of the initial mailing, then a second mailing package with a paper questionnaire is sent. Sampled addresses then have the option of which mode to use to complete the interview.

Month 2:   Prior to the end of CATI operations in 2017, all mail non-responding addresses with an available phone number are sent to CATI. After the end of CATI in 2017, data collection continued via mail and internet modes.

Month 3:   Prior to the end of CATI, a sample of mail non-responses without a phone number, CATI non-responses, and unmailable addresses were selected and sent to CAPI. After CATI was discontinued, a sample of mail non-responses and unmailable addresses are selected to CAPI.

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[2] Note that all CATI operations ended at the end of September, 2017.

SAMPLE DESIGN

Sampling rates are assigned independently at the census block level. A measure of size is calculated for each of the following governmental units:

- Counties
- Places
- School Districts (elementary, secondary, and unified)
- American Indian Areas
- Tribal Subdivisions
- Alaska Native Village Statistical Areas
- Hawaiian Homelands
- Minor Civil Divisions – in Connecticut, Maine, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and Wisconsin[3] (the 'strong" MCD states)
- Census Designated Places – in Hawaii only

The measure of size for all areas except American Indian Areas, Tribal Subdivisions, Alaska Native Village Statistical Areas, and Hawaiian Homelands is an estimate of the number of occupied HUs in the area. This is calculated by multiplying the number of valid ACS addresses on the sampling frame by an estimated occupancy rate at the block level as derived from the most recent Census. A measure of size for each Census Tract is also calculated in the same manner.

For American Indian, Tribal Subdivisions, and Alaska Native Village Statistical Areas, the measure of size is the estimated number of occupied HUs multiplied by the proportion of people reporting as American Indian or Alaska Native (alone or in combination) in the most recent census.

For Hawaiian Homelands, the measure of size is the estimated number of occupied HUs multiplied by the proportion of people reporting Native Hawaiian (alone or in combination) in the most recent census.

Each block is then assigned the smallest measure of size from the set of all entities of which it is a part. Average sampling rates are shown in Table 1.[4]

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[3] These are the states where MCDs are active, functioning governmental units.

[4] Beginning with the 2011 sample the ACS implemented a change to the stratification, increasing the number of sampling strata and changing how the sampling rates are defined. Prior to 2011 there were seven strata; there are now 16 sampling strata. The sample increase changed the target annual sample size from 2.9 million to 3.54 million.

Table 1. Average Sampling Rates for the United States by Sampling Stratum

Stratum Thresholds	2017-2021 Average Sampling Rate
0 < MOS[1] < 200	15.00%
200 ≤ MOS < 400	10.00%
400 ≤ MOS < 800	7.00%
800 ≤ MOS < 1,200	4.29%
1,200 ≤ MOS -and- 0 < TRACTMOS[2] ≤ 400	5.36%
1,200 ≤ MOS -and- 0 < TRACTMOS ≤ 400 H.R.[3]	4.93%
1,200 ≤ MOS -and- 400 < TRACTMOS ≤ 1,000	4.29%
1,200 ≤ MOS -and- 400 < TRACTMOS ≤ 1,000 H.R.	3.95%
1,200 ≤ MOS -and- 1,000 < TRACTMOS ≤ 2,000	2.61%
1,200 ≤ MOS -and- 1,000 < TRACTMOS ≤ 2,000 H.R.	2.40%
1,200 ≤ MOS -and- 2,000 < TRACTMOS ≤ 4,000	1.53%
1,200 ≤ MOS -and- 2,000 < TRACTMOS ≤ 4,000 H.R.	1.41%
1,200 ≤ MOS -and- 4,000 < TRACTMOS ≤ 6,000	0.92%
1,200 ≤ MOS -and- 4,000 < TRACTMOS ≤ 6,000 H.R.	0.85%
1,200 ≤ MOS -and- 6,000 < TRACTMOS	0.54%
1,200 ≤ MOS -and- 6,000 < TRACTMOS H.R.	0.49%

[1]MOS = Measure of size of the smallest governmental entity
[2]TRACTMOS = Census Tract measure of size.
[3]H.R. = areas where predicted levels of completed mail and CATI interviews are > 60%.

Table 2 shows the CAPI sampling rates. Note that CATI operations were discontinued in September, 2017. As part of the changes implemented in 2011, we determined areas where we began to select all non-responding addresses for CAPI.

Table 2. CAPI Subsampling Rates for the United States

Address and Tract Characteristics	2017-2021 CAPI Subsampling Rate
Addresses in Remote Alaska	100%
Addresses in Hawaiian Homelands, Alaska Native Village Statistical areas and a subset of American Indian areas	100%
Unmailable addresses that are not in the previous two categories	66.7%
Mailable addresses in tracts with predicted levels of completed mail and CATI interviews prior to CAPI subsampling between 0% and less than 36%	50.0%
Mailable addresses in tracts with predicted levels of completed mail and CATI interviews prior to CAPI subsampling greater than 35% and less than 51%	40.0%
Mailable addresses in other tracts	33.3%

For a more detailed description of the ACS sampling methodology, see the ACS Accuracy of the Data document. This document is available for 2020 as well as prior data years at: https://www.census.gov/programs-surveys/acs/technical-documentation/code-lists.html.

WEIGHTING METHODOLOGY

The multiyear estimates should be interpreted as estimates that describe a time period rather than a specific reference year. For example, a 5-year estimate for the poverty rate of a given area describes the total set of people who lived in that area over those five years much the same way as a 1-year estimate for the same characteristic describes the set of people who lived in that area over one year. The only fundamental difference between the estimates is the number of months of collected data, which are considered in forming the estimate. In this document only the procedures that are unique to the multiyear estimates are discussed.

To weight the 5-year estimates, 60 months of collected data are pooled together. The pooled data are then reweighted using the procedures developed for the 1-year estimates with a few adjustments. These adjustments concern geography, month-specific weighting steps, and population and housing unit controls. There is also one multiyear specific model-assisted weighting step. In addition, there were several modifications made to the overall weighting to accommodate the revised methodology of the 2020 1-year data.

Some of the weighting steps use the month of tabulation in forming the weighting cells within which the weighting adjustments are made. One such example is the variation in monthly response adjustment. In these weighting steps, the month of tabulation is used independently of year. Thus, for the 5-year, sample cases from May 2017, May 2018, May 2019, May 2020, and May 2021 are combined.

Since the multiyear estimates represent estimates for the period, the controls are not a single year's housing or population estimates from the Population Estimates Program, but rather are an average of these estimates over the period. For the housing unit controls, a simple average of the 1-year housing unit estimates over the period is calculated for each county or subcounty area. The version or vintage of estimates used is always the last year of the period since these are considered the most up-to-date and are created using a consistent methodology. For example, the housing unit control used for a given county in the 2017-2021 weighting is equal to the simple average of the 2017, 2018, 2019, 2020, and 2021 estimates that were produced using the 2021 methodology (the 2021 vintage). Likewise, the population controls by race, ethnicity, age, and sex are obtained by taking a simple average of the 1-year population estimates of the county or weighting area by race, ethnicity, age, and sex. For example, the 2017-2021 control total used for Hispanic males age 20-24 in a given county would be obtained by averaging the 1-year population estimates for that demographic group for 2017, 2018, 2019, 2020, and 2021. The version or vintage of estimates used is always that of the last year of the period since these are considered the most up to date and are created using a consistent methodology.

One multiyear specific step is a model-assisted (generalized regression or GREG) weighting step. The objective of this additional step is to reduce the variances of base demographics at the tract level in the 5-year estimates. While reducing the variances, the estimates themselves are relatively unchanged. This process involves linking administrative record data with ACS data.

The GQ weighting methodology imputes GQ person records into the 2017-2021 ACS 5-year. See the American Community Survey Accuracy of the Data (2021) for details on the GQ imputation.

In addition, a finite population correction (FPC) factor is included in the creation of the replicate weights for the 5-year data at the tract level. It reduces the estimate of the variance and the margin of error by taking the sampling rate into account. A two-tiered approach is used. One FPC is calculated for mail, internet, and CATI respondents and another for CAPI respondents. The CAPI is given a separate FPC to take into account the fact that CAPI respondents are subsampled. The FPC is not included in the 1-year data because the sampling rates are relatively small and thus the FPC does not have an appreciable impact on the variance.

For more information on the replicate weights and replicate factors, see the Design and Methodology Report at: https://www.census.gov/programs-surveys/acs/methodology/design-and-methodology.html.

Revised Methodology for 2017-2021 ACS 5-year HU Weighting

Due to issues with the non-response bias present in portion of the data collected in 2020 the ACS 5-year HU weighting was modified to enhance our methods to attempt to mitigate that bias observed in the 2020 data[5]. Our revised methodology worked to incorporate the entropy-balance weighting (EBW) methodology used to produce the 2020 ACS 1-year experimental data products into our standard production methodology outlined above.

To accomplish this integration, we had to devise a modified set of steps to partially process the 4 years of data from 2017–2019 and 2021 using our standard methods before combining those data with the 2020 data that had been processed using the EBW methodology. Those steps are detailed in this section.

Internal 2020 1-Year Weighting

We performed a standard run of the 2020 1-year HU weighting with a few additional steps to help account for the change in response:

Vacancy Rate Adjustment Factor (VRF)

This factor makes the total vacancy rate during the COVID impacted months in 2020 equal to the vacancy rate during the balance of 2020. This is to account for the reduced CAPI follow-up during those months. For all vacant cases in the COVID impacted months of 2020, VRF is computed and assigned based on the following groups:

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[5] For more information see the paper entitled "Addressing Nonresponse Bias in the American Community Survey During the Pandemic Using Administrative Data" located at: https://www.census.gov/library/working-papers/2021/acs/2021_Rothbaum_01.html.

Weighting Area × Month

Vacancy Status Adjustment Factor (VSF)

This factor adjusts the weight of vacant housing units during the COVID impacted months so that the distribution by type of vacancy is the same during COVID impacted months as it is for the balance of the year. For all vacant cases in the COVID impacted months of 2020, VSF is computed and assigned based on the following groups:

Weighting Area × Vacancy Type × Month

Occupied housing units are assigned a value of VSF = 1.0. Nonresponding housing units are assigned a weight of 0.0.

The VRF adjustment is calculated immediately before the standard NIF adjustment while VSF adjustment is calculated immediately after. All other adjustments for housing units and housing unit persons are the same as in a standard run. We preserve the final weights as well as the collapsing patterns used to create the demographic cells in the person weighting. We will use these during subsequent processing since the EBW use the demographic totals in their creation and would not be processed appropriately in those steps. In addition, this provides our weights for the vacant housing units which are not produced using the EBW methodology.

Modified Process for 2017-2021 5-Year HU Weighting

The early steps of the weighting are adjusted to apply only to the 2017-2019 and 2021 data as previously discussed. In addition, the application of controls is applied in two stages. This is necessary because, at the point of integration of the 2020 data with the remaining years, the EBW weights have already been adjusted for coverage whereas the intermediate weights for 2017–2019 and 2021 have not. By applying the first iteration of housing and person controls, we incorporate a coverage adjustment for both the 2017–2019, 2021 and 2020 data. This ensures that they are appropriately represented in the final steps of weighting and the 5-year estimates produced from them.

The details of how this process was modified is detailed below:

All Adjustments Through Variation in Monthly Response by Mode (VMS)

All adjustments calculated prior to VMS are performed in the standard manner.

Noninterview Factor (NIF)

This factor will only be calculated using the 2017-2019 and 2021 data and is subsequently only applied to the 2017-2019 and 2021 data.

Model Assisted Weighting (GREG)

This factor will only be calculated using the 2017-2019 and 2021 data and is subsequently only applied to the 2017-2019 and 2021 data.

Housing Unit Post-Stratification Factor (HPF)

This factor will be calculated twice. The first time it will be subject to the following revisions:

- The subcounty geographies used will be those defined for use in the 2020 1-Year weighting.

- The 2017-2021 5-year period will be broken up into two separate groups for this calculation.

    o One calculation will use the years 2017-2019 and 2021. That 4-year period will be controlled to 4/5 of the simple average from the 2017-2019 and 2021 independent estimate of housing units. The vintage of the independent estimates is still the most recent year.

    o The other calculation will use only the year 2020. It will be controlled to 1/5 of the 2020 independent estimate of housing units.

- The weights for 2020 will be redefined:

    o Occupied HUs = EBW for 2020

    o Vacant HUs = Final weight from internal 2020 1-year weighting run.

Person Weighting Factors

The person weighting will be performed twice. The first time it will be subject to the following revisions:

- The subcounty geographies and weighting areas used will be those defined for use in the 2020 1-Year weighting.

- The initial person weights for the 2020 data will be calculated as:

    EBW * HPF

- The 2017-2021 5-year period will be broken up into two separate groups for this calculation.

    o One calculation will use the years 2017-2019 and 2021. That 4-year period will be controlled to 4/5 of the simple average from the 2017-2019 and 2021

independent estimate of persons. The vintage of the independent estimates is still the most recent year.

- The other calculation will use only the year 2020. It will be controlled to 1/5 of the 2020 independent estimate of persons

- For the collapsing of groups during the calculation of the Demographic Raking Factor, the collapsing patterns are duplicated from the internal 2020 1-year HU weighting run.

- Do not round final person weights.

Housing Unit Weighting Factors

This step will be same except the final HU weight will not be rounded.

Housing Unit Post-Stratification Factor-Second Run (HPF2)

The initial weights will set equal to the final unrounded HU weight from previous step. All other steps are unchanged from standard multiyear processing and will be processed for the subcounty geographies and weighting areas normally defined for use in the 5-year weighting.

Person Weighting Factors-Second Run

The initial person weights will be defined as:

Final Unrounded Person Weight * HPF2

All remaining steps are identical to standard multiyear processing and will, like HPF2, use the subcounty geographies and weighting areas normally defined for use in the 5-year weighting.

ESTIMATION METHODOLOGY FOR MULTIYEAR ESTIMATES

For the 1-year estimation, the tabulation geography for the data are based on the boundaries defined on January 1 of the tabulation year, which is consistent with the tabulation geography used to produce the population estimates. All sample addresses are updated with this geography prior to weighting. For the multiyear estimation, the tabulation geography for the data are referenced to the final year in the multiyear period. For example, the 2017-2021 period uses the 2021 reference geography. Thus, all data collected over the period of 2017-2021 in the blocks that are contained in the 2021 boundaries for a given place are tabulated as though they were a part of that place for the entire period.

Monetary values for the ACS multiyear estimates are inflation-adjusted to the final year of the period. For example, the 2017-2021 ACS 5-year estimates are tabulated using 2021-adjusted

dollars. These adjustments use the national Consumer Price Index (CPI) since a regional-based CPI is not available for the entire country.

For a more detailed description of the ACS estimation methodology, see the ACS 1-year Accuracy of the Data document. This document is available for 2021 and prior data years at: https://www.census.gov/programs-surveys/acs/technical-documentation/code-lists.html.

CONFIDENTIALITY OF THE DATA

The Census Bureau has modified or suppressed some data on this site to protect confidentiality. Title 13 United States Code, Section 9, prohibits the Census Bureau from publishing results in which an individual's data can be identified.

The Census Bureau's internal Disclosure Review Board sets the confidentiality rules for all data releases. A checklist approach is used to ensure that all potential risks to the confidentiality of the data are considered and addressed.

Title 13, United States Code

Title 13 of the United States Code authorizes the Census Bureau to conduct censuses and surveys. Section 9 of the same Title requires that any information collected from the public under the authority of Title 13 be maintained as confidential. Section 214 of Title 13 and Sections 3559 and 3571 of Title 18 of the United States Code provide for the imposition of penalties of up to five years in prison and up to $250,000 in fines for wrongful disclosure of confidential census information.

Disclosure Avoidance

Disclosure avoidance is the process for protecting the confidentiality of data. A disclosure of data occurs when someone can use published statistical information to identify an individual who has provided information under a pledge of confidentiality. For data tabulations, the Census Bureau uses disclosure avoidance procedures to modify or remove the characteristics that put confidential information at risk for disclosure. Although it may appear that a table shows information about a specific individual, the Census Bureau has taken steps to disguise or suppress the original data while making sure the results are still useful. The techniques used by the Census Bureau to protect confidentiality in tabulations vary, depending on the type of data. All disclosure avoidance procedures are done prior to the whole person imputation into not-in-sample GQ facilities.

Data Swapping

Data swapping is a method of disclosure avoidance designed to protect confidentiality in tables of frequency data (the number or percentage of the population with certain characteristics). Data swapping is done by editing the source data or exchanging records for a sample of cases when creating a table. A sample of households is selected and matched on a set of selected key variables with households in neighboring geographic areas that have similar characteristics

(such as the same number of adults and same number of children). Because the swap often occurs within a neighboring area, there is no effect on the marginal totals for the area or for totals that include data from multiple areas. Because of data swapping, users should not assume that tables with cells having a value of one or two reveal information about specific individuals. Data swapping procedures were first used in the 1990 Census and were used again in Census 2000 and the 2010 Census.

Synthetic Data

The goals of using synthetic data are the same as the goals of data swapping, namely to protect the confidentiality in tables of frequency data. Persons are identified as being at risk for disclosure based on certain characteristics. The synthetic data technique then models the values for another collection of characteristics to protect the confidentiality of that individual.

Note: The data use the same disclosure avoidance methodology as the original 1-year data. The confidentiality edit was previously applied to the raw data files when they were created to produce the 1-year estimates and these same data files with the original confidentiality edit were used to produce the 5-year estimates.

ERRORS IN THE DATA

Sampling Error

The data in ACS products are estimates of the actual figures that would be obtained by interviewing the entire population. The estimates are a result of the chosen sample and are subject to sample-to-sample variation. Sampling error in data arises due to the use of probability sampling, which is necessary to ensure the integrity and representativeness of sample survey results. The implementation of statistical sampling procedures provides the basis for the statistical analysis of sample data. Measures used to estimate the sampling error are provided in the next section.

Increase to 5-Year Margins of Error Containing Data Collected in 2020

Note that, in general, margins of error for 5-year estimates containing data collected in 2020 increased compared to prior 5-year estimates. This was due to a reduced number of interviews resulting from the pandemic for the records collected in 2020. More information may be found in the data user note entitled "Increased Margins of Error in the 5-Year Estimates Containing Data Collected in 2020", which can be found at: https://www.census.gov/programs-surveys/acs/technical-documentation/user-notes/2022-04.html.

Nonsampling Error

Other types of errors might be introduced during any of the various complex operations used to collect and process survey data. For example, data entry from questionnaires and editing may introduce error into the estimates. Another potential source of error is the use of controls in the weighting. These controls are based on Population Estimates and are designed to reduce

variance and mitigate the effects of systematic undercoverage of groups who are difficult to enumerate. However, if the extrapolation methods used in generating the Population Estimates do not properly reflect the population, error can be introduced into the data. This potential risk is offset by the many benefits the controls provide to the ACS estimates, which include the reduction of issues with survey coverage and the reduction of standard errors of ACS estimates. These and other sources of error contribute to the nonsampling error component of the total error of survey estimates.

Nonsampling errors may affect the data in two ways. Errors that are introduced randomly increase the variability of the data. Systematic errors, or errors that consistently skew the data in one direction, introduce bias into the results of a sample survey. The Census Bureau protects against the effect of systematic errors on survey estimates by conducting extensive research and evaluation programs on sampling techniques, questionnaire design, and data collection and processing procedures.

An important goal of the ACS is to minimize the amount of nonsampling error introduced through nonresponse for sample housing units. One way of accomplishing this is by following up on mail nonrespondents during the CATI and CAPI phases. For more information, please see the section entitled "Control of Nonsampling Error".

MEASURES OF SAMPLING ERROR

Sampling error is the difference between an estimate based on a sample and the corresponding value that would be obtained if the entire population were surveyed (as for a census). Note that sample-based estimates will vary depending on the particular sample selected from the population. Measures of the magnitude of sampling error reflect the variation in the estimates over all possible samples that could have been selected from the population using the same sampling methodology.

Estimates of the magnitude of sampling errors – in the form of margins of error – are provided with all published ACS data. The Census Bureau recommends that data users incorporate margins of error into their analyses, as sampling error in survey estimates could impact the conclusions drawn from the results.

Confidence Intervals and Margins of Error

Confidence Intervals

A sample estimate and its estimated standard error may be used to construct confidence intervals about the estimate. These intervals are ranges that will contain the average value of the estimated characteristic that results over all possible samples, with a known probability.

For example, if all possible samples that could result under the ACS sample design were independently selected and surveyed under the same conditions, and if the estimate and its estimated standard error were calculated for each of these samples, then:

1. Approximately 68 percent of the intervals from one estimated standard error below the estimate to one estimated standard error above the estimate would contain the average result from all possible samples.

2. Approximately 90 percent of the intervals from 1.645 times the estimated standard error below the estimate to 1.645 times the estimated standard error above the estimate would contain the average result from all possible samples.

3. Approximately 95 percent of the intervals from two estimated standard errors below the estimate to two estimated standard errors above the estimate would contain the average result from all possible samples.

The intervals are referred to as 68 percent, 90 percent, and 95 percent confidence intervals, respectively.

Margins of Error

In lieu of providing upper and lower confidence bounds in published ACS tables, the margin of error is listed. All ACS published margins of error are based on a 90 percent confidence level. The margin of error is the difference between an estimate and its upper or lower confidence bound. Both the confidence bounds and the standard error can easily be computed from the margin of error:

$$\text{Standard Error} = \text{Margin of Error} / 1.645$$

$$\text{Lower Confidence Bound} = \text{Estimate - Margin of Error}$$
$$\text{Upper Confidence Bound} = \text{Estimate + Margin of Error}$$

Note that for 2005 and earlier estimates, ACS margins of error and confidence bounds were calculated using a 90 percent confidence level multiplier of 1.65. Starting with the 2006 data release, the more accurate multiplier of 1.645 is used. Margins of error and confidence bounds from previously published products will not be updated with the new multiplier. When calculating standard errors from margins of error or confidence bounds using published data for 2005 and earlier, use the 1.65 multiplier.

When constructing confidence bounds from the margin of error, users should be aware of any "natural" limits on the bounds. For example, if a characteristic estimate for the population is near zero, the calculated value of the lower confidence bound may be negative. However, as a negative number of people does not make sense, the lower confidence bound should be reported as zero. For other estimates such as income, negative values can make sense; in

these cases, the lower bound should not be adjusted. The context and meaning of the estimate must therefore be kept in mind when creating these bounds. Another example of a natural limit is 100 percent as the upper bound of a percent estimate.

If the margin of error is displayed as '*****' (five asterisks), the estimate has been controlled to be equal to a fixed value and so it has no sampling error. A standard error of zero should be used for these controlled estimates when completing calculations, such as those in the following section.

Limitations

Users should be careful when computing and interpreting confidence intervals.

Nonsampling Error

The estimated standard errors (and thus margins of error) included in these data products do not account for variability due to nonsampling error that may be present in the data. In particular, the standard errors do not reflect the effect of correlated errors introduced by interviewers, coders, or other field or processing personnel or the effect of imputed values due to missing responses. The standard errors calculated are only lower bounds of the total error. As a result, confidence intervals formed using these estimated standard errors may not meet the stated levels of confidence (i.e., 68, 90, or 95 percent). Some care must be exercised in the interpretation of the data based on the estimated standard errors.

Very Small (Zero) or Very Large Estimates

By definition, the value of almost all ACS characteristics is greater than or equal to zero. The method provided above for calculating confidence intervals relies on large sample theory, and may result in negative values for zero or small estimates for which negative values are not admissible. In this case, the lower limit of the confidence interval should be set to zero by default. A similar caution holds for estimates of totals close to a control total or estimated proportion near one, where the upper limit of the confidence interval is set to its largest admissible value. In these situations, the level of confidence of the adjusted range of values is less than the prescribed confidence level.

CALCULATION OF STANDARD ERRORS

Direct estimates of margin of error were calculated for all estimates reported. The margin of error is derived from the variance. In most cases, the variance is calculated using a replicate-based methodology known as successive difference replication (SDR) that takes into account the sample design and estimation procedures.

The SDR formula, as well as additional information on the formation of the replicate weights, can be found in Chapter 12 of the Design and Methodology documentation at: https://www.census.gov/programs-surveys/acs/methodology/design-and-methodology.html.

Beginning with the 2011 ACS 1-year estimates, a new imputation-based methodology was incorporated into processing (see the description in the Group Quarters Person Weighting Section). An adjustment was made to the production replicate weight variance methodology to account for the non-negligible amount of additional variation being introduced by the new technique.[6]

Excluding the base weights, replicate weights were allowed to be negative in order to avoid underestimating the standard error. Exceptions include:

1. *The estimate of the number or proportion of people, households, families, or housing units in a geographic area with a specific characteristic is zero.* A special procedure is used to estimate the standard error.

2. *There are either no sample observations available to compute an estimate or standard error of a median, an aggregate, a proportion, or some other ratio, or there are too few sample observations to compute a stable estimate of the standard error.* The estimate is represented in the tables by "-" and the margin of error by "**" (two asterisks).

3. *The estimate of a median falls in the lower open-ended interval or upper open-ended interval of a distribution.* If the median occurs in the lowest interval, then a "-" follows the estimate, and if the median occurs in the upper interval, then a "+" follows the estimate. In both cases, the margin of error is represented in the tables by "***" (three asterisks).

Calculating Measures of Error Using Variance Replicate Tables

Advanced users may be interested in the Variance Replicate Tables. These augmented ACS Detailed Tables include sets of 80 replicate estimates, which allow users to calculate measures of error for derived estimates using the same methods that are used to produce the published MOEs on data.census.gov. These methods incorporate the covariance between estimates that the approximation formulas in this document leave out.

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[6] For more information regarding this issue, see Asiala, M. and Castro, E. 2012. Developing Replicate Weight-Based Methods to Account for Imputation Variance in a Mass Imputation Application. In JSM proceedings, Section on Survey Research Methods, Alexandria, VA: American Statistical Association.

The Variance Replicate Tables are available for a subset of the 5-year Detailed Tables for eleven summary levels, including the nation, states, counties, tracts, and block groups. These will be released on an annual basis, shortly after the release of the regular 5-year data products.

The Variance Replicate Tables and their technical documentation (including table list and summary level list) can be found at: https://census.gov/programs-surveys/acs/data/variance-tables.html

Approximating Standard Errors and Margins of Error

Previously, this document included formulas for approximating the standard error (SE) for various types of estimates. For example, summing estimates or calculating a ratio of two or more estimates. These formulas are also found in the Instruction for Statistical Testing documents, which is available at https://www.census.gov/programs-surveys/acs/technical-documentation/code-lists.html. In addition, the worked examples have also been placed in the same location in the document called "Worked Examples for Approximating Margins of Error".

TESTING FOR SIGNIFICANT DIFFERENCES

Users may conduct a statistical test to see if the difference between an ACS estimate and any other chosen estimate is statistically significant at a given confidence level. "Statistically significant" means that it is not likely that the difference between estimates is due to random chance alone.

To perform statistical significance testing, data users will need to calculate a Z statistic. The equation is available in the Instructions for Statistical Testing document, which is available at https://www.census.gov/programs-surveys/acs/technical-documentation/code-lists.html.

Users completing statistical testing may be interested in using the ACS Statistical Testing Tool. This automated tool allows users to input pairs and groups of estimates for comparison. For more information on the Statistical Testing Tool, visit https://www.census.gov/programs-surveys/acs/guidance/statistical-testing-tool.html.

CONTROL OF NONSAMPLING ERROR

As mentioned earlier, sample data are subject to nonsampling error. Nonsampling error can introduce serious bias into the data, increasing the total error dramatically over that which would result purely from sampling. While it is impossible to completely eliminate nonsampling error from a survey operation, the Census Bureau attempts to control the sources of such error

during the collection and processing operations. Described below are the primary sources of nonsampling error and the programs instituted to control for this error.[7]

Coverage Error

It is possible for some sample housing units or persons to be missed entirely by the survey (undercoverage). It is also possible for some sample housing units and persons to be counted more than once (overcoverage). Both undercoverage and overcoverage of persons and housing units can introduce bias into the data. Coverage error can also increase both respondent burden and survey costs.

To avoid coverage error in a survey, the frame must be as complete and accurate as possible. For the ACS, the frame is an address list in each state, the source of which is the Master Address File (MAF). An attempt is made to assign each MAF address to the appropriate geographic codes via an automated procedure using the Census Bureau TIGER (Topologically Integrated Geographic Encoding and Referencing) files. A manual coding operation based in the appropriate regional offices is attempted for addresses that could not be automatically coded.

The MAF was used as the source of addresses for selecting sample housing units and mailing questionnaires. TIGER produced the location maps for CAPI assignments. Sometimes the MAF contains duplicates of addresses. This could occur when there is a slight difference in the address such as 123 Main Street versus 123 Maine Street, and can introduce overcoverage.

In the CATI and CAPI nonresponse follow-up phases, efforts were made to minimize the chances that housing units that were not part of the sample were mistakenly interviewed instead of units in sample. If a CATI interviewer called a mail nonresponse case and was not able to reach the exact address, no interview was conducted and the case became eligible for CAPI. Note that CATI operations were discontinued in September, 2017. During the CAPI follow-up, the interviewer had to locate the exact address for each sample housing unit. If the interviewer could not locate the exact sample unit in a multi-unit structure, or found a different number of units than expected, the interviewers were instructed to list the units in the building and follow a specific procedure to select a replacement sample unit. Person overcoverage can occur when an individual is included as a member of a housing unit but does not meet ACS residency rules.

Coverage rates give a measure of undercoverage or overcoverage of persons or housing units in a given geographic area. Rates below 100 percent indicate undercoverage, while rates above 100 percent indicate overcoverage. Coverage rates are released concurrent with the release of estimates on data.census.gov in the B98 series of detailed tables (table IDs B98011, B98012,

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[7] The success of these programs is contingent upon how well the instructions were carried out during the survey.

B98013, and B98014). Coverage rate definitions and coverage rates for total population for nation and states are also available in the Sample Size and Data Quality Section of the ACS website, at https://www.census.gov/acs/www/methodology/sample-size-and-data-quality/.

Nonresponse Error

Survey nonresponse is a well-known source of nonsampling error. There are two types of nonresponse error – unit nonresponse and item nonresponse. Nonresponse errors affect survey estimates to varying levels depending on amount of nonresponse and the extent to which the characteristics of nonrespondents differ from those of respondents. The exact amount of nonresponse error or bias on an estimate is almost never known. Therefore, survey researchers generally rely on proxy measures, such as the nonresponse rate, to indicate the potential for nonresponse error.

Unit Nonresponse

Unit nonresponse is the failure to obtain data from housing units in the sample. Unit nonresponse may occur because households are unwilling or unable to participate, or because an interviewer is unable to make contact with a housing unit. Unit nonresponse is problematic when there are systematic or variable differences in the characteristics of interviewed and non-interviewed housing units. Nonresponse bias is introduced into an estimate when differences are systematic; the nonresponse error of an estimate evolves from variable differences between interviewed and non-interviewed households.

The ACS made every effort to minimize unit nonresponse, and thus, the potential for nonresponse error. First, the ACS used a combination of mail, CATI, and CAPI data collection modes to maximize response. The mail phase included a series of three to four mailings to encourage housing units to return the questionnaire. Prior to the end of CATI operations in September of 2017, mail nonrespondents (for which phone numbers are available) were contacted by CATI for an interview. Finally, a subsample of the nonrespondents were contacted by personal visit to attempt an interview. Combined, these efforts resulted in a very high overall response rate for the ACS.

ACS response rates measure the percentage of units with a completed interview. The higher the response rate (and, consequently, the lower the nonresponse rate), the lower the chance that estimates are affected by nonresponse bias. Response and nonresponse rates, as well as rates for specific types of nonresponse, are released concurrent with the release of estimates on data.census.gov in the B98 series of detailed tables (table IDs B98021 and B98022). Unit response rate definitions and unit response rates by type for the nation and states are also available in the Sample Size and Data Quality Section of the ACS website, at https://www.census.gov/acs/www/methodology/sample-size-and-data-quality/.

Item Nonresponse

Nonresponse to particular questions on the survey can introduce error or bias into the data, as the unknown characteristics of nonrespondents may differ from those of respondents. As a result, any imputation procedure using respondent data may not completely reflect difference either at the elemental level (individual person or housing unit) or on average.

Some protection against the introduction of large errors or biases is afforded by minimizing nonresponse. In the ACS, item nonresponse for the CATI and CAPI operations was minimized by requiring that the automated instrument receive a response to each question before the next question could be asked. Questionnaires returned by mail were reviewed by computer for content omissions and population coverage and edited for completeness and acceptability. If necessary, a telephone follow-up was made to obtain missing information. Potential coverage errors were included in this follow-up.

Allocation tables provide the weighted estimate of persons or housing units for which a value was imputed, as well as the total estimate of persons or housing units that were eligible to answer the question. The smaller the number of imputed responses, the lower the chance that the item nonresponse is contributing a bias to the estimates. Allocation tables are released concurrent with the release of estimates on data.census.gov in the B99 series of detailed tables with the overall allocation rates across all person and housing unit characteristics in the B98 series of detailed tables (table IDs B98031 and B98032). Allocation rate definitions and allocation rates by characteristic at the nation and states are also available in the Sample Size and Data Quality Section of the ACS website, at https://www.census.gov/acs/www/methodology/sample-size-and-data-quality/.

Measurement and Processing Error

Measurement error can arise if the person completing the questionnaire or responding an interviewer's questions responds incorrectly. However, to mitigate this risk, the phrasing survey questions underwent cognitive testing and households were provided detailed instructions on how to complete the questionnaire.

Processing error can be introduced in numerous areas during data collection and capture, including during interviews, during data processing and during content editing.

Interviewer monitoring

An interviewer could introduce error by:

1. Misinterpreting or otherwise incorrectly entering information given by a respondent.
2. Failing to collect some of the information for a person or household.
3. Collecting data for households that were not designated as part of the sample.

To control for these problems, the work of interviewers was monitored carefully. Field staff was prepared for their tasks by using specially developed training packages that included hands-on experience in using survey materials. A sample of the households interviewed by CAPI interviewers was also reinterviewed to control for the possibility that interviewers may have fabricated data.

Processing Error

The many phases involved in processing the survey data represent potential sources for the introduction of nonsampling error. The processing of the survey questionnaires includes the keying of data from completed questionnaires, automated clerical review, follow-up by telephone, manual coding of write-in responses, and automated data processing. The various field, coding and computer operations undergo a number of quality control checks to ensure their accurate application.

Content Editing

After data collection was completed, any remaining incomplete or inconsistent information was imputed during the final content edit of the collected data. Imputations, or computer assignments of acceptable codes in place of unacceptable entries or blanks, were most often needed either when an entry for a given item was missing or when information reported for a person or housing unit was inconsistent with other information for the same person or housing unit. As in other surveys and previous censuses, unacceptable entries were to allocated entries for persons or housing units with similar characteristics. Imputing acceptable values in place of blanks or unacceptable entries enhances the usefulness of the data.