

## Instructions for Applying Statistical Testing to ACS 1-Year Data

This document provides some basic instructions for obtaining the ACS standard errors which are needed to carry out statistical testing, as well as how to perform the statistical testing.

### Obtaining Standard Errors

The location and type of ACS data, as well as when it was released, will determine if standard errors are readily available or users have to calculate them. If the estimate of interest is published on American FactFinder (AFF), then AFF should also be the source of the standard errors. Possible sources for data and where to get standard errors are:

#### 1. ACS Data From Published Tables on American FactFinder

All ACS estimates from tables on AFF include either the 90 percent margin of error or 90 percent confidence bounds. AFF may be found at: <http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml>. The margin of error is the maximum difference between the estimate and the upper and lower confidence bounds. Most tables on AFF containing 2005 or later ACS data display the margin of error.

Use the margin of error to calculate the standard error (dropping the “+/-” from the displayed value first) as:

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

where  $Z = 1.645$  for ACS data published from 2006 up to the present. Users of 2005 and earlier ACS data should use  $Z = 1.65$

If confidence bounds are provided instead (as with most ACS data products for 2004 and earlier), calculate the margin of error first before calculating the standard error:

$$\text{Margin of Error} = \max(\text{upper bound} - \text{estimate}, \text{estimate} - \text{lower bound})$$

All published ACS estimates use 1.645 (for 2006 and recent years) to calculate 90 percent margins of error and confidence bounds. ACS estimates for years earlier than 2006 should use 1.65. Other surveys may use other values.

#### 2. ACS Application Programming Interface (API)

In alignment with the Digital Government Strategy, the Census Bureau launched an application programming interface, or API, to allow the public to incorporate ACS and other Census statistics into websites and mobile apps.

Estimates and 90 percent margin of errors for the 1-year, 3-year and 5-year ACS Summary Files and Data Profiles are available through the Census API. The standard errors are calculated using the same method explained above in ACS Data From

Published Tables on American FactFinder. More information about the API may be found at <http://www.census.gov/developers/>.

### 3. ACS Public Use Microdata Sample (PUMS) Tabulations

Using the methods described in the PUMS Accuracy of the Data documentation users can calculate standard errors for their tabulations using a design factor method or a replicate weight method. For example, 2015 PUMS Accuracy of the Data documentation can be used with the 2015 ACS PUMS file to calculate standard errors. This document is available in the PUMS Documentation under the Technical Documentation portion of the ACS website, located at: <http://www.census.gov/programs-surveys/acs/technical-documentation/pums/documentation.html>.

NOTE: ACS PUMS design factors provided in the Accuracy of the PUMS document *should not* be used to calculate standard errors of full ACS sample estimates, such as those found in data tables on AFF. In addition, Census 2000 design factors *should not* be used to calculate standard errors for *any* ACS estimate.

#### Obtaining Standard Errors for Derived Estimates

Once users have obtained standard errors for the basic estimates, there may be situations where users create derived estimates, such as percentages or differences that also require standard errors.

All methods in this section are **approximations** and users should be cautious in using them. This is because these methods do not consider the correlation or covariance between the basic estimates. They may be overestimates or underestimates of the derived estimate's standard error depending on whether the two basic estimates are highly correlated in either the positive or negative direction. As a result, the approximated standard error may not match direct calculations of standard errors or calculations obtained through other methods.

- Sum or Difference of Estimates

$$SE(A + B + \dots) = SE(A - B - \dots) = \sqrt{SE(A)^2 + SE(B)^2 + \dots}$$

As the number of basic estimates involved in the sum or difference increases, the results of this formula become increasingly different from the standard error derived directly from the ACS microdata. Care should be taken to work with the fewest number of basic estimates as possible. If there are estimates involved in the sum that are controlled in the weighting then the approximate standard error can be tremendously different.

- Proportions and Percents

Here we define a proportion as a ratio where the numerator is a subset of the denominator, for example the proportion of persons 25 and over with a high school diploma or higher.

Let  $P = \frac{A}{B}$ .

$$SE(P) = \frac{1}{B} \sqrt{SE(A)^2 - P^2 \times SE(B)^2}$$

If the value under the square root sign is negative, then instead use

$$SE(P) = \frac{1}{B} \sqrt{SE(A)^2 + P^2 \times SE(B)^2}$$

If  $P = 1$  then use

$$SE(P) = \frac{SE(A)}{B}$$

If  $Q = 100\% \times P$  (a percent instead of a proportion), then  $SE(Q) = 100\% \times SE(P)$ .

- Means and Other Ratios

If the estimate is a ratio but the numerator is not a subset of the denominator, such as persons per household, per capita income, or percent change, then

$$SE\left(\frac{A}{B}\right) = \frac{1}{B} \sqrt{SE(A)^2 + \left(\frac{A}{B}\right)^2 \times SE(B)^2}$$

- Products

For a product of two estimates - for example if users want to estimate a proportion's numerator by multiplying the proportion by its denominator - the standard error can be approximated as

$$SE(A \times B) = \sqrt{A^2 \times [SE(B)]^2 + B^2 \times [SE(A)]^2}$$

Users may combine these procedures for complicated estimates. For example, if the desired estimate is  $P = \frac{A+B+C}{D+E}$ , then  $SE(A+B+C)$  and  $SE(D+E)$  can be estimated first, and then those results used to calculate  $SE(P)$ .

For examples of these formulas, please see any Accuracy of the Data document available on the ACS website at: <http://www.census.gov/programs-surveys/acs/technical-documentation/code-lists.html>.

## Instructions for Statistical Testing

Once standard errors have been obtained, doing the statistical test to determine significance is not difficult. The determination of statistical significance takes into account the difference between the two estimates as well as the standard errors of both estimates.

For two estimates, A and B, with standard errors SE(A) and SE(B), let

$$Z = \frac{A - B}{\sqrt{SE(A)^2 + SE(B)^2}}$$

If  $Z < -1.645$  or  $Z > 1.645$ , then the difference between A and B is significant at the 90 percent confidence level. Otherwise, the difference is not significant. This means that there is less than a 10 percent chance that the difference between these two estimates would be as large or larger by random chance alone.

This is the method used in determining statistical significance for the ACS Comparison Profiles published on AFF. Note that the user's determination of statistical significance may not match the results in the Comparison Profile for the same pair of estimates, because the significance tests for Comparison Profiles are made using unrounded standard errors. Standard errors obtained from the rounded margins of error or confidence bounds are unlikely to exactly match the unrounded standard error, and so statistical tests may differ.

Users may choose to apply a confidence level different from 90 percent to their tests of statistical significance. For example, if  $Z < -1.96$  or  $Z > 1.96$ , then the difference between A and B is significant at the 95 percent confidence level.

This method can be used for any types of estimates: counts, percentages, proportions, means, medians, etc. It can be used for comparing across years, or across surveys. If one of the estimates is a fixed value or comes from a source without sampling error (such as a count from the 2010 Census), use zero for the standard error for that estimate in the above equation for Z.

NOTE: Making comparisons between ACS single-year and multiyear estimates is very difficult, and is not advised.

In addition, using the rule of thumb of overlapping confidence intervals does not constitute a valid significance test and users are discouraged from using that method.