

Indicators Program



Margins of Error in the American Community Survey: Understanding Them and How to Use Them

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American Community Survey

The American Community Survey (ACS) is a nationwide survey program carried out by the U.S. Census Bureau to measure and describe the social, economic, housing, and demographic characteristics of the U.S. population. It is now the data program from which we get much of this type of information about our population and it includes data for the U.S., states, regions, counties, and local areas.¹

Because the ACS data are based on samples of the population rather than assessing the entire population, there is some level of uncertainty associated with the estimates of the characteristics. The uncertainty around an estimate due to sampling is called sampling error and, in general, is related to sample size. Larger samples tend to have smaller levels of sampling error. By pooling multiple months and years of surveys for the ACS, the sample size for a geographic level is increased which reduces the sampling error.

Margins of Error

The Census Bureau provides, for each characteristic estimate from the ACS, a margin of error (MOE) that helps to assess the amount of sampling error and thus the reliability associated with the estimate.^{1,2} Margins of error can be large or small and a smaller MOE, relative to the size of the estimate, usually represents a more precise estimate or one that is in sharper focus. A larger

MOE suggests that the estimate is less precise and less focused (Figure 1).²

The MOE is reported as +/- a numerical value that should be added to or subtracted from the point estimate value and which gives the upper and lower bounds of a 90% confidence interval around the estimate. The interval represents the range within which the true value of the estimate is expected to be with a level of confidence of 90%. Margins of error for ACS estimates should always be included when reporting ACS estimate values. In some cases, the estimates and MOEs are so much out of range that the ACS does not report them (Table 1).¹

Evaluating Margins of Error

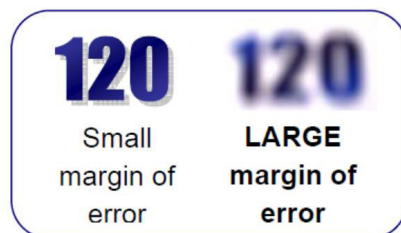
As MOEs become relatively larger, the less confidence there is that the point estimate is close to the true population value. It is not, however, the absolute size or magnitude of the error that is important but rather it is the magnitude of the MOE *relative* to the size of the

estimate. An estimate value that is numerically large may be able to have a MOE that also is numerically large and still be usable. In other cases, especially for small population areas or small subgroup populations, the MOE may be nearly as large as the estimate value which suggests caution with using that estimate.

As an example, the estimate of U.S. households from the 2011-2015 5-year ACS gives a margin of error of +/- 226,951 households (Table 1). This is a large MOE, larger than would be found for most other geographic areas. That MOE, however, is relative to the point estimate of nearly 117 million households, which is also a very large number. In contrast, the MOE for Marshalltown's median household income for households with a householder of two or more races is +/- \$20,273. In this case, the margin is more than half the size of the point median income estimate of \$38,409. Having a MOE that is this large, relative to the point estimate, is a caution for using that data. If there are lots of zeros or near zeros in the estimate, then it may not be very useful as well (Table 1).

Margins of error can be visualized as part of bar or line charts by utilizing features of graphing and charting programs. Lines showing the upper and lower bounds of a margin of error can be added to bars in a chart (Figures 2-4).^{1,2} Such visualizations help to show the

Figure 1.



From Julie Zimmerman²

Table 1. Median Household Income of Total Households and Households with Householder of Two or More Races, Margins of Error, and Coefficients of Variation, Selected Geographic Areas, American Community Survey¹ 5-Year Estimates, 2011-2015.

Geographic Area	Total Households			Median Household Income			Households with Householder of Two or More Races			Median Household Income		
	Number	MOE	CV %	\$	MOE \$	CV %	% of Total	MOE %	CV %	Estimate	MOE \$	CV %
United States	116,926,305	+/-226,951	0.12	53,889	+/-110	0.12	1.80%	+/-0.1	3.38	48,648	+/-306	0.38
State of Iowa	1,236,409	+/-3,802	0.19	53,183	+/-313	0.36	0.90%	+/-0.1	6.75	40,563	+/-2,810	4.21
Polk County	177,049	+/-1,147	0.39	60,061	+/-876	0.89	1.10%	+/-0.2	11.05	42,185	+/-5,701	8.22
Des Moines city	81,717	+/-963	0.72	46,290	+/-1,179	1.55	1.60%	+/-0.3	11.40	36,328	+/-7,906	13.23
Marshall County	15,297	+/-273	1.08	53,351	+/-1,636	1.86	1.00%	+/-0.6	36.47	38,973	+/-16,175	25.23
Marshalltown city	9,988	+/-261	1.59	50,396	+/-1,921	2.32	1.30%	+/-0.8	37.41	38,409	+/-20,273	32.09
Appanoose County	5,481	+/-175	1.94	41,394	+/-1,872	2.75	1.80%	+/-0.8	27.02	24,934	+/-12,588	30.69
Centerville city	2,443	+/-132	3.28	31,270	+/-4,201	8.17	3.20%	+/-1.9	36.09	24,671	+/-11,730	28.90
Adams County	1,718	+/-71	2.51	48,043	+/-5,022	6.35	0.90%	+/-0.8	54.04	(X)	(X)	(X)
Corning city	731	+/-57	4.74	41,849	+/-2,024	2.94	0.50%	+/-0.8	97.26	(X)	(X)	(X)

¹American Community Survey 5-Year Estimates 2011-2015, U.S. Census Bureau

size of the margin of error relative to the size of the estimate. Large population areas such as the U.S. and the state of Iowa (Table 1) have relatively small margins of error when compared with the size of those region's point estimates. In contrast, small population areas (e.g. Adams County, Corning) tend to show relative large MOEs (Figures 2-4).

Coefficients of Variation

Although in some of the examples noted above one can readily see that the error value is relatively large compared with the point estimate, there are other times when the situation may not be as clear. The Census Bureau suggests using the Coefficient of Variation (CV) as a way to assess the usability of an estimate.¹ The CV is a measure of the relative amount of sampling error associated with a sampling estimate. The CV is a ratio of the Standard Error (SE) of the estimate to the estimate itself and is usually expressed as a percent (formulas, Figure 5). The SE is simply the MOE divided by 1.645 (this is a constant since it is a 90% confidence interval). The resulting SE is then divided by the estimate value and multiplied by 100 to get a percent. The *smaller* the CV, the *higher* the relative reliability of the estimate (Figures 5-6).

Figure 2. Median Household Income with MOEs, ACS 5-year estimates, 2011-2015

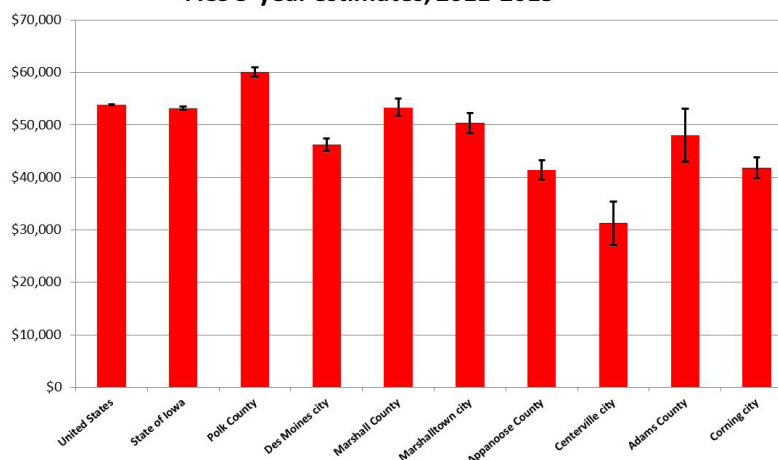


Figure 3. Median Household Income, Householder of Two or More Races with MOEs, ACS 5-year estimates, 2011-2015

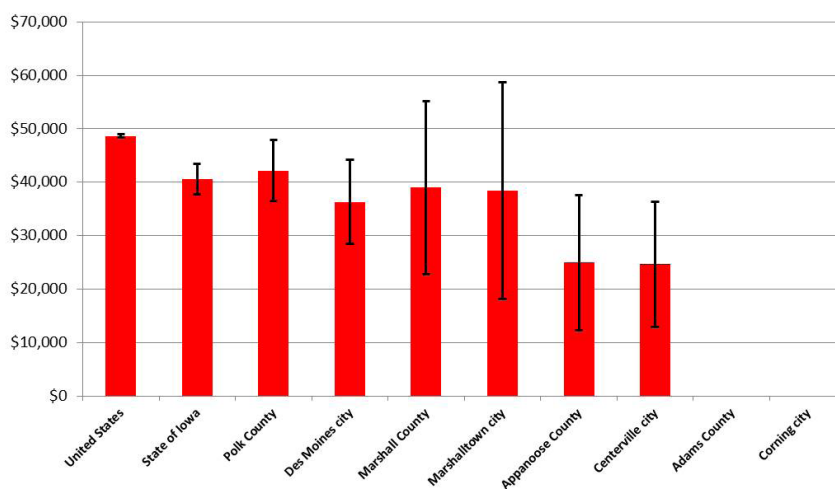


Figure 4.

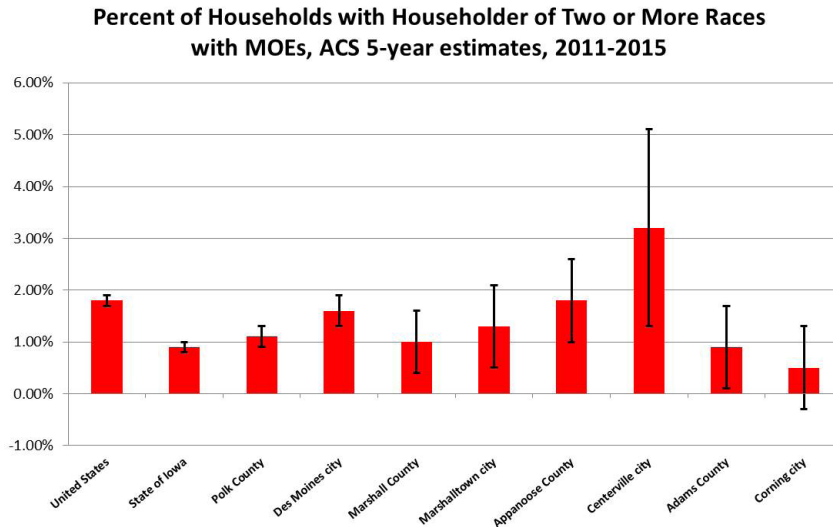


Figure 5.

Coefficient of Variation (CV):
Relative amount of sampling error associated
with a sample estimate

- $CV = (\text{Standard Error/Estimate}) * 100\%$
or
- $CV = ((\text{MOE}/1.645) / \text{Estimate}) * 100\%$

Figure 6.

Examples for Coefficient of Variation (CV)

- $CV = ((\text{MOE}/1.645) / \text{Estimate}) * 100\%$
- U.S., Households
- $CV = ((226,951/1.645) / 116,926,305) * 100$
- $CV = (137,964/116,926,305) * 100 = 0.00118 * 100 = 0.12\%$
- Marshalltown, Median Household Income of Households with Householder of Two Races
- $CV = ((20,273/1.645)/38,409) * 100$
- $CV = (12,324/ 38,409) * 100 = 0.3209 * 100 = 32.09\%$
- Corning, % of Households with Householder of Two Races
- $CV = ((0.80/1.645)/0.50) * 100$
- $CV = ((0.4863/0.50) * 100 = 0.9726 * 100 = 97.26\%$

CVs are provided for the four types of estimated variables in Table 1. Examples show the formula and calculations for three of the CVs in the table (Figure 6). The CVs in Table 1 range from 0.12% to 97.26%. For each of the four variables provided, the U.S. geographic region has the smallest CV. The U.S., of course, would have the highest sample size of households of the geographic regions listed in the table. The state of Iowa has the next smallest CVs. As the geographic regions get progressively smaller and the number of households and, thus, sample size in each region gets smaller, the CVs get progressively larger (Table 1).

Users of ACS data must make decisions about the usability of an estimate. In some cases, the MOE or CV of a particular estimate may be too large for it to be used. However, deciding what may be too large may depend on the circumstances and context of how the data are to be used. In some situations, a larger MOE or CV may be usable but for other purposes it may not.

The Census Bureau does not provide definitive guidelines to determine when a MOE or CV may be too large to make the estimate unusable. In general the Census Bureau says, “there are no hard and fast rules about the size of CVs.” It does, however, suggest “caution for proportions that are close to zero” (Figure 7).¹ The example provided here for the percent of households with a householder of two or more races (Table 1) illustrates the Census Bureau’s concern with very small percentages of small subgroup populations. The MOEs for these estimates for Adams County and Corning are as large or larger than the percentage point estimates and have CVs of 54% and 97% respectively (Figures 4, 6, Table 1).

Other organizations have suggested additional guidelines about what level of CV is acceptable and what level may be too high. ESRI, a geographic information system company, suggests

that a CV of 12% or less indicates an estimate with high reliability while a CV of 40% would signal low reliability (Figure 7).³ Similar criteria from the Office of Financial Management of the State of Washington suggest a CV of 15% or lower as indicating an estimate with high reliability while a CV of 30% or more indicates a need for caution (Figure 7).⁴ The National Research Council suggests that a CV of 10% to 12% is usually an acceptable level of precision (Figure 7).⁵ Overall, there seems to be a consensus that CVs of 15% or less indicate an estimate with high precision and reliability that may be usable for many types of contexts and purposes. On the other hand, users should be very cautious in using an estimate if the CV is 30% to 40% or higher.

Using these suggested guidelines and looking again at the estimates provided in Table 1, the estimates for the total household number as well as the median income estimates for the total households would be usable for all the geographic levels provided in the table, even the smaller sized areas. This is not the case for the estimates of the percent of households with a householder of two or more races nor for the median income estimates of those households. The geographic areas from Marshall County through the smallest (Corning) all have high CVs that show the estimates regarding households with a householder of two or more races may be unreliable. The Census Bureau does not even publish the estimates for Adams County or Corning. There are just too few of such households in these geographic areas to be able to estimate them reliably with the sample sizes used for the ACS.

Suggestions for Users

The ACS provides users with data that are updated much more frequently than those for the Decennial Census. It does, however, introduce some additional sampling and estimation issues, as shown here, that users must be aware of in order to properly use the data.

Figure 7.

Census Bureau says:¹

“no hard and fast rules about the size of CVs”

“caution for proportions that are close to zero”

ESRI, geographic information systems says:³

high reliability = CV ≤ 12%

medium reliability = CV 12% - 40%

low reliability = CV > 40%

Office of Financial Management, State of Washington says:⁴

high reliability = CV ≤ 15%

fair reliability = CV 15% - 30%

low reliability, caution = CV > 30%

National Research Council of the National Academies says:⁵

acceptable level of precision = CV 10% - 12%

In general, estimates for very large population areas or large subgroups will be relatively precise and reliable with small margins of error and CVs. Many, if not most of the estimates for such larger population areas and subgroups will be usable for most purposes. It is with small population areas and small subgroups that estimation issues become more problematic. There will be situations when MOEs and CVs for such estimates will be large enough that the estimates should not be used (Figures 2-6, Table 1).

When such a situation arises, there are some options and strategies that can be utilized in order to have data that is at an acceptable level of reliability. One option is to use an estimate for the next largest population area or geographic region that is relevant and provides reasonable CVs.^{2,6} For example, a county estimate could be used in place of the estimate of a very small town within that county for which its own estimates are not usable. Another example would be to use a similar neighboring, but larger town for the small town's estimate. In either case, there would need to be a reasonable similarity of demographic and social

characteristics between the original area and the area whose estimate is being substituted.

A second option may be to combine smaller, contiguous geographic areas to make a larger region that will then have a larger sample size and may have acceptable MOEs and CVs. Examples of this would be combining census tracts in a metropolitan area to larger neighborhood areas or combining counties into a multi-county region.^{1,6}

Another strategy can be to combine subgroups into larger groupings that are still relevant to thus have smaller MOEs. This could be combining income categories or age categories to have broader but fewer categories. As an example, use 20-year age groupings of people rather than 5-year age groupings. It is important to note, however, that when making combinations of geographic areas or aggregating cells of detailed data, the margins of error must also be recalculated for the *new* aggregated groups. The Census Bureau provides details on how to do that and users should consult the “compass” handbooks and other guides for aggregating margins of error.^{1,2,6,7}

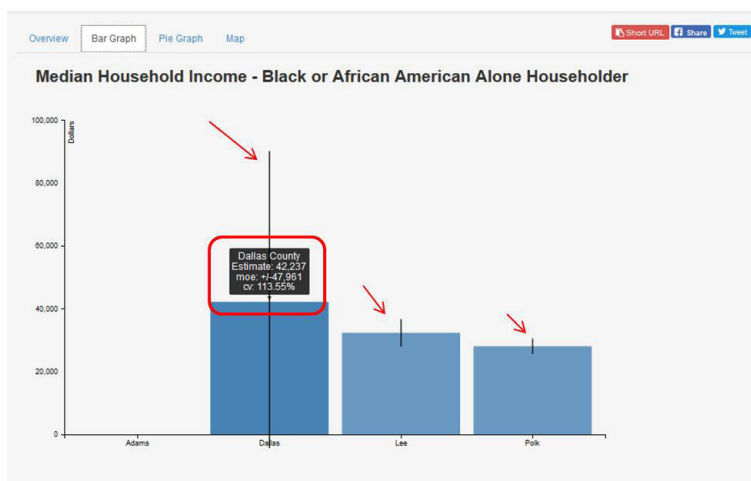
Figure 8.

What you can find on the Indicators Portal

- Data on many Topic and Subject Areas
- *Data for Decision Makers* County and Region Profiles
- Access to City Government Finance Data (IGFI)
- Tools for Designing Graphs and Maps
- Reports on Data Trends and Topics of Interest
- Educational Materials on Data Measures and their Use

Figure 9.

Median Household Income - Black or African American Alone Householder



In some cases, using an alternative data source for some of the ACS items may be feasible. If it is basic demographic data that are needed, these items are available from the Decennial Census⁸ as well as from the ACS. The Decennial Census is carried out as a complete count survey and thus does not involve sampling or margins of error. It would be a recommended alternative source for demographic items, especially for small population areas. In addition, some of the basic demographic, income, and poverty data for counties are also available from several of the Census Bureau's annual estimates programs and are another alternative source for these data.⁹

The Bureau of Economic Analysis¹⁰ annually estimates per capita income for counties and would be a different source for income information. Low income information for children and their families may be found using data from the free and reduced school meals program.¹¹ Additional low income information may be determined from the food stamp (SNAP) program eligibility as well.¹²

Overall, decisions about what level of MOEs and CVs are acceptable depend on the use of the data and the context of the situation. If the use is for a general profile of an area, it is possible that a somewhat larger margin of error may

be acceptable. If some type of exact planning or funding decisions are to be made with the data, then more caution regarding margins of error may be needed. It is also recommended that if the data are used in grant writing that attention is given to the "cut off" point for the grant eligibility. Agency evaluation of the grant application may focus on the estimate value and not take the MOEs into consideration. Even though some general guidelines are presented here, users of ACS data will likely have to make judgments about the usability of any particular estimate or set of estimates from the ACS.

ISU Indicators Portal

Iowa State University Extension and Outreach maintains a data and indicators portal that can be especially useful for ACS data users. At this portal (www.indicators.extension.iastate.edu)¹³ users can find data on many subject areas, tools for designing maps and graphs, and reports on population trends and data measures and their use, including this report (Figure 8).

One particularly useful feature for the ACS data on the indicators portal is that margin of error lines are automatically shown for bar graphs and coefficients of variation are displayed as well (figure 9). These features help a user to quickly visualize the data and the margins of error and to see if the estimates fall within a reliable range. The indicators portal is available for use by the general public as well as the staff, students, and faculty of Iowa State University.

Margins of Error in the American Community Survey

Notes:

¹The home web pages for the American Community Survey and guidance are:

<http://www.census.gov/acs/www/>

http://www.census.gov/acs/www/guidance_for_data_users/guidance_main/

http://www.census.gov/acs/www/guidance_for_data_users/training_presentations/

<http://census.gov/programs-surveys/acs/guidance/training-presentations/acs-affect-estimates.html>

http://www.census.gov/acs/www/guidance_for_data_users/handbooks/

<https://www.census.gov/programs-surveys/acs/guidance/training-presentations/acs-moe.html>

Useful materials to be found at these sites include:

A Compass for Understanding and Using American Community Survey Data; An Overview of the American Community Survey;

Understanding Multiyear Estimates from the American Community Survey; Things that May Affect the Estimates from the American Community Survey

²Good resources for understanding the ACS and for graphs with error bars

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<http://www.ca.uky.edu/snarl> <http://www2.ca.uky.edu/snarl/KentuckyByTheNumbers/ACSpages/ACSUsingtheData.htm>

New Kid in Town: Understanding Data from the American Community Survey

And Now for the Grain of Salt: Margins of Error and the American Comm Survey'

A Picture is Worth.: Using a Newer Program to Make Charts and Graphs with Data from the American Community Survey

³http://www.esri.com/data/esri_data/literature *The American Community Survey*

⁴http://www.ofm.wa.gov/pop/acs/userguide/ofm_acs_user_guide.pdf *American Community Survey: User Guide*

⁵<https://www.nap.edu/catalog/11901/using-the-american-community-survey-benefits-and-challenges>

⁶<https://www.census.gov/programs-surveys/acs/guidance/training-presentations/acs-moe.html>

Using ACS Estimates and Margins of Error; Fuller, Sirius, 2016

⁷www.prb.org/pdf14/section2-salvo.pdf *Using Small-Area Data from the ACS: Issues, Challenges, Solutions.;* Salvo, Joseph, 2014

⁸<http://www.census.gov/2010census/>

⁹<http://www.census.gov/programs-surveys/popest.html>; <https://www.census.gov//did/www/saipe/>

¹⁰<https://www.bea.gov/regional/>

¹¹<https://www.educateiowa.gov/document-type/free-and-reduced-lunch>

¹²<https://food-stamps.com/>

¹³<http://www.indicators.extension.iastate.edu>

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