Exploring a Method to Produce County-Level Supplemental Poverty Measure Estimates in the American Community Survey

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Abstract

The goal of this paper is to release a methodology to produce county-level Supplemental Poverty Measure (SPM) estimates from the 1-year American Community Survey (ACS). This methodology would only use publicly-available data in order to be transparent and reproducible. Currently, the only sub-national SPM estimates available using 1 year of survey data are at the Public Use Microdata Area (PUMA) level and at the state level using 1-year ACS data. In this paper, county-level SPM estimates are produced from PUMA-level estimates using a county to PUMA crosswalk from the Missouri Census Data Center. There are three main types of county-PUMA relationships: counties that are exactly equal to a PUMA; counties that span multiple PUMAs; and PUMAs that span multiple counties. In the first case, the county-level estimates are exactly equal to the PUMA-level estimate. In the second case, the county-level estimate is a population-weighted average of the PUMA-level estimates. In the third case, the relationship between the official poverty measure (OPM) from the 5-year ACS at the county and PUMA level is used along with 2010 county populations to apportion the SPM population among counties within a PUMA. Several checks are performed in order to validate the PUMA to county methodology.

[1] This paper is released to inform interested parties of ongoing research and to encourage discussion of work in progress. Any views expressed are those of the author and not necessarily of the U.S. Census Bureau. 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-7533841, Disclosure Review Board (DRB) approval number: CBDRB-FY24-SEHSD003-050). All comparative statements in this paper have undergone statistical testing, and, unless otherwise noted, all comparisons are statistically significant at the 10 percent significance level.

I. Introduction

The National Academy of Sciences (NAS) released a report in 2023, "An Updated Measure of Poverty: (Re)Drawing the Line", that stated that researchers and policymakers' default to using the official poverty measure (OPM) when they would prefer to use the supplemental poverty measure (SPM) due to the OPM's availability at the sub-state level. The OPM is available for geographies of 65,000 or more using the 1-year American Community Survey (ACS), for all geographies using the 5-year ACS, and for all counties and school districts using 1-year Small Area Income and Poverty Estimates (SAIPE).[2] The SPM is currently available at the national level using 1-year of the Current Population Survey Annual Social and Economic Supplement (CPS ASEC) and at the state level using 3-years of CPS ASEC.[3] The SPM is also available as a research measure at the state and public use microdata area (PUMA) level using 1-year ACS.[4] While sub-state estimates are available currently, PUMA-level estimates are not generally meaningful to researchers, policy makers, or the media. Therefore, the purpose of this paper is to provide a methodology to produce county-level SPM estimates for all counties using 1-year public use ACS data.[5]

PUMAs are the smallest geographic unit available on the public use file. According to the 2021 5-year ACS, the 2,351 PUMAs range in size from around 80,000 people to around 300,000 people. The 3,143 counties in the U.S., which are not identified on the ACS public use file, are much more variable. They range in size from less than 100 people to nearly 10 million people according to the 2021 5-year ACS.

ACS SPM poverty statuses were estimated for all people on the ACS public use file using the methodology from Glassman and Wilson (2023). This methodology involves the imputation of a number of noncash benefits and expenses from the CPS ASEC at the state level. There is no calibration, validation, or review of sub-state geographies to check for reasonableness.

County-level SPM estimates were produced from PUMA-level estimates using a county to PUMA crosswalk from the Missouri Census Data Center. This is easier said than done. There are three main types of county-PUMA relationships: counties that are exactly equal to a PUMA (3.1 percent); counties that span multiple PUMAs (29.4 percent); and PUMAs that span multiple counties (67.5 percent).

The method of producing county-level estimates from PUMA-level estimates is straightforward for the first two types of counties. In the first case, the county-level estimates are exactly equal to the PUMA-level estimate. In the second case, the county-level estimate is a population-weighted average of the PUMA-level estimates. The third case is the most complex.

The method offered in this paper for the third case combines attributes of two methods to assign PUMA estimates to counties from the literature. The first method comes from Graven and Turner

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[2] OPM estimates are available from the 1-year ACS and the 5-year ACS at https://data.census.gov.

[3] SPM estimates from the CPS ASEC are located at https://www.census.gov/topics/income-poverty/supplemental-poverty-measure/library/publications.html.

[4] State-level ACS SPM estimates are available at https://www.census.gov/data/tables/time-series/demo/supplemental-poverty-measure/ACS-SPM-State-Tables.html. PUMA-level ACS SPM estimates can be calculated from ACS SPM public use files located at https://www.census.gov/data/datasets/time-series/demo/supplemental-poverty-measure/acs-research-files.html.

[5] For the methodology used to produce the SPM in the ACS, refer to https://www.census.gov/content/dam/Census/library/working-papers/2023/demo/SEHSD-wp2023-21.pdf.

(2011). The authors created county-level uninsurance rates from PUMA uninsurance rates by using the relationship between uninsurance rates and poverty rates at the PUMA level and the relationship between poverty rates at the county level and the PUMA level.

The second method comes from a report done by the Office of the Assistant Secretary for Planning and Evaluation in the Department of Health and Human Services. This report also tries to estimate county uninsurance rates from PUMA uninsurance rates. Rather than using poverty estimates, the PUMA estimate is apportioned across the counties based on overall 2020 census populations (Office of the Assistant Secretary for Planning and Evaluation 2022).

The method used in this paper utilizes both of these works by combining the relationship between county and PUMA OPM estimates from the 2021 5-year ACS along with 2010 county population information to assign PUMA SPM estimates to counties.

A number of checks are done to validate the method and the data. First, a key assumption is made that the OPM relationship between county and PUMA is similar for the SPM. To validate this inter-geographical relationship assumption, ratios of PUMA to state OPM and SPM are compared. Second, the county-weighted national average SPM rate is compared to the PUMA-weighted average national SPM rate and the national SPM rate. The same is done for the OPM and for the Multidimensional Deprivation Index (MDI) as robustness checks.

Third, since there are no internal county-level SPM estimates to compare results against, two alternative comparisons are made. County-level SPM rates are compared to a method where all counties in a PUMA have the same SPM rate as the PUMA. The SAIPE program produces county-level OPM estimates using 1 year of ACS data. County OPM rates using the methodology from this paper are compared to SAIPE OPM estimates. Finally, county-level SPM rates are compared to county-level measures of well-being such as the OPM, MDI, unemployment rate, labor force participation rate, and percent uninsured.

There are a number of reasons why the production of county-level SPM estimates are useful and needed. First, researchers, including those on the NAS panel and those throughout the research community have expressed an interest in this information. Second, counties can make use of this information. Large counties may be able to make use of PUMA estimates, but the vast majority of counties are located within a PUMA and may or may not share qualities with the other counties in that PUMA. These estimates, along with SAIPE OPM estimates, allow counties to have significant information on the well-being of their populations using up-to-date 1 year of ACS data. Third, while PUMA-level SPM rates are produced as research measures, they have actually not been assessed for validity and reasonableness. County rates would facilitate this assessment due to the amount of well-being data available at the county level. Finally, this methodology is useful in general in that it uses the public use ACS SPM file along with publicly available data from data.census.gov and the Missouri Census Data Center. It's transparent, easily reproduceable, and transferable to other type of estimates.

The paper is organized as follows. In Section 2, the data is described and the methodology for translating PUMA estimates to county estimates is detailed. In Section 3, county-level SPM estimates are shown and the reasonableness of these estimates is discussed. Section 4 concludes.

II. Data and Methods

The data used in this paper comes from the ACS 1-year public use estimates. The ACS is a nationwide household survey designed to provide communities with reliable and timely demographic, social, economic, and housing data for the nation, states, congressional districts, counties, places, and localities every year.[6] It has an annual sample size of about 3.5 million addresses across the United States and Puerto Rico, and includes both housing units and group quarters (e.g., nursing facilities and prisons).[7] The ACS is one of the best sources of sub-national economic, social, and employment characteristics and its large sample size allows for analyses by demographic characteristics and small area geographies. The ACS public use file is a subset containing about 2/3 of the cases of the ACS internal file.

To determine OPM status, a person or family's cash income is compared to a poverty threshold that varies by family size and composition. For SPM status, the definition of a family is expanded to include any coresident unrelated children, foster children, and unmarried partners and their relatives. Noncash benefits are added to cash income and expenses like taxes and tax credits, work and childcare expenses, and medical expenses are subtracted from cash income to get a new definition of resources. Finally, poverty thresholds are based on spending on food, clothing, shelter, utilities, and telecommunications in the SPM, while for the OPM thresholds are based on three times the cost of a minimum food diet in 1963, adjusted for inflation. Furthermore, SPM poverty thresholds are adjusted based on geographic differences in housing costs and vary by housing tenure level.

SPM rates and standard errors are first produced at the PUMA-level from the 2021 ACS 1-year public use estimates.[8] Published PUMA-level and county-level OPM estimates and standard errors from the 2021 ACS 5-year estimates are used from data.census.gov.

County-level SPM estimates can be produced from PUMA-level estimates using a county to PUMA crosswalk from the Missouri Census Data Center. Counties are either exactly equal to a PUMA, span multiple PUMAs, or combined with other counties into a PUMA.

The method of producing county-level estimates from PUMA-level estimates is straightforward for the first two types of counties. In the first case, the county-level SPM rates and standard errors are exactly equal to the PUMA-level SPM rates and standard errors. In the second case, the county-level SPM rate is a population-weighted average of the PUMA-level estimates. Similarly, the standard errors for these counties can be calculated using the formula: $SE(A+B) = \sqrt{[SE(A)^2+SE(B)^2]}$.

The third case is the most difficult one. The easiest method would be to simply assign every county in a PUMA the same SPM rate. However, while simple, this method sacrifices accuracy and does not offer much of an advantage over using PUMA-level estimates. The method offered in this paper combines the relationship between county and PUMA OPM estimates from the 2021 5-year ACS along with county population information to assign PUMA SPM estimates to counties.

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[6] For technical documentation for the ACS, refer to https://www.census.gov/programs-surveys/acs/technical-documentation.html.

[7] While people living in group quarters are sampled in the ACS, those living in institutional group quarters (e.g., nursing homes or correctional facilities) are not included in the poverty universe. Homeless populations are not included in the sample universe unless they are living in shelters at the time of the survey.

[8] SPM rates are not calculated for people living in Puerto Rico.

The overall idea of this methodology is to ensure that the number of people in poverty in each county of a PUMA sums up to the number of people in poverty in that PUMA. The method requires three pieces of publicly available information: 2021 5-year ACS county OPM rates and county populations for every county in the U.S. downloaded from data.census.gov and the 2021 1-year ACS public-use file.

The first part of this method is to estimate the relationship between county- and PUMA-level official poverty from the 5-year ACS. Example estimates from a county (039) in a PUMA (1400) in Maryland (24) are shown in parentheses to facilitate understanding. The county OPM rate (20.4) is multiplied by the county population (19,030) to get the number of people in official poverty in the county (3,882). Then the county official poverty populations within a PUMA are added together to get the PUMA official poverty population (22,745). Finally, the county official poverty population is divided by the PUMA official poverty population to get the percent of a PUMA official poverty population in each county (17.1).

The second part of the method is to use this relationship to apportion 1-year PUMA ACS SPM rates across counties. The number of people in SPM poverty in each PUMA can be calculated by multiplying the 2021 1-year ACS PUMA SPM rate (8.9) by the population of the PUMA (169,694). This number (15,040) is multiplied by the percent of a PUMA official poverty population in each county (17.1) to get the number of people who are SPM poor in each county (2,567). This value is then divided by the county populations (19,030) to get the county SPM rate (13.5).[9]

There is an important consideration that should not be overlooked. While there may be a clear need and want for measures of well-being at the county-level using 1-year data, there is a tradeoff. The PUMA rates may lack utility, but they do come directly from the data without the need for any transformations or assumptions. The county rates have tremendous utility, but most are based on a PUMA-level rate crosswalked to a county-level rate based on an assumption about the relationship between OPM rates at the county and PUMA levels.

III. Results

a. Comparison of PUMA-level map to County-level map

In this section, SPM rates are displayed on a U.S. map at the PUMA level (Figure 1) and at the county level (Figure 2). SPM rates and standard errors are published in an excel table accompanying this paper. The same five SPM rate categories are used in each figure to facilitate comparisons. The most noticeable difference in the figures is the size of the geographic units. PUMAs are created to partition states into areas that contain at least 100,000 people, while about 80 percent of counties contain less than 100,000 people.

[9] Refer to Appendix for how to calculate standard errors.

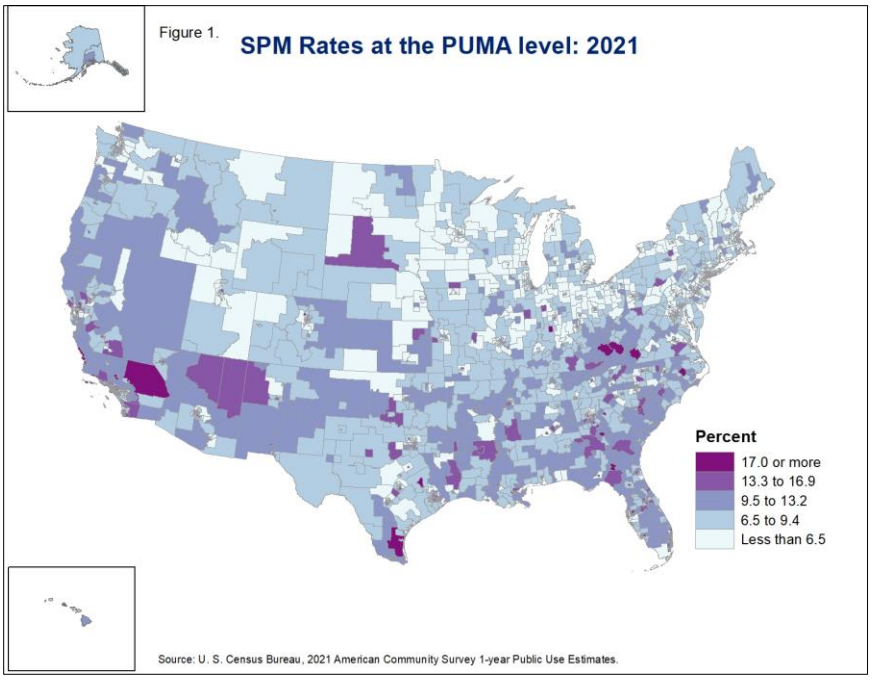
Figure 1.
SPM Rates at the PUMA level: 2021
Percent
17.0 or more
13.3 to 16.9
9.5 to 13.2
6.5 to 9.4
Less than 6.5
Source: U. S. Census Bureau, 2021 American Community Survey 1-year Public Use Estimates.

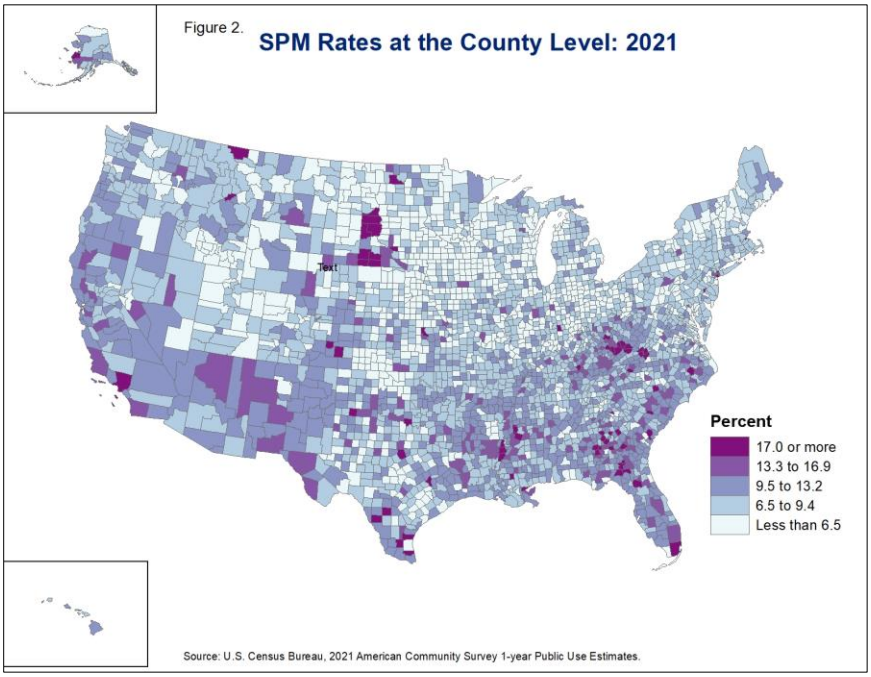
Figure 2.
SPM Rates at the County Level: 2021
Text
Percent
17.0 or more
13.3 to 16.9
9.5 to 13.2
6.5 to 9.4
Less than 6.5
Source: U.S. Census Bureau, 2021 American Community Survey 1-year Public Use Estimates.

In Table 1, the percent of PUMAs and counties in each SPM rate category and the percent of the population in PUMAs and counties in each SPM rate category from Figures 1 and 2 are shown. PUMAs represented populations at the extremes: a person was more likely to be living in a PUMA in the highest poverty category than a county in the highest poverty category or in a PUMA in the lowest poverty category than in a county in the lowest poverty category.

Table 1. Percent of Geographic Areas and Percent of Population in Geographic Areas in Each SPM Rate Category

	Percent of geographic areas			Percent of population		
SPM rates (percent)	**PUMAs**	**Counties**	**Difference**	**PUMAs**	**Counties**	**Difference**
17.0 or more	8.46%	2.90%	5.57	8.41%	6.82%	1.59
13.3 to 16.9	10.04%	6.87%	3.17	10.10%	8.53%	1.56
9.5 to 13.2	25.86%	24.47%	1.39	25.80%	30.23%	-4.43
6.5 to 9.4	31.39%	36.53%	-5.13	31.59%	39.13%	-7.54
Less than 6.5	24.25%	29.24%	-4.99	24.10%	15.28%	8.82

Source: U.S. Census Bureau, 2021 American Community Survey, 1-year Public Use estimates.

b. Inter-geographic relationship check

A key assumption is made that the relationship between county and PUMA for the OPM rates is similar for the SPM rate. To validate this inter-geographical relationship assumption, ratios of PUMA to state OPM and SPM populations from the 2021 ACS 1-year public use estimates are compared.

Table 2 shows the average ratios of the number of people in poverty in a PUMA to the number of people in poverty in the state where the PUMA is located. While on average the number of people in poverty in a PUMA, both OPM and SPM, is approximately 2.3 percent of the number of people in poverty in the state, OPM ratios range from 0.04 percent to 45.93 percent while the SPM ratios range from 0.06 percent to 50.85 percent. The difference in OPM and SPM PUMA to state ratios is approximately 0.01 percentage points on average, but it ranges from -7.11 percentage points (OPM ratio higher than SPM) to 10.50 percentage points (SPM ratio higher than OPM). This shows that overall the assumption needed for this methodology to work holds.

Table 2. Average Ratios of PUMA to State Poverty Populations: 2021

	Estimate	Standard error
SPM	2.27%	0.66
OPM	2.26%	0.58
Difference (SPM less OPM)	0.01	0.88

Source: U.S Census Bureau, 2021 American Community Survey, 1-year Public Use estimates

In Table 3, there is a more detailed breakdown in PUMA to state poverty ratios. In about 18 percent of PUMAs, the OPM ratio was significantly different from the SPM ratio. In approximately 10 percent of PUMAs, the OPM ratio was higher than the SPM ratio, while the SPM ratio was higher than the OPM ratio in about eight percent of PUMAs.

While this seems like a lot of significant differences, most of the ratio differences were small. The difference in ratios was one percentage point or higher in only about 4.4 percent of PUMAs and the difference was two percentage points or higher in only about 1.5 percent of PUMAs. Table 3 is further evidence that the underlying assumption holds.

Table 3. Significant Differences in Ratios of PUMA to State Poverty Populations: 2021

	SPM ratio higher		OPM ratio higher		Total	
	Number of PUMAs	Percent of total PUMAs	Number of PUMAs	Percent of total PUMAs	Number of PUMAs	Percent of total PUMAs
Any difference	191	8.12%	238	10.12%	429	18.25%
At least 1 pp difference	39	1.66%	65	2.76%	104	4.42%
At least 2 pp difference	16	0.68%	19	0.81%	35	1.49%

Source: U.S. Census Bureau, 2021 American Community Survey, 1-year Public Use estimates.

c. Weighted national averages

In Table 4, three national averages are shown for the SPM, OPM, and Multidimensional Deprivation Index (MDI). The MDI is a measure of well-being that takes both income and non-income based measures into account. It has 6 dimensions: standard of living, education, health, economic security, housing quality, and neighborhood. In order to be considered multidimensionally deprived, a person must face deprivation in at least 2 of these dimensions.[10]

National averages are computed in three ways. The national average is calculated from the micro data using population weights. The county rate uses the county rates calculated from the methodology in this paper. In order to get a national rate, each county rate is multiplied by the county population, summed up, and divided by the total U.S. population. The same method is used to get a national rate using PUMA rates.

The main finding is that whether using the SPM, OPM, or MDI, there was no significant difference in rates between national averages no matter how the average is calculated. This is an important result because the county results are post implementation of the county methodology and the PUMA results and national results are pre implementation of the county methodology.

Table 4. Comparison of National Averages: 2021

	County		PUMA		National	
	Estimate	Standard error	Estimate	Standard error	Estimate	Standard error
SPM	9.87	1.09	9.80	1.66	9.73	0.04
OPM	12.77	0.75	12.66	1.97	12.60	0.06
MDI	16.42	1.73	16.24	1.99	16.13	0.05

Source: U.S. Census Bureau, 2021 American Community Survey, 1-year Public Use estimates.

[10] For more information, refer to https://www.census.gov/content/dam/Census/library/working-papers/2021/demo/sehsd-wp2021-03.pdf.

d. Checks against comparable methods

In Table 5, the OPM rates and SPM rates are calculated using two methods. The population method is the method used in this paper to calculate county-level poverty rates. The comparison method is different for the two poverty rates. For the SPM rate, the comparison method is similar to the population method except that all counties within a PUMA are assigned the same poverty rate as the PUMA. For the OPM rate, the comparison method is SAIPE OPM estimates.

In both cases, the county-weighted national average poverty rates were not significantly different when using the population method or the comparison method. Furthermore, the SPM population and comparison methods and the OPM population and comparison methods were highly correlated with each other.

Table 5. County-Weighted National Averages By Different Methods: 2021

	Population method		Comparison method		Correlation	
	Estimate	Standard error	Estimate	Standard error	Estimate	Standard error
SPM	9.87	1.09	9.85	0.98	0.7601	0.0107
OPM	12.77	0.75	12.80	1.77	0.8650	0.0096

Source: U.S. Census Bureau, 2021 American Community Survey, 1-year Public Use Estimates and 2021 SAIPE estimates.

e. Compare against well-being measures

In Table 6, simple correlations (r) are shown for 7 measures of county-level well-being. The SPM, OPM, and MDI rates are all calculated using the methodology from this paper. The labor force participation (LFP) rate, unemployment rate, uninsured rate, and lack of internet access in the household rate are all available at the county level from the 2021 5-year ACS estimates on data.census.gov.

As a means of discussion, a strength of relationships rule of thumb is borrowed from The Basic Practice of Statistics by Moore et. al (2013): $r < 0.3$ (none or very weak); $0.3 < r < 0.5$ (weak); $0.5 < r < 0.7$ (moderate); $r > 0.7$ (strong).[11]

The county SPM rates have a strong positive correlation with county OPM rates, a moderate positive correlation with county MDI rates and county SAIPE rates, a weak positive correlation with the county unemployment rate and lack of internet access rate, and a weak negative correlation with the county labor force participation rate.

The county OPM rates have a strong positive correlation with the county MDI rates and the county SAIPE rates, a moderate positive correlation with the county unemployment rate and lack of internet access rate, a weak positive correlation with the county uninsured rate, and a moderate negative correlation with the county labor force participation rate.

[11] In this case, r refers to the absolute value of the correlation coefficient.

The county MDI rates have a strong positive correlation with the county SAIPE rates, a moderate positive correlation with the lack of internet access rate, a weak positive correlation with the county unemployment rates and county uninsured rates, and a weak negative correlation with the county labor force participation rate.

Table 6. Simple Correlations of County Well-being Measures: 2021

	SPM	OPM	MDI	SAIPE	LFP	Unemployment rate	Uninsured rate	No internet access
SPM	1	0.82	0.56	0.68	-0.40	0.47	0.24	0.34
OPM		1	0.77	0.87	-0.56	0.54	0.33	0.56
MDI			1	0.75	-0.49	0.44	0.47	0.57
SAIPE				1	-0.66	0.58	0.36	0.66
LFP					1	-0.39	-0.26	-0.60
Unemployment rate						1	0.13	0.31
Uninsured							1	0.35
No Internet access								1

Note: LFP = labor force participation rate.
Source: U.S. Census Bureau, 2021 American Community Survey, 1-year Public Use estimates, 2021 American Community Survey, 5-year estimates, and 2021 SAIPE Estimates.

IV. Conclusion

Sub-state estimates of poverty, both the OPM and SPM, are already available at the PUMA-level using 1-year data. While helpful, PUMAs lack utility in that they are statistical entities. Therefore, most people do not know what PUMA they live in and government agencies and services act at the county level rather than the PUMA level. Furthermore, poverty rates using the OPM are available at the county-level using 5-year data currently. There is a clear need and want for measures of well-being at the county-level using 1-year data. Another use of county-level rates is validation of the ACS SPM methodology. There are numerous well-being measures and economic indicators available at the county-level, and not at the PUMA-level, that may be able to be used to validate county SPM estimates.

In this paper, a new method is proposed to create county-level SPM estimates from PUMA-level SPM estimates. A number of checks are performed to validate this method. A main assumption of the method that inter-geographic relationships (county to PUMA) for the SPM are the same for the OPM was supported with similar PUMA to state relationships. Weighted national averages of counties or PUMAs for the OPM, SPM, and MDI were not significantly different. Furthermore, weighted national averages for the OPM and SPM were not significantly different than relevant comparison methods. Finally, the OPM, SPM, and MDI county rates were correlated with each other and with a selection of other measures of county well-being. In sum, this method does a good job of creating county-level SPM rates from PUMA-level SPM rates.

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Appendix

Steps to calculate standard errors for counties within a PUMA

a. The county OPM rate is multiplied by the county population to get the number of people in official poverty in the county.
    i. The standard error for the county OPM rate is multiplied by the county population.

b. The county official poverty populations within a PUMA are added together to get the PUMA official poverty population.
    i. Standard errors from a.i. are added together using the formula: SE(A+B) = sqrt[SE(A)^2+SE(B)^2].

c. The county official poverty population is divided by the PUMA official poverty population to get the percent of a PUMA official poverty population in each county.
    i. Following formula is used: (1/PUMA official poverty population)*sqrt[(a.i.)^2+(county official poverty population/PUMA official poverty population)^2*(b.i.)^2]

d. The number of people in SPM poverty in each PUMA is multiplied by the percent of a PUMA official poverty population in each county to get the number of people who are SPM poor in each county.
    i. Following formula is used: sqrt[(c.i.)^2*(PUMA SPM rate)^2+(percent of PUMA official poverty population in each county)^2 *(standard error of PUMA SPM rate)^2]* (PUMA population)

e. The number of people who are SPM poor in each county is divided by the county populations to get the county SPM rate.
    i. d.i. is divided by the county population