*Journal of Survey Statistics and Methodology (2022) **00**, 1–20*

INTEGRATING ADMINISTRATIVE AND SURVEY DATA TO ESTIMATE WIC ELIGIBILITY AND ACCESS

LINDEN MCBRIDE*
THOMAS B. FOSTER
RENUKA BHASKAR
MARK PRELL
MARIA PEREZ-PATRON
ERIK VICKSTROM
BRIAN KNOP
MICHAELA DILLON

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) provides benefits to low-income, nutritionally at-risk women, infants, and children. To administer WIC, officials and program managers at the federal and state levels want to understand who is eligible for the program, who among the eligible population chooses to

LINDEN MCBRIDE is a Research Economist, THOMAS B. FOSTER is a Senior Sociologist, AND RENUKA BHASKAR is a Survey Statistician with the US Census Bureau, Center for Economic Studies, 4600 Silver Hill Rd, Washington, DC 20233, USA. MARK PRELL is a Senior Economist with the US Department of Agriculture, Economic Research Service, 1400 Independence Ave., SW, Mail Stop 1800, Washington, DC 20250-0002, USA. MARIA PEREZ-PATRON is a Statistician/Demographer, ERIK VICKSTROM is a Supervisory Survey Statistician, BRIAN KNOP is a Survey Statistician, AND MICHAELA DILLON is a Research Economist with the US Census Bureau, Center for Economic Studies, 4600 Silver Hill Rd, Washington, DC 20233, USA.

We are grateful to the Alabama, Arizona, Colorado, Connecticut, Idaho, Illinois, Indiana, Kansas, Maine, Michigan, Montana, Oklahoma, Pennsylvania, South Dakota, Utah, and Wisconsin state WIC agencies for providing the data that supported this research. We are additionally grateful to Grant Lovellette, Nikolas Pharris-Ciurej, Joan Agostinelli, and the Alabama, Arizona, and Oklahoma state WIC agencies for invaluable reviews and feedback. All errors are our own.
Any views expressed are those of the authors and not those of the US Census Bureau. The findings and conclusions in this publication are those of the authors and should not be construed to represent any official USDA or US Government determination or policy.
The Census Bureau's Disclosure Review Board and Disclosure Avoidance Officers have reviewed this information product for unauthorized disclosure of confidential information and have approved the disclosure avoidance practices applied to this release: CBDRB-FY2022-CES005-009, CBDRB-FY22-CES014-049, CBDRB-FY19-167, CBDRB-FY19-575, CBDRB-FY20-154, and CBDRB-FY21-108.
*Address correspondence to Linden McBride, US Census Bureau, Center for Economic Studies, 4600 Silver Hill Road, Washington, DC 20233, USA; E-mail: linden.mcbride@census.gov.

https://doi.org/10.1093/jssam/smac035
Published by Oxford University Press on behalf of the American Association for Public Opinion Research 2022.

participate, and who is not accessing the program despite their eligibility. Novel individual-level data linkages between restricted-use WIC Administrative Records and the American Community Survey provide WIC access rates estimated at the state and county levels, as well as estimates disaggregated by the demographic and socioeconomic characteristics of individuals and their households. These estimates are developed by the Census-FNS-ERS Joint Project, a research partnership among the US Census Bureau, the US Department of Agriculture's Food and Nutrition Service and Economic Research Service, and state WIC agencies that provide the requisite WIC administrative data to the Census Bureau. This article details and evaluates our current data linkage and estimation methods, reports results, and identifies areas for improvement and further research.

KEYWORDS: Administrative data; Data linkage; Methods; Program participation; Survey data; WIC.

Statement of Significance

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is the country's third-largest food and nutrition assistance program, receiving nearly $6 billion in funding and serving approximately 6 million women, infants, and children annually. Key research issues for WIC administration include who is eligible for WIC, who accesses WIC, and who does not participate and why. This article is the first to document methods developed by the Census Bureau and the US Department of Agriculture's Food and Nutrition Service and Economic Research Service (i) to link WIC Administrative Records with American Community Survey data and (ii) to use the novel linked dataset to estimate WIC eligibility and access rates for infants and children at the state and sub-state levels; without the linked data, such estimates are not available at the sub-state level. This article will serve as a resource for both researchers and administrators of WIC programs.

1. INTRODUCTION

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is administered by the US Department of Agriculture (USDA) Food and Nutrition Service (FNS). Through this program, USDA FNS provides federal

grants to US states and territories to support "supplemental foods, health care referrals, and nutrition education for low-income pregnant, breastfeeding, and non-breastfeeding postpartum women, and to infants and children up to age five who are found to be at nutritional risk" (USDA FNS 2021a). WIC is the third-largest food and nutrition assistance program in the United States, after the Supplemental Nutrition Assistance Program (SNAP) and the National School Lunch Program. WIC receives approximately $6 billion of federal funding each year and is a cost-effective nutrition program (Carlson and Neuberger 2021; USDA FNS 2021b). WIC participation is associated with improved birth and childhood outcomes (Bitler and Currie 2005; Hoynes et al. 2011).

Approximately every year, FNS provides national- and state-level estimates of WIC eligibility and access. These estimates help FNS predict national- and state-level funding needs, measure WIC performance, and identify coverage gaps among different demographic groups (Gray et al. 2022a). The most recent national[1] assessments indicate that 11.0 million people, or 42.2 percent of the population of pregnant/postpartum women, infants, and children under age 5, were eligible for WIC benefits on an average month in 2019 (Gray et al. 2022a). Of those eligible, 57 percent, or 6.3 million people, accessed benefits, with uptake differing for women, infants, and children. While 98 percent of eligible infants and 85 percent of eligible postpartum women accessed WIC benefits, only 45 percent of eligible children and 52 percent of eligible pregnant women did so (Gray et al. 2022a).

These estimates, provided by FNS, are comprehensive across WIC participation categories in that they include estimates of the eligibility and access rates of infants, children, and pregnant and postpartum women at both state and national scales, including US territories. However, due to limitations in the source data, these estimates offer limited insight into whether and how WIC eligibility and access rates vary within states, for example, across counties or other sub-state geographies, or by the demographic and socioeconomic characteristics of individuals and their households. To better understand WIC eligibility and participation patterns, which can support state and local efforts to provide outreach to eligible populations, such statistics and analyses are needed at the sub-state level.

The Census Bureau, FNS, and the Economic Research Service (ERS), the social science research arm of USDA, formed a joint project to acquire restricted-use WIC administrative data from state WIC agencies and to link the administrative data on WIC participants with survey data from the American Community Survey (ACS) at the individual level. These novel data linkages allow for the estimation of eligibility and access rates for infants and children[2]

1. These estimates include US territories American Samoa, Guam, the Northern Mariana Islands, Puerto Rico, and the US Virgin Islands.

2. A limitation of the data and the current methodology is that they do not support estimation of eligibility among pregnant and postpartum women; the ACS does not include items that collect

at the state and county levels for selected states, as well as disaggregated estimates by the demographic and socioeconomic characteristics of individuals and their households. These estimates are designed to complement FNS estimates.

The estimation of WIC eligibility and access rates is one effort among many at the Census Bureau that leverages the complementary strengths of administrative and survey data through data linkage. Other recent examples include a study that uses linked administrative and survey data to examine excess mortality rates during the COVID-19 pandemic (Foster et al. 2022) and a collaboration with the US Department of Housing and Urban Development to evaluate the potential of property tax records to improve housing surveys (Binder et al. 2022).

The objectives of this article are to detail our current data linkage and estimation methods and to report WIC eligibility and access rates for the 16 states that shared data with the Census Bureau in 2019. Results are reported at the state level and, within a state, by selected demographic characteristics.

In the next section, we describe the data available for estimating the eligibility and access rates of infants and children at the state and sub-state levels. We then summarize rules governing WIC eligibility. These eligibility rules guide our approach to estimating WIC eligibility and participation. We then detail our estimation methods and report results for 16 states along with detailed results and data visualizations for two states, Arizona and Wisconsin. Finally, we conclude with plans to improve our methodology.

2. DATA

The Census Bureau receives WIC administrative records (ARs) detailing monthly participant information from state partners with whom we have established data sharing agreements. In 2019, the year for which results are shared in this article, we had data sharing agreements with Alabama, Arizona, Colorado, Connecticut, Idaho, Illinois, Indiana, Kansas, Maine, Michigan, Montana, Oklahoma, Pennsylvania, South Dakota, Utah, and Wisconsin. Efforts to establish new state partners are ongoing.

States exercise their own discretion when negotiating agreements and sharing data with the Census Bureau, but certain information is required to implement our methodology, facilitate individual-level linkages across datasets, and distinguish WIC participants in the ARs from non-participants. First, our methodology requires at least two successive years of WIC ARs to produce state-level estimates and at least four successive years of WIC ARs to produce county-level estimates. Second, individual-level linkages between WIC ARs

direct information on pregnancy and/or breastfeeding behaviors. Estimates of WIC participation (as distinct from access) rates are developed as a research product by the Census; however, in this article, we focus on the estimation of eligibility and access rates for infants and children.

and the ACS require the assignment of unique, anonymous Protected Identification Keys (PIKs). PIKs are assigned to both WIC ARs and ACS respondents by the Census Bureau's Person Identification Validation System (PVS) (Wagner and Layne 2014) using Personally Identifiable Information (PII) such as names, dates of birth, and Social Security Numbers (SSNs). Once PIKs are assigned, and before researchers gain access to the data, PII is stripped to protect the anonymity of individuals in the ARs. Third, we require some indicator or method for distinguishing active participants from any non-participants that may be included in the WIC ARs. We often use benefits issued, received, or redeemed, depending on what is available, as an indicator of participation, but some states opt out of sharing benefits information and, instead, include variables flagging active participants or simply restrict the data to WIC participants. We are currently working with states to ensure that we are correctly identifying participants in the data they send.

Once data sharing agreements are reached, numerous data quality checks are made by the data ingest team as the WIC AR data are securely transferred to the Census Bureau, PVS processed, and cleaned and standardized by researchers prior to estimating eligibility and participation. When data are received, the ingest team ensures that the necessary variables are included on the ARs and that case/client counts on the received files are consistent with expectations. Once ingested, WIC ARs are passed to the PVS team, which assigns PIKs to individuals found in the ARs and scrubs the ARs of the PII used to assign PIKs. It should be noted that the timing of the data ingest process and availability of reference data used in the PVS process affects the PVS team's ability to assign PIKs particularly for infants for whom reference data are not yet available. Lower PIK rates for infants relative to older children may lead to underestimates of access rates for this age group and the Census Bureau is investigating improving PIK rates for infants by delaying the PVS process for these files.

Finally, Census Bureau researchers gain access to the WIC ARs and, prior to estimating eligibility and access rates, benchmark the state-level monthly counts of infants and children present in the AR file against publicly available counts published by FNS ("WIC Data Tables" 2022) to confirm that the WIC ARs include the full universe of WIC participants; such a benchmarking table, comparing the average and standard deviation of monthly AR and FNS counts in 2019, is available as table C9 in the supplementary material online. Where the WIC AR data and FNS data differ, the differences are often accounted for by AR data availability and our data cleaning practices in light of data availability. Following the Code of Federal Regulations 7 CFR Part 246.2 (2011), FNS counts "those who were enrolled in WIC and claimed their benefits" (Gray et al. 2022a, p. i) as participants, where "claimed" means that the individual has received their WIC benefits but does not necessarily mean that the benefits have been redeemed. However, the data we receive from states sometimes include a participant flag, sometimes include all enrollees without other

indicators of participation, and sometimes include data on the issuance, receipt, and/or redemption of benefits. On a state-by-state basis, we identify participants by using the indicators within each dataset suggesting that an individual has enrolled in WIC and claimed their benefits, with the overall goal of bringing our counts closer in line with the published counts provided by FNS. Although data availability differs by state, we are working to harmonize the data cleaning practices across states. At a minimum, when benchmarking the AR data, we ensure that the AR data follow the same trends as the FNS data over time, even if there is a gap between our data sources in the number of participants. If data quality issues surface during the data ingest process, the Census Bureau works iteratively with state data providers to address them and begins the data processing and quality assessments again.

As a result of this ingest process, the AR data we receive from the state WIC agencies and ultimately use for estimation are of high quality in terms of completeness and accuracy. The AR data include monthly WIC participants for a state over a two-year period and provide the detail necessary to both determine participation status and facilitate individual-level linkages across data sources. It should be noted, however, that state AR data do not capture those individuals who receive WIC benefits through Indian Tribal Organizations (ITOs) because ITOs have their own administrative systems and function as their own independent state-level agencies. Therefore, in some cases, we may underestimate the access rates of eligible groups due to our inability to observe their access in the AR data.[3] Aside from this limitation, the AR data have high accuracy and reliability: unlike measures of WIC participation rooted in survey measures, the AR data are not subject to recall errors. In addition, the PVS process ensures the confidentiality and anonymity of WIC recipients, and the data sharing agreements ensure that the final statistical research products are timely and relevant to the states with which we work.

Our statistical goal in acquiring the AR data is to estimate WIC access[4] rates. The WIC access rate, as detailed below, is the percentage of those participating in WIC out of those estimated to be eligible. The AR data register WIC participants; the AR data do not provide information about the nonparticipating WIC-eligible population. They also contain limited information on the demographic characteristics, such as race and ethnicity, of participating individuals. Therefore, to estimate WIC access rates, and to do so at the sub-

3. For example, in table 1, the Non-Hispanic American Indian and Alaska Native (NH AIAN) group in Arizona has low access rates relative to eligibility rates; this is due to the fact that we receive data only from the Arizona Department of Health Services WIC program and not from the Navajo or Inter-Tribal Council of Arizona WIC program.

4. In general terms, a WIC access rate parallels what is defined by FNS as a "coverage rate," the share of the eligible population "covered" or served by WIC. In our estimates, we use the term "access rate" in part to distinguish how the linkage-based methodology of obtaining an access rate differs fundamentally from other methods that have been used to estimate WIC coverage rates.

state level, it is necessary to combine state ARs with a data source that captures the broader population. For this purpose, we rely on the ACS.

The ACS is an ongoing, nationally representative survey of US households. The ACS collects data on household and individual characteristics, including age, sex, race, ethnicity, income, participation in social protection programs, and household and family structure. We use the restricted-use ACS data in conjunction with the WIC AR to estimate WIC eligibility among infants and children under five years of age. Importantly, the ACS collects data throughout the year. As a result, state-level estimates for 2019 make use of survey data collected from January 2019 through December 2019; for estimates at the county level, we combine three years' worth of ACS data (US Census Bureau 2017).

As noted above, the AR data received from states are linked at the individual level with ACS responses using PIKs. The average of state-level WIC AR PIK rates was 95 percent in 2019 and the average of state-level ACS PIK rates was 96 percent in 2019.[5] Because our access rates depend on AR-ACS data linked via PIK, if PIKs are not missing at random, then PIK missingness is likely to bias our estimates. In fact, prior research has shown that PIK missingness is correlated with observable characteristics such as race, ethnicity, education, income, English language ability, employment status, and citizenship status (Bond et al. 2014). To address these biases in PIK assignment in the ACS, we use a probit model to estimate the probability of PIK assignment as a function of relevant observable characteristics.[6] The product of the inverse probability of having a PIK and the ACS weights provide PIK-adjusted survey and replicate weights that are applied to our estimates. This process serves to upweight observations with characteristics that are less likely to receive a PIK, thereby increasing the representativeness of our linked AR-ACS sample.[7] Table C10 in the supplementary material online demonstrates the extent to which these weighting schemes upweight the linked AR-ACS data. The second column of table C10 (WIC AR) shows the raw AR counts for 2018–2019. The subset of these AR data that can be linked to the ACS is linked, and ACS weights are applied to the linked data in column 3 (ACS weighted). Comparison of the

5. Disclosed under delegated authority CBDRB-FY2022-CES005-009.

6. The probabilities are estimated via probit models, with the child model specified as Pr(PIK|race, ethnicity, age, poverty status, intra-state, and inter-state migration status) and the adult model specified as Pr(PIK|race, ethnicity, age, poverty, education, marital status, English ability, intra-state, and inter-state migration status).

7. Our objective in reweighting the linked ACS estimates by 1/Pr(PIK) is to correct for the bias that is introduced by the fact that certain demographic groups are less likely to have a PIK than other demographic groups. An alternative approach such as post-stratification based on control totals would not work in this setting, as we are estimating an unknown population distribution from the available data. It should be noted that the sampling and replicate weights we use for our estimates produce statistics that are representative of the state population living in housing units and not that living in group quarters (e.g., prisons, nursing homes, college dorms, and shelters).

ACS weighted and WIC AR columns shows that, absent any accounting for the probability of being assigned a PIK, the ACS weights alone provide a serious underestimate of the WIC participating population. In the final column (adjusted ACS weighted), the PIK-adjusted weights are applied, bringing the linked data closer in count to the AR data, of which it is an estimate.

Note that, while we correct for missingness in PIK assignment in the ACS, we are unable to do so in the AR due to the fact that the correlates of PIK assignment are inconsistently available within and across states. Assessing the extent to which the PIK assignment process impacts the representativeness of our estimates, especially among demographic subgroups, is an objective for future research.

3. ESTIMATION

3.1 WIC Eligibility Criteria

To qualify for WIC, categorical, residential, income, and nutritional criteria must be met (USDA FNS 2020). Federal guidelines for categorical eligibility include women who are pregnant or postpartum (within the sixth month of birth if not breastfeeding, and within the twelfth month of birth if breastfeeding), infants through the end of the month they turn one, and children through the end of the month they turn five. Residential eligibility requires only that applicants live in the state or territory where they apply; there is no length of residence or citizenship requirement for residential eligibility (USDA FNS 2020). Income eligibility is met if household income falls at or below 185 percent of the Federal Poverty Line, as set annually by the Department of Health and Human Services. Individuals are considered adjunctively income-eligible for WIC if they participate in Medicaid, SNAP, or Temporary Assistance for Needy Families (TANF) (Gray et al. 2022a); adjunctive eligibility means that an individual is "automatically" income-eligible for WIC based on participation in another means-tested program. In addition, some individuals are adjunctively income eligible if other household members are eligible for Medicaid or TANF. The nutritional requirement entails assessment by a competent professional authority who can determine that the individual is at "nutrition risk" based on either medical or dietary conditions (USDA FNS 2020). Medical conditions can include anemia, being underweight, or having had poor pregnancy outcomes in the past; dietary conditions include a poor diet as defined by failure to follow USDA dietary guidelines. Standards and implementation differ by state agency (National Research Council 2003).

The criteria above are set at the federal level, but states may relax or restrict these criteria at their discretion, within certain limits. For example, states may exercise discretion with respect to both the time scale over which they consider household income (weekly, monthly, annually) and the extent to which they

consider various members of the household as contributing to household size (National Research Council 2003). Furthermore, adjunctive eligibility rules may differ by state. For example, Minnesota includes as adjunctively eligible those who are participating in the Minnesota Family Investment Program, the Energy Assistance Program, Reduced or Free School Lunch, and Head Start in addition to Medicaid, SNAP, and TANF ("Am I Eligible for WIC?" 2021).

Given the multifaceted nature of WIC eligibility criteria and the potential for state-level variation in thresholds, it can be challenging to accurately estimate eligibility. Ultimately, individual eligibility determinations can be made only by program administrators. Because of the difficulties inherent in detailing and implementing state-specific eligibility criteria, we default to federal eligibility guidelines when estimating eligibility among infants and children in the ACS, as detailed below. In describing our methods, we highlight any necessary deviations from the federal rules and make clear where we make approximations or assumptions, as well as any associated biases that might be introduced therein.

In general, the methods we follow are adapted from earlier methods developed by ERS to estimate SNAP eligibility and access rates (Newman and Scherpf 2013). We estimate eligibility in the ACS based on the eligibility criteria as follows.

3.1.1 Categorical criteria.

We first use age information from the ACS to identify infants and determine whether children meet the categorical eligibility requirement of being under the age of five.

3.1.2 Residential criteria.

We use locations reported in the ACS to determine state of residence, and we assume that all members of an ACS household are residents of that state. This approach is aligned with federal eligibility requirements in that there are no length of residence requirements for WIC eligibility.

3.1.3 Income criteria.

To estimate income eligibility, we aggregate incomes across all individuals in an ACS household, except when multiple families are present in a household, in which case we aggregate income in that subfamily. ACS respondents are asked to reference the previous 12 months when reporting annual income, and we sum income from the following sources when calculating total subfamily income: wages and salary income; self-employment income; interest, dividends, and net rental income; Social Security and retirement income; Supplemental Security income; and any payments from public assistance or welfare payments. If total income falls below 185 percent of the federal poverty line, we consider all infants and children in that ACS household (or

subfamily) eligible for WIC. Following federal eligibility guidelines, we update our income eligibility thresholds annually.

The ACS item that collects income information asks for income received "over the previous 12 months" rather than in a particular calendar year. Income reported for a 12-month period does not capture month-to-month fluctuations in income within that period. Therefore, it is likely that our approach—relying on 12-month income as self-reported in the ACS to estimate income eligibility—results in an underestimate of income eligibility because a household that is income-eligible for WIC for only a portion of the 12 months may not be captured by the 12-month data. In addition, in estimating state and national eligibility rates, FNS found that failure to account for state-level differences in WIC certification periods (whether one must recertify every 6 or every 12 months) and monthly income fluctuations led to an underestimate of eligibility of infants and children. Relying on monthly income data from the Survey of Income and Program Participation (SIPP), FNS has generated adjustment factors to correct for these underestimates (Gray et al. 2022a, 2022b). We do not currently make such adjustments but investigating use of adjustment factors is an objective of future work.

We identify the adjunctively income-eligible population using ACS responses detailing participation in Medicaid, SNAP, and TANF. As noted above, some states also deem individuals adjunctively eligible via participation in other state-level programs (e.g., Minnesota's Family Investment program), but we lack these data and do not attempt to make eligibility determinations on this basis; however, households participating in these programs with annual incomes below 185 percent of poverty are likely included in our eligibility criteria based on their income.

3.1.4 Nutritional criteria.

The ACS includes no items that allow for an assessment of nutritional need, so we assume that all infants and children meeting one or more of the eligibility criteria above also meet the nutritional criteria. In practice, the nutrition requirement is nearly always met by otherwise eligible individuals based on the inadequacy of their diets (Bitler et al. 2003; National Research Council 2003). In fact, a 2002 report by the Institute of Medicine (IOM) on dietary risk assessment in the WIC program commissioned by FNS recommended that "all women and children (ages 2–5 years) who meet the eligibility requirements of income, categorical, and residency status [can be presumed to] also meet the requirement of nutrition risk" on the basis of failure to meet dietary guidelines (Institute of Medicine (US) Committee on Dietary Risk Assessment in the WIC Program, 2002, p. 9). Despite the nearly universal nutritional risk among those otherwise eligible, state and sub-state agency screening on the basis of nutritional risk is highly heterogeneous, as most states use locally developed or adapted screening tools (Institute of Medicine (US) Committee on Dietary

Risk Assessment in the WIC Program, 2002). The 2002 IOM report found that screening practices ranged "from a blank box in which an individual could write her recollection of what was eaten the previous day to a four-page food frequency questionnaire that would allow a computer-generated summary of the dietary analysis" (p. 30). Both because our data do not allow us to capture this local heterogeneity, and because there is evidence that the otherwise eligible population meets the nutritional criteria, we do not exclude from our eligibility estimates any infants or children on the basis of not meeting these criteria, which may result in a minor overestimate of eligibility.

3.1.5 Other criteria.

Because we default to federal guidelines and do not attempt to capture state and local variation in eligibility criteria, our estimation of eligibility can miss infants and children who are eligible for WIC benefits. Moreover, young children tend to be undercounted in censuses and surveys. Therefore, any infant or child not flagged as eligible in the ACS data but found to be in receipt of benefits in the WIC ARs is categorized as eligible for our estimates.

3.2 Estimating WIC Eligibility and Access Rates

We calculate the WIC eligibility rate for a state as the estimated number of *WIC-eligible* infants and children relative to the estimated *total number* of infants and children in the state:

$$\text{WIC eligibility rate} = 100\times \frac{\text{estimated WIC eligible infants and children in the ACS or in ARs}}{\text{estimated number of infants and children in the ACS}}$$

The denominator, the number of infants and children in a state, is estimated from the ACS using ACS weights. The numerator, WIC eligibility, is estimated as described above; note that the estimates of eligible infants and children in the numerator include some infants and children who were participating in WIC in the WIC ARs, even though they were not estimated to be eligible by eligibility rules applied to available survey data.

To calculate WIC access rates for a given state for infants and children, we first link, via PIK, estimated-eligible individuals from year y ACS to the WIC ARs from year $y-1$ and y. Those individuals successfully linked across the two sources are considered eligible participants, while those who cannot be linked are considered eligible non-participants.

As noted above, the ACS reference period for income is the previous 12 months (rather than a calendar year) and the ACS respondents for a given year can be surveyed in any month of the year. Together, these survey conditions mean that across all ACS respondents, the 12-month reference period for income includes months that straddle two calendar years. For example, an ACS respondent in January 2019 reports income for the previous 12 months of

January 2018 through December 2019. An ACS respondent in December 2019 reports income for November 2018 through November 2019. Therefore, the 2019 ACS includes income-reporting periods that stretch across two years, beginning in January 2018. To ascertain if a WIC-eligible person in the 2019 ACS participated in WIC, it is necessary to check on two years' worth of WIC ARs—2018 and 2019. Therefore, a WIC access rate estimates the receipt of WIC benefits across a two-year period for anyone deemed eligible in a given calendar year.

Once ACS responses are linked to WIC ARs, we calculate access rates among infants and children within each state as the number participating over the number eligible as follows:

$$\text{WIC access rate} = 100\times \frac{\text{estimated WIC participating infants and children in ARs}}{\text{estimated WIC eligible infants and children in the ACS or in ARs}}$$

We also estimate the eligibility and access rates of infants and children by the characteristics of the infants and children, by the characteristics of the householder, and by the characteristics of the household. The householder is defined as "the person, or one of the people, in whose name the home is owned, being bought, or rented" (US Census Bureau 2022) while the household is defined as indicated above: all individuals in the ACS household or, where present, the subfamilies in the household. Infant and child characteristics include race, ethnicity, age, and sex; household characteristics include age, sex, education status, marital status, employment status, and disability status; household characteristics include household size and urban/rural household location.

3.3 County-Level Estimates

A strength of our use of ARs and our linking methodology is that it enables us to obtain sub-state estimates. Therefore, in addition to generating state-level eligibility and access rates, we estimate county-level eligibility and access rates for infants and children if at least four consecutive years of AR data are available. We produce the county-level estimates as detailed above, but link three years of 1-year ACS data with four years of AR data (instead of one year of ACS data with two years of AR data as is done for the state-level estimates).[8] Pooling the data across multiple years allows us to maintain sufficient sample sizes in small, less populated counties while also maintaining the representativeness of the data. Therefore, county-level estimates represent the average

8. In earlier versions of these estimates, we used as many as five years of ACS linked with six years of WIC AR data but currently use three years consistently to facilitate interpretation of the estimates over time.

eligibility and access rates over the three years of ACS data pooled to produce them.

3.4 Margins of Error

Each of the estimates detailed above is accompanied by a margin of error which, added to and subtracted from a given point estimate, offers a 95 percent confidence interval around that estimate that captures ACS sampling error, survey non-response, and frame issues as well as non-random variation in the likelihood of PIK assignment. We calculate the margins of error by, first, using ACS sampling and replicate person weights—adjusted by the inverse probability of PIK assignment in the ACS as a function of a set of demographic characteristics, as discussed above—to produce standard errors for each estimate. We then multiply these standard errors by the critical z-value of 1.96 to obtain the margin of error, denoted ME in the tables below. Note that the margins of error we report do not adjust for the family wise error rate.

3.5 Estimates

Using the procedures detailed above, we produce estimates of WIC eligibility and access rates for infants and children. These estimates are available as detailed state profiles, which are sent to the states with which we have data sharing agreements, as well as in the form of an online interactive data visualization tool available to the public at https://www.census.gov/library/visualizations/interactive/wic-eligibility-participation.html.

To report our results here, we take three approaches. First, estimates for all 16 states are available in tables A1–A4 in the supplementary material online; these tables display the full range of eligibility and access rates by state, and access rates by age, race and ethnicity, and by household type. Second, parts of the 2019 Arizona and Wisconsin state profiles have been reproduced in tables 1–3; these provide examples of our state profiles and are discussed in detail below. Third, screen captures of the online data visualizations for Arizona and Wisconsin are shown in figure 1 to demonstrate the interactive tool. Note that all values reported in this article have been rounded following Census Bureau disclosure avoidance rounding rules.

The 2019 Arizona and Wisconsin WIC eligibility and access rate estimates for infants and children are shown in table 1. The table's detail reflects the utility of our data linkage and estimation procedures, as these sub-state estimates are not feasible using other data sources and methods. The table shows that WIC eligibility rates are greater in Arizona than they are in Wisconsin—53.9 percent ($\pm$1.9) of infants and children are estimated to be WIC eligible in the former, but only 39.4 percent ($\pm$1.9) in the latter (Z score for null of equivalence is 10.86). However, access rates for the two states are statistically

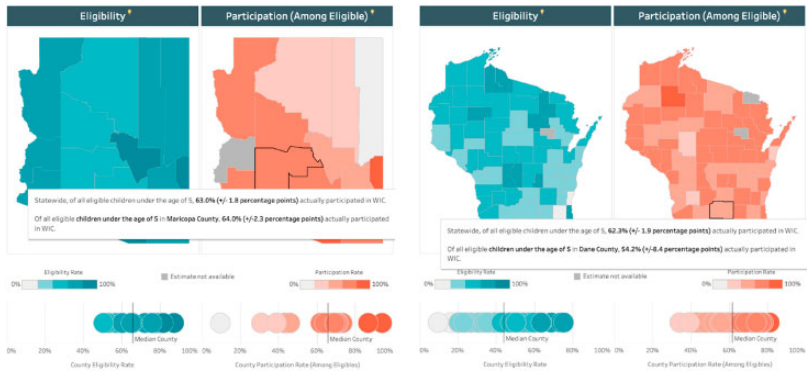

Figure 1. Data Visualization Tool: Arizona and Wisconsin.
SOURCE.—ACS (2019) and Arizona and Wisconsin WIC ARs (2018–2019). Interactive tool available online at https://www.census.gov/library/visualizations/interactive/wic-eligibility-participation.html. CBDRB-FY19-167, CBDRB-FY19-575, CBDRB-FY20-154, and CBDRB-FY21-108.

indistinguishable (61.3 ± 3.1 in Arizona; 62.3 ± 3.0 in Wisconsin; Z score for null of equivalence is 0.45). Thus, while a larger proportion of infants and children in Arizona are eligible for WIC, the states serve a similar proportion of their eligible population.

In addition, we observe that while eligibility rates do not significantly vary by age of child within each state, access rates generally fall with the child's age (see table B5 in the supplementary material online for pairwise statistical comparisons). Note that FNS reports similar trends by age of infant/child but shows consistently and precipitously decreasing coverage rates from age zero to age four, as well as lower uptake at age four than we report here (see Gray et al. 2022a, table 4.1). The differences between our linkage-based access rates and the coverage rates of FNS methodology are due, in part, to the fact that we link 2019 ACS data, which have income-reporting periods that straddle 2018 and 2019, with two years of AR data (2018–2019). As a result, our access rate estimates for, for example, one-year olds (aged 12–23 months) include WIC benefit receipt sometime during age zero years (0–11 months) and one year (12–23 months). Another source of difference may be the challenge, discussed above, of assigning PIKs to zero-year olds.

In addition to within-state heterogeneity in access rates by age of child, there is heterogeneity in eligibility rates by race and ethnicity within and across states while access rates exhibit less variation within and across states (table 1).

In table 2, we observe eligibility and access rates for infants and children, categorized by socio-demographic characteristics of the householder (in contrast to characteristics of the infant or child as seen in table 1). In both Arizona and Wisconsin, we see a U-shaped curve in eligibility rates as the householder

Table 1. Eligibility and Access Rates (%) by Infant and Child Characteristics, 2019

State	Arizona				Wisconsin			
Rate	Eligibility		Access		Eligibility		Access	
Statistic	Est	ME	Est	ME	Est	ME	Est	ME
Total	53.9	±1.9	61.3	±3.1	39.4	±1.8	62.3	±3.0
Age								
0	55.7	±4.4	68.1	±5.8	38.1	±4.8	68.4	±6.6
1	54.7	±4.0	72.1	±6.3	38.7	±4.3	77.6	±5.3
2	54.0	±3.7	57.6	±6.7	39.3	±4.0	61.8	±5.8
3	54.7	±4.3	59.9	±5.6	39.4	±3.6	59.5	±6.4
4	50.7	±3.8	50.0	±6.3	41.4	±3.6	47.5	±6.8
Race/ethnicity								
NH White	34.4	±3.0	49.7	±6.3	26.7	±2.1	53.2	±3.6
NH Black	79	±9.4	72.5	±11.9	85.7	±6.6	73.5	±7.6
NH AIAN	72.2	±8.4	11.9	±6.0	82.2	±14.7	82.2	±14.8
NH Asian	21.1	±10.7	43.3	±27.4	43.3	±11.3	67.2	±15.6
Other NH	45.4	±7.8	45.7	±12.4	55.8	±9.3	68.1	±12.8
Hispanic	68	±2.9	71.2	±3.9	68.3	±5.7	68.2	±7.9

NOTE.—MEs represent the margin of error at the 95 percent confidence level. NH indicates non-Hispanic; AIAN indicates American Indian or Alaska Native.
SOURCE.—ACS (2019) and Arizona and Wisconsin WIC ARs (2018–2019). CBDRB-FY19-167, CBDRB-FY19-575, CBDRB-FY20-154, and CBDRB-FY21-108.

increases in age, with ages 35–44 being the nadir (see table B6 in the supplementary material online for pairwise statistical comparisons). In addition, we see variation within and across the states in terms of eligibility rates by sex of householder but no statistical difference in access rates by sex within or across the states (see table B7 in the supplementary material online for pairwise statistical comparisons). In addition, the estimates suggest consistent patterns in eligibility rates by marital status (never married has the highest rate of eligibility), education (eligibility decreases with education), employment status (unemployed has the highest rate of eligibility), and disability status (householders with a disability have higher eligibility rates). Meanwhile, access rates for each of these characteristics are largely statistically indistinguishable within state and across the states (see table B8 in the supplementary material online for pairwise statistical comparisons).

Table 3 offers more information about the characteristics of households that contain infants and children who are eligible for and accessing WIC. Several patterns stand out in this table as well: larger and single/other parent

Table 2. Eligibility and Access Rates (%) by Householder's Characteristics, 2019

State	Arizona				Wisconsin			
Rate	Eligibility		Access		Eligibility		Access	
Statistic	Est	ME	Est	ME	Est	ME	Est	ME
Age of householder								
<25	83.0	±4.9	56.9	±7.1	79.7	±7.2	63.0	±9.1
25 to 34	55.2	±3.2	64.3	±4.3	40.6	±2.7	61.7	±3.9
35 to 44	39.3	±3.6	57.5	±6.7	27.0	±3.4	58.9	±7.1
45+	59.0	±7.8	64.3	±10.8	54.4	±9.4	77.5	±9.8
Sex of householder								
Male	46.5	±3.1	64.0	±4.8	31.7	±2.9	60.0	±5.3
Female	59.7	±2.8	59.6	±4.1	46.1	±2.9	63.7	±4.2
Marital status of householder								
Married	39.6	±2.3	64.2	±4.3	25.6	±1.9	58.5	±4.5
Widowed, divorced, separated	71.5	±5.4	56.2	±9.6	53.8	±7.9	62.9	±8.3
Never married	81.2	±2.8	59.4	±4.6	76.7	±3.7	65.9	±4.8
Education of householder								
< HS diploma	90	±3.6	65.8	±6.6	82.8	±5.7	55.4	±9.7
HS diploma	75.7	±4.7	62.8	±5.0	66.7	±3.8	66.3	±5.2
Some college	55.8	±3.3	59.3	±5.9	46.0	±3.8	66.8	±4.9
Bachelor +	18.3	±2.5	53.4	±9.1	12.7	±2.2	46.9	±8.7
Employment status of householder								
Employed	47.8	±2.5	62.3	±3.3	34.2	±1.8	62.0	±3.7
Unemployed	81.4	±8.0	58.4	±13.9	79.8	±8.7	68.9	±12.9
NLF	71.1	±4.2	59.8	±6.6	65.8	±5.2	61.6	±7.1
Disability status of householder								
No disability	52.0	±1.9	60.8	±3.2	37.9	±1.8	61.4	±3.1
Disability	79.8	±6.1	65.5	±9.5	65.8	±7.8	71.7	±12.8

NOTE.—MEs represent the margin of error at the 95 percent confidence level. HS indicates high school; NLF indicates not in labor force.
SOURCE.—ACS (2019) and Arizona and Wisconsin WIC ARs (2018–2019). CBDRB-FY19-167, CBDRB-FY19-575, CBDRB-FY20-154, and CBDRB-FY21-108.

households have greater eligibility but, surprisingly, they generally do not have greater access rates. In both Arizona and Wisconsin, urban locales have greater access rates, suggesting that accessibility of services may play a role in access. Overall, the insights available in these tables can assist WIC administrative offices with outreach, targeting, and renewal of benefits.

Finally, the online interactive data visualizations allow users to explore WIC eligibility and access rates across demographic and socioeconomic subgroups by county, conditional on adequate sample size. Data visualizations for

Table 3. Eligibility and Access Rates (%) by Household Characteristics, 2019

State	Arizona				Wisconsin			
Rate	Eligibility		Access		Eligibility		Access	
Statistic	Est	ME	Est	ME	Est	ME	Est	ME
Number of individuals residing in household								
2–3	42.5	±4.1	58.8	±6.7	37.4	±4.1	63.9	±7.1
4	45.2	±4.3	58.5	±6.4	28.9	±2.7	60.8	±5.5
5	56.6	±4.6	67.3	±6.1	42.7	±4.5	64.9	±5.7
6+	70.6	±4.3	60.4	±5.7	62.2	±4.3	59.8	±6.6
Household type								
Married couple	36.6	±2.4	65.2	±4.5	24.4	±1.9	58.8	±4.9
Single parent	79.9	±3.8	53.7	±7.6	76.3	±5.0	66.3	±7.1
Single with partner	68.5	±6.5	69.8	±8.3	58.8	±6.2	71.9	±8.6
Other	83.3	±4.6	56.2	±6.0	80.3	±5.5	54.4	±7.3
Locale type								
Urban	53.8	±2.0	62.5	±3.5	41.9	±2.3	66.0	±3.8
Rural	54.6	±6.4	49.8	±9.4	33.1	±2.7	50.3	±4.3

NOTE.—MEs represent the margin of error at the 95 percent confidence level.
SOURCE.—ACS (2019) and Arizona and Wisconsin WIC ARs (2018–2019). CBDRB-FY19-167, CBDRB-FY19-575, CBDRB-FY20-154, and CBDRB-FY21-108.

Arizona and Wisconsin for the years 2017 to 2019 have been captured from the interactive tool and are shown in figure 1; the figures display data on the eligibility and access rates of infants and children by county. Each state's capital county is highlighted to demonstrate one of the interactive features of the tool—the ability to highlight and compare county-specific estimates with the state median. From the figures, we can see not only variation in eligibility and access rates across the counties within each state but also county-level discrepancies between eligibility and access rates within each state.

In Arizona, county-level point estimates of eligibility rates range from 50.5 percent in Coconino County to 87.4 percent in Santa Cruz County; meanwhile, point estimates of access rates range from 10 percent in Apache County[9] to 94 percent in Santa Cruz County (US Census Bureau 2021a, 2021b). Overall, the figure shows greater variation in access than in eligibility and low uptake in

9. As noted above, those individuals accessing WIC via the Navajo or Inter-Tribal Council of Arizona WIC are not observed in our data. The population of Apache County was 70.4 percent AIAN in 2020 (US Census Bureau 2021); therefore, the variation in access rates in Arizona and the discrepancy between eligibility and access rates in this county may be overstated.

several high-eligibility counties in Arizona; however, both the variation and the low uptake are likely due to the fact that we do not have data on WIC uptake from the Navajo or Inter-Tribal Council of Arizona WIC—the agencies most likely to serve the populations in these counties. Individuals may be accessing WIC but are not observable within the AR data we receive from Arizona Department of Health Services. Maricopa County, the highlighted county that hosts the state capital, has eligibility (52.5 percent ± 1.5) and access rates (64.0 percent ± 2.3) that are close to the state median eligibility and access rates (56.1 ± 1.0 and 63.0 percent ± 1.8, respectively; *Z* scores for nulls of equivalence are 2.0 and 0.34, respectively) (US Census Bureau 2021a, 2021b).

In Wisconsin, we again see county-level variation in eligibility and access rates across the state, with point estimates of eligibility ranging from 9.6 percent in Ozaukee County to 75.4 percent in Ashland County and point estimates of access rates ranging from 34 percent in Richland County and 81.0 percent in Sawyer County. Dane County, where the county seat is the state capital, has an eligibility rate lower than the state median (24.0 percent ± 2.9 as compared with 41.4 percent ± 1.0; *Z* score for null of equivalence is 5.67) but an access rate statistically indistinguishable from the state median (54.2 percent ± 8.4 as compared with 62.3 percent ± 1.9; *Z* score for null of equivalence is 0.94).

4. CONCLUSION

The tables and interactive data visualization tool highlight both the advantages and limitations of our data linkage and estimation procedures. A strength of the estimates is that they are more granular than other available estimates, capturing eligibility and access rates at the sub-state level and for various demographic subgroups within a state. However, our current data linkage and estimation procedures have several limitations as well. For example, our eligibility estimates rely on survey-reported annual income, which may be measured with error and does not capture month-to-month income variation. The income reported to the ACS can result in classifying a household as ineligible for WIC, based on income over a 12-month period, even though that same household could be eligible for WIC for some part of that 12-month period due to temporarily low income for some months. A possible avenue for future research is the derivation and suitability of adjustment factors, perhaps, following FNS, derived from the SIPP, that can take into account monthly income dynamics and address underestimation of WIC eligibility.

Additional limitations include the facts that estimates are not available for all states, and no estimates are available for ITOs. As noted, ITOs function as their own independent state-level agencies and Census does not have an active data sharing agreement with an ITO.

Finally, our estimates are incomplete in that they do not reflect the eligibility of pregnant and postpartum women. Developing reliable estimates of eligibility and access among women is an avenue for future research. The ACS does not identify pregnant, postpartum, or breastfeeding women; however, we can produce estimates of the number of eligible pregnant and postpartum women from the ACS survey data using birth date and relationship data for children in the ACS household, though not without error. (For example, pregnant women who miscarry will not be captured; we will likely overestimate length of pregnancy for preterm babies and underestimate it for overdue babies; if the ACS survey is completed by someone other than the mother, we will have to make assumptions about whether the child is biologically related to the mother.) Following methods developed by FNS, we can also estimate the number of breastfeeding women using data from the Centers for Disease Control.

Producing reliable estimates of the number of WIC-eligible women is an objective for future work. In addition, assessing the extent to which the PIK assignment and weighting process impacts the representativeness and reliability of our estimates is an objective for future work. Finally, there is additional work to be done on identifying the determinants of the gap between eligible and participating populations.

The Census Bureau, ERS, and FNS are working to make restricted-use individual-level WIC and SNAP data available for approved extramural researchers with approved projects. Please contact the Administrator at a Federal Statistical Research Data Center for more information about how to apply for access to restricted-use data held at the Census Bureau.

Supplementary Materials

Supplementary materials are available online at academic.oup.com/jssam.

REFERENCES

7 CFR 246.2 (2011), "Participants." Available at https://www.ecfr.gov/current/title-7/subtitle-B/chapter-II/subchapter-A/part-246.

"Am I Eligible for WIC?" (2021), "Minnesota Department of Health." Available at https://www.health.state.mn.us/people/wic/eligibility.html.

Binder, A., Molfino, E., and Voorheis, J. (2022), "Comparing the 2019 American Housing Survey to Contemporary Sources of Property Tax Records: Implications for Survey Efficiency and Quality," CES 22-18, U.S. Census Bureau, June 2022.

Bitler, M. P., and Currie, J. (2005), "Does WIC Work? The Effects of WIC on Pregnancy and Birth Outcomes," *Journal of Policy Analysis and Management*, 24, 73–91.

Bitler, M. P., Currie, J., and Scholz, J. K. (2003), "WIC Eligibility and Participation," *The Journal of Human Resources*, 38, 1139–1179.

Bond, B., Brown, J. D., Luque, A., and O'Hara, A. (2014), "The Nature of the Bias When Studying Only Linkable Person Records: Evidence from the American Community Survey," CARRA Working Paper Series, 30.

Carlson, S., and Neuberger, Z. (2021), "WIC Works: Addressing the Nutrition and Health Needs of Low-Income Families for More Than Four Decades." Available at https://www.cbpp.org/research/food-assistance/wic-works-addressing-the-nutrition-and-health-needs-of-low-income-families.

Foster, T. B., Fernandez, L., Porter, S., and Pharris-Ciurej, N. (2022), "Age, Sex, and Racial/Ethnic Disparities and Temporal-Spatial Variation in Excess All-Cause Mortality During the COVID-19 Pandemic: Evidence from Linked Administrative and Census Bureau Data," CES 22-18, U.S. Census Bureau, May 2022.

Gray, K. F., Balch-Crystal, E., Giannarelli, L., and Johnson, P. (2022a), *National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2019*, Alexandria, VA: U.S. Department of Agriculture Food and Nutrition Service, p. 97.

———. (2022b), *Appendices: National- and State-Level Estimates of WIC Eligibility and WIC Program Reach in 2019*, Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, p. 114.

Hoynes, H., Page, M., and Stevens, A. H. (2011), "Can Targeted Transfers Improve Birth Outcomes?: Evidence from the Introduction of the WIC Program," *Journal of Public Economics*, 95, 813–827.

Institute of Medicine (US) Committee on Dietary Risk Assessment in the WIC Program (2002), *Dietary Risk Assessment in the WIC Program*, Washington, DC: National Academies.

National Research Council (2003), *Estimating Eligibility and Participation for the WIC Program: Final*, Washington, DC: The National Academies Press.

Newman, C., and Scherpf, E. (2013), "Supplemental Nutrition Assistance Program (SNAP) Access at the State and County Levels: Evidence From Texas SNAP Administrative Records and the American Community Survey," Economic Research Report, p. 47.

US Census Bureau (2017), "ACS Information Guide," Suitland, MD: US Census Bureau. Available at https://www.census.gov/programs-surveys/acs/library/information-guide.html

US Census Bureau (2021a), "Women, Infants, and Children (WIC) Program Eligibility and Participation," *Census.gov*. Available at https://www.census.gov/library/visualizations/interactive/wic-eligibility-participation.html.

US Census Bureau (2021b), "Arizona: 2020 Census," *Arizona: 2020 Census*. Available at https://www.census.gov/library/stories/state-by-state/arizona-population-change-between-census-decade.html.

US Census Bureau (2022), "Census Glossary: Householder," *Census Glossary: Householder*. Available at https://www.census.gov/glossary/www.census.gov/glossary/#term_ZIPCode.

USDA FNS (2020), "WIC Eligibility Requirements." Available at https://www.fns.usda.gov/wic/wic-eligibility-requirements.

USDA FNS (2021a), "Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) | Food and Nutrition Service." Available at https://www.fns.usda.gov/wic.

USDA FNS (2021b), "WIC Program Grant Levels by Fiscal Year." Available at https://www.fns.usda.gov/wic/wic-program-grant-levels-fy.

Wagner, D., and Layne, M. (2014), "The Person Identification Validation System (PVS): Applying the Center for Administrative Records Research and Applications' (CARRA) Record Linkage Software," CARRA Working Paper Number 2014-01, 1–20.

"WIC Data Tables" (2022), *Food and Nutrition Service: WIC Data Tables*. Available at https://www.fns.usda.gov/pd/wic-program.