3. ESTIMATING STANDARD ERRORS

A key activity in the development of prevalence estimates is the determination of their precision. This is important in assessing the overall accuracy of the estimates, and is required in order to determine whether observed changes over time or differences between population subgroups are statistically significant.

Standard errors computed by most common statistical packages are not accurate estimates of the standard errors for the prevalence estimates calculated from a complex-sample survey such as the CPS. The formulae used by programs such as SAS and SPSS are valid only for statistics computed from simple random samples. The CPS, however, does not use a simple random sample. Rather, it is based on a stratified cluster design where addresses from different areas are sampled with different probabilities. Because of unequal initial sampling probabilities together with adjustments needed to account for household non-response, sample weights must be used to estimate population characteristics from the CPS. SAS and SPSS do, if used correctly, deal appropriately with sample weights when computing standard errors. However, these packages do not currently deal with the stratification or clustering in the sample design. Other statistical packages such as STATA and SUDAAN can calculate unbiased standard errors based on complex samples, but CPS does not disclose the sampling information needed to implement these packages.

With the CPS, the combined effects of stratification and clustering produce samples that are less statistically efficient than simple random samples because households from the same cluster tend to be more similar than households randomly drawn from the population, the effective sample size is smaller than the nominal sample size. For that reason, the standard error estimates that fail to account for the CPS sample design (such as those currently produced by SAS or SPSS) will generally be too small.

There are a number of approaches to estimating standard errors of population estimates from a complex sample design such as the CPS. Given the limited sample-design information publicly available on the CPS data, the most accurate standard error estimates are produced using balanced repeated replication methods (BRR). Using the method as implemented in WestVars Complex Samples, version 3.0 (a statistical package implemented as an SPSS supplementary module), standard errors were estimated for publication with the prevalence estimates in *Household Food Security in the United States, 1998 and 1999: Detailed Statistical Report* (Cohen, et al., 2002). Details of the application of these procedures to the 1998 and 1999 food security data are described below. However, not all researchers will have the software needed to adequately implement BRR methods. In the latter part of this chapter we assess the feasibility of using the Census Bureau's generalized variance functions (GVF's), with appropriate adjustments, to approximate standard errors of food security prevalence rates.

A. Balanced Repeated Replication Methods (BRR)

The basic premise of the Balanced Repeated Replication (BRR) methods used to compute standard errors for the food insecurity prevalence estimates from the CPS food security supplements is that data collected is treated as a population, which is subsampled in the same way that the original sample was selected from the larger universe. The estimated statistic is calculated for the total sample and then the total sample is repeatedly subsampled in a way that reflects the sampling design of the total set of data. After the subsampling takes place, the statistic of interest is calculated for each subsample, and the variability among these subsamples is used to estimate the sampling error of the statistic.

More specifically, balanced repeated replication (BRR) methods are generally used with multistage stratified sample designs. After grouping all primary sampling units (PSU's) into strata, two PSU's are selected from each stratum using sampling with replacement. This provides two independent estimates for each stratum. Next a series of "replicate samples" is drawn. In each replicate sample, one of the two psus in each strata is included. A total of 2^n different subsamples is possible (where n is the number of strata). It is not necessary to form all possible replicates because the variance can be estimated with full information using fewer than the full complement of replicates. The minimum number of replicates needed to have full information is the smallest integer that is divisible by 4 and greater than or equal to n.

The calculation of standard errors for the food security prevalence estimate used "State" as the strata and the month in which the household entered the sample (the rotation group coded as HRMIS in the dataset) as the PSU[2]. The variable HRMIS was recoded into two groups: odd month (1,3,5,7) and even (2,4,6,8), which served as the two independent samples within each stratum. The food security weights (person weights for the person files and household weights for the household files) were used as sample weights. There were 52 balanced replicates used to develop these standard errors.

When population totals are known, the precision of the variance estimates can be improved using a poststratification weighting procedure after initial replicate estimates are calculated. This creates adjusted weights for respondents in each replicate so that the sums of the adjusted replicate weights are equal to the known population totals. For this analysis of the Food Security Supplement data in which "States" were used as strata, replicate weights in the two independent samples within each stratum were adjusted to sum to that State's known population total. Within each PSU-stratum combination, all weights were adjusted by the same ratio.

It should be noted, that although the 8th rotation was used to test new versions of the food security supplement with households in which there was more than one adult or more than one child, the cases in this rotation that were the same as those in all other rotations, were included in the calculation of the prevalence estimates and thus were included in the calculation of the standard errors. Households with more than one adult or more than one child were assigned a weight equal to "missing" in the editing of the data file. Thus, their values would automatically be dropped in the calculation of standard errors. Comparisons of prevalence rates between those remaining in the 8th rotation and those in other rotations indicate that this smaller, selective population in the 8th rotation does not create a noticeable bias in the calculation of overall standard errors for the population and the subgroups.

[2] Stratifying by state does not completely replicate the original sampling procedure, which is also stratified within states. Therefore, standard errors estimated using this procedure may be somewhat biased downward.

B. Assessment of the Feasibility of Using Generalized Variance Estimates

In addition to directly estimating the relevant standard errors and confidence intervals, we conducted an assessment of the feasibility of using the Census Bureau's generalized variance functions (GVFs) to approximate standard errors of food security prevalence rates. Descriptions of the CPS sample design, weights, procedures for implementing GVFs and relevant tables of factors (often called a and b parameters) are provided by the Census Bureau in Source and Accuracy Statements that accompany their public use data files. The GVFs provided by the Census Bureau are designed to compute standard errors for two types of estimates: subpopulation total numbers and percentages of the population or subpopulations, with a specific characteristic (such as food insecurity). Although the Census Bureau provides instructions for their application to tables with two or more dimensions as well as for their use when computing quantiles (such as medians) and averages, the Census Bureau's GVFs are designed to be used primarily for unidimensional tabulations of population characteristics.

The standard error of an estimated number using the GVFs with food security data is obtained as follows:

$$s_x = \sqrt{ax^2 + bx}$$

S_x is the approximate standard error with x being the size of the estimate (weighted) and a and b are the parameters associated with the particular type of characteristic. For food security measurement purposes, the following a and b parameters are provided by the Census Bureau for the 1998 and 1999 monthly files for household estimation:

	a parameter	b parameter
Total or White Population	-0.000010	2,068
Black Population	-0.000075	1,871
Hispanic Population	-0.000145	3,153

The approximate standard error of an estimated percentage is derived using the following formula:

$$s_{x,p} = \sqrt{\frac{b}{x} p(100 - p)}$$

Here $s_{x,p}$ is the approximated standard error with x being the total (weighted) number of people, or households in the base of the percentage, p is the percentage, and b is the parameter or factor associated with the characteristic in the numerator of the percentage. The b parameter is the same presented above.

The GVF parameters provided by the Census Bureau are based on the sample size of the monthly labor force survey. However, a small proportion of households that complete the labor force survey decline to complete the supplement. Further, in 1998 and 1999, part of the 8th rotation was not used to estimate prevalence rates. Thus, for the purposes of calculating GVF-based standard errors for prevalence estimates calculated from food security supplement data it is necessary to adjust the parameters to reflect the true number of cases in the supplement, accounting for the loss in sample size. To accomplish this, the b parameters above are adjusted as follows where b_a is the adjusted b parameter, N is the total unweighted number of household records in the full CPS and n_s is the unweighted number of cases used to estimate prevalence in the supplement[3]:

$$b_a = b(\frac{N}{n_s})$$

Using data for all households in 1998 we estimated standard errors following the GVF procedures with the adjustment for reduced sample size in the supplement (see Table 3.1). The estimated standard errors derived from the GVF procedures were generally smaller than those derived using BRR methods. For the prevalence of food insecurity for all households the GVF-based standard error estimate is .05 percentage points smaller than BRR-based estimate. Among the subpopulations there are four groups for which the GVF-based estimates of standard errors for the prevalence of food insecurity are larger than the BRR estimates: other non-Hispanic households (.21 percentage points), households living with incomes 185 percent of poverty or more (.01

percentage points), households living in the Northeast (.01 percentage points) and those living in the West (.06 percentage points). For most subpopulations, the GVF-based estimates are smaller than the BRR-based estimates with a range between .02 and .8 percentage points. There is no difference in the estimates of food insecure households for elderly people living alone.

A similar pattern is found for estimates of the prevalence of food insecurity with hunger. For all households, the GVF-based estimate is .03 percentage points smaller than the BRR-based estimate. For all but four subpopulations, the GVF-based estimates are smaller than the BRR-based estimates; the range of the difference is between .01 and .23 percentage points. There is one subgroup for which there is no difference between the estimates (those with no children under 18 years of age) and three subgroups for which the GVF-based estimates are larger than the BRR-based estimates: "other" households with children (.05 percentage points), other non-Hispanic households (.14 percentage points) and households living in the West (.07 percentage points).

In general, then, GVF methods appear to underestimate standard errors, which should be kept in mind if they are used with food security statistics. However, both GVF and BRR methods have advantages and drawbacks. One disadvantage of using replication methods is the potential for flaws in the estimates if the design of the replicates does not mimic the full-sample design. These variance estimates will be subject to bias. However, the major disadvantage of replication is the intensive computer effort required (with respect to equipment and person hours) and the need for acquiring appropriate software.

Similarly, there are several drawbacks to using the GVFs. Although these are called *generalized* variance functions, the a and b parameters used when applying the GVFs are specific to (1) the data being used, (2) the weights being used, (3) the outcome (trait) being measured, and (4) the population (group or sub-group) being assessed. For example, in the current application, parameters would be needed for the food security

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[3] The same ratio (N/n_s), based on the full CPS, was used to adjust the b parameter for all subpopulations.

supplement sample (distinct from the CPS core sample), the food security supplement weights, and food insecurity (the outcome). Working with that combination of sample-weight-outcome, separate sets of parameters would be needed for the full population and for each of the subgroups of interest (such as race, ethnicity, household types, states, regions, or age groups). As an alternative, parameters can sometimes be borrowed from other applications. For example, GVF parameters used for unemployment (from the CPS core) or for poverty (from the March supplement) might be appropriate. Or parameters from one population subgroup can sometimes be applied to other groups (this is the procedure described by the Census Bureau when applying its parameters to tables with two or more dimensions). However, there is no assurance of the accuracy of the standard errors computed in this way.

There are two advantages to using GVF methods. The first is that approximate standard errors for estimates derived from microdata can be calculate without specialized software. The second is that standard errors can be calculated for published statistics.

In summary, if the computer equipment, software and staff time is available, the replication methods will provide more accurate estimates of standard errors. However, the GVF-based estimates are much easier and less costly to calculate and can be substituted for BRR estimates, acknowledging that they generally underestimate standard errors by approximately 25 percent.

TABLE 3.1: Household Food Security Status by Selected Household Characteristics, 1998.				
	STANDARD ERRORS			
	GVF-BASED ESTIMATE		BRR ESTIMATE	
Characteristic	Food Secure	Food Insecure with Hunger	Food Secure	Food Insecure with Hunger
	Percentage Points	Percentage Points	Percentage Points	Percentage Points
All Households	0.15	0.09	0.20	0.12
Household Composition				
With Children < 6	0.46	0.23	0.56	0.29
With Children < 18	0.30	0.16	0.38	0.22
Married Couple Families	0.30	0.14	0.43	0.15
Female Head, No Spouse	0.78	0.50	0.88	0.57
Male Head, No Spouse	1.32	0.76	2.12	0.99
Other Households with Child[e]	2.12	1.35	2.17	1.30
With No Children < 18	0.17	0.11	0.20	0.11
More Than One Adult	0.19	0.12	0.27	0.16
Women Living Alone	0.38	0.25	0.40	0.30
Men Living Alone	0.48	0.33	0.51	0.36
Households With Elderly	0.24	0.13	0.29	0.18
Elderly Living Alone	0.37	0.22	0.37	0.26
Race and Hispanic Ethnicity				
White, Non-Hispanic	0.15	0.09	0.18	0.11
Black, Non-Hispanic	0.56	0.37	0.68	0.39
Hispanic[f]	0.88	0.51	1.05	0.55
Other Non-Hispanic	0.84	0.46	0.63	0.32
Household Income-to-Poverty Ratio				
Under 1.00	0.67	0.48	0.72	0.51
Under 1.30	0.55	0.37	0.57	0.39
Under 1.85	0.41	0.26	0.47	0.33
1.85 and Over	0.14	0.07	0.13	0.08
Income Unknown	0.37	0.22	0.76	0.37
Area of Residence[g]				
Inside Metropolitan Area	0.17	0.10	0.23	0.13
In Central City	0.35	0.22	0.37	0.26
Not In Central City	0.22	0.12	0.37	0.18
Outside Metropolitan Area	0.35	0.20	0.39	0.28
Census Geographic Region				
Northeast	0.34	0.20	0.33	0.26
Midwest	0.29	0.16	0.50	0.19
South	0.27	0.16	0.34	0.28
West	0.36	0.21	0.30	0.14

Source: Tabulations of Current Population Survey, Food Security Supplement data.
e,f,g, -- See End Notes