Comparison of Variance Estimates in a National Health Survey

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Abstract

The National Health Interview Survey (NHIS) is one of the major data collection programs of the National Center for Health Statistics (NCHS). This survey has a complex design that covers an approximately 10-year sample design period, and was redesigned most recently with the 2006 NHIS. The actual design features multiple stages of sampling and weighting adjustments. Simplified and user-friendly procedures have been developed for both in-house and public-use design-based analyses for use with linearization-based methods. In particular, for NHIS public-use data, a standardized design, modified to prevent identification of sampled geographical areas and simplified to consist of two sampled clusters per stratum, has been provided. For simplified procedures to be acceptable to the NHIS-user community, estimates of standard errors produced from simplified structures should be close to those produced by using detailed NHIS design and weighting information, e.g., using Yates-Grundy-Sen forms for two-stage variances and linearization of the final weights. In this study the standard error estimates produced from standardized designs are compared to those produced using detailed methods.

Key Words: Sample survey, variance estimation

1. Introduction[1]

The National Health Interview Survey (NHIS) is a multi-purpose health survey conducted by the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention (CDC), and is the principal source of information on the health of the civilian, noninstitutionalized, household population of the United States. The NHIS has been conducted continuously since its inception in 1957. The data collected in the NHIS are obtained through a complex sample design involving stratification, clustering, and multistage sampling. The previous (1995-2005) sample design and the current design (2006-2014), are both based on independent Area and Permit frames with design levels that are geographically clustered. The 2006-2014 sample design incorporates county-based Primary Sampling Units (PSUs), state level stratification for the first-stage of sample selection to facilitate the creation of efficient variance estimators, fewer minority (Hispanic, non-Hispanic black) density strata in some PSUs than the previous design, Census-defined block-clusters, and continued use of the “4-panel” sub-design strategy for linkage to the Medical Expenditure Panel Survey as well as for sample reduction as

1 The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the Agency for Healthcare Research and Quality or the National Center for Health Statistics, Centers for Disease Control and Prevention.

needed (Ezzati-Rice, et al., 2001).

Beginning in 2007, NCHS initiated the creation of “standardized” public-use design structures for variance estimation in the NHIS that would provide simple structures for maximum usage by data analysts; identify consistent structures over each approximately 10- year sample design period that allow for analysis of pooled historical data across surveys; and provide standard error estimates “close” to the “best” in-house design structure standard error estimates (Parsons, et al., 2007). Because the NHIS has design levels that are geographically clustered, the public-use and in-house design structures differ in order to satisfy requirements that publicly released data avoid identification and disclosure risk. The public-use structures consist of Pseudo-Strata containing at least two Pseudo-PSUs per Pseudo-Stratum, with masked codes that can be used directly in variance estimation software. Typically, along with these codes, computer software packages for complex design-based variance estimation require a final weight estimator. For the NHIS, this estimator is non-linear since it incorporates a poststratification adjustment to the U.S. Census Bureau population control totals. This introduces an additional component of sampling variability to the targeted estimator. Although the Taylor series linearization method (Wolter, 2003) is widely used by data analysts for computing standard errors from complex surveys, most software algorithms ignore this variability and assume that the final survey weight can be treated as a non-variable sampling weight (Parsons, 2010). Thus, the survey weight which includes both the inverses of probabilities of selection and weighting adjustments to reduce bias and variability is treated as if strictly based on the inverse of selection probabilities. In this paper, standard error estimates from the NHIS public-use “standardized” structure are compared to standard error estimates from its in-house design structure. In addition, we compare variance estimates where final weights are treated as inflation weights versus a linearization of the final weights.

2. Methods

For this research, we used data from the 2006 National Health Interview Survey Person-Level and Sample Adult files. SUDAAN software (RTI, 2005) was used for analysis of both the public-use and in-house design structures. The Taylor series linearization method was used to calculate standard errors for the public-use design. To calculate standard errors for the in-house design, we used the Yates-Grundy-Sen 2-stage variance estimator form that included the joint probabilities of PSU selection and block-cluster sampling within minority density strata (Botman, et al., 2000).

Our study considered 11 variables from the 2006 NHIS files. Person-Level file variables included activity limitation, health insurance status, fair or poor health, saw health professional based on 2-week recall of event, and number of doctor visits in the past year. Sample Adult file variables included usual place to go for medical care, obesity status, engaged in regular leisure-time physical activity, current smoking status, diagnosed diabetes, and current asthma condition. We considered person-level means and totals for these variables classified by gender, race/ethnicity, and age domains. Using SUDAAN, for each structure we compared the coefficient of variation (CV) for these estimates along with and without linearization of the final poststratification weight. The poststratification adjustment assures that the NHIS estimates by age-gender-race/ethnicity classes of the civilian noninstitutionalized U.S. population agree with independently determined population controls prepared by the U.S. Census Bureau. For both in-house and public-use data, a pre-poststratification weight (WTIA) is available for linearization. This weight consists of the product of the inverse of the probability of household selection, the inverse of adult selection (for that subsample), household nonresponse adjustment, and a first-stage ratio adjustment to reduce the between-PSU sampling variation among the nonself-representing PSUs by Census region, race/ethnicity, and metropolitan area classes.

3. Results

To compare the coefficient of variations (CV) using the public-use "standardized" structure with "best" in-house structure, for each domain and variable, we used the following:

1) Yates-Grundy-Sen variance estimator with final weight treated as inflation weight (F);
2) Yates-Grundy-Sen variance estimator along with linearization for poststratification (FP);
3) Taylor series linearization with final weight treated as inflation weight (P); and,
4) Taylor series linearization along with linearization for poststratification (PP).

The cases 3) and 4) were restricted to public-use information.

Figures 1-4 provide limited comparisons of these four methods applied to the two design structures using the 2006 NHIS data. Figures 1 and 2 compare the CV's of means and totals for persons with activity limitation, while Figures 3 and 4 compare the CV's of means and totals for the number of doctor visits. We see that the patterns for CV's for estimated means for the public-use structure closely follow the in-house estimates over all domains. However the patterns for CV's for estimated totals are slightly larger for the public-use structure, with the differences between public-use and in-house CV's ranging from 0.5 percentage points to 1.5 percentage points, depending on the selected domain. Also, note that the lowest CV estimates occur with linearization of the final weights, regardless of design structure.

Tables 1 and 2 provide an additional assessment of Yates-Grundy-Sen methods by comparing variance estimates from the 2006 NHIS obtained by treating final weights as inflation weights versus a linearization of the final weight. Using the "best" in-house structure, Table 1 compares the ratio of CV's for all persons, while Table 2 compares the ratio of CV's for a specific subdomain (i.e., elderly non-Hispanic blacks). Both tables show that treating the final survey weight as an inflation weight may cause estimated standard errors of totals to be almost 3.5 times larger than estimates produced with linearization of poststratification weights, depending on variable examined.

4. Discussion

Estimates based on the public-use "standardized" structure appeared to be sufficient when compared to the in-house structure (i.e., using Yates-Grundy-Sen estimator and availability of finer levels of sampling ratios). Although treating the final weights as sampling weights may cause a moderate impact on estimated means and totals, it still may be a reasonable strategy if software limitations necessitate. For many health variables, empirical evidence suggests that the inflation in the estimated standard errors of means may be of little practical importance (Botman, et al., 2000).

In 2006, the survey was faced with a budget shortfall. As a result, the size of the 2006

NHIS sample was reduced by approximately 50% during July-September 2006, a 1/8 sample reduction overall for the year. This cutback was in addition to the ongoing overall 12.5% reduction due to the new sample design in 2006 (NCHS, 2007). Note that we did not make any adjustments to make the sample more representative of a "full" NHIS. The sample reductions in the 2006 NHIS file caused modest increases in the standard error estimates, when compared to the previous design for selected variables by domain.

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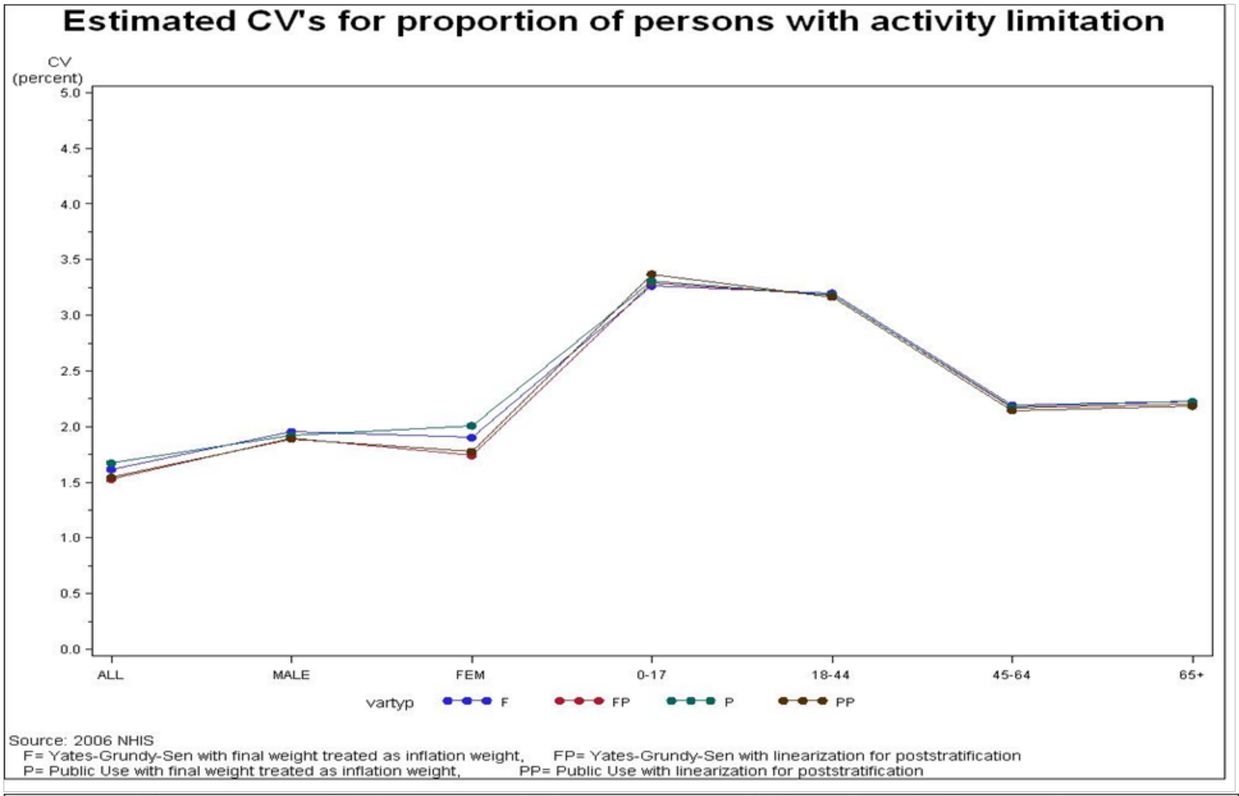
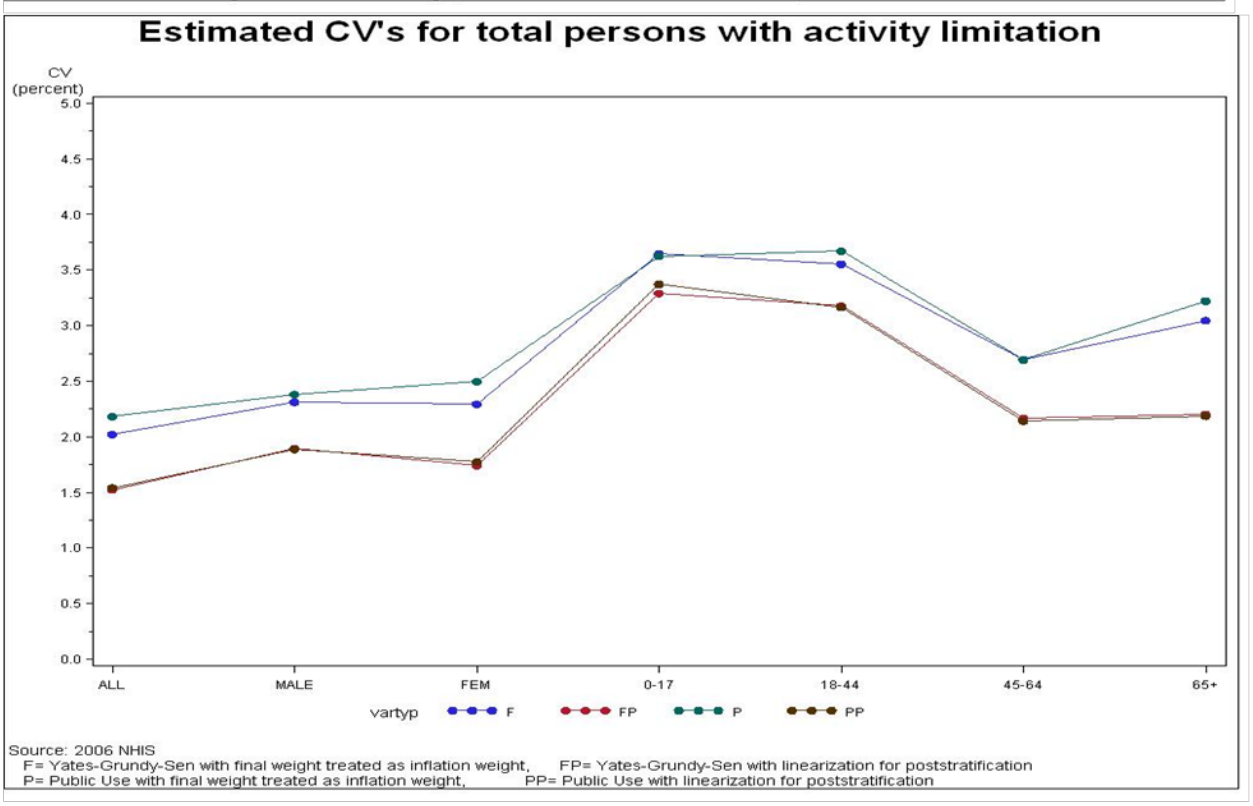
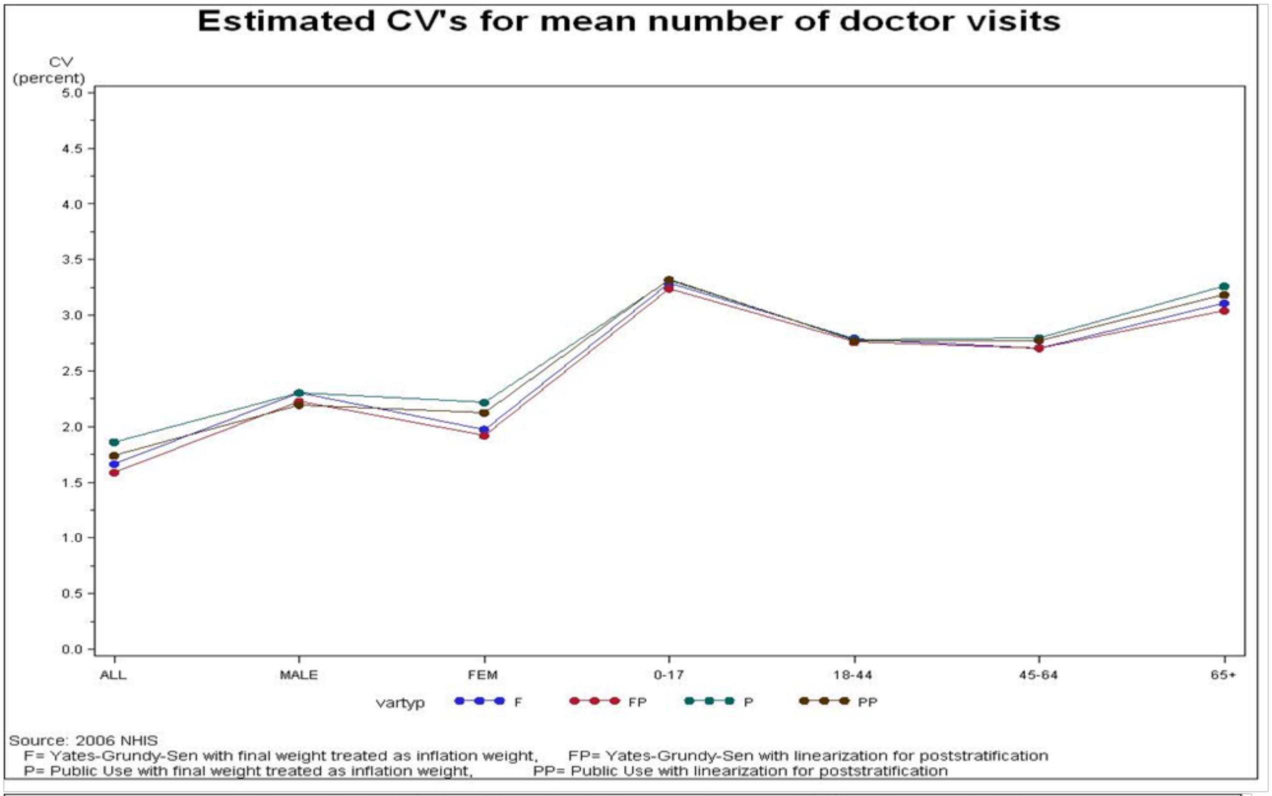
Figures 1. and 2. Comparison of public-use versus in-house design structure: 2006 NHIS





Figures 3. and 4. Comparison of public-use versus in-house design structure: 2006 NHIS



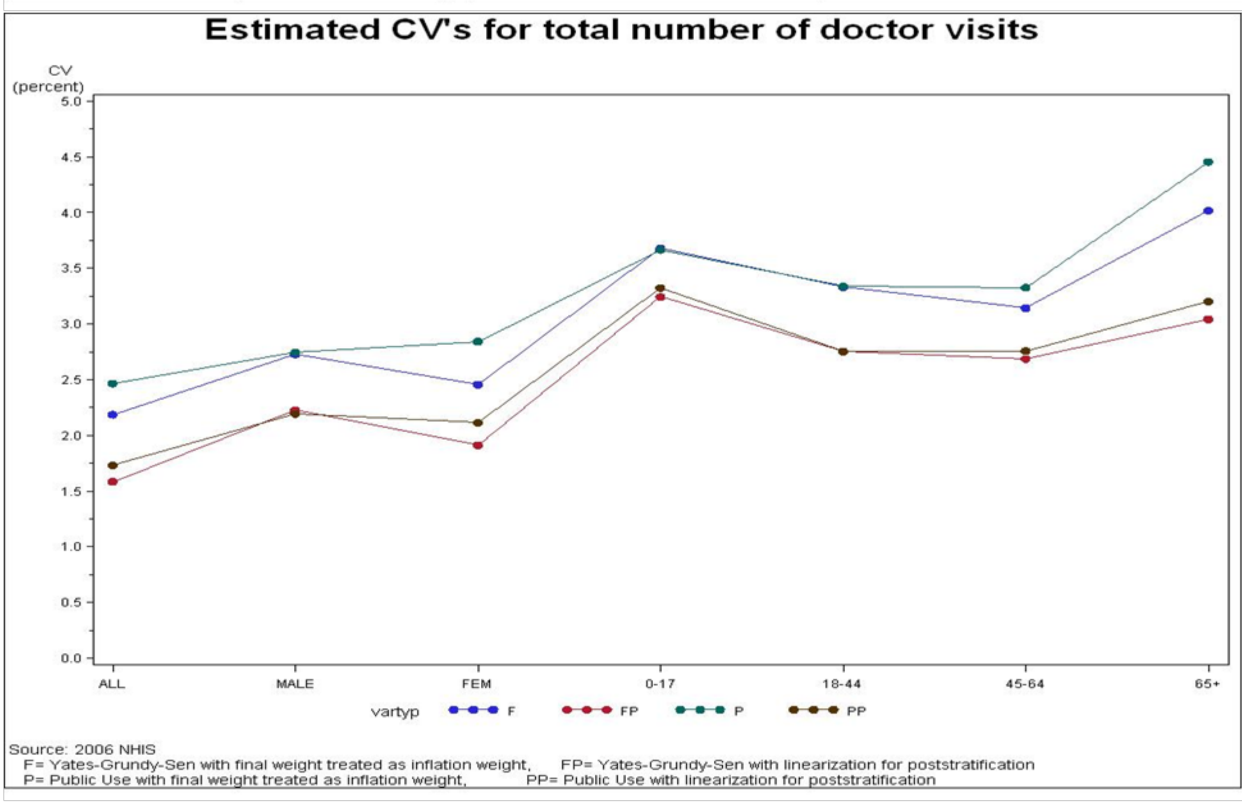


Table 1. Impact of poststratification on variance using Yates-Grundy-Sen estimator: All persons, 2006 NHIS

Domain and variable	Estimated Totals			
All persons	Number in thousands	CV (FP)	CV (F)	Ratio CV(F)/ CV(FP)
Has activity limitation	35,776	1.53	2.02	1.32
Without health insurance	43,730	1.58	2.10	1.33
Has fair or poor health	27,766	1.74	2.12	1.22
Saw health professional, 2-week recall	42,913	1.21	1.80	1.49
Doctor visits in past year	1,626,668	1.59	2.19	1.38
Usual place to go for medical care	181,636	0.42	1.45	3.46
Obese persons	54,050	1.40	1.94	1.39
Regular leisure-time physical activity	65,776	1.51	2.09	1.38
Current smoking status	45,296	1.65	2.14	1.30
Diagnosed with diabetes	17,110	2.73	3.07	1.13
Current asthma	8,372	3.92	4.18	1.06

Table 2. Impact of poststratification on variance using Yates-Grundy-Sen estimator: Non-Hispanic blacks 65-74 years old, 2006 NHIS

Domain and variable	Estimated Totals			
Non-Hispanic Black 65-74 years	Number in thousands	CV (FP)	CV (F)	Ratio CV(F)/ CV(FP)
Has activity limitation	603	5.99	7.54	1.26
Without health insurance	34	32.08	31.86	0.99
Has fair or poor health	661	6.33	8.07	1.28
Saw health professional, 2-week recall	443	7.65	9.10	1.19
Doctor visits in past year	16,531	9.74	10.56	1.08
Usual place to go for medical care	1,952	1.90	6.48	3.41
Obese persons	795	6.69	9.46	1.41
Regular leisure-time physical activity	423	12.63	15.20	1.20
Current smoking status	293	13.53	14.95	1.10
Diagnosed with diabetes	661	7.95	9.97	1.25
Current asthma	49	31.59	32.06	1.01

(F) Yates-Grundy-Sen variance estimator with final weight treated as inflation weight

(FP) Yates-Grundy-Sen variance estimator along with linearization for poststratification