ESTIMATION AND ANALYSIS EFFECTS RESULTING FROM A SAMPLE SIZE REDUCTION IN A LARGE NATIONAL SURVEY

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1 Introduction

The National Health Interview Survey (NHIS) is a multipurpose national survey, sponsored by the National Center for Health Statistics (NCHS), based on a stratified multistage area probability sample.[1] The NHIS sample assigned to each quarter of the year (and within quarter by week) is representative of the target population. The NHIS, thus, is designed to yield estimates for each calendar quarter as well as annual estimates.

Table 1 Estimated Number of All and Selected Specific Acute Incidence Conditions for each quarter. 1992 NHIS

All and Selected Conditions	1992 January-March	April-June	July-September	October-December
	Number per 100 persons per Quarter			
All	56.6	39.3	34.5	51.5
Infective and parasitic diseases	6.3	5.9	4.5	5.7
Respiratory conditions	30.6	14.5	12.0	28.6
Digestive system conditions	1.9	1.7	1.7	1.6

Note: Excluded are medical conditions involving neither medical attention nor activity restriction

Source: Table 50. Current Estimates from the 1992 NHIS

Differences in NHIS estimates for particular characteristics by calendar quarter are common for several reason, including seasonality in the prevalence of several acute conditions. Table 1, for example, illustrates some seasonal patterns in the 1992 NHIS estimates. These patterns vary somewhat from year to year.[2] In general, the overall number of acute incident conditions are higher in the winter than in the spring. For respiratory conditions the seasonal pattern is even sharper.

For other survey characteristics there may be fewer seasonal effects. For example, the overall proportion of the entire population reporting excellent or very good health status usually does not vary by quarter.

For 1993, NCHS experienced a funding shortfall for the NHIS data collection, largely because the survey included data collection for fewer than the usual number of supplementary health topics. To compensate, NCHS reduced the size of the usual NHIS household sample assigned to the second quarter by 46 percent.

This design change reduced overall 1993 NHIS nominal sample size by about 12 percent. Because of the way the 1993 NHIS sample size was reduced, the reduction in 1993 NHIS effective sample size is slightly larger, because the strategy used increased the variability in the survey weights. This paper looks at some estimation and analysis effects from the 1993 NHIS sample reduction.

Section 2 discusses the 1993 reduction in the NHIS sample size and NHIS quarterly weighting strategy for the basic health and demographic questionnaire. The variability in the 1991, 1992, and 1993 NHIS sampling weights is also compared. Section 3 quantifies the distribution of the variation in weights for domains defined by race, sex, and age. Section 4 discusses an approach to reduce such variation in the weights. It also explores the variance-bias effects of a re-weighting strategy for obtaining annual 1993 NHIS estimates by averaging the 1993 "weekly" NHIS estimates from the rather than by averaging the NHIS "quarterly estimates." Section 5 summarizes the paper.

2. NHIS Quarterly Sample Size and Processing

The usual annual NHIS sample size is 48,000 households, which are usually spread evenly over each of the four quarters of the year, with about 12,000 households assigned to each quarter. In 1993, with the exception of the second quarter the NHIS sample for each calendar quarter contained about 12,000 households. The NHIS sample for the second quarter of 1993 contained about 6,500 households (= 12,000 × 7/13, the sample only in 7 out of the 13 (7/13 ≈ 46 percent) weekly assignments of the second quarter was retained. Because of the way the NHIS sample is allocated to the weekly assignments in each quarter, the NHIS subsample actually fielded in the second quarter is still a probability sample.

Figure 1 shows a boxplot of 1993 annual NHIS weights by quarter using SAS[3]. This plot clearly demonstrates the difference in the distribution of the sampling weights by quarter. One reason for the quarterly weighting is that NHIS is designed to yield estimates for each calendar quarter. The last quarter of 1980 was the most recent occasion when the NHIS did not conduct data collection for the sample assigned to more than 1 week in a survey quarter. For that quarter the NHIS did not conduct data collection for 2 weekly samples. For several recent years NCHS has dropped the sample assigned to the first weekly assignment of the survey year in order train NHIS interviewer on supplementary questionnaires to be added for that survey year.

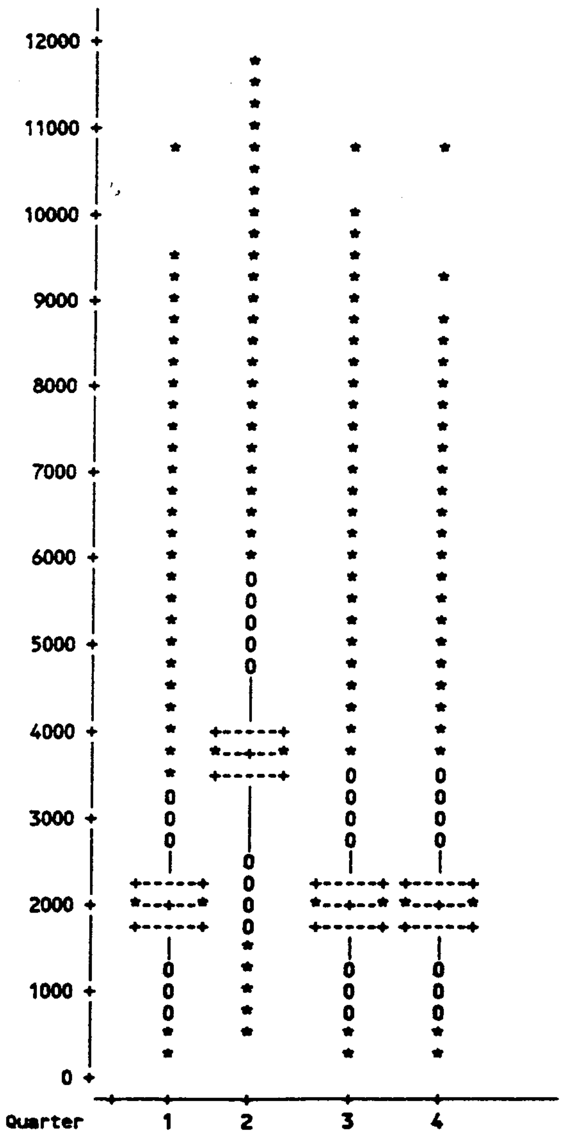

Figure 1 Boxplot of 1993 annual NHIS weights by quarter

The NHIS sample design has another features that allows the sample size to be reduced, which does not introduce such variability in the weights. This procedure was used to reduce the 1985 NHIS sample size by 1/4 and the 1986 NHIS sample size by 1/2. Such approaches were not taken because it was desirable to spread the reduction in workload evenly over the survey interviewers; under the other approaches some interviewers would have no NHIS assignments for an entire quarter, which, for example, would make it difficult for them to retain their NHIS data collection skills. Moreover these approaches would have complicated the analyses of the survey data, because fewer PSUs would be in the second quarter than in the other quarters.

With the quarterly processing and weighting of the 1993 data, the usual basic NHIS quarterly weights for the sample drawn and fielded in the second quarter of 1993 was inflated by 13/7.

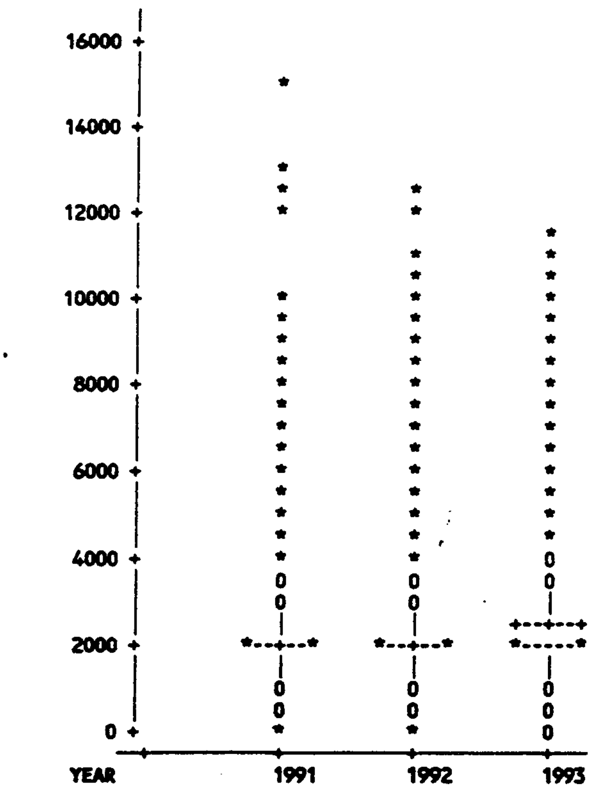

Figure 2 Boxplot of 1991, 1992, and 1993 annual NHIS weights

Although the NHIS is not based on a self–weighting sample, the NHIS sampling weights for the core sample are generally not too variable in size. The CV of the 1991 (final annual) NHIS sampling weights is about 34 percent; the CV for the 1992 NHIS weights is 38 percent; and the CV for the 1993 weights is 38 percent. The 1992 NHIS had other features that increased the variabilities of the sampling weights; thus, the CV of the 1991 NHIS represents a more typical CV for the NHIS weights.

Figure 2 show a boxplot from SAS[3] for the final sampling weights for the 1991, 1992, and 1993 NHIS samples. While for each year the final NHIS sampling weights for the annual sample are clustered near the average value of about 2,000, the boxplot shows the wider distribution of these sampling weights in 1993. This special weighting also affected the number of extreme large weights in the NHIS. For example, in the 1993 NHIS the sampling weights for 35 persons in the sample were greater than 10,000, about $5 \times \overline{wt}$; 10 in 1992, and 4 in 1991. In the 1993 NHIS, the sampling weight for 70 persons was over 8,000, about $4 \times \overline{wt}$; 34 in 1992 and 29 in 1991. Such large extreme weights can cause complications in analysis.

In addition to other implications, this plot clearly demonstrates that some observations in the sample have a larger influence on the survey estimates than others. Moreover, this plot clearly demonstrates that some observations in the sample have a substantially less influence on the survey estimates than others.

We, thus, consider whether it would be worthwhile to reweight the 1993 NHIS to equalize the weights across the NHIS weekly samples. Under this alternative strategy, one would increase the statistical efficiency of the sample design (e.g., smaller design effects) but would increase the mean square error of the estimates for variables with a seasonal affect in the NHIS. Under this alternative scheme, we would calculate the bias as the difference between the estimate under the usual NHIS estimation procedure and the estimate resulting from the alternative weighting procedure. On the other hand, under this alternative strategy, one would increase the statistical efficiency of the sample design (e.g., smaller design effects) but would not have a bias component in the mean square error from weighting for variables without a seasonal affect in the NHIS. We look at the variances and bias effects using a reweighted annual file for these identified characteristics of interest in section 4.

This variation in the sampling weights is attributable to several design features. Botman[4] discusses the relationship between several statistical design features for the NHIS and the variability of the final annual NHIS sampling weights. The inflation of the weights for the fielded sample for the second quarter of the 1993 NHIS, because of the sample size reduction, introduced additional variation in the sampling weights. This additional variation in the sampling weights is not large but is noticeable; about 1/7 of the 1993 NHIS sample will be approximately double weighted (≈ 13/7).

3 Distribution of the NHIS Sampling Weights for Race, Sex, and Age Domains

Table 2 show the coefficient of variation in the final annual NHIS weights by year according to age, sex, and race. Table 2 demonstrates that the increase in the variability of weights was spread fairly evenly over age, sex, race subdomains, as would be expected. The effects, however, were slightly less pronounced for Blacks as their sampling weighs are already subject to more variation, because of the NHIS sample design itself Not only does the 1993 have a larger number of extreme weight than the 1991 but it has more variable weights than occur in the prior two years.

4 Alternative Weighting Approaches

If one analyses NHIS data using variables not related to data that vary by season such as acute conditions, one might want to consider the beneficial effect on sampling variances of reweighting the file by considering the the NHIS a sample for 1993 as being made up of 46 weekly samples for the 52 weekly samples in the year. Of course, one would have to well document the approach in order to one's data reproducible and the provide a cogent rationale for the particular way that one modifies the weights. In essence we explore the variance—bias effects of a re—weighting strategy for obtaining annual 1993 NHIS estimates by averaging the 1993 "weekly" estimates from the rather than by averaging the "quarterly estimates."

Disproportionate sampling can be used as a variance reduction technique in an optimized sampling design, where disproportionately fewer units are sampled in strata with high interviewing costs and disproportionately more units are sampled in strata with higher population variance. In other circumstances, disproportionate sampling decreases survey efficiency by increasing the design effect of survey estimator.

Kish[5] notes in these cases that, the increase in the design effect due to disproportionate sampling can be gauged by the relative variance (the square of coefficient of variation) of the sampling weights.

Such reweighting cuts the ratio of the largest sampling weight to the smallest sampling weight overall and for each race—sex—age subdomain. This approach, however, modestly reduces the CV of the sampling weights, cutting the overall CV of the weights by about 3 percentage points.

The effect of these weighting strategies on survey estimates and variances may depend on the particular characteristic of interest and domains of study. To obtain clues on the effects we look at the variances and bias in table 3 for variable strongly related to the time of the year as shown in table 1.

5 Summary

The papers looks at the implications of a sample reduction in a large survey. For several reasons the reduction had to be concentrated in the sample assigned to one quarter. To protect against seasonal influences, the data were weighted by quarter. For most estimates this strategy slightly increases the sampling variances because this strategy increases the variability of the sampling weights and provides protection against seasonality issues. For some estimates, however, this strategy increases the sampling variances without a concurrent reduction in bias.

References

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Table 2. Coefficient of Variation in Percent of NHIS Final Sampling Weights: 1991, 1992, 1993

RACE	SEX	AGE	1991	1992	1993
			Coefficient of Variation (Percent) of Final Weights		
.	.	.	34	38	38
.	MALE	.	34	38	38
.	FEMALE	.	34	38	38
NONBLACK	.	.	31	36	36
BLACK	.	.	50	49	50
NONBLACK	MALE	.	31	36	36
NONBLACK	FEMALE	.	31	36	36
BLACK	MALE	.	51	48	51
BLACK	FEMALE	.	49	49	49
NONBLACK	MALE	0—17	31	38	35
NONBLACK	MALE	18—44	31	36	36
NONBLACK	MALE	45—64	29	32	36
NONBLACK	MALE	65+	29	32	33
NONBLACK	FEMALE	0—17	30	38	35
NONBLACK	FEMALE	18—44	31	36	37
NONBLACK	FEMALE	45—64	29	33	35
NONBLACK	FEMALE	65+	31	33	36
BLACK	MALE	0—17	49	48	49
BLACK	MALE	18—44	49	46	50
BLACK	MALE	45—64	47	50	50
BLACK	MALE	65+	55	51	51
BLACK	FEMALE	0—17	49	48	48
BLACK	FEMALE	18—44	47	47	49
BLACK	FEMALE	45—64	45	52	49
BLACK	FEMALE	65+	55	49	50

Source: Unofficial tabulations from the NHIS

Table 3: Annual estimates from the 1993 NHIS

Characteristic	Current Practice Estimate (E_c)	Current Practice Standard Error SE(E_c)	Alternate Procedure Estimate (E_a)	$\frac{SE_A^2 + (E_{cp} - E_A)^2}{(SE_{cp})^2}$
		TOTAL POPULATION		
Excellent Health (%)				
White	38.61	0.34	38.59	1.00
Black	29.90	0.70	29.99	1.01
Average Annual # Doctor Visits				
White	6.21	0.09	6.25	1.01
Black	5.70	0.18	5.75	1.02
Average # of Acute Incident Conditions per 100 persons				
White	195.58	3.77	201.28	1.06
Black	162.92	7.19	166.38	1.04
		POPULATION AGED 65+		
Excellent Health (%)				
White	17.00	0.45	17.18	1.02
Black	9.26	0.94	9.19	0.98
Average Annual # Doctor Visits				
White	10.71	0.40	10.76	1.01
Black	12.07	1.01	12.04	1.08
Average # of Acute Incident Conditions per 100 persons				
White	114.62	6.49	116.83	1.04
Black	110.38	14.91	117.76	1.14

Source: Unofficial tabulations and estimates from the 1993 NHIS