EVALUATION OF HOSPITAL SERVICE AREAS AS PSUs FOR THE NATIONAL HEALTH INTERVIEW SURVEY [1]

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SUMMARY

This describes results of research into alternative definitions of PSUs for the National Health Interview Survey (NHIS). The National Center for Health Statistics (NCHS) asked the Census Bureau to evaluate Hospital Service Areas (HSAs) as potential PSUs for the 1990 redesign of the NHIS.

HSAs are used as units of analysis in health services research. They are defined as one or more contiguous counties that are relatively self-contained with respect to the provision of routine hospital care. That is, anybody within a HSA seeking health care services would most likely do so within the HSA.

We looked at four sets of HSAs:

- 800 L: approximately 800 HSAs with a restriction that MSAs remain intact (Linked) within HSAs
- 800 U: approximately 800 HSAs with no restriction on MSAs (Unlinked) within HSAs
- 1400 L: approximately 1400 HSAs with a restriction that MSAs remain intact (Linked) within HSAs
- 1400 U: approximately 1400 HSAs with no restriction on MSAs (Unlinked) within HSAs

The method used to form the four sets of HSAs is described in Makuc (1990).

Basing our evaluation on a comparison of between-PSU variances, we concluded that, for constant cost:

- between-PSU variances increase when the number of PSUs is reduced;
- between-PSU variances increase when MSAs are linked;
- Hispanic variances increase more than non-Hispanic variances.

PURPOSE OF THE STUDY

Traditionally we have formed PSUs by combining adjacent counties so the resulting PSUs are heterogeneous with respect to important characteristics. Theoretically this reduces the between-PSU variance of survey estimates. If HSAs are more homogeneous than the traditional PSUs, estimates from a sample using HSAs would tend to have higher between-PSU variances.

However, NCHS has other programs which may benefit from a design based on HSAs and from closer integration with the NHIS. These benefits might outweigh the loss in precision of NHIS estimates if the loss isn't too great. The purpose of this research was to estimate the loss in precision.

DESIGN OF THE STUDY

To evaluate the alternative PSUs, we measured the between-PSU variance of evaluation variables for each of five designs—one for each HSA set plus the current design. We made the designs as consistent as possible with the current design. We used the stratification of nonself-representing (NSR), or noncertainty, PSUs of the current design and stratified the NSR areas of the designs for the alternative PSUs using the same stratification program and variables. We stratified within the four geographic regions and within MSA and non-MSA status as we did in the current design.

The stratification program tries to minimize a function of the form:

$$V_i^2 = \sum_k \sum_j Y_{.k} Y_{jk} \left(\frac{X_{ijk}}{Y_{jk}} - \frac{X_{i.k}}{Y_{.k}} \right)^2$$

where Y_{jk} is the measure of size for the jth PSU in stratum k and X_{ijk} is the value of the ith stratification variable for the jth PSU in stratum k. The dot indicates the summation over the missing subscript.

The stratification variables, from the 1980 census, were:

- Number of persons 16+ employed in manufacturing
- Number of Hispanic persons 16+
- Number of persons 0+ in poverty
- Number of persons 16+ unemployed
- Number of occupied housing units with income < $15,000
- Number of persons 0+ in urban areas

The measure of size variable was civilian noninstitutional population 0+.

In our evaluation, we used an existing stratification program that stratifies and computes variances on estimates of totals. We were unable to stratify on ratios, proportions, or other statistics.

EVALUATION VARIABLES

NHIS data are only available for sample PSUs. We needed data from all areas of the country for this evaluation. Therefore, we used variables which were available for the entire country under the assumption that they would provide a reasonable indication of how a change in PSU definitions would affect NHIS variables.

The 181 variables for which we computed variances are listed in Table 1. The estimates for the evaluation variables in NSR areas are in Table 3. We simply summed each variable over all NSR PSUs.

Variables 96 through 470 are from the 1980 Census of Population. They include population, poverty status, education, and work disability by race, sex, age, and Hispanic origin.

Variables 493 through 519 came from the March 1989 Area Resource File. This file is developed and maintained by the Office of Data Analysis and Management in the Health Resources and Services Administration. These variables include births and deaths for the total population, and of Blacks and females, deaths by age, deaths due to certain causes, and other variables related to the availability of health services.

Variables 520 and 521 came from the 1988 Medicare File on Short-Stay Hospital Stays from the Health Care Financing Administration. These were the number of hospital stays in the county and the number of hospital stays by residents of the county.

As with the stratification variables, the evaluation variables were estimates of totals. The program we used did not compute variances for any statistic other than totals.

SAMPLE DESIGNS

A. Keeping Costs Constant

To keep the costs constant with the current design, we assumed the same sample size and the same number of areas—counties, not PSUs—in sample. We also assumed no change in within-PSU sampling procedures.

Why do these assumptions mean cost will remain constant? The larger PSUs could mean more travel within PSUs which would be more expensive. However, we would, as much as possible in the alternative designs, keep weekly interviewer assignments within a single county or within adjacent counties as we do now. Also, not all PSUs have a resident interviewer. Interviewers have to travel to and stay overnight in these PSUs until they complete their assignments. Fewer PSUs in sample could possibly reduce these travel costs.

Taking all these factors into account, we felt that the costs of the alternative designs would be roughly the same as now. We asked the Census Bureau's Field Division staff for their opinion, and they agreed.

B. Determining the Number of Sample PSUs

The current design has 73 NSR strata. Two PSUs are selected from each NSR strata.

We created a sample design for each set of HSAs. At first we tried to keep all current self-representing (SR), or certainty, PSUs self-representing in the alternative designs. However, the HSAs that contained the current SR PSUs also contained a substantial amount of the current NSR counties and population. This would cause the SR population in the alternative designs to be far greater than in the current design and would distort the comparisons we wanted to make.

Next, we converted some of the smaller HSAs that had initially been SR to NSR until the population in each region was about the same as in the current design. This was an improvement, but there were still too many counties in the SR areas to satisfy our cost constraint.

Finally, we found a SR population cutoff for each set of HSAs. HSAs with more population than the cutoff were made SR. The cutoffs were determined so that the average NSR stratum size was somewhat smaller than twice the size of the smallest SR HSA and the expected number of counties in sample was about the same as now.

Table 2 shows the five sample designs.

BETWEEN-PSU VARIANCES OF THE EVALUATION VARIABLES

Table 4 shows the between-PSU variances of the evaluation variables. The variance calculation used the following formula:

$$V_I^2 = \frac{1}{2}\sum_k \sum_j Y_{jk}\left(Y_{.k} - 2Y_{jk}\right)\left(\frac{X_{ijk}}{Y_{jk}}\right)^2 +$$

$$\sum_k \sum_j \sum_{t \neq j} Y_{jk}Y_{tk}\left(\frac{X_{ijk}}{Y_{jk}}\right)\left(\frac{X_{itk}}{Y_{tk}}\right)\left[\alpha_k\left(\frac{1}{Y_{.k} - 2Y_{jk}} + \frac{1}{Y_{.k} - 2Y_{tk}}\right) - 1\right]$$

where

$$\alpha = \frac{Y_{.k}}{2}\left[1 + \sum_j \frac{Y_{jk}}{Y_{.k} - 2Y_{jk}}\right]^{-1}$$

X_{ijk} and Y_{jk} are defined as before except X is now an evaluation variable. This formula is based on the Durbin method of selecting 2 PSUs per stratum.

Relative between-PSU variances (the between-PSU variance divided by the square of the estimate) are in Table 5. Table A summarizes Table 5.

Variable 497, total number of deaths due to breast cancer, had the maximum relative between-PSU variance for all designs except 800 U, where the maximum occurred for variable 405, total Hispanic population 65+ in poverty.

On average, the Hispanic variables had higher relative between-PSU variances than total or Black. The averages of the Hispanic variables were 2.46% (for the 800 L) design, 2.68% (800 U), 1.93% (1400 L), 2.11% (1400 U), and 1.18% (1980).

The averages for the Black variables were only slightly higher than the overall averages.

Variable 510, the number of birthdays in January and March, helped to validate the calculations. Its relative between-PSU variance was very low, between 0.00% and 0.01% for all five designs, as expected.

DESIGN EFFECTS FOR THE EVALUATION VARIABLES

A. Between-PSU Design Effects

We divided the between-PSU variances from the four alternative designs by those of the current design to get between-PSU variances relative to the current design, or design effects. The design effects are shown in Table 6 and summarized in Table B.

The variables with the maximum design effects were: 312, total Hispanic population 18-44 with no high school (800 L and 1400 L); 311, total Hispanic population 0-17 with no high school (800 U); and 510, total number of birthdays in January and March (1400 U).

The variable with the second highest design effect for design 1400 U was another Hispanic variable, 389, total Hispanic population 18-44. The birthday item has very little variance, so a large design effect is unimportant.

Several other results are seen in this table. Average design effects are well over 1.0. The designs based on 800 PSU had higher design effects than the 1400 PSU designs. Also, linking MSAs increases variances.

These results were not a surprise. The two 800 PSU designs had roughly equal NSR populations. However, the linked design had 40 NSR strata, while the unlinked design had 50. Similarly, the 1400 PSU designs also had about the same NSR populations, but the linked design had 50 NSR strata compared to 72 for the unlinked design. The current design has 73 NSR strata. Also, the unlinked HSAs probably stratify better than linked HSAs.

B. Total Design Effects

The between-PSU design effects exaggerate the overall effect on NHIS estimates. Most of the variance in NHIS estimates is due to within-PSU sampling. Previous experience with NHIS estimates tells us that the between-PSU variance for NHIS estimates is usually less than--sometimes much less than--20 percent of the total.

We computed a total design effect by assuming that 20 percent of the variance of the current design would increase by the amounts in Table 6 and that 80 percent of the variance would not change. Since the sample size and within-PSU procedures would remain constant in the alternative designs, the assumption that the within-PSU variance wouldn't change seemed reasonable. These total design effects are shown in Table 7 and are summarized in Table C.

The variables with the maximum total design effects are the same as in Table 6 mentioned above.

The between-PSU variance in the current design may be much less than 20 percent for most items. We recalculated Table C under the assumption that the between-PSU variance is only 10 percent. The results are in Table D.

COMPARISON OF TOTAL AND HISPANIC DESIGN EFFECTS

Because of a particular interest in improving Hispanic estimates in the redesign, we repeated the information in Tables A, B, and D for 30 Hispanic variables and the corresponding variables for the total population. This data is shown in Tables E, F, and G, respectively. This shows more clearly the increases in design effects for Hispanic variables.

NCHS' FINAL DECISION ON PSU DEFINITIONS

For the 1990 NHIS redesign, NCHS decided to retain census-based PSUs instead of one of the four alternative PSU definitions based on HSAs. HSA-based PSUs would conflict with two objectives of the 1990 redesign: improvement in Hispanic estimates and ability to produce state estimates.

As shown in our study, HSA-based PSUs increase sampling error, especially for Hispanic estimates. The 1990 redesign of NHIS will use a within-PSU sampling procedure that includes the oversampling of Blacks and Hispanics which should improve the reliability of minority estimates. Use of HSAs as PSUs would minimize the gains of within-PSU oversampling.

Because HSAs cross state boundaries, use of HSAs as PSUs is not the best choice for producing state estimates. The census-based PSUs that the 1990 NHIS would use are defined completely within state.

REFERENCE

Makuc, D. (1990), "Use of Cluster Analysis to Identify Health Care Service Areas," American Statistical Association 1990 Proceedings of the Section on Social Statistics, 260-265.

FOOTNOTES

[1] This paper reports the results of research undertaken by Census Bureau staff. The views expressed are attributable to the author and do not necessarily reflect those of the Census Bureau.

Table A. Summary of Relative Between-PSU Variances of the Evaluation Variables

Summary	800 L	800 U	1400 L	1400 U	1980
Average	0.68%	0.64%	0.57%	0.64%	0.49%
Minimum	0.00%	0.00%	0.00%	0.00%	0.00%
Maximum	9.71%	6.61%	6.21%	21.79%	20.28%
75th Percntl	0.70%	0.53%	0.59%	0.49%	0.45%

Table B. Summary of Between-PSU Design Effects of the Evaluation Variables

Summary	800 L	800 U	1400 L	1400 U
Average	2.64	2.28	1.82	1.46
Minimum	0.49	0.28	0.30	0.54
Maximum	5.71	5.19	3.43	2.76
75th Percntl	2.80	2.57	1.96	1.54

Table C. Summary of Total Design Effects of the Evaluation Variables (assumes between-PSU is 20% now)

Summary	800 L	800 U	1400 L	1400 U
Average	1.33	1.26	1.16	1.09
Minimum	0.90	0.86	0.86	0.91
Maximum	1.94	1.84	1.49	1.35
75th Percntl	1.36	1.31	1.19	1.15

Table D. Summary of Total Design Effects of the Evaluation Variables (assumes between-PSU is 10% now)

Summary	800 L	800 U	1400 L	1400 U
Average	1.16	1.13	1.08	1.05
Minimum	0.95	0.93	0.93	0.95
Maximum	1.47	1.42	1.24	1.18
75th Percntl	1.18	1.16	1.10	1.05

Table E. Summary of Relative Between-PSU Variances of 30 Hispanic Evaluation Variables

Summary	800 L	800 U	1400 L	1400 U	1980
Average	2.46%	2.68%	1.93%	2.11%	1.18%
Minimum	1.24%	1.09%	0.87%	1.04%	0.42%
Maximum	5.64%	6.61%	6.00%	6.28%	5.03%
75th Percntl	3.01%	3.27%	2.27%	2.49%	1.52%

Table F. Summary of Between-PSU Design Effects of 30 Hispanic Evaluation Variables

Summary	800 L	800 U	1400 L	1400 U
Average	4.20	3.73	2.35	2.12
Minimum	1.58	1.35	1.36	1.13
Maximum	5.71	5.19	3.43	2.75
75th Percntl	5.02	4.52	2.70	2.47

Table G. Summary of Total Design Effects of 30 Hispanic Evaluation Variables (assumes between-PSU is 10% now)

Summary	800 L	800 U	1400 L	1400 U
Average	1.32	1.27	1.14	1.11
Minimum	1.06	1.03	1.04	1.01
Maximum	1.47	1.42	1.24	1.18
75th Percntl	1.40	1.35	1.17	1.15