State Sampling Allocation Strategies for the 2016 Redesigned National Health Interview Survey (NHIS)

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Abstract

The NHIS is a multi-purpose face-to-face health survey conducted annually by the National Center for Health Statistics (NCHS). Historically, the NHIS has been designed to produce accurate national-level statistics on an annual basis. The traditional design has been based upon a one-time probability sample of coarsely defined geographical units containing population dwellings to be sampled over a 10 year NHIS design cycle. The current NHIS objectives, however, are broader in scope than in the past. Now, the 10 year survey objectives also include the ability to achieve accurate estimates for state and targeted minority populations, but on an "as needed" basis. Budgetary and operational constraints have presented challenges in achieving an optimal design. As a compromise, the final redesign is structured with a nationally-focused design as its core, but the design contains large reserve samples that can be used to achieve state or minority objectives. A recent focus on state-level heath care has placed a priority on the allocation of sample to achieve state objectives. In this paper we present the state allocation strategies to be implemented in 2016.

1. Introduction

The National Health Interview Survey (NHIS), a source of health information for the United States, is a multi-purpose in-person interview health survey conducted annually since 1957 by the National Center for Health Statistics (NCHS). The reader is referred to Parsons et al. (2014) for methodological details for the 2006-2015 and past designs. To accommodate a changing population and new survey objectives, the complex-design structure of the NHIS is redesigned every decade to allow for up to a 12 year cycle of continuous sample. A key feature of the 2016 design cycle, scheduled to start in January 2016, is its flexibility to increase or decrease the size and geographical locations of sample depending upon current objectives. The reader is referred to Moriarity and Parsons (2015) and Parsons (2014) for discussion of the proposed 2016 redesign and flexibility. In late 2014, NCHS leadership gave first priority to national estimates, however, the ability to make state estimates, subject to available funds, was a second priority. The flexible nature of the design allowed a cost-neutral state reallocation of the proposed 2016 sample that enhanced state potential in the smaller populated states but with little loss of precision at the national level. Again in mid-2015 when additional funds became available, new sample was allocated to selected states for improved precision.

As state-level estimation is now an active objective for the NHIS, the remainder of this paper demonstrates the potential of flexible sample allocation in achieving annual state-level estimates.

[1]*The second author's contribution was during her employment at NCHS.*

2. Examples of Flexible NHIS Designs

A collection of possible NHIS designs, structured to cover continuous monthly face-to-face data collection from 2016 to 2028 (if needed), will be subsamples from a large parent design (P) with the following features:

Design **P**:

- The parent design consists of a collection of independent state designs.
- Each state has a large and identified systematic sample of geographical clusters "on-the-shelf" which can serve as NHIS sample; for most states these geographical clusters have the potential to provide samples of 3,000 or more housing units per year.
- Sampled geographical areas are subsampled to form locations for cost-efficient face-to-face interviewer workloads which have the potential to cover up to 12 years of data collection.
- For any given year in the 12 year NHIS cycle, the "on-the-shelf" sample will be designated as either an active or reserve sample.
- Implementation depends on funding/annual objectives.
- The large "on-the-shelf" sample is based on systematic sampling techniques. All annual designs are based on subsampling by systematic sampling or simple random sampling. This methodology leads to straightforward multiplicative rules for computing the probabilities of selection.
- Master design structures for the "on-the-shelf" designs are maintained by U.S. Bureau of the Census.

The parent design, P, has two major national sub-designs, referred to as N.1 and N.2. The N.1 design is planned for a typical NHIS budget and is structured as a national-level self-weighting design. The N.2 design, planned as a sub-design of N.1, is available for implementation whenever major budget reductions develop. These national designs have the following features:

Design **N.1**:

- This is considered as a national self-weighting design with state sample sizes roughly proportionate to state population size.
- This design is cost-neutral with respect to the 2006-2015 NHIS design.
- All states are included.
- Approximately 35,000 completed household interviews per year are expected.

Design **N.2**:

- This design is considered as a "minimal" required NHIS sub-design for national estimation.
- This design is intended for major budget reductions.
- The design is static with respect to sampled areas over a 12 year NHIS cycle.
- Approximately 25,000 completed household interviews per year are expected.
- The tally of 10,000 households removed from design N.1 in forming the static design N.2 are also associated with flexible sample reallocations consistent with changing survey objectives.
- Each state will have sample.
- The design is approximately self-weighting at the national level.

With the recent focus on health statistics within states, NCHS was encouraged to place more emphasis on state-level sampling design structures than was done during the 2006-2015 design cycle. This need led to two state designs, referred to as S.1 and S.2, which have the following features:

Design **S.1**:

- This design is cost-neutral with respect to the national design N.1.
- Within some of the larger populated states the sample for design N.1 is reallocated to some of the smaller states.
- Each state has a self-weighting sample.
- Overall, national sample size is about the same size as in design N.1.
- The reallocations of sample are intended to allow all states to have the ability to produce state estimates with 1 to 3 years of data. One year of data is needed for the largest states, and 3 years of data are needed for the smallest states.

Design **S.2**:

- This is a sample enhanced design using design S.1 as its base.
- Extra funding received for 2016 is used to increase sample for mid-level populated states. It is expected that 45 states will have adequate annual sample to provide state estimates.
- Design S.2 is the design planned for implementation for the year 2016.

3. Evaluations of Flexible NHIS Designs

3.1 National Evaluations of Designs N.1, N.2, S.1, and S.2

Design N.1 will represent a standard self-weighting national NHIS design; it will be used as a baseline for national-level comparisons with respect to its modified design versions N.2, S.1, and S.2. As mentioned in the Introduction, the NHIS also targets having accurate minority domain estimates at the national level, (for this work, "minority" will cover Hispanic, non-Hispanic black and non-Hispanic Asian households). The following Table provides the expected raw sample sizes, and the design effects from using differential sampling rates for states to increase or decrease sample size. This increased variability in sampling weights reduces the effective sample size at the national level. The cost-neutral transition from national design N.1 to state design S.1 results in only a small design effect increase while increasing annual state capabilities as well as now having 2 to 3 year state estimates based on pooling years of data. Within the level of rounding, the order of magnitude of precision for national minority estimates should be similar between designs N.1 and S.1. Enhanced state design S.2 greatly increases annual state capabilities as additional resources are only directed toward mid-sized states, but consequently, there are 16% and 11% losses of effective sample sizes for national and minority domains, respectively.

Table: National and State Level Estimation Basics

	All Interviewed[1] Households		Interviewed Minority Households		Annual[4] State
Design	n[2]	Deff.w[3]	n	Deff.w	Count
N.1	35	1.00	11.0	1.00	23
N.2	25	1.01	8.0	1.01	16
S.1	35	1.03	11.0	1.02	26
S.2	43	1.16	12.5	1.11	45

[1/] Expected number of households, n, with completed interviews
[2/] n measured in 1,000's
[3/] Deff.w is a national design effect due to differential sampling within states, excluding weighting adjustments and clustering effects
[4/] Expected number of states capable of producing an annual estimate

3.2 State Evaluations of Designs N.1, N.2, S.1, and S.2

Assessing a state's potential to produce an annual estimate is somewhat subjective. Assuming that the NHIS sampling design leads to unbiased estimation of population proportions, the precision level for an entire state and the degrees of freedom for a variance estimator will be used to evaluate potential. For this evaluation, a state's effective sample size will be defined as

$$Eff\_n = n / [\text{deff} \cdot f_{df}] \quad \text{where}$$

N = expected total completed household interviews within a state,
$deff$ = design effect,
f_{df} = min (2 , t^2 (df, 0.975) / z^2(0.975)) with
z (0.975) = 1.96 and t (df, 0.975) being corresponding z- and t-statistic cutoffs where df is the state degrees of freedom for a design-based variance estimator.

For this evaluation the $deff$ parameter was assigned the value 1.2, and the df parameter was computed using a Satterthwaite approximation applied to the state-level sampling strata and expected cluster sizes. A sample size deflation factor, f_{df} , was imposed to place a stronger penalty on a state's potential whenever the number of clusters in the sample was limited. This version of effective sample size attempts to standardize a confidence interval length to that of a simple random sample using a z-statistic.

For each design, P, N.1, N.2, S.1, and S.2 this expected effective sample size, Eff_n, was computed at the state level. Using the expression: $(1-p)/p = Eff\_n \cdot CV^2(\hat{p})$ the following criteria were used to define an acceptable magnitude of size for Eff_n to support state-level estimation.

- Whenever a true state proportion p is 0.10, then *Eff_n* yields a coefficient of variation CV $(\hat{p}) \leq 0.15$.
- If a state has effective size *Eff_n*, then the smallest true state proportion, p that can be estimated at precision level CV $(\hat{p}) \leq 0.10$ is at the value $p = 0.15$.

Figure 1 displays 9 ordered classes representing the magnitudes of *Eff_n* along with CV's and minimum p's as specified by the criteria above. For the each of the designs, P, N.1, N.2, S.1, and S.2, a state's class membership is established and plotted in Figures 2 to 6. (The figures are plotted using the *R* package "statebins".) The "color-coded" state evaluation of potential goes from red to yellow to blue, corresponding to a poor to marginal to good evaluation. The discretized range categories used in the figures have the lower bound *Eff_n* = 400 defining the threshold for a state to be classified as "Marginal". A few States had an *Eff_n* value in the very high 300 range and were clearly separated from the smaller values. These states were moved to the "Marginal" class to better reflect potential.

3.2 Discussion of State Evaluations of Designs N.1, N.2, S.1, and S.2

These evaluations are all based on conceptual design structures when sampling up to the household level. In practice, aberrations from idealized frameworks are to be expected along with additional structures needed for within-household sampling. Typical weighting adjustments have not been considered. These figures should be considered as providing orders-of-magnitude for state-level precision.

It is important to note that the sample size counts are all based on household counts. The number of persons expected per household is approximately 2.5, so the 2016 NHIS design will have about 108,000 sampled persons, thus an effective size, *Eff_n*, based on persons would be larger than the corresponding value estimated for households, but for persons, an additional *deff* parameter inflation factor would be needed to account for within household clustering.

In many states, in particular for those labeled as with "marginal" (yellow) potential, the combining of two or more years of sample will greatly enhance potential. Given adequate funding, many of the marginal states will have sample reallocated to different within-state clusters, thus increasing the degrees of freedom as well as having multiple years of sample. In particular, state subdomains may need multiple years of data for required precision and will need pooled years of sample.

References

Parsons VL, Moriarity C, Jonas K, et al. 2014. Design and estimation for the National Health Interview Survey, 2006–2015. National Center for Health Statistics. Vital Health Stat 2(165).

Moriarity C, Parsons, V, 2015. 2016 Sample Redesign of the National Health Interview Survey, In *JSM Proceedings*, Statistical Research and Methods Section, Alexandria, VA: American Statistical Association. Submitted.

Parsons, V. 2014. Designing Flexibility for State Samples into the 2016 NHIS. In *JSM Proceedings*, Statistical Research and Methods Section, Alexandria, VA: American Statistical Association. 3037-3043.

Fig 1: Legend for Figures 2,3,4,5,6

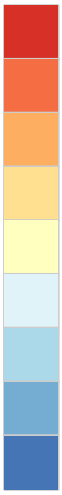
(1) State Effective Sample Size

(2) %CV at p = 0.10

(3) Minimum p to achieve a 10% CV

(4) Potential for State Estimation

Poor to Good (RED --> BLUE)



Eff n	%CV(p=0.10)	min p	Potential
(0, 50)	[42, +)	[67, +)	Poor
[50, 100)	[30,42)	[50,67)	
[100, 250)	[19,30)	[29,50)	
[250, 400)	[15,19)	[20,29)	
[400, 650)	[12,15)	[13,20)	Marginal
[650, 950)	[10,12)	[10,13)	
[950,1300)	[8,10)	[7,10)	
[1300,2500)	[6, 8)	[4, 7)	
[2500,3000)	[5, 6)	[3, 4)	Good

Fig 2: Annual State Potential − Maximum Sample Design P
All Reserve Sample Used

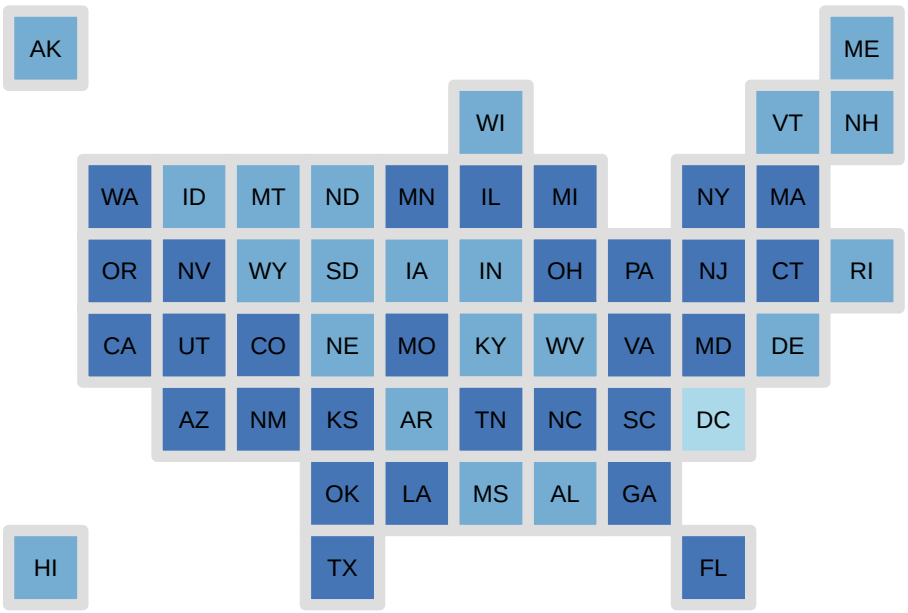


Fig 3: Annual State Potential − National Design N.1
35,000 Interviews, PPS by State

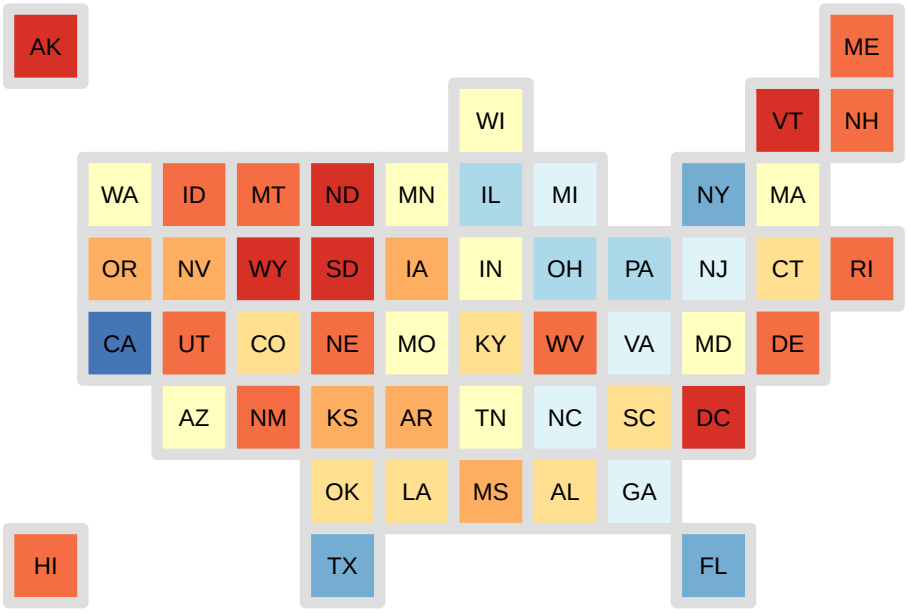


Fig 4: Annual State Potential − National Design N.2
25,000 Interviews, Reduced Funding

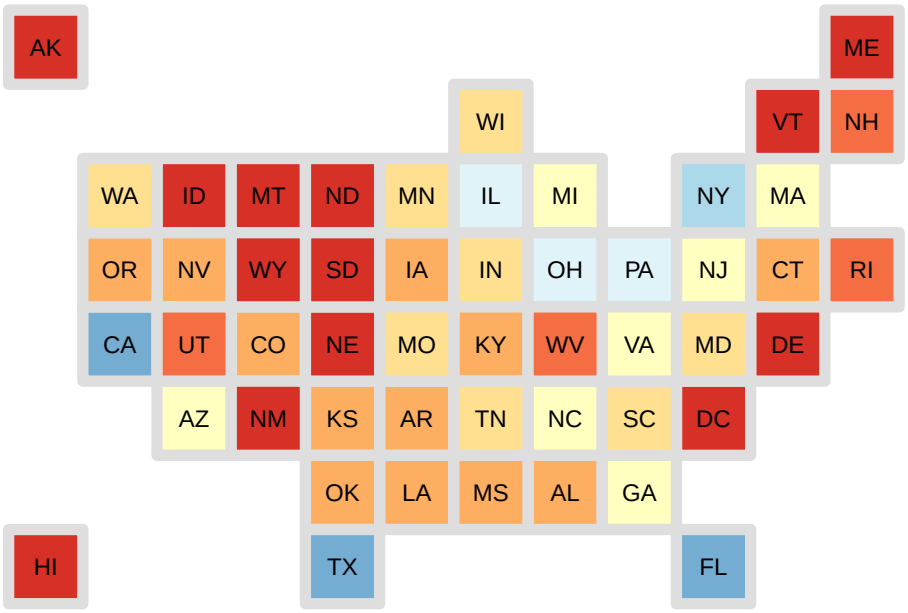


Fig 5: Annual State Potential − State Design S.1
35,000 Interviews, Reallocation to Smaller States

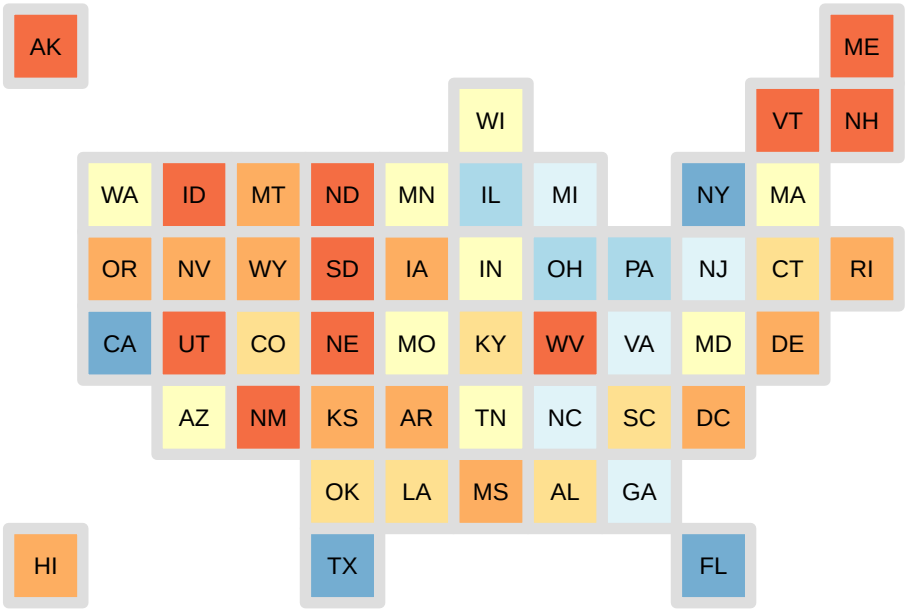


Fig 6: Annual State Potential − 2016 State Design S.2
43,000 Interviews, Middle−Size State Expansion