Designing Flexibility for State Samples into the 2016 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 statistics at the national level. The traditional design has been based upon a one-time sample of coarsely defined geographical units, typically a probability sample of counties and block clusters, to define the areas for annual household sampling conducted over a 10 year NHIS design cycle. Recently, there has been a greater interest in structuring geographical flexibility into the NHIS. In particular, with recent attention given to state-level health measures, the NCHS wants the NHIS to have the ability to expand and contract the sample in targeted states in order to meet estimation needs within existing budgetary conditions. Any flexible design structure must be cost-effective, implementable in a timely fashion with respect to field operations, and be amenable to creating the design features needed for data analysis for both annual and multiple years of data. In this work a proposed systematic sampling method which meets many of the goals of a flexible design is discussed.

Key Words: systematic sampling ; sample expansion

1. Introduction

The National Health Interview Survey (NHIS) is a multi-purpose in-person interview health survey conducted annually since 1957 by the National Center for Health Statistics (NCHS), and is a source of health information for the United States. The reader is referred to Parsons et al. (2014) for methodological details for the current and past NHIS designs. To accommodate a changing population and new survey objectives, the complex-design structure of the NHIS is redesigned every decade with the current redesign starting date planned for January 2016. The current and previous NHIS designs were designed to be geographically fixed-in-place over a possible 12 year design cycle. For those cycles of the NHIS, the geographical locations for the in-person interviews, typically a sample of counties and metropolitan areas, were determined for the first year of the survey cycle, but with little variation, stayed the same over the entire 12 year cycle. Different housing units were targeted, but to keep survey costs under control, the field operations were confined to the same geographical areas.

In the past, the target of focus for the NHIS was the health of the nation as a whole. Recently, there has been greater attention given to the collection of health measures at the state level. The current NHIS is not designed with state estimation as an active objective, but to some degree, the largest and midsized states have sufficient sample to support design-based state estimation methodologies. Since the current design and its operations

are somewhat fixed to cover a 12-year period, any modifications required to increase state-level geographical sampling coverage within the existing framework become difficult to implement. Such a modification was requested during the years 2011-2014 when additional funding for the NHIS was made available to expand state-level estimation capabilities. Adding new geographical areas for sampling demonstrated that many of the existing design structures were difficult to expand while still retaining tractable structures for survey weighting and variance estimation. To avoid such expansion problems in future designs, one of the objectives for the redesigned 2016 NHIS is to create a design structure that is flexible to changing NHIS priorities that may require sample adaptation. These changes include sample enhancements, reductions and resource reallocations. As of this writing much of the work is still in progress, and many decisions on the final form of a flexible redesigned NHIS still must be made. This work presents an outline of a flexible design strategy that may accommodate the changing needs of the NHIS.

2. **Flexible NHIS Embedded Designs**

The proposed NHIS redesign structures are anticipated to create a design cycle covering years 2016 to possibly 2025. For this NHIS cycle the survey must retain its national character over the entire cycle, but have greater adaptability to enhance geographical coverage, particularly at the state level. The survey objectives and corresponding design structures can be stated more specifically as follows:

1. First and foremost, the NHIS must retain its main priority of being a national survey, capable of producing accurate, reliable estimates at the national level and for many national subdomains of interest over the life of the survey cycle.

2. State-level sampling objectives are to be given a higher priority than were given in the past. If the NHIS is to be considered as source of information for producing state-level health statistics, there should be a design plan to achieve 1000 completed interviews per state if funding resources permit.

3. The full survey cycle should cover up to 10 years of planned data collection with two reserve years and have design structures covering such a period.

4. The design should be flexible in allowing sample changes to meet current and future needs. The design structures should permit straight-forward computations for probabilities of selection to cover sample size enhancements, reductions and cost neutral reallocations of sample. Variance estimation should be amenable to data analysis for both annual and time trend analyses.

5. As the NHIS requires an advanced well-planned field operation for face-to-face interview, all geographical locations and sampling structures must be known well in advance of the time designated for field implementation.

6. Assuming traditional funding, a national sample can support about 35,000 housing units that lead to complete interview status. With the flexibility requirement, there will be an embedded “minimal” national subdesign that yields about 25,000 completed interviews. This minimal design will have design structures quite similar to previous NHIS designs.

To meet the objectives outlined above, a design plan is being considered (but as of this writing not yet finalized) such that each state will have an extended sample over and above what is needed for a national or a state-focused design. This design consists of a core sample plus a reserve or inactive sample. This reserve can be thought of as a sample "on the shelf" available for usage, and this sample will have many of the structures needed for setting up field work already specified.

More specifics will be provided in section 3 below, but first we briefly state the strategy to achieve flexibility. To create a core plus reserve sample, we define a collection of state-stratified systematic samples of clusters, where each cluster represents a potential interviewer workload of housing units. These housing unit clusters are somewhat hypothetical at this stage, but the geographical location up to the county level and the size is completely specified. These systematic samples cover over and above what are needed for either core or state samples. The sample representing the core NHIS design with anticipated 35,000 completed interviews is systematically subsampled from the larger sample, and within the core sample an embedded subsample with an anticipated 25,000 completed interview selected. The stratification of the large sample and some cluster size controls provides mathematically tractable sampling properties of the selected samples. This structure provides great flexibility in adding or removing sample in targeted areas.

2.1 Examples of Possible Flexible Annual NHIS-Generated/Embedded Designs

The flexibility of the sampling mechanism can produce several designs that cover many of the objectives stated in section 2.

Design A: National PPS Baseline: 35,000 completed interviews. Design A would be considered a version of a traditional NHIS.

Design B: Minimal PPS NHIS: 25,000 completed interviews. Design B $\subset$ A (read as "design B is a subsample of design A"). Design B would remain fixed over the time cycle of the NHIS in that its sampled geography would remain fixed over time.

Design C: Equal sample size state design, about 700 completed housing unit interviews per state, cost neutral with respect to design A. Design B $\subset$ C for all states, but for large states, design C $\subset$ A, and for small states, design A $\subset$ C.

Design D: Enhanced mid-sized state sample with reallocated large state samples, about 1000 completed interviews in mid-sized states, and cost neutral with respect to A. Here, the large state samples of design D use the entire samples of the large states of design B, but the sample sizes are smaller than the corresponding state samples for the design A. In these large states, the sample size balance between design A and design B is reallocated to the mid-sized states. This reallocation results in Design B $\subset$ D for all states, but for the large states design D = B, and for smaller states design B $\subset$ D.

3. **Outline of Sampling Methodology for Embedded Designs**

The sampling method is somewhat involved, but the basic steps are outlined below.

1. Each State is partitioned into a universe of county-based Primary Sampling Units (PSUs). Each PSU has a measure of size equal to its 2010 Census housing unit count.

2. The within-state PSUs are partitioned into substrata:

   LM: Large Metro Areas
   SM: Smaller Metro and non-Metro Areas

3. The LM- and SM-type PSUs are each partitioned (conceptually) into uniform sized clusters of housing units, each containing K units, a value consistent with a field operation workload, and the size of K can vary by state and type of substratum.

4. Operational considerations dictate the following relations for the LM- and SM-type strata:

Relative Field Cost:	cost per LM Housing Unit	<	cost per SM Housing Unit
Cluster size:	size LM cluster	<	size SM cluster
Number Sample Clusters:	sample size SM	<	sample size LM

5. Large systematic samples of K-sized clusters within each state's LM and SM strata are drawn to define hit geography to create a large inclusive core + reserve sample.

6. Each large systematic sample consists of several smaller systematic subsamples. One such sub-sample defines the National Core Design A, and the other available sub-samples define the reserve.

7. The Census Bureau does a finer level of sampling within the sampled geography.

3.1 Example of methodology for the State of Indiana (IN)

Note, to avoid disclosure, the design structures used in this example are hypothetical but indicative of the planned design.

In the map Figure below, the dark brown shaded areas signify the largest metropolitan areas of Indiana and are defined to be the LM-type strata. The blue, light brown and white areas define the SM-type strata, and those areas designated with a "+" are Census designated MSA areas of the state. If the SM-type strata were defined to consist of 40 universe PSUs labeled $a, b,\ldots,N$, then such a partition could be presented as a list of PSUs implicitly sorted by MSA status and measures of size as is done in Table 1. A systematic sample based on the PSU measure of size is taken. The systematic sampling parameters are defined so that the resulting sample is of sufficient size to cover present and future needs. In this example 28 geographical areas were selected or "hit" by the systematic selection process, for example PSU "a" was hit 3 times as this was the largest PSU by

size in the list. The *E.hit* value (rounded) of Table 1 signifies the expected number of times each PSU in the SM stratum is hit when using the systematic sampling process.

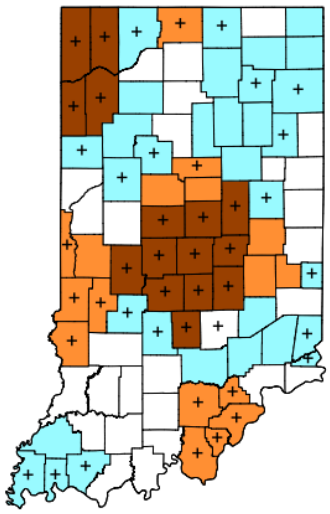
The SM stratum Core + Reserve sample is defined to hit 28 clusters, each defined to contain about 100 housing units for field interview. For the LM stratum a systematic sample of a large number of smaller sized clusters will also be taken to cover both a core + reserve sample (details omitted).

This SM systematic sample of 28 hits is labeled *nn* in the Table 1, but has been reordered to form 4 dispersed systematic samples of size 7. The systematic sample coded 01 to 07 (highlighted in red) represents a hypothetical Core sample, and the sample coded 08 to 28 (highlighted in blue) represents its complementary Reserve sample. The Reserve and Designs A, B, C and D discussed earlier can be expressed using these labels:

National Design	**A**:	01,02,03,04,05,06,07
Reserve sample	**:**	08,09,…,28
Minimal Design	**B**:	01,02,03,04,05
Equal State Design	**C**:	01,02,03,04,05,06
Enhanced Mid-State	**D**:	01,02,03,04,05,06,07,08,09

Figure: Hypothetical Core + Reserve Sample in Indiana

IN: Locations of National + State(reserve) PSU Samples



+ : MSA areas
LT brown: National PSU Areas
Blue: State(reserve) PSU Areas
DRK brown: certainty PSU Areas (National and State)

Table 1: Hypothetical Sample in the State of Indiana

PSU	E.hit	Sys.Sample	PSU	E.hit	Sys.Sam	PSU	E.hit	Sys.Sam
a	3	13,20,27	o	1	17	C	0	.
b	2	06,09	p	1	.	D	0	.
c	2	23	q	1	03	E	0	22
d	2	02,16	r	1	12	F	0	.
e	1	11,25	s	1	.	G	0	.
f	1	18	t	1	26	H	0	.
g	1	04	u	0	.	I	0	15
h	1	14	v	0	19	J	0	.
i	1	28	w	0	.	K	0	.
j	1	21	x	0	.	L	0	.
k	1	07	y	0	05	M	0	.
l	1	.	z	0	.	N	0	01
m	0	10	A	0	.			
n	2	24	B	0	08			

nn = Sampled PSU for National Design
nn = Sampled PSU for State(Reserve) Design .. = Not sampled

4. Potential of a Flexible Design for State Estimation

The core national design A has a sampling structure that should allow accurate estimation roughly on a par with past NHIS designs. However, at the state level the traditional available funding for the NHIS only supports a national design that allows accurate design-based estimation for the larger states. Table 2 provides the expected potential for a large, a medium and a small populated state when using a national design structured as in design A.

Table 2: Hypothetical One-year National PPS Core Design-A
Selected State Evaluations

	Completed household interviews (expected)	Degrees freedom variance	Potential design-based estimation	Reserve needed for estimation states
Georgia	1100	27	good	none
Indiana	750	15	fair	a little
Montana	150	1	poor	a lot

The state of Georgia core design sample size appears adequate for estimation. The state of Indiana can support some coarse level estimation. Adding about 2 reserve SM PSUs and a proportional amount to its LM stratum will elevate it to an expected 1000+ completed interviews. The state of Montana is one of the less populated states and needs substantial reserve to achieve sufficient state sample for design-based estimation. In general, having increased funding, using multiple years of data and re-allocation of sample from large to smaller states are the means of achieving state-level estimation.

5. Design work in Progress.

This work only focuses on an early stage of the 2016 NHIS redesign planning when the major goal was to have design flexibility in modifying NHIS sampling structures quickly to achieve accurate precise state-level estimates while keeping the national objectives intact. Other challenges in developing a viable 2016 sampling plan are the impact of the transition from an area and building permit frame to a predominately vendor address frame, the high costs of screening procedures to target minority populations, and the increasing level of non-response. These issues may result in major modifications to the design structures as presented in this write-up.

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Reference

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