Optimal Sampling Designs for National Surveys of Students

Ronaldo Iachan, ICF International
Will Robb, ICF International
Kate Flint, ICF International
Mirna Moloney, ICF International

1. Introduction

This paper investigates a number of redesign options for national surveys of students. These surveys often seek to oversample particular demographic sub-groups of students, such as African Americans or Hispanics, in order to generate precise estimates for these subgroups. These surveys use multistage stratified sampling designs with primary sampling units (PSUs) that are defined geographically—for example, as counties or county groupings—in order to provide cost-effective data collection. These designs typically select PSUs with probabilities proportional to size (PPS) using a measure of size (MOS) based on some function of student enrollment, with the MOS calibrated so that the sample yields the required number of students by demographic subgroup. The canonical design uses an unmodified student enrollment as MOS.

Using a sampling frame constructed for national surveys, we will generate simulated samples under a variety of sampling designs (1000 samples for each parameter combination). Designs will be evaluated using several metrics, including the effective sample size and sample yields for the target sub-groups. The parameters examined will include the MOS function, and alternative PSU stratifications. Here, we will compare a stratification based on urban status and minority concentrations with a simpler stratification that capitalizes on the new NCES urban status classification of all schools and districts into 12 locales that represent degrees of urbanicity.

2. Overview of traditional sampling design

We will focus on two national surveys that share many design features. These features are summarized below:

- Multistage stratified random sampling designs
- Primary sampling units (PSUs) based on counties or county groupings
- Second stage units (SSUs) are schools or schools linked into SSUs to provide all grades of interest
- Ultimate sampling units are students selected via intact classes
- Stratification at the first stage defined by urban status (urban/rural) and minority concentrations
- Selection of PSUs and schools (SSUs) with probabilities proportional to size (PPS) using an appropriate measure of size (MOS)
- Sample sizes determined by precision required for key subgroups particularly those defined by race/ethnicity and by school level or by grade

To achieve required sample sizes for black and Hispanic students, the design has adopted three main measures to oversample these students by selecting with greater probabilities the schools and areas (PSUs) with higher concentrations of minority students.

1. Disproportional allocation of PSUs to the strata with higher minority concentrations
2. PPS selection using a weighted enrollment MOS that assigns greater coefficients to minority student enrollments
3. Selecting double classes in schools with greater minority concentrations

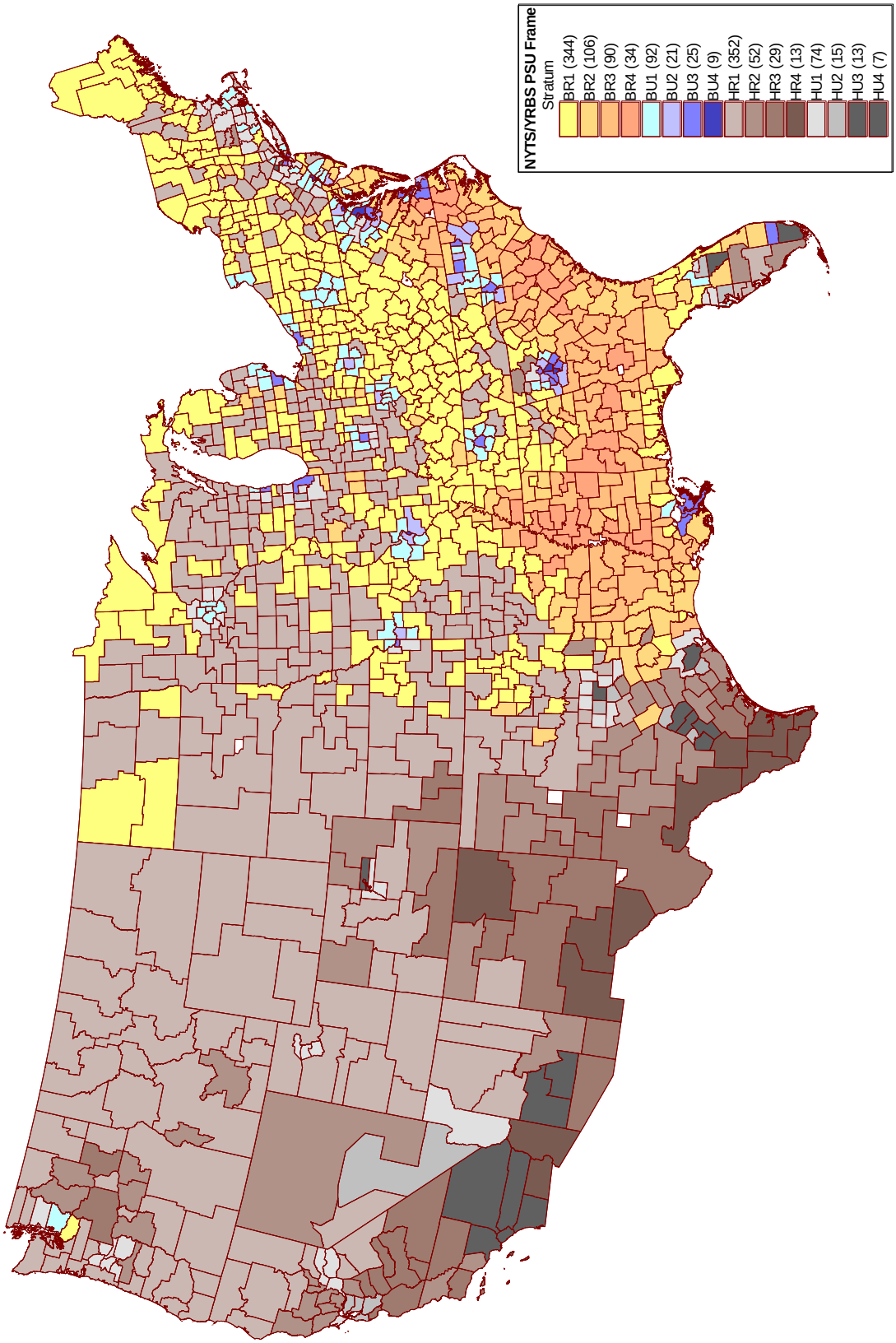
For the redesign effort in coming survey cycles, we are investigating the effectiveness of relaxing the first two measures by adopting a proportional allocation and selecting with unweighted enrollment MOS. Both modifications will enhance the precision of overall survey estimates. The simulation studies examined the feasibility of these methods in achieving the target sample sizes for black and Hispanic subgroups, in particular. These modifications have been made possible by the changing demographic landscape of the US student population with growing proportions of Hispanics in particular.

3. Stratification

Stratification of PSUs is used in national school surveys to control allocation across the urban-rural continuum as well as to support oversampling of African Americans and Hispanics. The construction of the 16 strata reflects these characteristics (Exhibit 1), splitting PSUs along urban/rural lines into two classes that divide the student population into roughly even proportions, and further dividing the PSU based on predominant race/ethnicity (i.e., black or Hispanic) and race/ethnic concentration. This latter split is complex, but allows for differential allocation to PSU with higher concentrations of African Americans and Hispanics, as these groups have different geographic distributions. Given a possible reduction in the need for the design to focus on oversampling African Americans and Hispanics, it may be possible to construct strata that provide a more even spread of the sample across the urban-rural continuum. In addition, the traditional stratification considers two measures that are associated, urbanicity and minority concentrations. It may be possible to distill these two measures into one synthetic index or composite measure.

The primary candidate for this would be a more graduated measure of urbanicity; the NCES Locale Code is one such measure. Exhibit 2 presents the distribution of public schools by Locale Code. Exhibit 3 presents the student distribution side by side with the number of schools per stratum. Using Locale code in the construction of first stage strata would provide a more consistent distribution of students by urbanicity. As the concentration of African Americans varies by locale, as shown in Exhibit 4, this scheme could support oversampling of this group if necessary. This exhibit shows a pattern of increasing concentrations of non-minority Whites as Locales go up from more urban (Locale=11 for Large City) to less urban (Locale=43 for Remote Rural). In other words, consistently and predictably, minority concentrations are greater in the more urban locales.

Exhibit 1: Current YRBS-NYTS PSU Stratification



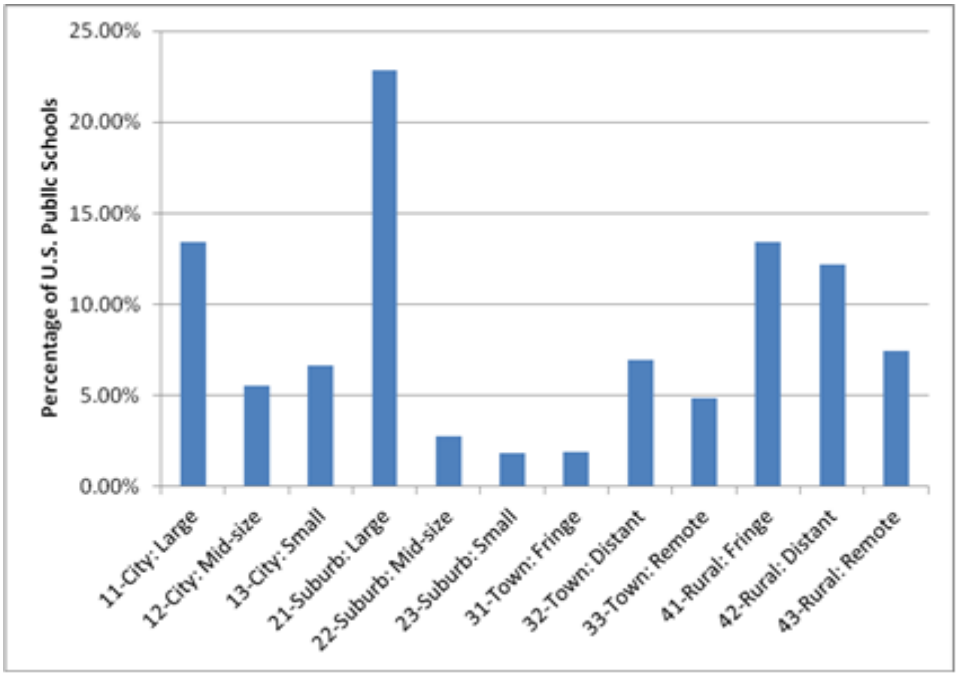


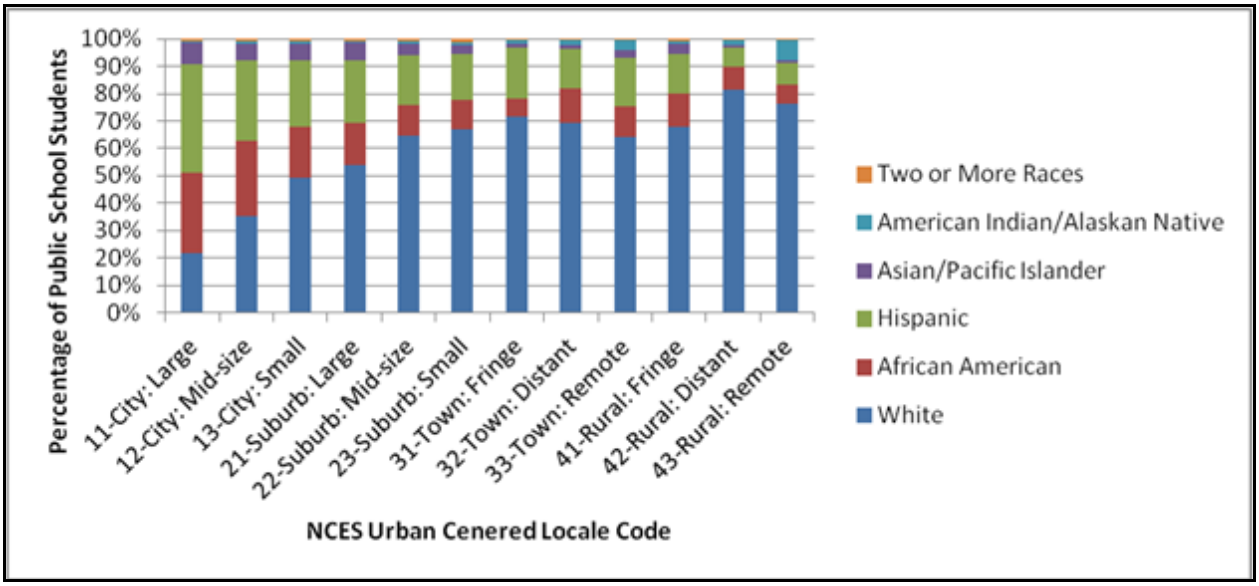
Exhibit 2: Distribution of Public Schools by Locale Code

Exhibit 3: Number of Students per Locale

NCES urban-centric locale code	Schools	Students	Percent of Students

11	2386	2028116	14.27%
12	792	889981	6.26%
13	952	1106060	7.78%
21	3279	4159787	29.27%
22	416	438775	3.09%
23	296	282901	1.99%
31	347	266016	1.87%
32	1374	901804	6.35%
33	958	535080	3.76%
41	2716	2302341	16.20%
42	3147	948526	6.67%
43	2481	353259	2.49%

Exhibit 4: Student Race/Ethnic Distribution by Locale Code



4. Simulation Studies

To explore the sets of inter—related parameters, we conducted three simulation studies. The first study showed that minority yields for both surveys could be achieved with a more efficient sampling design based on proportional allocation and an unweighted enrollment measure of size. To compensate for the slight decrease in minority yields, the design would change the double class sampling in two ways: a) increase the extent of double class sampling (i.e., the number of sample schools with double class sampling) and b) focus the double sampling more intensely on schools with higher concentrations of minority students. These would be achieved by selecting schools with more than a certain threshold percentage of black or Hispanic students (two parameters that are studied jointly).

The second simulation study focused on the stratification of PSUs by NCES locale. This simulation selected samples from a PSU frame re-stratified into the 12 NCES locales. Exhibit 5 presents the expected minority yields over the simulated samples, demonstrating that the target minority sample sizes are met for this new stratified design.

The revised sampling design is labeled two-stage stratified sampling of schools in contrast to the one-stage school sampling design that we also investigated. This sampling design alternative considers school samples selected directly in one stage rather than via PSUs in two stages. In other words, the 2-stage sample of schools becomes a 1-stage sample, and the 3-stage sample of students becomes a 2-stage sample. This alternative would seem to have advantages in reduced clustering and smaller variances.

Exhibit 6 presents a comparison centered on minority yields where the two stratifications are coupled with the two alternate designs with 1-stage and 2-stage samples of schools. The shortcomings of the two-stage sampling design, particularly when coupled with the new stratification as apparent from the median yields, are due to an artifact discussed in the next section. In essence, the classification of PSUs was based on the NCES classification of schools and thus lacks efficiency or "resolution". This finding suggests an improved approach also discussed next.

Exhibit 5 Minority Yields from Two-stage Stratified Samples of 162 Public Schools (3 per PSU)

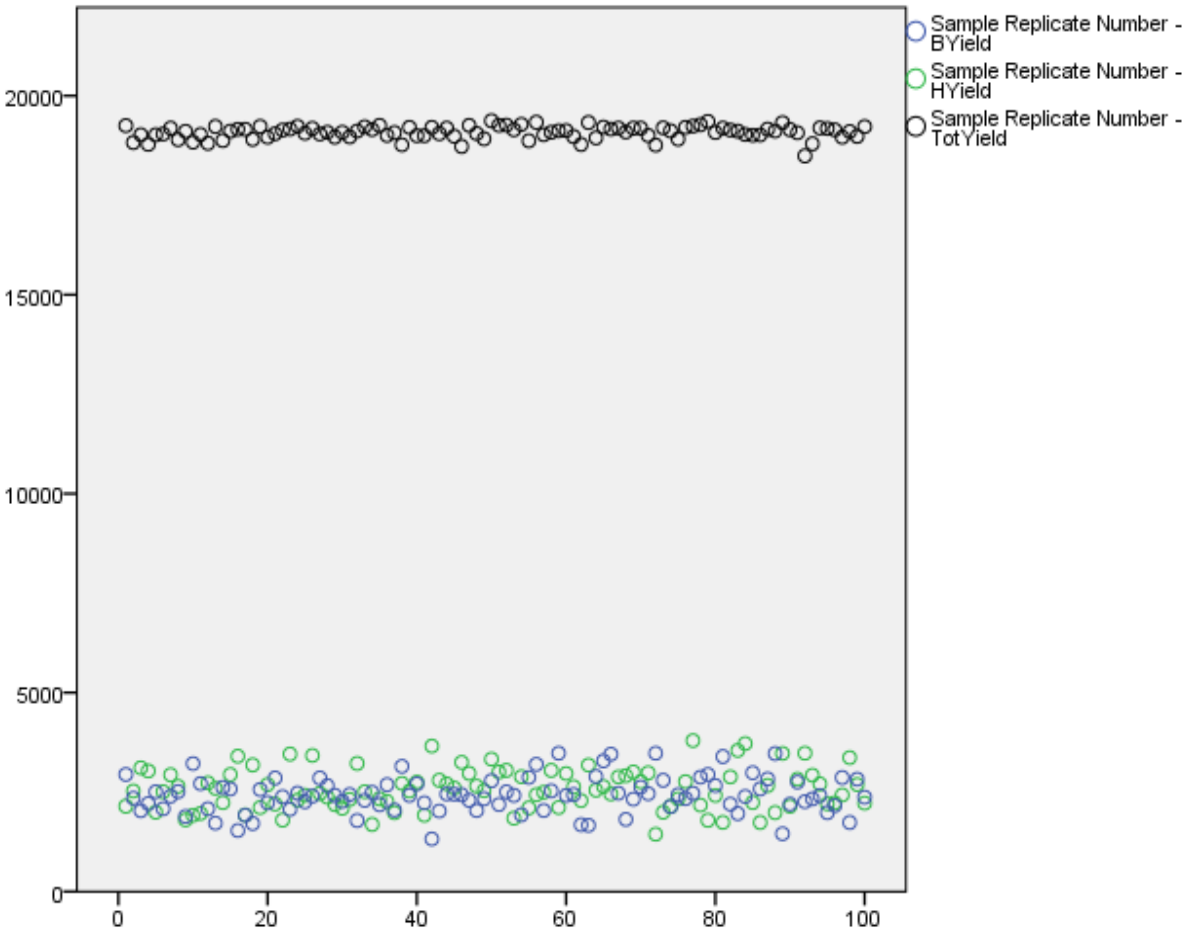


Exhibit 6 **Distribution of Minority Yields over 100 replicated samples selected with two alternate design stratifications**

New Stratification (NCES Locales)			
Variable	**Minimum**	**50th Pctl**	**Maximum**
Black Yield	2,368.6	3,162.9	4,374.7
Hispanic Yield	2,747.1	3,765.9	4,702.1
Total Yield	19,154.0	19,358.5	19,440.0
Variable	**Minimum**	**50th Pctl**	**Maximum**
Black Yield	1,841.6	2,987.4	3,956.2
Hispanic Yield	2,027.9	3,261.4	4,955.3
Total Yield	18,836.0	19,295.0	19,440.0
Traditional Stratification			
Variable	**Minimum**	**50th Pctl**	**Maximum**
Black Yield	2,720.4	3,207.7	3,858.8
Hispanic Yield	3,058.7	3,789.3	4,461.1
Total Yield	19,044.0	19,341.5	19,440.0
Variable	**Minimum**	**50th Pctl**	**Maximum**
Black Yield	2,482.8	3,109.3	3,794.6
Hispanic Yield	3,327.5	3,988.2	4,603.7
Total Yield	18,881.0	19,259.0	19,440.0

5. Conclusions and Discussion

The paper examined a revised stratification based on NCES locales. This stratification would be coupled with other new features of the design revised to enhance overall precision by attenuating oversampling.

The PSU assignment to strata was based on predominant locale. Therefore, the stratification loses some of the potential focus and resolution. For the redesign, we will next consider PSUs based on school districts, rather than on counties, and assignments of school districts to locales as these are also available from the NCES classification

An additional advantage of using NCES locales is that post-stratification totals become readily available for the same strata from NCES files for public schools (Common Core of Data, CCD) and for private schools (Private School Survey, PSS).