ISSUES IN SAMPLING BLACKS AND HISPANICS IN SCHOOL-BASED SURVEYS

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I. Overview of Problem

Surveys of school children sponsored by the Federal government are often required to produce student estimates by race/ethnicity (especially of Blacks and Hispanics). At the same time, it is not acceptable to categorize students by race/ethnicity at the building level, so that efficient methods of sampling at that level are precluded. Further complicating the matter are the requirements to minimize respondent burden in the aggregate (total sample size) and at the building level (students/classes per school). In this situation, it becomes an important objective to increase the proportion of minority students in the sample in the best possible way.

At the outset it should be noted that oversampling of minority populations under the constraints presented can only be accomplished if there is a significant degree of racial/ethnic variation from school to school. If all schools had similar racial distributions, then any sample of schools, regardless of selection method, would have that average racial/ethnic distribution. Further, given the problems with structuring sampling operations by race/ethnicity within the school setting, the student samples would also tend towards the average racial/ethnic distribution. In that scenario, it would be impossible to increase the proportions of minority students sampled.

Nevertheless, U.S. schools do have significant racial/ethnic diversity and it is possible to oversample minority students through a variety of methods. A key point is that the opportunities for oversampling are limited by empirical racial/ethnic distributions.

This paper investigates alternative methods of increasing the percentage of Black and Hispanic students drawn in a national sample of secondary schools.

II. Methodology

Enrollments by school building in the 12th grade as reported to the Center for Education Statistics in the Common Core of Data for 1987 were used where available. If the data were not available, estimates for the 12th grade for those schools reporting the existence of a 12th grade were derived by dividing total school enrollment as reported to Quality Education Data by the number of grades in the school. Also, the percentage Black and percentage Hispanic per school were captured in the Common Core of Data at the school level, but only at the district level by QED. As a result, the data on racial/ethnic composition tend to understate the true amount of variation in the schools. Schools with less than an estimated 20 students at the 12th grade were eliminated from the file.

The full dataset consists of 27,450 schools with twelfth grades. For purposes of this analysis, a 1/6 random sample of 4,575 schools was taken as a preliminary step. The performance of a given sampling method was assessed by selecting 100 samples of 200 schools with 25 students selected per school and tabulating the estimated average percentage of Blacks and average percentage of Hispanics over all the samples.

Under common pps sampling models as applied to school surveys, schools districts are selected as the primary sampling units, schools are selected as the secondary sampling units, and classes as the tertiary sampling units. Selections at the district and school levels are made on a pps basis and a fixed number of classes are selected. This model will produce a self weighting under certain somewhat idealized circumstances.

In the models to be discussed, the school district-level cluster has been eliminated, in favor of a simpler model for exploratory purposes: schools are selected as pps and a fixed number of classes, assumed to have an equal size (25 students) are taken. Because the models to be discussed distort the measure of sizes employed, they produce large variation in weights and increases in variance estimates. Kish (1963) defines a design effect (deff) as the ratio of the actual variance ($Var(Y_d)$) to the variance of a simple random sample of the same size ($Var(Y_s)$). Williams, Folsom, and LaVange (1983), proposed a method of partitioning the deff to represent various design features, which was simplified in Potter (1988). Following Potter, to measure the design effect due to weighting we will use the following statistic:

$$\frac{n\sum_{i=1}^{n} w_i^2}{(\sum_{i=1}^{n} w_i)^2}$$

where n is the sample size and w_i the weight of case i. The design effect measured in this way assesses the impact of weight variation for estimates that implicitly involve the entire sample rather than subsets. To assess what might be the impact of weight variation on subsets of the sample, such as an estimate based on responding Blacks, an analogous design effect was defined. If p_i is the percentage of a minority in school j, w_i is the weight assigned to a student in school i (all students in a school have the same weight), and n_i is the size of school i, then the design effect due to weighting for the Black subdomain will be defined as the following:

$$\frac{(\sum_{i=1}^{n} np_i)(\sum_{i=1}^{n} np_i w_i^2)}{(\sum_{i=1}^{n} np_i w_i)^2}$$

III. Weighted Measure of Size Models

One approach to the problem of increasing minority sample sizes is to adjust school population estimates to disproportionately increase the probability of selection of schools with large minority enrollments. If B_i is the number of Blacks in school i, H_i the number of Hispanics, and O_i the number of other students in school i, then functions of the form $aB_i + bH_i + cO_i$ may be used to compute a size measure for school i.

A series of sample draws were simulated that assessed the performance of the weighted measure of size approach in increasing minority percentages for various values of the weighting parameters. Two types of models were tested: one type was based on the percentages of Blacks and Hispanics and the other type on the estimated enrollments of Blacks and Hispanics.

IV. Sampling in Proportion to Percentage Black and Hispanic

The first class of measures of size analyzed was based on functions of the percentage minority composition of schools. This is not a measure of size at all, but rather a measure of concentration. In effect, schools with high minority concentrations had high selection probabilities. If PB_i is the percentage of Blacks in school i, PH_i the percentage of Hispanics, and PO_i the number of other students in school i, then functions of the form $aPB_i + bPH_i + cPO_i$ were assessed. Setting c=1 and noting that $PB_i + PH_i + PO_i = 1$, we can eliminate PO_i from the weighting function, obtaining:

$$1 + (a - 1)PB_i + (b - 1)PH_i$$

The performance of this weighting function was assessed at a=1,2,4,8, and 16 and b=1,2,4,8, and 16 in all combinations, i.e., 25 different weighting functions. We note that at a=1, b=1, the measure of size is unity for all schools so the pps method becomes a random sample without any consideration of size or concentration.

Figures 1 and 2 chart the average percentage of Blacks and Hispanics in the samples drawn, respectively, as a function of the a,b parameters. It shows that functions of this form can significantly raise the concentration of minorities in the sample. For Hispanics, with a=16, b=1, the concentration was raised from 6.1 percent of the sample to 22.5 percent, a 369 percent increase, while only modestly reducing the percentage of Blacks from 9.6 to 9.3 percent. For Blacks, with a=1, b=16, the concentration was raised from 9.6 percent to 32.3 percent of the sample; a 336 percent increase.

A maximum combined weighting, with a=16, b=16, produced a sample that was estimated to be 15 percent Hispanic and 26 percent Black.

Several linear models were tested in an effort to predict expected percentages of Blacks and Hispanics in the sample as a function of the a,b parameters. The models were estimated over a database consisting of the results of the 2,500 sample draws with 100 draws per combination of (a,b) values. Two models performed quite well:

Parameter Estimates for Predicting Percentage Hispanics (R^2=.88)

Variable	DF	Param. Est.	Stdrd. Error	T for H0: Param.=0	Prob>|T|
INTERCEP	1	6.468264	0.08402697	76.978	0.0000
A	1	-0.063224	0.01020362	-6.196	0.0001
B	1	1.053325	0.01020658	103.201	0.0000
AB	1	-0.027896	0.00123752	-22.542	0.0001

Parameter Estimates for Predicting Percentage Black (R^2=.94)

Variable	DF	Param. Est.	Std. Error	T for H0: Param.=0	Prob>|T|
INTERCEP	1	10.593337	0.08617518	122.928	0.0000
A	1	1.470854	0.01046449	140.557	0.0000
B	1	-0.086678	0.01046752	-8.281	0.0001
AB	1	-0.024175	0.00126915	-19.048	0.0001

Figure 1 Percentage of Blacks For Selected Weighting Factors (% Blacks MOS)

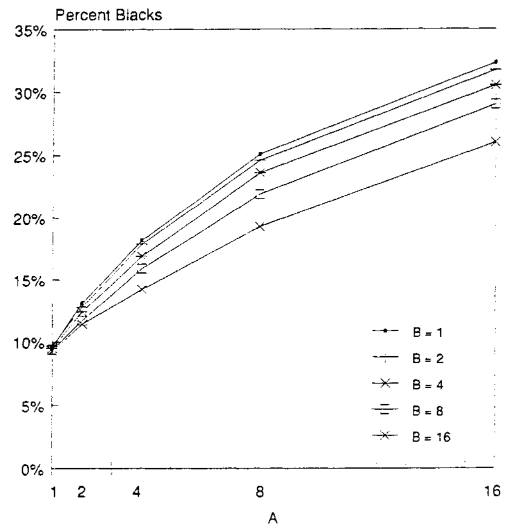
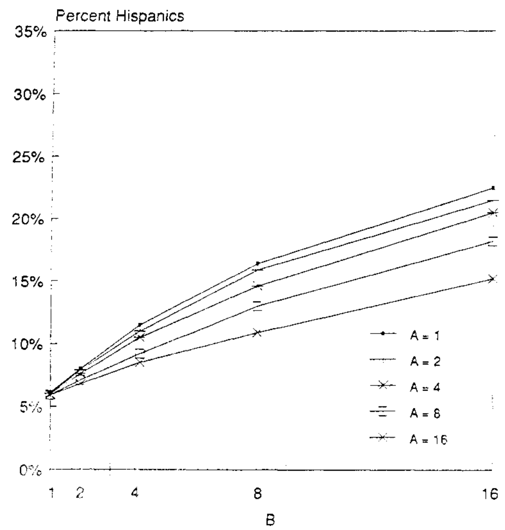


Figure 2 Percentage Hispanics For Selected Weighting Factors (% Hispanic MOS)



V. Sampling in Proportion to Weighted Measures of Enrollment

The second class of measures was based on measures of school size. In these measures H_i, B_i, and O_i are the estimated school populations of Hispanic, Blacks, and Others. As was the case with the previous analysis, the parameters a and b took on the values 1, 2, 4, 8, and 16 in all combinations and the unweighted percentages of Blacks and Hispanics in the samples were tabulated. This class of functions also significantly raised the raw percentages of Blacks and Hispanics in the samples. For identical a,b values, the percentage of Hispanics in these samples exceeded the percentages selected previously. In most cases, the percentages of Blacks in the sample was also higher. For (a,b)=(1,16) the percentage Hispanic reached 25.4 percent; for (a,b)=(16,1) the percentage Black reached 32.8 percent. For combined minority weighting, (a,b)=(16,16), the sample was 17.1 percent Hispanic and 25.9 percent Black. Figures 3 and 4 graph the data for Blacks and Hispanics, respectively.

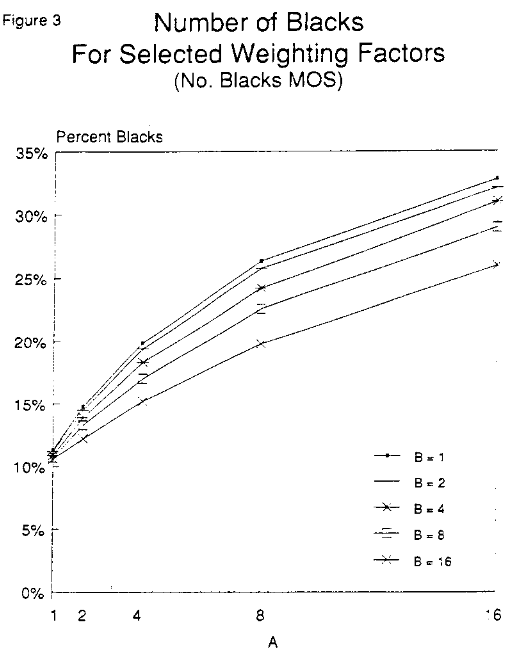
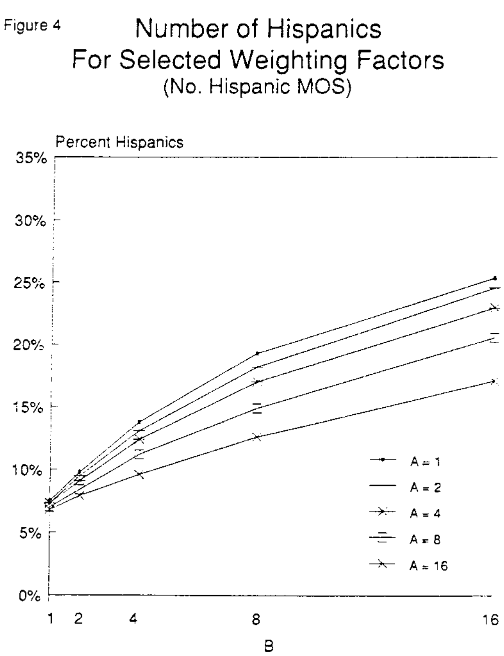
Figure 3


Figure 4


Predictive equations were also developed for these weighting models. The model to predict the percentage of Hispanics in a sample draw had an R^2 of .94; the model for Blacks had an R^2 of .93. It is linear in the a and b parameters with an (ab) interaction term.

Parameter Estimates for Predicting Percentage Hispanics (R^2=.93)

Variable	DF	Param. Est.	Stdrd. Error	T for H0: Param.=0	Prob>|T|
INTERCEP	1	7.806102	0.06614420	118.016	0.0000
A	1	-0.084603	0.00800939	-10.563	0.0001
B	1	1.175398	0.00800939	146.752	0.0000
AB	1	-0.032159	0.00096986	-33.159	0.0001

Parameter Estimates for Predicting Percentage Black (R^2=.94)

Variable	DF	Param. Est.	Std. Error	T for H0: Param.=0	Prob>|T|
INTERCEP	1	12.436132	0.08855089	140.441	0.0000
A	1	1.387376	0.01072262	129.388	0.0000
B	1	-0.130702	0.01072262	-12.189	0.0001
AB	1	-0.023927	0.00129840	-18.428	0.0001

VI. Varying Numbers of Classes Selected Per Grade

Another approach to increasing the numbers of minority students is to increase the sample size in schools with high percentages of minorities. For example, if the percentage of the target group in a school exceeds a critical value, the size of the sample drawn from the school is increased, e.g., from 1 class per grade to 2 or 3 per grade. This approach has the advantage of limiting weight variation to no more than a 2x or 3x multiple. The sampling rate can also be increased by enlarging the sample of schools in the high minority strata.

The ability to increase samples in a school is limited by two factors, the size of the school and the burden placed on the school by a large scale sample. Analysis of school sizes, among schools with more than 20 students, show the following short-fall rates as a function of desired school sample size:

Number of Classes	Desired Sample	Shortfall Rate
1	25	0%
2	50	2%
3	75	4%
4	100	6%

Schools with less than 20 students per grade are often melded with other schools prior to sampling or excluded from the frame.

A series of analyses were done to evaluate the impact of varying the number of classes per grade on the expected percentages of minority students in the sample. Focusing on Blacks for the moment, the full data set was sorted on the percentage of Blacks in the school. For each school the expected percentage Black was calculated based on the assumption that a sampling rate of 25 students per school was applied to schools with a lower Black percentage and a higher sampling rate (50 or 75 students per school) for schools with an equal or larger Black percentage. All schools in the 1/6th sample were included in the analysis.

Figures 5 and 6 plot the expected percentage of Blacks in the sample as a function of the percentage of schools that are oversampled, for 2x and 3x oversampling rates. Figures 7 and 8 present similar graphs for Hispanics. If the goal were to maximize minority percentages, the optimal points at which to supplement would be the following:

Group	Factor	Group Percentage	Percent Oversampled	Cutoff Percentage
Blacks	2x	14.8%	19.7%	14%
Blacks	3x	18.6%	16.7%	18%
Hispanics	2x	9.7%	15.9%	9%
Hispanics	3x	12.4%	13.3%	12%

For example, if an oversampling factor of 2x is applied to schools that are 14 percent or more Black then 19.7 percent of schools would have additional classes drawn and the overall expected percentage of Blacks in the sample would be 14.8 percent.

On a combined basis, if supplemental classes are selected if either the Black percentage exceeds 14 percent or the Hispanic percentage exceeds 9 percent, then 32 percent of schools would have supplemental classes drawn and the percentages of Blacks and Hispanics would be 13.7 percent and 8.4 percent, respectively. Less then 10% of the schools with supplements would qualify based on both Black and Hispanic percentages.

VII. Design Effects of Weighted Measures of Sizes with Supplementation

In this analysis, the use of a weighted measure of size was combined with variable school sample sizes and the estimated design effects due to weighting computed for the entire sample and for Black and Hispanic subsamples. The analysis was run using both types of size measures for parameter values of a=1, 8, and 16 and b=1, 8, and 16. School samples were doubled if the percentage Black exceeded 18 percent or the percentage Hispanic exceed 16 percent.

Table 1 compares the performance of the two measures of size. Of note are the following: (1) the design effects due to weighting are substantially greater for analyses using percentage minority-based measures of size in comparison to measures based on enrollments; (2) in comparison to sampling without supplementation and controlling for the weighting function used, the average percentage of Hispanics in the samples increased by an additive 4.4 percent and the average percentage of Blacks by 3.2 percent. The impact of supplementation was inversely related to the level of weighting of the corresponding minority size measures, e.g., as the weight placed on Hispanic enrollments increased, the additional impact of supplementing samples decreased.

Finally, Table 2 examines the estimated design effects for Blacks and Hispanics using weighted measures of size based on minority enrollments with and without supplementation. The index of effectiveness shown is the ratio of the effective sample under the weighting function and considering the design effect to the original sample size. An index of effectiveness greater than 1 would suggest that the effective sample size has increased for the minority group analyses.

Based on the indices of effectiveness, it would appear that it is more effective to increase sample sizes by use of supplementation than solely by altering the weighting function. Generally speaking, the indices for the supplementation case were higher than in the nonsupplementation case, holding the weighting factors constant. Second, it would appear that the methods described may not be able to increase the effective sample size for both Blacks and Hispanics by much more than 50 percent. Simply increasing the weighting factors results in large design effects due to weighting and ultimately reduces the effective sample size.

Table 1--Minority Proportions and Design Effects for Weighted Measure of Size with Supplementation.

1. Weighted Number of Student Measure

A	B	Percent Black	Percent Hispanic	Design Effect
1	1	15.4%	10.2%	1.07
1	4	14.3%	18.5%	1.21
1	16	12.1%	31.6%	1.80
4	1	26.2%	9.2%	1.29
4	4	23.5%	15.4%	1.41
4	16	18.3%	27.8%	1.92
16	1	39.2%	7.8%	2.15
16	4	36.6%	11.1%	2.19
16	16	29.9%	19.7%	2.53

2. Weighted Percentage of Minorities Measure

A	B	Percent Black	Percent Hispanic	Design Effect
1	1	14.3%	8.4%	1.77
1	4	13.1%	15.6%	1.88
1	16	11.6%	28.3%	2.53
4	1	24.8%	7.8%	2.01
4	4	22.7%	13.2%	2.12
4	16	17.8%	25.0%	2.58
16	1	38.9%	6.8%	3.05
16	4	37.1%	9.7%	3.07
16	16	30.6%	17.5%	3.34

Table 2

1. Weighted Measure of Size Based on Enrollments with Supplementation

A	B	Percent Black	Percent Hispanic	Design Effects Black	Design Effects Hispanic	Effectiveness Index Black	Effectiveness Index Hispanic
1	1	15.4%	10.2%	1.07	1.08	1.25	1.26
1	4	14.3%	18.5%	1.15	1.48	1.08	1.67
1	16	12.1%	31.6%	1.63	2.45	0.65	1.72
4	1	26.2%	9.2%	1.44	1.20	1.58	1.02
4	4	23.5%	15.4%	1.42	1.47	1.44	1.40
4	16	18.3%	27.8%	1.57	2.35	1.01	1.58
16	1	39.2%	7.8%	2.26	1.72	1.51	0.60
16	4	36.6%	11.1%	2.18	1.69	1.46	0.88
16	16	29.9%	19.7%	2.09	2.27	1.24	1.16

2. Weighted Measure of Size Based on Enrollments without Supplementation

A	B	Percent Black	Percent Hispanic	Design Effects Black	Design Effects Hispanic	Effectiveness Index Black	Effectiveness Index Hispanic
1	1	11.5%	7.5%	1.00	1.00	1.00	1.00
1	4	11.0%	13.8%	1.06	1.19	0.90	1.55
1	16	10.5%	25.6%	1.45	1.74	0.63	1.96
4	1	19.6%	7.3%	1.18	1.07	1.44	0.91
4	4	18.6%	12.2%	1.16	1.65	1.39	0.99
4	16	15.3%	23.0%	1.27	1.65	1.05	1.86
16	1	32.6%	6.8%	1.64	1.48	1.73	0.61
16	4	31.1%	6.8%	1.57	1.32	1.72	0.69
16	16	26.1%	17.1%	1.51	1.57	1.50	1.45

VIII. Data Quality Issues

After all of the effort to assure sufficient numbers of

Figure 5
Percentage of Blacks in Sample
(2X Oversample)

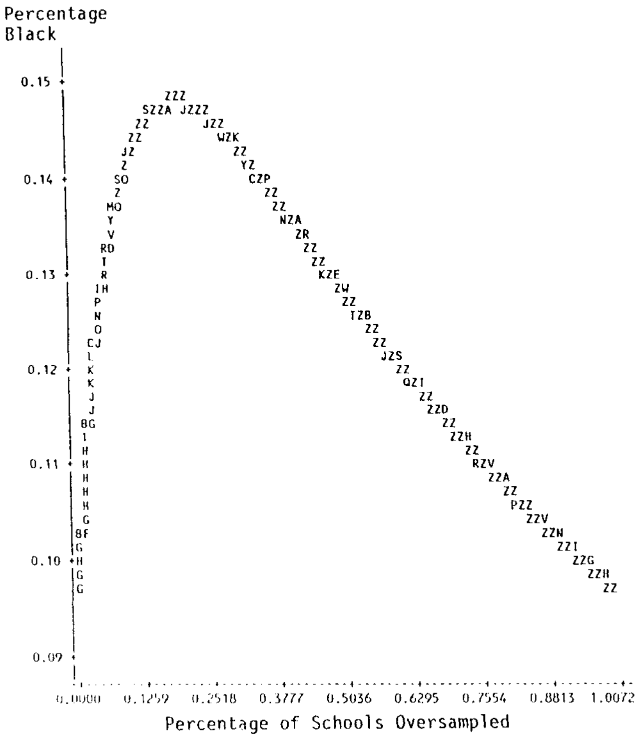


Figure 6
Percentage of Blacks in Sample
(3X Oversample)

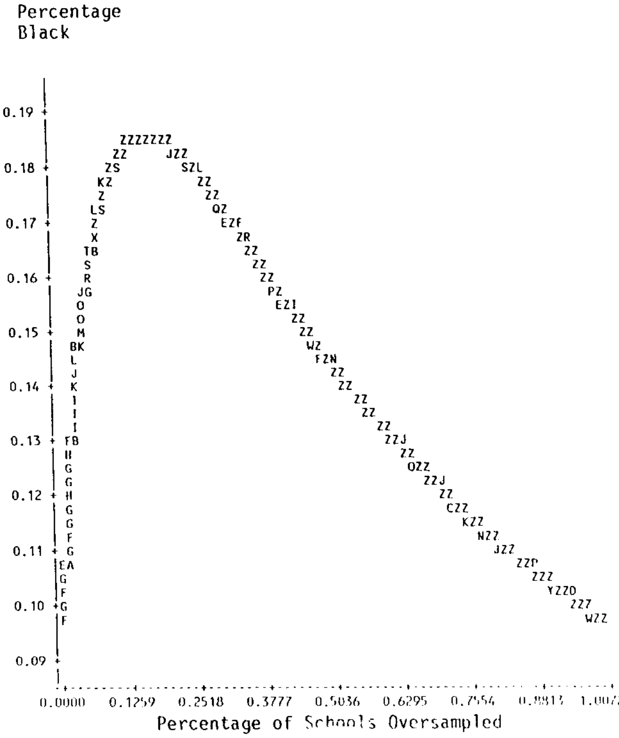


Figure 7
Percentage of Hispanics in Sample
(2X Oversample)

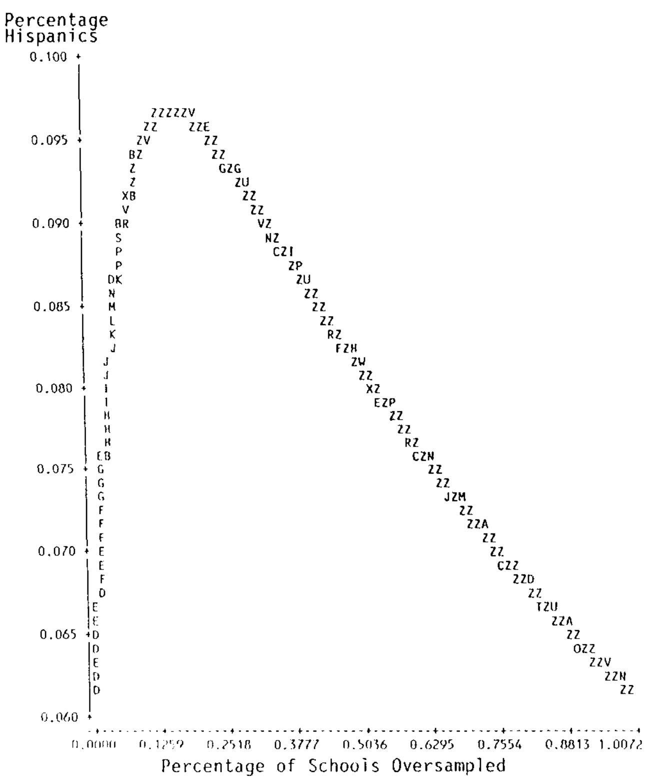
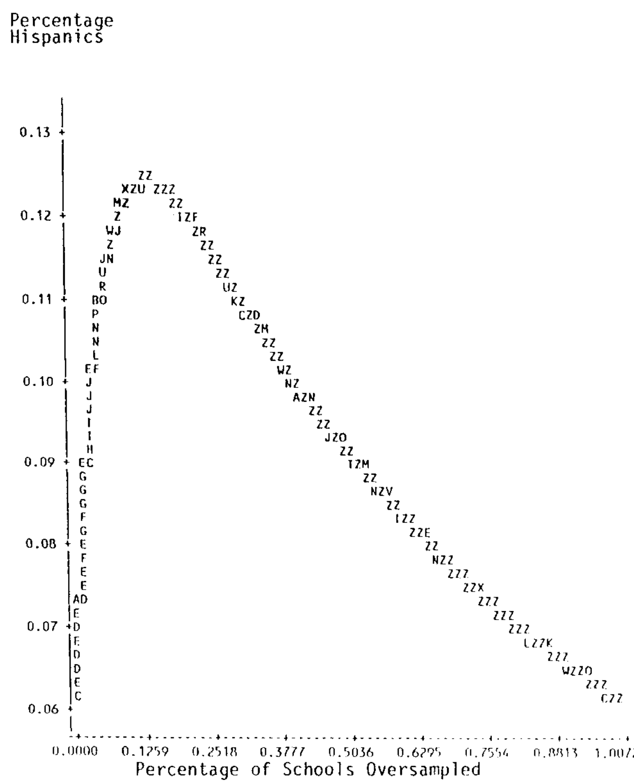


Figure 8
Percentage of Hispanics in Sample
(3X Oversample)



students by race/ethnicity category, the results can be influenced by a number of factors.

A critical issue is that actual race/ethnicity data must be collected from the students themselves. This can be extremely problematic, especially for Hispanic students. Approved OMB racial/ethnic categories sometimes do not correspond to student self-perceptions. For example, although Puerto Ricans are a priori considered to be Hispanics, in a recent survey about 30 percent of the Puerto Rican students considered themselves to be "Native Americans."

Another factor is that the Common Core of Data from NCES is incomplete, so that in many states, estimates of minority percentages are accurate down to the school district level and not the school level. For districts with a heterogeneous populations and large variations in racial/ethnic compositions among schools, the available data will not target minorities accurately.

IX. Summary

The use of a weighted measure of size can effectively increase the percentage of minority group students in a typical multipurpose school survey. Although the increase in minority sample concentration is not directly proportional to the weighting function, accurate linear models can be used to project the effects of the weighting function.

Beyond a moderate level of increase (i.e., 50 percent), however, the increase in survey design effects outweigh the value of the increased sample size. The use of measures based on school enrollments by racial/ethnic group were found to be more effective than measures based on the percentage of racial/ethnic groups, both in terms of increasing minority group samples and in terms of relatively smaller design effects. Strategies that increase sample sizes in schools with large concentrations of minority students also help, to a moderate extent, to increase effective sample sizes.

Bibliography

Kish, L. *Survey Sampling*. New York: John Wiley & Sons, Inc. 1963.

Potter, F. "Survey of Procedures to Control Extreme Sampling Weights." Proceedings of the Survey Methods Section, American Statistical Association, 1988.

Williams, R.L., Folsom, R.E., and LaVange, L.M., "The implications of sample design on survey analysis" in Statistical Methods and the Improvement of Data Quality. New York: Academic Press, 1983.