AN ANALYSIS OF RESPONSE RATES OF SASS 1993-94

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1. Introduction

This paper addresses the most pervasive and challenging source of nonsampling error in estimates from sample surveys which is the error associated with incomplete data. Incomplete data resulting from three sources are of particular importance in sample surveys: item nonresponse, unit nonresponse, and undercoverage.[1] The concern for nonresponse, whether item or unit, is twofold. Nonresponse reduces the sample size and thus increases the sampling variance. Respondents may also differ significantly from nonrespondents, thus, the estimate obtained from respondents can be biased and the magnitude of this bias may be unknown. Concerns about bias are generally greater as the rate of nonresponse increases.

The particular focus of this paper is to quantify the extent of unit nonresponse in the 1993-94 Schools and Staffing Survey (SASS) conducted by the National Center for Education Statistics (NCES) and to assess the impact of differences in the known characteristics of respondents and nonrespondents for different subgroups of the survey populations in order to provide some indication of the *potential* effects of nonresponse bias. The results of this study can be used to further control and adjust survey estimates for bias, and improve survey operations. While the scope of this paper is chiefly descriptive, inferential modeling of the response rates is also provided as an example for future SASS research.

2. 1993-94 SASS

The 1993-94 SASS is the third study of public and private elementary and secondary schools in a series of surveys begun in 1987-88 by NCES. Survey data from schools, local education agencies (LEAs), administrators, and teachers in the United States were collected by mail with telephone follow-up of nonrespondents first during the 1987-88 school year and again during the 1990-91 and the 1993-94 school years. The series provides data on school and teacher characteristics, school operations, programs and policies, teacher demand and supply, and the opinions and attitudes of teachers and school administrators about policies and working conditions. The analytic power of the data is enhanced by the ability to link survey data for individual LEAs, schools, administrators, and teachers. In 1993-94 new library, librarian and student SASS components were initiated that could also be linked. In addition, computer assisted telephone interviewing (CATI) facilities were introduced for the first time during the 1993-94 SASS and were used extensively for nonresponse follow-up.

The 1993-94 SASS consists of thirteen components: the School Surveys, the School Administrator Surveys, the Teacher Surveys, the Teacher Demand and Shortage Survey, the Library Surveys, the Librarian Surveys, and the Student Record Surveys. Some 13,000 schools and administrators, and 67,000 teachers were selected. In addition, 5,500 local education agencies associated with the selected schools and 100 districts not associated with schools were selected in the 1993-94 SASS. Some 7,600 libraries and librarians, and 6,900 student records were also selected. Details pertaining to the frame, stratification, and sample selection for each of the survey components are presented in Abramson *et al.* (1996).

3. Weighted Unit Response Rates

For each survey of SASS, weighted unit response rates were calculated. The weighted response rates were derived by dividing the sum of the basic weights for the interview cases by the sum of the basic weights for the eligible cases (the number of sampled cases minus the out-of-scope cases). The basic weight for each sample case was assigned at the time of sampling as the inverse of the probability of selection.

In the first stage of this study we tested whether there is a significant difference between respondents and nonrespondents for a range of characteristics. To make this kind of inference to the underlying population based on SASS data, the conventional Pearson chi-squared statistic is not appropriate anymore. Tests were performed using a modified Pearson test statistic called Rao-Scott3 (RS3)[2]. A

[1] Madow, W., Nisselson, H., and Olkin, I. (1983). *Incomplete Data in Sample Surveys, Vol. 1, Report and Case Studies*. New York: Academic Press.

[2] Rao, J. and Scott, A. (1981). "The Analysis of Categorical Data from Complex Sample Surveys: Chi-squared Tests for Goodness of Fit and Independence in Two-way Tables." *Journal of the American Statistical*

statistical software package called the WesVarPC® 2.0 provides a convenient procedure for this purpose. WesVarPC® not only calculates the weighted response rates, the standard error, the sample size and design effect, but also provides the Rao-Scott3 statistic that reflects the complex sample design.

Within the public and private sectors, the results of the significance tests are fairly uniform. That is, if respondents are significantly (or not significantly) different for a variable for a public sector survey component then they are likely significant (or not significant) for other public sector components as well. There are some interesting differences in results of the significance tests when compared across the public and private survey components. The most striking contrast in results exists for the variable "school sampled in 1990-91 SASS". Whether or not a school was surveyed in the 1990-91 SASS proved not to be significant for all of the public school components, while it was significant for all of the private school components.

Some interesting patterns arise when response rates are looked at across surveys. Tables 3.1 (public components) and 3.2 (private components) show the tests results and rankings of response rates for different levels of a selected set of variables that are common across all surveys. For public components the response rates for minority enrollment and urbanicity show some very strong patterns. Schools with a minority enrollment greater than 50.5 percent had the lowest response rates for all public components except the Student Record Component. Furthermore, minority enrollment showed a significant association with response status for all public components except the Student Record Component. Urbanicity showed a very strong pattern, with rural/small towns having the highest response rate, followed by urban fringe/large towns, and then central cities with the lowest response rates. This pattern was the same for all components except the Student Record Component. But, as with minority enrollment, urbanicity showed a significant association with response status for all public components except the Student Record Component. For private components the response rates for region and school size show some patterns. The Midwest region had the highest response rates for all private components except the Student Record Component. While response rates for schools with 1 to 149 students were always the lowest for all private components except the Student Record Component. Similar to the public side region and school size showed a significant association with response for all private components except the Student Record Component.

The rankings, when viewed across the public and private components, show two variables with similarities - school level and urbanicity. For school level, eight of the 12 public and private components have secondary schools with the highest response rate followed by elementary schools, and then combined schools. School urbanicity also showed a fairly strong ranking pattern, where eight of the 12 public and private components have schools in rural/small towns with the highest response rate followed by those in urban fringe/large towns, and then those in central cities.

4. Hierarchical Response Patterns

In the second stage of this study we examined the hierarchical nature of the nonresponse in the 1993-94 SASS. The aim was to find out about the *jointness* of nonresponse; for example to learn whether administrators in responding schools are more or less likely to respond than administrators in nonresponding schools. Specifically, we tested to see if there is a significant difference in response rates of each of the following types of respondents: (1) public and private school administrators, (2) public and private schools, (3) public and private school teachers, (4) public and private school libraries, (5) public and private school librarians, and (6) local education agencies (LEAs) when "linked" with the response status of other SASS components.

The results indicated that all units in the 1993-94 SASS (e.g. administrators that are "linked" within other units such as schools) are more likely to respond when the "linked" unit responds and in a large number of cases the difference in response is significant

5. Components of Nonresponse/Cooperation Rate

To measure the ability of a survey to establish contact with sampled units, the reasons for nonresponse are important In the 1993-94 SASS, three categories of reasons were recorded: 1) **refusal**, the nonrespondent refuses to take part in the survey; 2) **unable-to-contact**, contact with the nonrespondent was not able to be made through the nonresponse followup procedures; and 3) **other**, for example the questionnaire was not returned or the questionnaire was returned but it was incomplete.

Two teacher components had very high unable-to-contact rates (17.9%). For those instances with high unable-to-contact rates it is sensible to look at a **cooperation rate**, which is the response rate given the cases can be contacted. The cooperation rate is the number of interviews divided by the number of eligible

Association, 76: 221-230. Rao, J. and Scott, A. (1984). "On Chi-squared Tests for Multiway Contingency Tables with Cell Proportions Estimated from Survey Data." *The Annals of Statistics*, 12: 46-60.

cases contacted: Cooperation Rate = Interview / (Interview + Refusal + Other). Compare with the Response Rate = Interview / (Interview + Refusal + Unable to Contact + Other). The advantage of using the cooperation rate is that it controls for differences due to the unable-to-contact cases. Using the cooperation rate will eliminate the confounding effect associated with unable-to-contact cases.

To illustrate this confounding effect the significance tests for the teacher components were calculated using the cooperation rates since their unable-to-contact rates are the highest of all the components and the difference between their response and cooperation rates were among the highest (see Tables 5.1 and 5.2 below)

Table 5.1 -- Weighted response and cooperation rates: Public School Teacher Component (Rates in percent)

Variable	Response Rate	Cooperation Rate
School Type		
Regular	88.26	89.25
Non-regular	86.25	88.42

Table 5.2 -- Weighted response and cooperation rates: Private School Teacher Component (Rates in percent).

Variable	Response Rate	Cooperation Rate
Urbanicity		
Rural/Small town	83.10	85.38
Urban/large town	80.41	82.48
Central City	78.79	82.64
New Teacher		
Yes	81.02	85.16
No	80.05	82.76

The tests results for the public teacher component indicated that using cooperation rates the variable school type was not significant anymore (see table 5.3). The reason for this is that the low response rates for the non-regular schools is due to a higher unable-to-contact rate than regular schools.

Table 5.3 -- P-value of the Independence Test: Public School Teacher Component

Variable	P-value based on Response Rate	P-value based on Cooperation Rate
School Type	0.0172	0.1092

For the private school component, the lower response rate in central cities is due to a high unable-to-contact rate. After adjusting for this, by removing the unable-to-contact cases, urbanicity is not significant (see table 5.4). On the another hand, there is a high unable-to-contact rate for new teachers and that caused a low response rate for the new teachers. After the unable-to-contact cases are removed, the new teachers have a significantly higher cooperation rate than the others and the variable new teacher becomes significant.

Table 5.4 -- P-value of the Independence Test: Private School Teacher Component.

Variable	P-value base on Response Rate	P-value based on Cooperation Rate
Urbanicity	0.0094	0.0923
New Teacher	0.3206	0.0107

6. Multivariate Model (Public School Component)

In the last stage of our study we assessed the multivariate adjusted effects (on the response rates) of the significant variables which were identified in the first stage of our study (see section 3). We fitted multivariate logistic regression models. In this section three issues will be discussed: model selection, model interpretation, and comparisons of univariate unadjusted results with multivariate adjusted results.

In our model selection, we began with the following potential variables which were considered in the univariate analysis: *urbanicity*, *region*, *school level*, *school size*, *school type*, *minority enrollment*, *sampled with certainty*, *submitted a teacher list*, *source*, and *sampled in the 1990-91 SASS*. Variable *submitted a teacher list*, which has the most significant effect on the school nonresponse, is eliminated from the multivariate model due to interpretation difficulties. This variable is more like a questionnaire variable rather than a design variable in terms of the time we observe the variable. We can not use it to predict the probability of school response. The variables *sampled in the 1990-91 SASS* and *sampled with certainty* are dropped from the model due to their ignorable contribution to the model.

The software package WesVarPC® was used to fit the multivariate logistic regression model with the seven selected independent variables as well as seven separate univariate logistic regression models for those variables. Table 6.1 presents a comparison of the p-values for the Rao-Scott, univariate logistic regression model, and multivariate logistic regression model tests.

It is noted that p-values for the Rao-Scott test (Rao and Scott, 1984, or RS3 in WesVarPC output) and the univariate logistic regression are pretty close. The only significant difference between these two tests is for variables *source* and *school type*, but their p-values are still comparable. If we test the hypotheses at 0.01 level, both tests will reach the same conclusion of significance.

However, the multivariate logistic model test results are very different from Rao-Scott test results and the univariate logistic model test results, especially for variables *minority enrollment*, *urbanicity*, *region*, and *school type*. Variables *minority enrollment*, *urbanicity*, and *region* are highly significant in the Rao-Scott tests and the univariate logistic regression model, but they are not significant at all, with high p-values of 0.3936,

0.1016 and 0.1115, respectively, in the multivariate logistic regression model when we adjust for other variables simultaneously. This happens because there exists an antagonism effect on these variables. We must take into account of this antagonism effect when we interpret the effects of minority enrollment, urbanicity and region. The significant effects of these three variables shown in the univariate analysis are simply caused by imbalance of the other significant variables among these three variables. On the other hand, there exists an synergysm effect on variable *school type*. In the multivariate logistic regression model, *school type* is significant (at 0.01 level) with a p-value of 0.0047, but it is not significant in the univariate logistic regression model or by Rao-Scott test with p-values of 0.0397 and 0.0719, respectively. That means that some information about school nonresponse provided by school type is covered by the noise of other factors. We must retrieve that part of information by adjusting to other factors simultaneously through a multivariate model.

For the other three variables, *school size*, *school level* and *source*, it seems that there is neither an antagonism effect nor a synergism effect. The univariate results are almost identical to the multivariate results for those variables. The four-level variable *school size* is the most significant variable for explaining the variation of school nonresponse.

The entropy for the multivariate model is 2.13%. As pointed out by the documentation for WesVarPC®, this entropy may not be appropriate to measure the strength of the association.

Table 6.2 presents the parameter estimates, standard errors, odds ratios and p-values of the tests for the dummy variables which represent the independent variables in the multivariate logistic regression model. The parameter estimates and odds ratios describe the nature of the association between the school nonresponse and the selected independent factors.

We found that the response rate of a rural/small town school is barely significantly higher than a central city school with an odds ratio of 1.377, although the overall factor urbanicity is not significant with a p-value of 0.1016. *School level*, *school size*, and *school type* are all significant factors for the school nonresponse. A combined school and an elementary school are both less likely to respond to the survey than a secondary school; a smaller school is more likely to respond than a larger school. The odds ratio comparing a school with enrollment between 1 and 149 students and a school with an enrollment of 750 or more students is 2.316; non-regular school is less likely to respond than a regular school with an odds ratio about one-half. However, *Minority enrollment*, *region* and *source* has no significant effect on the school nonresponse.

We also fit a reduced model which eliminates all dummy variables that are not significant at 0.1 level in the full model. The results of the reduced model for school level, school size, school type and source are almost identical to those in the full model presented in Table 8.2. However, in the reduced model, urbanicity is highly significant with P-value of 0.0063, but this p-value is for the testing the difference of the school response rate between rural/small town schools and all other schools. Similarly, the test to compare the Midwest vs the other three regions is barely significant at 0.05 level.

In summary, we find that school size, school level, and school type are the only three factors which have a significant effect on school nonresponse. Neither the three-level variable urbanicity or the four-level region variable have significant overall effects, but a rural/small town school has a significantly higher probability to respond than an urban fringe/large town or a central city school, and the Midwest has significantly higher response rate than other regions. Minority enrollment, which is highly significant in the univariate model, is not significant at all in the multivariate model. The sample frame source "CCD update" is a little better than other three sources (close to significant), but the other three sources are not significantly different at all.

7. Conclusions

Results of assessing the differences in known characteristics of respondents and nonrespondents for different subgroups of the sampled populations indicated that patterns of nonresponse among characteristics such as region, urbanicity, school level, and school size persisted from the 1990-91 survey round to the current round. For example, response rates for rural/small town public schools were the highest and response rates for central city schools were the lowest in both 1990-91 and 1993-94. In addition, a set of characteristics including some of those mentioned above, whether a school submitted a teacher list, and minority enrollment in a school were shown to have significant differences between respondents and nonrespondents.

One of the more striking results of our analysis pertain to the examination of whether response patterns in a survey component are hierarchically associated with response patterns of linked components. Our analysis showed response rates were higher among linked responding units versus linked nonresponding units. For example, response rates for LEAs were higher for those LEAs linked with responding schools versus those linked with nonresponding schools.

Response rate components (e.g. out-of-scope rates, refusals, non-locatables, etc.) were examined in an attempt to provide tools to monitor the quality of the SASS frame and the corresponding 1993-94 SASS survey statistics. Out-of-scopes rates for the public components were lower than their private counterparts. In addition, out-of-scope rates for the private school library component, and both the public and private school librarian components were quite high. Cooperation rates for components with high non-locatable rates, such as the teacher component, were calculated and tested. In most cases, for the teacher survey, the significance results were different for cooperation rates versus response rates indicating that the unable to contact cases had a confounding effect on the results of these significance tests.

Finally, the results of fitting a multivariate logistic regression nonresponse model for the public school component were compared to the univariate level significance results. School size, school level, and school type were the three factors shown to jointly have a significant effect on school nonresponse. These results show that the effects of some variables on the response status can be explained by the other variables hence a reduced model is preferable. The model results can be used to adjust weights for nonresponse.

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Table 3.1 -- Public component response rate ranks: Schools and Staffing Survey 1993-94, Public Administrator, School, Teacher, Library, Librarian, and Student Components.

Component	Administrator	School	Teacher	Library	Librarian	Student
Variable						
Minority Enrollment (test result)	S	S	S	S	S	NS
Less than 5.5%	1	1	1	2	3	1
5.5 - 20.5%	2	2	2	1	1	4
20.5 - 50.5%	3	3	3	3	2	2
Greater than 50.5%	4	4	4	4	4	3
Region (test result)	S	S	S	NS	NS	S
Midwest	1	1	1	2	2	1
Northeast	3	4	4	3	1	3
South	2	2	2	1	3	2
West	4	3	3	4	4	4
School Level (test result)	NS	S	NS	S	S	NS
Elementary	3	2	2	2	2	2
Secondary	2	1	1	1	1	3
Combined	1	3	3	3	3	1
School Size (test result)	S	S	S	S	NS	NS
1 to 149	1	1	1	4	4	1
150 to 499	2	2	2	3	2	3
500 to 749	3	3	3	1	3	2
750 or more	4	4	4	2	1	4
Urbanicity (test result)	S	S	S	S	S	NS
Rural/small town	1	1	1	1	1	2
Urban fringe/large town	2	2	2	2	2	3
Central City	3	3	3	3	3	1

"S" indicates a significant association between respondents and nonrespondents for the different levels of the variable.
"NS" indicates that there is not a significant association between respondents and nonrespondents for the different levels of the variable.

Table 3.2 -- Private component response rate ranks: Schools and Staffing Survey 1993-94, Private Administrator, School, Teacher, Library, Librarian, and Student Components.

Component	Administrator	School	Teacher	Library	Librarian	Student
Variable						
Region (test result)	S	S	S	S	S	NS
Midwest	1	1	1	1	1	2
Northeast	3	3	3	4	4	3
South	4	2	2	2	3	4
West	2	4	4	3	2	1
School Level (test result)	S	S	S	S	S	NS
Elementary	2	1	2	2	2	1
Secondary	1	1	1	1	1	2
Combined	3	3	3	3	3	3
School Size (test result)	S	S	S	S	S	NS
1 to 149	4	4	4	4	4	3
150 to 499	3	1	2	3	3	2
500 to 749	2	3	1	2	1	4
750 or more	1	2	3	1	2	1
Urbanicity (test result)	NS	NS	S	S	NS	NS
Rural/small town	3	1	1	1	3	2
Urban fringe/large town	2	2	2	2	2	3
Central City	1	3	3	3	1	1

"S" indicates a significant association between respondents and nonrespondents for the different levels of the variable.
"NS" indicates that there is not a significant association between respondents and nonrespondents for the different levels of the variable.

Table 6.1 -- P-values for Rao-Scott, univariate logistic regression model, and multivariate logistic regression model tests (Public School)

Variable	Rao-Scott (RS3)	Univariate Model	Multivariate Model
Urbanicity	0.0001	0.0001	0.1016
Region	0.0030	0.0109	0.1115
Minority Enrollment	0.0002	0.0002	0.3936
Source	0.0175	0.0605	0.0746
School Level	0.0100	0.0119	0.0116
School Size	0.0000	0.0001	0.0001
School Type	0.0719	0.0397	0.0047

Table 6.2 -- Parameter Estimate, Odds Ratio and P-value: Public School.

Pairwise Comparison	Parameter Estimate	Standard Error	Odds Ratio	P-value
Urbanicity				
Rural/small town vs Central City	0.32	0.154	1.377	0.0410
Urban fringe/large town vs Central city	0.07	0.159	1.073	0.6600
Region				
Midwest vs West	0.29	0.162	1.336	0.0844
Northeast vs West	-0.12	0.179	0.887	0.4928
South vs West	0.18	0.136	1.197	0.2019
Minority Enrollment				
Less than 5.5% vs Greater than 20.5%	0.16	0.136	1.174	0.2458
5.5-20.5% vs Greater than 20.5%	0.11	0.119	1.116	0.3615
Source				
CCD update vs others	0.46	0.254	1.584	0.0746
School Level				
Combined vs Secondary	-0.36	0.156	0.698	0.0268
Elementary vs Secondary	-0.23	0.089	0.795	0.0140
School Size				
1 to 149 vs 750 or more	0.84	0.156	2.316	0.0000
150 to 499 vs 750 or more	0.40	0.120	1.492	0.0015
500 to 749 vs 750 or more	0.30	0.152	1.350	0.0543
School Type				
Non-regular vs Regular	-0.68	0.229	0.507	0.0047