MULTIVARIATE MODELING OF UNIT NONRESPONSE FOR 1990-91 SCHOOLS & STAFFING SURVEYS

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I. Introduction

This paper presents selected results of a study which analyzed unit nonresponse for the components of the 1990-91 Schools and Staffing Surveys (SASS): schools, principals, teachers, and school districts. SASS is a periodic, integrated system of sample surveys on elementary and secondary schools in the United States sponsored by the National Center for Education Statistics (NCES) of the U.S. Department of Education and administered by the U.S. Bureau of the Census.

The study was motivated by the need to identify potential sources of nonsampling error in the SASS estimates associated with nonresponse. Nonresponse is a concern depending on the amount of incompleteness that exists in the data and the difference in the characteristics between respondents and nonrespondents. We developed a multivariate model of unit nonresponse to try to explain the relationship of these factors to the level of unit nonresponse for each of the components of SASS. We also studied the results of the modeling effort across the SASS components.

One of the reasons that it is so hard to evaluate nonsampling error from unit nonresponse in a survey is the lack of data from nonrespondents, which is critical in the evaluation. As a result, the scope of our study is limited to the few frame variables for which data were collected for all sampled schools, teachers, administrators, and districts. It was conjectured that these variables might have a plausible effect on nonresponse. As will be seen, this conjecture was at least somewhat optimistic.

II. The Surveys and Sample Design

SASS is comprised of four interrelated national surveys:
1. The School Survey included data on school programs and services, student characteristics and staffing patterns. For private schools additional information was collected on aggregate demand for both new and continuing teachers.
2. The School Administrator Survey collected background information from principals on their education, experience, and compensation, and their perceptions of the school environment and educational goals.
3. The School Teacher Survey collected information on demographic characteristics of public and private school teachers, their education, qualifications, income sources, working conditions, plans for the future, and perceptions of the school environment and the teaching profession.
4. The Teacher Demand and Shortage Survey (TDS) targeted public school district personnel who provided information about their district's student enrollment, number of teachers, position vacancies, new hires, teacher salaries and incentives, and hiring and retirement policies.

The target populations for the 1990-91 SASS surveys included U.S. elementary and secondary public and private schools with students in any of grades 1-12, principals and classroom teachers in those schools, and local education agencies (LEAs) that employed elementary and/or secondary level teachers. (In the private sector, since there is no counterpart to the LEAs, information on teacher demand and shortages was collected directly from individual schools. Nonresponse in the Teacher Demand and Shortage data was analyzed for the public sector only.)

Three primary steps in the sample selection process were followed during the 1990-91 SASS. The School Survey sample forms the basis for all other survey samples.
1. A sample of schools was selected first for the School Survey. The same sample was used for the School Administrator Survey.
2. For each school in the School Survey, a list of teachers was obtained from which a sample was selected for inclusion in the Teacher Survey.
3. The sample for the Teacher Demand and Shortage Survey was formed from responses from all private schools selected in the School Survey and all LEAs administrating public schools already in the School Survey sample.

Details pertaining to the frame, stratification, sorting, and sample selection for each of the four surveys of SASS are presented in Kaufman and Huang (1993).

III. Weighted Unit Response Rates

For each survey of SASS, weighted unit response rates were calculated. The weighted unit response rates were derived by dividing the sum of the weights for the interviewed cases by the sum of the weights for the eligible cases (the number of sampled cases minus the number of out-of-scope cases). In other words, the weighted unit response rate specifies what proportion of a population is covered by the respondents.

The simplest weighted response rate uses the unit of collection as the population. However, other populations can be used. For example, the public school survey collects many characteristics: some are specific to the school as an entity; some relate to the teaching staff or to the student body. Therefore, for the School and Administrator components of SASS, three alternative adjusted response rates were calculated:

- **School-based response rate**: This measure is calculated by weighting the responding (R) and nonresponding schools (N) by the inverse of their base sample selection probabilities (or base weights). Once the schools are so weighted, the rates are determined for each group being considered by calculating the ratios R/(R+N) and multiplying by 100 to convert them to percents. For example, a 90% school-based response rate for the public school survey means that 90% of public schools are covered by the respondents.
- **Teacher-based response rate**: This measure is calculated in the same way as the school-based response rate, except a school's base weight is multiplied by the number of teachers in the school before calculating the response ratio as above. For example, a 90% teacher-based response rate for the public school survey means that 90% of the teacher population is covered by the responding schools.
- **Student-based response rate**: This measure is calculated in the same way as the school-based response rate, except a school's base weight is multiplied by the number of students in the school before calculating the response ratio.

Similarly, LEA-based, school-based and student-based weighted unit response rates were calculated for the Teacher Demand and Shortage component of SASS. However, for the teacher component only one weighted unit response rate was calculated using an adjusted base weight.

For each of the SASS surveys, the three different weighted response rates were examined graphically and it was determined that little differences existed between the simple weighted response weight and the alternative measures. Therefore, for modeling purposes we confined our analysis to using the most simple weighted response rate, i.e., using the unit of collection as the population.

Overall unit response rates are high for the SASS surveys and, as expected, better for the public rather than for the private component (see table 1). However, unit nonresponse remains a concern because of the complex, hierarchical nature of the SASS design, and there is room for improvement (Moonesinghe, Smith and Gruber, 1993). Also, unit response rates vary considerably across the states within each of the public surveys and across affiliations within each of the private surveys (see "highest" and "lowest" columns in table 1).

Table 1: Response Rates for 1990-91 SASS Surveys

Survey Component	Overall	Highest	Lowest
Public School	95.30	99.61	80.99
Private School	83.95	97.89	59.03
Public Administrator	96.69	100.00	82.35
Private Administrator	90.05	98.85	72.39
Public Teacher	90.33	97.88	69.40
Private Teacher	84.31	94.83	57.12
TDS (public LEAs)	93.49	100.00	76.96

Multiple regression techniques were employed in order to examine the combined effects of other stratification variables, such as urbanicity. school size, and school level within each of the components.

IV. Methodology

Exploratory Analysis:

In the first stage of this study we undertook an exploratory analysis of unit nonresponse behavior within each of the SASS surveys. We focused only on a limited number of variables for which we conjectured a plausible effect on response rates, and used comparable, simple structure, complete logistic regression models for each analysis. Here the goal was to develop a model of response rates by state or affililiation for each of the survey components-- not just to see how frame variables such as urbanicity vary in their effects by state or affiliation. We used the simple base school weight divided by the mean base weight for the state for public components and the simple base school weight divided by the mean base weight for the affiliation for private components. We modeled nonresponse on urbanicity, school level, school size for the School, Administrator, and Teacher surveys and on urbanicity, number of schools in the LEA, number of students in the LEA for the School Teacher Demand and Shortage survey. Within each of the survey components, we selected a final model which included an additional categorical variable which grouped either states or affiliations into clusters through a stepwise, modeling procedure. The objective was to

reduce the variability in response due to the states/associations in order to concentrate on the variation caused by the frame variables.

The stepwise modeling procedure began by fitting the data to a complete, baseline model which contained all categorical frame variables for each of the states/affiliations separately without any clustering. No interactions were modeled. The goodness-of-fit of the model fitted was evaluated on the basis of how well it estimated response at the state/affiliation level. A t-value was calculated for each state using the observed and fitted response rate. The variance was adjusted using the average design effect for proportions at the state/affiliation level (Salvucci and Weng, 1995) as follows:

$$\frac{\text{Response Rate - Estimated Response Rate}}{\sqrt{(\text{Design Effect})}\dfrac{(\text{Response Rate})(1 - \text{Response Rate})}{\text{Sample Size}}}$$

The design effects used in the calculation of the t-values for states or affiliations within each of the survey components in this stepwise modeling process were:

Public School Survey:	1.7433
Public School Administrator Survey:	1.7807
Public School Teacher Survey:	2.8493
Private School Survey:	2.0488
Private School School Administrator Survey:	2.3694
Private School Teacher Survey:	1.9053
TDS (public LEA's):	1.8603

Successive models fitted included all frame variables and differed only in how they clustered states/affiliations into groups The criterion used for segregating states/affiliations in the successive models was that the t-value be smaller than -2 or greater than 2 -- a two-tail t-test at the .05 percent significance level. If the t-value criterion by state/association cluster was not violated the modeling procedure was terminated; otherwise the plot of the estimated response rate versus the actual response rate was used to identify outliers, the clusters were redefined, a new model was fitted, and the cycle was repeated.

Final model specifications

Final logistic regression models (developed as above) were fitted for each of the surveys. These involved all of the frame variables studied for the particular survey and an additional categorical variable which divided states or affiliations into clusters for the public and private component surveys respectively.

For example the final multiple logistic model used for the Public School Survey was:

$$g(x)=b_0+\sum_{i=1}^{2}b_{1i}x_{1i}+\sum_{j=1}^{2}b_{2j}x_{2j}+\sum_{k=1}^{3}b_{3k}x_{3k}+\sum_{g=1}^{4}b_{4g}x_{4g}$$

where $P(Y=1|x) = \pi(x)$ is defined as the conditional probability that the outcome is present and

$$\pi(x)=\frac{e^{g(x)}}{1-e^{g(x)}}$$

where x_{1i}, i=1,2, 3 are the variables coding urbanicity, x_{2j}, j=1,2,3 the variables coding school level, x_{3k}, k=1,2,3,4 the variables coding school size and x_{4g}, g=1,2,..,m the variables coding state/affiliation groupings. No variable interactions (the combined effect of two or more variables) entered into the model.

V. Findings

For each final model we fitted the odds ratios to define more closely subpopulations with significant nonresponse differentials. A summary of our findings follows:

♦ For the public component of the School Administrator, School and Teacher surveys, only urbanicity and state were significant in modeling unit nonresponse. (Tables 2-7)

Table 2: State cluster odds ratios, Public School Survey

- Group 1: The District of Columbia, Maryland, New Jersey, New York (81.0% through 88.3%)
- Group 2: Alaska, Massachusetts (91.1% through 92.0%)
- Group 3: Hawaii, Illinois, Indiana, Utah (98.7% through 99.6%)
- Group 4: Connecticut, Delaware, North Carolina, Virginia, Washington (92.2% through 93.3%)
- Referent Group: The Remaining 36 States (93.9% through 98.7%)

(in parentheses are the response rate intervals for the cluster)

Group Comparison	Odds Ratio	Confidence Interval	
		Lower 95%	Upper 95%
Group 1 vs Referent	0.27	0.17	0.44
Group 2 vs Referent	0.38	0.17	0.83
Group 3 vs Referent	3.53	0.92	13.55
Group 4 vs Referent	0.49	0.28	0.86
Group 1 vs Group 2	0.73	0.31	1.72
Group 1 vs Group 3	0.08	0.02	0.31
Group 1 vs Group 4	0.56	0.29	1.07
Group 2 vs Group 3	0.11	0.02	0.49
Group 2 vs Group 4	0.77	0.31	1.92
Group 3 vs Group 4	7.25	1.76	29.82

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Surveys: 1990-91 (Public School Questionnaires).

Table 3: Urbanicity odds ratios, Public School Survey

Urbanicity Type Comparison	Odds Ratio	Confidence Interval	
		Lower 95%	Upper 95%
Urban Fringe / Large Town vs Rural / Small Town	0.52	0.35	0.79
Central City vs Rural / Small Town	0.47	0.31	0.70
Urban Fringe / Large Town vs Central City	1.12	0.75	1.66

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Surveys: 1990-91 (Public School Questionnaires).

Table 4: State group odds ratios for the Public School Administrator Survey

- Group 1: The District of Columbia, Maryland, New York (82.3% through 89.5%)
- Group 2: Idaho, Illinois, Indiana, Montana, Utah, West Virginia (99.3% through 100.0%)
- Group 3: Louisiana, New Jersey, Washington (92.4% through 93.7%)
- Referent Group: The Remaining States (94.4% through 99.2%)

Group Comparison	Odds Ratio	Confidence Interval	
		Lower 95%	Upper 95%
Group 1 vs Referent	0.21	0.12	0.36
Group 2 vs Referent	10.77	1.12	103.95
Group 3 vs Referent	0.38	0.20	0.73
Group 1 vs Group 2	0.02	0.00	0.19
Group 1 vs Group 3	0.55	0.26	1.17
Group 2 vs Group 3	28.35	2.77	290.31

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Surveys: 1990-91 (Public School Administrator Questionnaires).

Table 5: Urbanicity odds ratios for the Public School Administrator Survey

Urbanicity Type Comparison	Odds Ratio	Confidence Interval	
		Lower 95%	Upper 95%
Urban Fringe / Large Town vs Rural / Small Town	0.50	0.29	0.86
Central City vs Rural / Small Town	0.33	0.20	0.55
Urban Fringe / Large Town vs Central City	1.52	0.94	2.44

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Surveys: 1990-91 (Public School Administrator Questionnaires).

Table 6: State group odds ratios for the Public Teacher Survey

- Group 1: The District of Columbia, New York (68.5% through 79.6%)
- Group 2: Alabama, Alaska, California, Connecticut, Florida, Hawaii, Kentucky, Maryland, Nevada, New Mexico, New Jersey, Ohio, Rhode Island, Washington (86.3% through 91.0%)
- Group 3: Massachusetts, Michigan (84.3% through 84.8%)
- Group 4: Illinois, Utah (96.4% through 97.7%)
- Group 5: Texas, Virginia (91.6% through 91.7%)
- Referent Group: The Remaining States (89.6% through 96.5%)

Group Comparison	Odds Ratio	Confidence Interval	
		Lower 95%	Upper 95%
Group 1 vs Referent	0.24	0.17	0.33
Group 2 vs Referent	0.50	0.41	0.60
Group 3 vs Referent	0.34	0.25	0.48
Group 4 vs Referent	2.06	1.11	3.84
Group 5 vs Referent	0.72	0.51	1.00
Group 1 vs Group 2	0.48	0.35	0.66
Group 1 vs Group 3	0.70	0.46	1.07
Group 1 vs Group 4	0.12	0.06	0.23
Group 1 vs Group 5	0.34	0.22	0.51
Group 2 vs Group 3	1.45	1.05	2.01
Group 2 vs Group 4	0.24	0.13	0.45
Group 2 vs Group 5	0.70	0.50	0.97
Group 3 vs Group 4	0.17	0.08	0.33
Group 3 vs Group 5	0.48	0.31	0.74
Group 4 vs Group 5	2.88	1.46	5.69

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Surveys: 1990-91 (Public School Teacher Questionnaires)

Table 7: Urbanicity odds ratios for the Public School Teacher Survey

Urbanicity Type Comparison	Odds Ratio	Confidence Interval	
		Lower 95%	Upper 95%
Urban Fringe / Large Town vs Rural / Small Town	0.74	0.62	0.88
Central City vs Rural / Small Town	0.63	0.53	0.75
Urban Fringe / Large Town vs Central City	1.17	0.98	1.39

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Surveys: 1990-91 (Public School Teacher Questionnaires)

◆ For the private components of the School Administrator and Teacher surveys, only affiliation was significant. (Tables 8-9)

Table 8: Affiliation group odds ratios for the Private School Administrator Survey

- Group 1: Area Frame, National Society for Hebrew Day Schools, Other Jewish, American Association of Christian Schools, All Else (72.4% through 86.1%)
- Group 2: Solomon Schechter Day Schools, Lutheran Church - Missouri Synod, Evangelical Lutheran Church - Wisconsin Synod, Evangelical Lutheran Church in America, Other Lutheran (97.3% through 98.9%)
- Referent Group: Association of Military Colleges and Schools of U.S., Catholic, Friends, Episcopal, Seventh-Day Adventist, Christian Schools International, National Association of Private Schools for Exceptional Children, Montessori, National Association of Independent Schools (92.2% through 96.2%)

Comparison	Odds Ratio	Confidence Interval	
		Lower 95%	Upper 95%
Group 1 vs Referent	0.28	0.16	0.50
Group 2 vs Referent	1.98	0.53	7.44
Group 1 vs Group 2	0.14	0.04	0.52

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Surveys: 1990-91 (Private School Administrator Questionnaires)

Table 9: Affiliation odds ratios for the Private School Teacher Survey

- Group 1: National Society for Hebrew Day Schools, Other Jewish, American Association of Christian Schools (59.8% through 63.5%)
- Group 2: Association of Military Colleges and Schools of U.S., Lutheran Church - Missouri Synod, Evangelical Lutheran Church - Wisconsin Synod, Other Lutheran, Christian Schools International (90.3% through 94.8%)
- Group 3: Area Frame, Montessori (75.0% through 76.9%)
- Group 4: Catholic, Solomon Schechter Day Schools (85.7% through 88.0%)
- Referent Group: Friends, Episcopal, Evangelical Lutheran Church in America, Seventh-Day Adventist, National Association of Private Schools for Exceptional Children, National Association of Independent Schools, All Else (79.2% through 86.0%)

Group Comparison	Odds Ratio	Confidence Interval	
		Lower 95%	Upper 95%
Group 1 vs Referent	0.37	0.25	0.54
Group 2 vs Referent	2.37	1.46	3.83
Group 3 vs Referent	0.68	0.48	0.96
Group 4 vs Referent	1.44	1.03	2.02
Group 1 vs Group 2	0.16	0.09	0.27
Group 1 vs Group 3	0.54	0.35	0.83
Group 1 vs Group 4	0.26	0.17	0.39
Group 2 vs Group 3	3.49	2.10	5.79
Group 2 vs Group 4	1.64	1.00	2.69
Group 3 vs Group 4	0.47	0.32	0.70

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Surveys: 1990-91 (Private School Teacher Questionnaires)

For the Private School survey, the significant variables were affiliation and school level. (Tables 10-11)

Table 10: Affiliation odds ratios for the Private School Survey

- Group 1: Area Frame, National Society for Hebrew Day Schools, Other Jewish, American Association of Christian Schools (59.0% through 74.0%)
- Group 2: Lutheran Church - Missouri Synod, Evangelical Lutheran Church - Wisconsin Synod, Evangelical Lutheran Church in America (95.5% through 97.9%)
- Group 3: Solomon Schechter Day Schools, National Association of Private Schools for Exceptional Children, Montessori, National Association of Independent Schools, All Else (81.1% through 86.5%)
- Referent Group: Association of Military Colleges and Schools of U.S., Catholic, Friends, Episcopal, Other Lutheran, Seventh-Day Adventist, Christian Schools International (89.4% through 94.2%)

Group Comparison	Odds Ratio	Confidence Interval Lower 95%	Confidence Interval Upper 95%
Group 1 vs Referent	0.24	0.14	0.42
Group 2 vs Referent	2.35	0.63	8.68
Group 3 vs Referent	0.54	0.31	0.96
Group 1 vs Group 2	0.10	0.03	0.38
Group 1 vs Group 3	0.45	0.28	0.73
Group 2 vs Group 3	4.33	1.16	16.10

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Surveys: 1990-91 (Private School Questionnaires).

Table 11: School level odds ratios for the Private School Survey

School Level Comparison	Odds Ratio	Confidence Interval Lower 95%	Confidence Interval Upper 95%
Elementary vs Combined	1.53	1.03	2.27
Secondary vs Combined	2.35	1.05	5.26
Elementary vs Secondary	0.65	0.29	1.45

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Surveys: 1990-91 (Private School Questionnaires).

For the public component of the Teacher Demand and Shortage Survey the significant variables were state and the number of students in the LEA. (Tables 12-13)

Table 12: State group odds ratios for the Teacher Demand and Shortage Survey

- Group 1: Connecticut, Maryland, New Jersey, Vermont (77.0% through 87.5%)
- Group 2: Delaware, The District of Columbia, Kansas, Nevada, Tennessee, Colorado, Iowa, Nebraska, Oklahoma, South Dakota, West Virginia, Washington (97.0% through 100.0%)
- Group 3: California, Montana, North Dakota, Oregon (91.2% through 95.1%)
- Referent Group: The Remaining States (90.1% through 100.0%)

Group Comparison	Odds Ratio	Confidence Interval Lower 95%	Confidence Interval Upper 95%
Group 1 vs Referent	0.40	0.20	0.81
Group 2 vs Referent	4.78	1.51	15.12
Group 3 vs Referent	1.27	0.56	2.87
Group 1 vs Group 2	0.08	0.02	0.30
Group 1 vs Group 3	0.32	0.12	0.82
Group 2 vs Group 3	3.76	1.00	14.07

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Surveys: 1990-91 (Teacher Demand and Shortage Survey Questionnaires).

Table 13: Odds ratios for the number of students in local education agency for the Teacher Demand and Shortage Survey

Number of Students in LEA Comparison	Odds Ratio	Lower 95%	Upper 95%	Number of Students in LEA Comparison	Odds Ratio	Lower 95%	Upper 95%
0 to 299 vs 25,000 Plus	0.62	0.09	4.47	300 to 599 vs 1,000 to 2,499	1.14	0.42	3.04
300 to 599 vs 25,000 Plus	1.73	0.22	13.45	300 to 599 vs 2,500 to 4,999	1.11	0.30	4.07
600 to 999 vs 25,000 Plus	1.18	0.16	8.91	300 to 599 vs 5,000 to 9,999	1.31	0.29	5.99
1,000 to 2,499 vs 25,000 Plus	1.52	0.23	9.89	300 to 599 vs 10,000 to 24,999	1.00	0.16	6.40
2,500 to 4,999 vs 25,000 Plus	1.57	0.28	8.79	600 to 999 vs 1,000 to 2,499	0.78	0.30	1.98
5,000 to 9,999 vs 25,000 Plus	1.32	0.23	7.74	600 to 999 vs 2,500 to 4,999	0.75	0.21	2.68
10,000 to 24,999 vs 25,000 Plus	1.73	0.24	12.57	600 to 999 vs 5,000 to 9,999	0.89	0.20	3.96
0 to 299 vs 300 to 599	0.36	0.14	0.90	600 to 999 vs 10,000 to 24,999	0.68	0.11	4.24
0 to 299 vs 600 to 999	0.53	0.21	1.29	1,000 to 2,499 vs 2,500 to 4,999	0.97	0.34	2.78
0 to 299 vs 1,000 to 2,499	0.41	0.18	0.90	1,000 to 2,499 vs 5,000 to 9,999	1.15	0.32	4.16
0 to 299 vs 2,500 to 4,999	0.40	0.12	1.29	1,000 to 2,499 vs 10,000 to 24,999	0.88	0.17	4.63
0 to 299 vs 5,000 to 9,999	0.47	0.11	1.93	2,500 to 4,999 vs 5,000 to 9,999	1.18	0.40	3.50
0 to 299 vs 10,000 to 24,999	0.36	0.06	2.10	2,500 to 4,999 vs 10,000 to 24,999	0.91	0.20	4.06
300 to 599 vs 600 to 999	1.47	0.50	4.30	5,000 to 9,999 vs 10,000 to 24,999	0.77	0.16	3.63

Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Surveys: 1990-91 (Teacher Demand and Shortage Survey Questionnaires).

VI. Conclusions

Our study carries implications for handling nonresponse during data collection -- by either undertaking intensive follow up studies where nonresponse is significant or simply increasing sample size where nonresponse is random -- and/or the analysis level -- by adjusting for nonresponse along significant variables. For example, our results focus attention on the states for the public school survey and affiliations for the private school survey as variables accounting for variation in nonresponse. The U.S. Bureau of the Census has rightfully selected these variables for nonresponse adjustments, as already noted by Shen, Palmer and Tan (1992) in a similar study.

The results of our study, however, suggest that variability in nonresponse can be accounted for by only those variables which were shown to be significant in our modeling. Given these findings some re-evaluation might be in order on how nonresponse adjustments are made with regard to variables from which nonresponse bias does not appear to arise. For example, adjusting for school level in the Public School Administrator, School and Teacher surveys might lead to overadjustments if one considers the results of our analysis which suggest that variation in nonresponse along this particular variable may be random when adjustments are made for state clusters and urbanicity.

Our study, although preliminary, shows how statistical modeling can be of assistance in defining subpopulations with nonresponse differential. Nonresponse bias can then be reduced using poststratification techniques. Further statistical modeling examining the effect of additional covariates should lead to a better understanding of unit nonresponse. This will have considerable practical consequences for improving the SASS data base at the collection stage and for adjusting for nonresponse while conducting analysis.

Bibliography

Fay, R. (1986), "Causal models for patterns of nonresponse." *Journal of the American Statistical Association* 81: 354-365.

Groves, R. M. (1989), *Survey errors and survey costs*. New York: John Wiley & Sons.

Hosmer, D. W. and Lemeshow, S. (1989), *Applied Logistic Regression*. New York: John Wiley & Sons.

Jabine, T. (1994), *Quality Profile for SASS, Aspects of the Quality of Data* in *the Schools and Staffing Surveys (SASS)*. Technical Report, NECS 94-340. Washington, DC: National Center for Education Statistics.

Kaufman, S. and Huang, H. (1993), *1991 Schools and Staffing Survey: Sample Design and Estimation*, Technical Report, NECS 93-449, Washington, DC: National Center for Education Statistics.

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

Madow, W.G. and Olkin, I. (1983), *Incomplete Data in Sample Surveys, Vol. 3, Proceedings of the Symposium*. New York: Academic Press.

Madow, W. G., Olkin, I. and Rubin, D. B. (eds) (1983), *Incomplete Data in Sample Surveys, Vol 2, Theory and Bibliographies*. New York: Academic Press.

Smith, W., Moonesinghe, R., Smith, W. and Gruber, K. (1993), "Characteristics of Nonrespondents to the 1990-91 Schools and Staffing Survey." *Proceedings of the Section on Survey Research Methods, American Statistical Association*, pp. 698-703. Alexandria, VA: American Statistical Association.

National Academy of Sciences (U.S.) (1992), *Combining Information. Statistical Issues and Opportunities for Research in the Combination of Information*. Washington, D.C.: National Academy Press.

Oh, L. H. and Scheuren, F. J. (1983), "Weighting Adjustment for Unit Nonresponse," in Madow, W. G., Olkin, I. and Rubin, D. B. (eds), *Incomplete Data in Sample Surveys, Vol 2, Theory and Bibliographies*, pp. 143-184. New York: Academic Press.

Pregibon, D. (1984), "Logistic Regression Diagnostics," *Annals of Statistics* 9.

Salvucci, S. and Weng, S. (1995), *Design Effects and Generalized Variance Functions for the 1990-91 Schools and Staffing Surveys (SASS) - Volume I*, Washington, DC: National Center for Education Statistics.

Shen, P., Palmer, R.J., and Tan, A.I. (1992), "Characteristics of Nonrespondents in the Schools and Staffing Surveys' School Sample," *Proceeedings of the Section on Survey Research Methods, American Statistical Association*. Alexandria, VA: American Statistical Association.