MAIL VERSUS TELEPHONE RESPONSE IN THE 1991 SCHOOLS AND STAFFING SURVEYS**

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I. Introduction

The 1991 Schools and Staffing Surveys (SASS) were designed to be primarily mail-out/mail-back surveys. Sample units not responding by mail are contacted as part of the telephone follow-up. Due to the high cost of conducting a telephone interview as compared to an interview conducted by mail, attempts are made to maximize the mail response rate. Mail responses alone, however, are unacceptably low due to the great potential for bias nonresponse adjustment would produce. Telephone follow-up, therefore, is necessary to increase overall survey response rates. This mixed mode of data collection, however, causes some concern about response bias due to mode.

In this paper, we shall address the issue of possible response bias as well as identify particular subgroups where mail response is low so resources may best be concentrated in improving overall mail response for the surveys. Section II describes the SASS surveys in general. Section III presents the methodology we will use to identify possible mode bias. Section IV presents the results. Section V gives our conclusions and suggestions for further research.

This paper analyzes the effect upon the data caused by mode of interview for school data only. Teacher, administrator, and public school district data could also be analyzed in the same way.

II. Background

A. General Survey Description

1. Frame Construction

The 1991 Schools and Staffing Surveys consists of a school, a teacher, and for public schools a Local Education Agency or school district survey. Public schools were identified on the Common Core of Data (CCD), a file containing all public schools in the nation, created by the National Center for Education Statistics from lists provided by the states. This CCD was matched to the previous SASS public school sampling frame. Non-matches from the previous frame were included with the CCD to make up the public school sampling frame for 1991.

The private schools were selected from a list frame, constructed by matching multiple lists obtained from private school organizations, State Departments of Education, and a private vendor. This frame is thought to include 80-90% of private schools. To increase the coverage of the survey, an area frame was constructed by selecting 120 Primary Sampling Units (PSUs), consisting of counties or groups of counties. Within these sample counties, lists of schools were obtained from local sources, such as yellow pages, churches and fire marshals. These lists were unduplicated with the list frame. The remaining schools, not matching to the list frame, make up the area frame.

2. Design

Public schools were stratified by state, grade level, and Indian/non-Indian. Probabilities of selection were computed, proportional to the square root of the number of teachers in the school conditioned on the 1988 selection. The probabilities were adjusted to obtain the desired proportion of overlapping schools from 1988. Approximately 9900 sample public schools were selected systematically within each of the 165 strata.

Private schools were stratified by 18 affiliations, 3 grade levels, and census region for the list frame, and by PSU and grade levels for the area frame. Probabilities of selection were computed and adjusted similarly to the public schools. Approximately 3300 private schools were selected, systematically within each stratum.

3. Data Collection

School questionnaires were mailed to schools. They were asked to fill them out and mail them back to the Census Bureau. After four weeks, if the school hadn't responded, we sent out a second questionnaire. If after three more weeks the school hadn't responded, we called them and attempted to complete the interview by telephone. Schools still not responding by telephone were classified as noninterviews.

4. Estimation

Schools' probabilities of selection were adjusted for school merges and other situations that would affect the probability of selection. The inverse of the probability of selection became the basic weight. This basic weight was adjusted to account for noninterviews using noninterview adjustment cells. A ratio adjustment was also applied which adjusted the characteristics of the sample schools to the characteristics of the whole sample frame.

B. Issues to be Addressed

Four issues will be addressed in our discussion of mode of interview. The first issue is what types of respondents are more likely to respond by mail. We examine this issue in order to identify certain subgroups of schools where a more concentrated effort at improving mail response rates has the greatest potential benefit, thereby lowering overall survey costs.

The second issue involves comparing response categories by mode of interview so as to identify items with mode differences. At this point, we still won't know if the response differences represent inherent differences in the types of respondents or if it represents response bias. It is merely being used as a tool to narrow down the number of items we need to look at further.

The third issue involves conducting covariance analysis on the items identified with mode differences to try to filter out inherent differences in the characteristics of the respondents and measure the difference due solely to mode of interview. Since this analysis has been done for more than one item, a rank-sum test was used to make an objective probability statement that addresses the question of whether or not there is response bias due to mode.

The fourth issue involves item nonresponse and comparing item nonresponse rates between the two modes of interview.

III. Methodology

A. Comparison of Response Categories

Responses to questionnaire items were compared using a chi-square test for independence, whereby the two modes of interview (mail, telephone) were compared across response category. Continuous variables were categorized into approximately five categories.

The usual Pearson Chi-Square test produced in SAS by PROC FREQ is inappropriate for this analysis due to the complex sample design. So, Rao and Scott's (1984) correction to the standard chi-square, which requires knowledge of the cell

** This paper reports the general results of research undertaken by Census Bureau staff. The views expressed are attributable to the author(s) and do not necessarily reflect those of the Census Bureau.

design effects, was used in our analysis. Design effects were obtained based on the estimated variance using 48 pseudo-replicates.

Comparisons were made using unweighted and weighted data. Unweighted data was analyzed as a preliminary step in this analysis. Items showing significant differences were analyzed using weighted data, adjusted by the appropriate design effect.

B. Analysis of Covariance

Regression models were fit to the data within each block constructed using the stratification variables (for example, within affiliation and grade level). Questionnaire items were treated as the dependent variables and some selected variables which were believed to be related to dependent variables and "untainted" by mode of interview were used as the covariates. The square root of the number of teachers was also included in the model to take into account the effect of the probability of selection on the covariance analysis (see Nathan and Holt (1980)). Finally, mode of interview and its corresponding interaction with the covariate were also included in the model. Our goal is to filter out the effects of inherent differences in the respondents and the effects of the design upon the responses by mode. This section describes this covariance analysis.

The mode research methodology uses a combination of parametric and nonparametric approaches:

To perform a rank-sum test, it is necessary first to express the data from different questionnaire items in common units via a transformation to relative deviate within each block. This is done by subtracting the overall mean from each observation and dividing by the within-block sample standard deviation.

Assumption:

The linear model for our study can be written as

$$Y_{ijkl} = \alpha_{jl} + \lambda_{il} X_{ijkl} + \beta_{il} Z_{ijkl} + e_{ijkl} \qquad (1)$$

where Y_{ijkl} represent the lth variable (questionnaire items) after standardization for the kth subject (school) in block i (association x grade level) receiving the jth treatment (mail, telephone). X_{ijkl} and Z_{ijkl} are the corresponding covariate and the square root of the number of teachers and e_{ijkl} is random error.

$$E(Y_{ijkl}) = \alpha_{jl} + \lambda_{il} X_{ijkl} + \beta_{il} Z_{ijkl} = \mu_{ijkl}$$

$$(cov(Y_{ijkl}, Y_{i'j'k'l'})) = \sigma^2_{ll'} \text{ if } i=i',\ k=k'$$
$$= 0 \text{ otherwise}$$

In matrix notation the vector $Y_{ijk.} = (Y_{ijk1}, ..., Y_{ijkL})'$ are independently distributed with mean $\mu_{ijk.} = (\mu_{ijk1}, ..., \mu_{ijkL})'$ and covariance matrix:

$$\sum_{(L \times L)} = \begin{pmatrix} \sigma^2_{11} & \cdots & \sigma^2_{1L} \\ \vdots & & \vdots \\ \sigma^2_{L1} & \cdots & \sigma^2_{LL} \end{pmatrix}$$

The null hypothesis is:

$$Ho: \alpha_{i.} = \alpha_{i'.} \text{ for } i=1,...,I \quad \text{where } \alpha_{i.} = \begin{pmatrix} \alpha_{i1} \\ \vdots \\ \alpha_{iL} \end{pmatrix}$$

Now, perform analysis of covariance for different variables within each block using ordinary least squares (OLS).

The adjusted mean for $\alpha_{jl} + \lambda_{il}\bar{X}_{..l} + \beta_{il}\bar{Z}_{...l}$ is estimated by

$$\hat{\alpha}_{jl} + \hat{\lambda}_{il}\bar{X}_{..l} + \hat{\beta}_{il}\bar{Z}_{...l} = \bar{Y}_{ij.l} - \hat{\lambda}_{il}(\bar{X}_{ij.l} - \bar{X}_{..l}) - \hat{\beta}_{il}(\bar{Z}_{ij.l} - \bar{Z}_{...l})$$

and denoted by $\bar{Y}^a_{ijl}$, where $\hat{\alpha}_{jl}$, $\hat{\lambda}_{il}$ and $\hat{\beta}_{il}$ are ordinary least square estimates within block i. Note that the difference between adjusted means of treatments 1 and 2 is

$$\bar{Y}^a_{i1.l} - \bar{Y}^a_{i2.l} = (\bar{Y}_{i1.l} - \bar{Y}_{i2.l}) - \hat{\lambda}_{il}(\bar{X}_{i1.l} - \bar{X}_{i2.l}) = \hat{\alpha}_{i1l} - \hat{\alpha}_{i2l}$$

Since treatments are homogeneous with respect to X_{ijkl} and Z_{ijkl} under the model (1), the difference between the adjusted treatment means can be interpreted as $\bar{X}_{ijl}$ and $\bar{Z}_{ijl}$.

After the analysis of covariance for different variables within each block, we have I independent pairs of vectors $(\bar{Y}^a_{i1.}, \bar{Y}^a_{i2.})$ for $i=1,...,I$ where:

$$\bar{Y}^a_{i1.} = \begin{pmatrix} \bar{Y}^a_{i1.1} \\ \vdots \\ \bar{Y}^a_{i1.L} \end{pmatrix} \text{ and } \bar{Y}^a_{i2.} = \begin{pmatrix} \bar{Y}^a_{i2.1} \\ \vdots \\ \bar{Y}^a_{i2.L} \end{pmatrix},$$

Note that $\bar{Y}^a_{ijl}$ is correlated to $\bar{Y}^a_{i'j'l'}$ for all j, where j =1, ..., J,and l, where l =1,...,L. Even though $\bar{Y}^a_{i1.}$ and $\bar{Y}^a_{i2.}$ are not best linear unbiased estimates (the best unbiased estimate can be obtained by the generalized least squares method (GLS) which requires estimation of Σ), covariates were considered and, $\bar{Y}^a_{i1.}$ and $\bar{Y}^a_{i2.}$ are consistent estimates of α_{i1} and α_{i2} under the model (1).

Finally perform a rank-sum-type test. Let R_{ijl} represent the rank of $\bar{Y}^{a}_{ijl}$ among all values of variables in the pooled set of J x L sample in block i.

Since data from different items have been standardized, define S_{ij} as the sum of the rank assigned to the i block in sample j (treatment). Perform a one-way analysis of variance on the $\{S_{ij}\}$ values, when the number of blocks is large enough (based on asymptotic normality) and perform a sign test on the $Z_i = S_{i1} - S_{i2}$ for i = 1, ..., I when i is small.

IV. Results

A. Mail Response Rates for Selected Subgroups

Tables A-1 through A-4 present mail response rates for selected subgroups. Tables A-1 and A-2 present mail response rates for private schools. Tables A-3 and A-4 present mail response rates for public schools. Note that this analysis is conditioned on the sample that was selected in 1991, so no standard errors are used.

As Table A-1 reveals, mail response rates show great difference by affiliation. Lutheran, Catholic, Military, and Christian Schools International show the highest mail response rates, tending toward 60% or more, which we would consider high for private schools. Jewish, Friends, and American Association of Christian Schools show low rates - 45% or less.

Table A-2 shows a high mail response rate for the Chicago and Kansas City Regional Offices, and a low mail response rate for New York. The affiliation differences may be the cause of the differences seen in these three tables, but that cannot be determined from this analysis.

Other results reveal a fairly low mail response rate for combined schools and a high mail response rate for nonmetropolitan schools.

Table A-3 shows a low mail response rate for large central cities. Table A-4 shows a low mail response rate for the New York Regional Office. The low response rate for large city schools may be the cause of this.

Other results show the mail response rate for public schools by state. Rates vary from 48% in the District of Columbia to 81% in Delaware. There appears, however, to be no geographic patterns, such as by size or region.

B. Comparison of Response Categories

A fairly substantial number of items show a significant effect by mode of interview. Based on chi-square analysis alone, however, it is impossible to tell if these differences are due to mode or represent inherent differences in the characteristics of the respondents for each mode of interview. If, for example, from our results presented in Section A above, we believe Jewish schools have a low mail response rate, then this analysis will show mode differences for any item correlated with Jewish schools, even if mode does not influence the actual responses given. For this reason, chi-square analysis is used only as a tool to further narrow the scope of the covariate analysis to follow, and is not being used to draw conclusions about any biases that may be caused by mode of interview.

C. Covariate Analysis

Tables B-1 and B-2 list the results of the covariate analysis. Table B-1 shows the number of significant paired comparisons (blocks) for selected public school items. Table B-2 lists the results for selected private school items. See Attachment C for an example of the output produced in SAS by PROC GLM, which was used to carry out the covariance analysis.

Table B-1 shows that for the items where a reasonable linear regression model could be fit, 3 of 27 paired comparisons were significantly different at the a=.10 level. This seems to indicate no effect upon the data due to mode. However, there appears to be some trend in the block level adjusted means (not shown) whereby the telephone respondents seem to give larger values than do the mail respondents, even when the size covariate is corrected for.

As explained in Section III. B., due to the possible correlation among the questionnaire items being analyzed and due to the possible phenomena being observed, we shall need to undertake a rank-sum type test using standardized block-level means. This analysis is presented in Section IV.D.

Table B-2 gives the results of the covariate analysis for private school data items. It shows 17 of 203 significant paired comparisons at a=.10. This would seem to indicate no differences due to mode. Again, however, this analysis suffers the same difficulties as mentioned previously for the public school data items. Thus, rank-sum type tests also need to be conducted for these items.

D. Nonparametric Testing

As described in Section III, the adjusted means within each block (stratum) were standardized across treatment (mode) and item (questionnaire item). Standardized values were ranked and one-way testing was conducted on the sums.

For the public school items and some of the private school items, there were only nine blocks, resulting in too few degrees of freedom. Thus, a sign test was conducted on the ranked sums rather than a one-way analysis of variance.

The result of sign testing for the public school items listed in Table B-1 did not reveal a significant difference at α = .10. Thus, we would fail to conclude there is evidence of an effect due to mode of interview.

For the three private school items from Table B-2 with only nine blocks, the sign test, again, did not reveal a significant difference due to mode. For the three items with 41 blocks, however, the result of the one-way analysis of variance revealed a significant effect at α = .01.

Due to this strong piece of evidence, we would generally conclude there is evidence of a difference in the data due to mode for private schools.

E. Item Nonresponse

Item nonresponse rates were computed for every item from all questionnaires from the 1991 SASS by Census Bureau staff. It is generally believed that mail responses produce a higher item nonresponse rate. Thus, a null hypothesis that there is no difference in item response rates was tested using a sign test. For both public and private schools, this hypothesis was rejected at α = .10. However, since we used all the items from the questionnaires and there is believed to be substantial correlation in response among the items, particularly between adjacent items, this result must be viewed with some skepticism. As a method of analyzing sets of items with reduced correlation, five samples were selected systematically across all the items. The sign test was conducted on all five samples and all five revealed a significant difference at α .10. Thus, our evidence is consistent with the belief that mail responses have a higher item nonresponse rate.

V. Conclusions

Based on the results of the covariate analysis presented in Section IV.C., we would conclude that there is little if any effect upon the data due to mode of interview. The results of the nonparametric testing, however, revealed some evidence of a difference at least for private schools. It is important to note that the items from the school questionnaire that we have been studying are generally "objective" in nature. They are items that could be considered descriptive of the school and not items we would consider to be greatly subject to the feelings and opinions

of the respondent. Some such questions are included on the teacher questionnaire, and will be studied by the Census Bureau in the near future.

In the absence of any large bias due to mode of interview, it is in the interest of the SASS surveys for the Census Bureau and the National Center for Education Surveys to undertake methods for improving the overall mail response rate in order to reduce cost. Section IV.A. has identified some subgroups for which the mail response rate is relatively poor, specifically for large city public schools, and for specific affiliations of private schools. Dillman (1991) suggests methods for improving mail response rates, such as questionnaire design, use of reminders, and length of the questionnaire. Also, establishment of better contact with the specific school organizations mentioned should help to improve mail response rates. Mail response rates are generally good for the SASS surveys, but we believe there is room for improvement.

VI. References

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Table A-1: Private School Mail Response Rate by Affiliation (List Frame Only)

Affiliation	Mail Response Rate
Association of Military Colleges and Schools - US	66.7%
Catholic	63.0%
Friends	42.3%
Episcopal	50.5%
National Society for Hebrew Day Schools	35.1%
Solomon Schecter	42.5%
Other Jewish	36.1%
Lutheran - Missouri Synod	73.6%
Ev Lutheran Ch - Wisconsin Synod	66.0%
Ev Lutheran Ch in America	71.3%
Other Lutheran	58.2%
Seventh-day Adventis	57.0%
Christian Schools International	64.0%
American Association of Christian Schools	30.7%
NA of Private Schools for Exceptional Children	58.1%
Montessori	48.5%
NA of Independent Schools	48.8%
All Other	50.3%
TOTAL	55.3%

Table A-2: Private School Mail Response Rate by Regional Office (List Frame Only)

Affiliation	Mail Response Rate
Boston	56.7%
New York	42.9%
Philadelphia	56.1%
Detroit	55.6%
Chicago	69.5%
Kansas City	65.1%
Seattle	57.2%
Charlotte	54.7%
Atlanta	53.0%
Dallas	53.8%
Denver	55.2%
Los Angeles	52.3%
TOTAL	55.7%

Table A-3: Public School Mail Response Rate by Type of Locale

Affiliation	Mail Response Rate
Large Cen City	54.9%
Mid-size Cen City	66.4%
Urban fringe of large cen city	65.2%
Urban fringe of mid-size cen city	69.5%
Large town - nonMSA	73.7%
Small town	71.4%
Rural	67.0%
TOTAL	67.3%

Table A-4: Public School Mail Response Rate by Regional Office (List Frame Only)

Affiliation	Mail Response Rate
Boston	68.4%
New York	54.5%
Philadelphia	70.0%
Detroit	63.5%
Chicago	71.7%
Kansas City	65.4%
Seattle	67.8%
Charlotte	71.4%
Atlanta	71.9%
Dallas	65.7%
Denver	65.3%
Los Angeles	64.4%
TOTAL	67.3%

Table B-1: Results of Covariate Analysis for Public School

Item	R-square	Model Variables	Number of Significant Paired Comparison (a = .10)
Number of Students	0.93	grade mode urbanicity CCD # students	2 of 9
Number of teachers	0.86	grade mode urbanicity CCD # teachers	1 of 9
Number of teachers-education beyond bachelor's	0.66	grade mode urbanicity CC # teachers	0 of 9
Number of new teachers	0.21	*	*

* Good fit if could not be found

Table B-2: Results of Covariate Analysis for Private School Items

Item	R-square	Model Variables	Number of Significant Paired Comparison (a = .10)
Number of Students	0.93	urbanicity grade mode PSS # students	1 of 9
Student % minority	0.18	*	*
Enrollment in chapter 1	0.53	association PSS # teachers mode	1 of 11
Tuition	0.62	grade mode urbanicity PSS # teachers	4 of 42
FTE teachers	0.83	grade mode urbanicity PSS # teachers	2 of 9
# state certified teachers	0.68	grade mode urbanicity PSS # teachers	2 of 41
Number of teachers	0.81	grade mode urbanicity PSS # teachers	2 of 9
Number of teachers-education beyond bachelor's	0.69	grade mode urbanicity PSS # teachers	2 of 41
Number of new teachers	0.58	grade mode urbanicity PSS # teachers	3 of 41
Starting Salary	0.16	*	*

* Good fit could not be found