Approaches to a Nonresponse Bias Analysis in an Adult Literacy Survey

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Abstract

Nonresponse bias can be an important source of survey error, and the most recent OMB guidelines place added emphasis on the need to evaluate the impact of nonresponse on key survey estimates. Standard approaches to nonresponse bias analyses rely mainly on demographic information available for the entire sample. Since nonresponse bias can vary from statistic to statistic, these analyses do not necessarily provide an indication of bias in the key statistics of the survey. This paper describes approaches to performing a more extensive nonresponse bias analysis using data directly related to the survey statistics. The approaches include an assessment of the relationship between auxiliary variables and the survey statistics, a comparison of the statistics for late versus early respondents, and an analysis of nonrespondents whose reasons for nonresponse may correlate with survey statistics. The approaches were used in the nonresponse bias analysis for the 2003 National Assessment of Adult Literacy (NAAL).

Keywords: Response Rate, Key Statistics, Disposition Code

1. Introduction

In a standard nonresponse bias analysis, survey respondents and nonrespondents are compared on available demographic information. This type of analysis only provides an indication of nonresponse bias to the extent the auxiliary demographic variables are related to the outcome statistics of the survey.

This paper suggests methods for expanding the basic demographic analysis to better assess the potential for bias in the key statistics. In particular, it will include approaches for using outcome-related analysis variables and outcome-related reasons for nonresponse to assess the potential for nonresponse bias. Outcome-related analysis variables are defined as the key statistics of the survey or variables directly related to the key statistics. For example, in a survey on smoking, outcome-related variables might include the proportion of the population that smokes or measurements of attitudes toward smoking. Outcome-related reasons for nonresponse relate to persons who do not complete the survey because of a reason directly related to the key statistic, for instance, if a person is not able to respond to a health survey because of illness.

This paper is a continuation of "Identifying and Reducing Nonresponse Bias Throughout the Survey Process" (Krenzke et al, 2005). The 2005 paper focused on identifying and reducing nonresponse bias before and during data collection, while this paper centers on evaluating the potential for nonresponse bias after data collection.

This section includes a description of the National Assessment of Adult Literacy (NAAL) Survey and a brief description of nonresponse bias. The remainder of the paper will describe four stages of the nonresponse bias analysis for NAAL. As shown in Table 1, the first stage is the basic analysis using auxiliary demographic variables (section 2.1). The second extends the basic analysis by incorporating multiple data collection stages, weighting adjustments, and additional sources of information, but it is still limited to demographics (section 2.2). Finally, in the last two stages, bias in the key statistics is assessed through outcome-related analysis variables (section 3) and outcome-related reasons for nonresponse (section 4).

Table 1. Summary of nonresponse bias analysis stages

Level	Analyses			
Basic demographic analysis	Chi-square	Logistic regression	Segmentation	
Basic extended	Cumulative nonresponse	Weighting effects	Non-interview report forms	
Outcome-related analysis variables	Correlations	Re-weighting	Late versus early respondents	Range of potential bias
Outcome-related reasons for nonresponse	Literature review	Descriptive statistics		

While this paper describes the approaches used in the 2003 NAAL, the majority of the figures presented here are hypothetical, since results are under review by NCES. All hypothetical figures are noted as such.

The results of the NAAL nonresponse bias analysis will appear in three forthcoming reports. The 2003 NAAL Technical Report will include the basic demographic analysis. The 2003 NAAL Nonresponse Follow-up Study Report will include the basic extended analysis and the analysis of outcome-related variables. The 2003 NAAL Analysis of ESL Nonparticipants will include the analysis for outcome-related reasons for nonresponse.

1.1 National Assessment of Adult Literacy (NAAL)

The approaches described here were used in the nonresponse bias analysis for the 2003 National Assessment of Adult Literacy, or NAAL. NAAL is a national household survey of adults, 16 years or older, sponsored by the National Center for Education Statistics (NCES). It involves a four-stage, stratified cluster design.

The goal of NAAL is to measure adult literacy levels in English. The survey consists of three stages: a screener, an extended interview, and an assessment. As shown in Table 2, the first two stages have response rates under 85 percent and so require a nonresponse bias analysis, according to NCES standards.

Table 2. NAAL 2003 response rates

Stage	Response rate (%)
Overall	62
Screener	82
Extended interview	78
Assessment	97

1.2 Nonresponse Bias

As stated in section 1.1, a nonresponse bias analysis is required if response rates fall below a certain cutoff. This is because nonresponse bias is a function of the response rate (W_R), as evident in Equation 1. The other component is the difference between respondents and nonrespondents *on the outcome variable of interest* $\left(\bar{Y}_R - \bar{Y}_N\right)$. This implies that nonresponse bias can differ from variable to variable.

$$Bias(\bar{y}_R) = (1 - W_R)(\bar{Y}_R - \bar{Y}_N) \qquad (1)$$

The idea is reflected in the most recent OMB guidelines (2006), which state that "It is important that agencies attempt to assess nonresponse bias on key survey estimates." They also note that it is not sufficient to simply examine the demographic composition of the sample or assume weighting adjustments will eliminate nonresponse bias. The methods presented in this paper will attempt to address these guidelines.

2. Demographic Analysis

As stated in section 1, a basic analysis using demographic variables is only an indication of nonresponse bias to the extent that the auxiliary variables are related to the outcome variables of interest. According to OMB, more is needed. This section will describe the basic analysis (section 2.1) and an extension to the basic analysis (section 2.2), as conducted for NAAL.

2.1 Basic Analysis

The basic analysis for NAAL was carried out separately for the screener and interview stages, in accordance with NCES standards. It evaluated the potential for nonresponse bias using design weights and auxiliary demographic information. The design weights were base weights that accounted for design features such as clustering.

For auxiliary demographic information at the screener stage, Census 2000 block and block group-level data was available. Variables were selected that were believed to be related to literacy, such as the percent of persons with less than a high school education, or the percent speaking Spanish at home and English not well or not at all. At the extended interview level, variables from the screener were also used, including age, race/ethnicity, and gender. A list of auxiliary variables for the NAAL nonresponse bias analysis is provided in Table 3.

Table 3. Auxiliary demographic variables for the 2003 NAAL nonresponse bias analysis

Stage	Source	Variables
Screener	Census 2000	Region
		MSA status
		Average household size
		Percent aged 25+ with less than high school education
		Percent aged 5-64 speaking Spanish at home and English not well or not at all
		Percent below 150% of poverty
		Median income
		Percent who rent
Extended interview	Screener	Age
		Race/ethnicity
		Gender

A chi-square analysis is one method that uses the auxiliary demographic information to evaluate nonresponse bias. It was used as the first step in the nonresponse bias analysis for NAAL. The distribution of respondents was compared to the distribution of nonrespondents on the auxiliary variables using a chi-square test of independence. A hypothetical example is provided in Table 4. The chi-square test indicates a statistically significant relationship between metropolitan statistical area (MSA) status and response status, with a larger proportion of nonrespondents in MSAs.

Table 4. Hypothetical chi-square analysis

MSA Status	Respondents %	Non-respondents %	Chi-square statistic	Chi-square p-value
Non-MSA	23	18	7.26	0.007
MSA	77	82		

While the chi-square analysis evaluated one variable at a time, a logistic regression was used to evaluate the relationship between response status and multiple (primarily) main effect auxiliary variables. In particular, it could be used to test the significance of auxiliary variables not used in weighting adjustments. In the previous example, MSA status is significantly related to response status in the chi-square test, which may cause some concern if it was not used in weighting. However, the logistic regression shows that once the weighting variables of poverty and race/ethnicity were included in the model, MSA status is no longer significant.

Table 5. Hypothetical logistic regression results

Predictor	F-test p-value
Weighting variables	
Percent below poverty	0.055
Race/ethnicity	0.002
Nonweighting variables	
Average household size	0.647
MSA status	0.578

To better capture the interactions between auxiliary variables, a segmentation analysis was carried out using the CHAID software. CHAID uses a classification algorithm to divide the sample into subgroups that best explain differential response rates. It could be used to identify pockets of low response rates and potential nonresponse bias. Figure 1 shows an example of a tree from a segmentation analysis, where the low response rate cells are shaded.

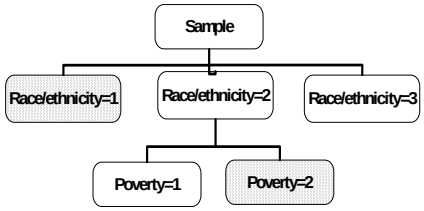

Figure 1. Hypothetical segmentation analysis

This basic nonresponse bias analysis is a good initial assessment of nonresponse bias and can be useful in identifying demographic variables to help reduce the potential for nonresponse bias through weighting adjustments. However, it has its limitations. For instance, it does not reflect the nonresponse bias in the final sample after weighting adjustments, since it is performed for each data collection stage separately using base weights. It also only considers limited data sources. Therefore, an extension to the basic analysis is needed.

2.2 Extended Basic Analysis

For NAAL, the demographic analysis was extended by evaluating the cumulative effects of nonresponse, the effects of weighting, and data from non-interview report forms.

The methods in the basic analysis evaluated each data collection stage separately, according to NCES guidelines. In the extended basic analysis, these same methods were used to evaluate nonresponse bias accrued over multiple data collection stages, since bias in one stage may not be significant over multiple stages. For instance, lower response rates for large households at the screener level may balance out with higher response rates at the interview level, resulting in little nonresponse bias overall.

Each of the methods in the basic analysis made use of base weights, and so they did not capture any reduction in nonresponse bias from weighting. Therefore, an analysis was conducted to compare the distribution of respondents (using final adjusted weights) to the distribution of the eligible sample (using base weights). Comparisons were also made to the population distribution.

Finally, an analysis of non-interview report forms was performed for NAAL. The non-interview report forms identified observable demographic information and reasons for nonresponse not captured in the disposition codes[1]. For NAAL, the forms contained

[1] Disposition codes are codes assigned during data collection indicating the response status and reason for nonresponse, if applicable.

information on the prevalence of gated communities in the West as a reason for incomplete screeners. They also provided information on specific types of disabilities or the language spoken when there was a language barrier. The forms could potentially indicate whether the reasons for nonresponse are related to literacy and suggest ways to improve response rates for future surveys. For instance, a predominance of Spanish speakers among nonrespondents might suggest the need for more bilingual interviewers in certain areas.

The basic analysis and basic extended analysis can be performed using readily available demographic data that exists for both respondents and nonrespondents. However, the extent of this benefit depends on how highly correlated the demographic variables are with the survey outcome. If they are not highly correlated, then the basic analysis and basic extended analysis would not reflect nonresponse bias in the outcome.

3. Analysis of Outcome-Related Variables

The demographic analyses described above assessed nonresponse bias in demographic statistics, not necessarily the key statistics. The next step of the analysis for NAAL was to evaluate bias specifically on outcome-related variables.

The available literacy variables were interview items, such as "How often do you read newspapers or magazines in English?" or "How difficult is it for you to understand a telephone conversation in English?", and three types of literacy score measures (prose, document, and quantitative). The outcome-related variables were only available for respondents, so the question arises as to how they can be used to evaluate nonresponse bias.

3.1 Correlations

One way to use outcome-related variables to evaluate nonresponse bias is to analyze the relationship between the auxiliary variables from the demographic analysis and the outcome-related variables. For NAAL, correlations of the demographic variables with literacy score measures were calculated using final, nonresponse-adjusted weights. Regressions were also processed to assess the relationship of literacy with multiple demographic variables, since a demographic variable might not be significantly related to literacy after accounting for the other auxiliary variables in the model. In addition, simple frequencies were produced of interview items by education, which was used in the demographic analysis.

For auxiliary variables that were used in weighting adjustments, a low correlation with the outcome variables implies that including these variables in weighting adjustments did little to decrease the nonresponse bias. On the other hand, a high correlation would imply a potentially high reduction in bias. For auxiliary variables not used in weighting that were shown to be significantly related to response status in the demographic analysis, a high correlation with the outcome variables would suggest potential bias in key statistics. Such a finding would inform weighting decisions in future surveys.

Table 6 shows select demographic variables and their correlations with NAAL literacy scores. The variables in the table that were not used in weighting, percent minority and percent of renters, had a low to moderate correlation with the outcome[2]. In addition, correlations of the continuous variables were compared with the corresponding categorical recoded variables used for weighting adjustments. Categorizing the variables had little impact on the correlation with literacy.

Table 6. NAAL correlations of select auxiliary demographic variables and literacy score measures

		Absolute correlation with prose literacy				
Variable	Source	<0.1	0.1-0.2	0.2-0.3	0.3-0.4	>0.4
Variables used in weighting						
Average household size	Census 2000		x			
Percent with less than high school education	Census 2000					x
Percent speaking Spanish at home and English not well or not at all	Census 2000				x	
Percent below 150% of poverty	Census 2000				x	
Median income	Census 2000			x		
Age	Screener		x			
Variables considered but not used in weighting						
Percent minority	Census 2000	x				
Percent who rent	Census 2000			x		

[2] While the percent minority and the percent of renters had been considered for use in weighting adjustments, they were not included because they were not significantly related to response status or literacy after accounting for the other weighting variables, and only a limited number of variables could be used in weighting adjustments.

A disadvantage of this approach is that it is limited to respondents, and thus might be affected by differences in respondents and nonrespondents that were not eliminated through the weighting adjustments. For instance, if no relationship is found between median income and prose literacy, it may be that the low-income low-literacy sample disproportionately did not respond. However, the effects of this are expected to be small, and results of the analysis can be used to improve weighting adjustments in the future.

3.2 Re-weighting

Re-weighting can be a useful technique in assessing bias in the outcome variable if the following conditions hold:

- Significant bias in a demographic variable was found in the basic nonresponse bias analysis;
- The demographic variable was not used in the weighting adjustments; and
- The demographic variable was found to be significantly correlated with the outcome variable.

For example, in Table 6, the percent who rent was found to have a moderate correlation with literacy and was not used in weighting. If estimates of this variable were found to be biased in the basic analysis, the final weights can be re-poststratified to control totals for the percent of renters. Then the resulting literacy estimates can be compared to those before re-weighting. A hypothetical example in Table 7 shows little change in the literacy estimates after re-weighting, indicating little bias in the outcome variable as a result of differences between respondents and nonrespondents in the auxiliary variable. This may be because the percent who rent was related to another variable used in weighting.

Table 7. Hypothetical literacy scores before and after re-weighting

	Final weight prose score		Re-weighted prose score	
Percent who rent	Mean	Standard error	Mean	Standard error
Overall	280.05	1.345	280.06	1.349
30% or less	275.74	1.212	275.80	1.214
Greater than 30%	287.86	1.188	287.97	1.191

3.3 "Late" Versus "Early" Respondents

Another method used to evaluate nonresponse bias using outcome-related variables is a comparison of late versus early respondents. For NAAL, late respondents were defined as the last 10 percent of respondents based on the interview completion date. These responses were mostly obtained during a period of focused follow-ups and upgraded field operations. Early and late respondents were compared using t-tests for the differences in mean literacy scores. A significant difference implied: 1) the nonresponse bias was potentially reduced by obtaining the late respondents; and 2) nonresponse bias may still be present to the extent that late respondents are similar to nonrespondents. An example of a similar type of analysis can be found in Krenzke and Griffin (1997).

The effectiveness of this approach to evaluating nonresponse bias depends on the validity of the assumption that late respondents are similar to nonrespondents. This depends largely on the strategies used in the late data collection effort. If no additional effort was made to gain hard-to-reach respondents during the final data collection period, then the late respondents will be more similar to the previous respondents than the nonrespondents and will not provide a good indication of nonresponse bias.

3.4 Range of Potential Bias

The approaches to evaluating nonresponse bias in the outcome variable rely on the availability of outcome data and assumptions about nonrespondents. If the assumption that late respondents are similar to nonrespondents does not hold, or outcome data is not available, an analysis can be performed to provide an indication of the extent of potential bias in the key statistics. For NAAL, the bias formula (1) was used to calculate how different respondents and nonrespondents need to be to bias the population literacy estimate by varying degrees. For instance, if the overall response rate is 80 percent, respondents' and nonrespondents' mean literacy scores need to differ by 25 points in order to bias the national estimate by 5 points:

$$
\begin{aligned}
W_R &= 0.8 \\
Bias\left(\bar{y}_R\right) &= 5 \\
\left(\bar{Y}_R - \bar{Y}_N\right) &= \frac{Bias\left(\bar{y}_R\right)}{\left(1 - W_R\right)} \\
&= \frac{5}{1 - 0.8} \\
&= 25
\end{aligned}
$$

A similar analysis was performed for the First International Adult Literacy Survey in Murray (1998).

4. Analysis of Outcome-Related Reasons for Nonresponse

In addition to evaluating outcome-related variables, an analysis can also be done of sampled persons with known characteristics related to outcome.

In the case of NAAL, disposition codes were used to identify such groups. Of particular interest were persons who could not complete a stage of the survey because of a literacy-related reason. An example of this is a language barrier, where the sampled person spoke a language other than English. Evaluating the prevalence and characteristics of the language barrier cases may help reduce nonresponse bias in future surveys through improved response rates for these groups.

A literature review was one method used in NAAL to evaluate English language difficulties according to the prevalence and characteristics of persons in the NAAL sample. For instance, the 2000 Decennial Census includes data on languages spoken at home and the ability to speak English for the US population. In addition, the 1995 National Household Education Survey contained information on characteristics of English as a Second Language (ESL) class participants. For instance, it included rates of participation in ESL classes and demographics of ESL participants. This review helped frame relationships between demographics and low levels of English literacy.

The literature review was used to confirm the results from a chi-square analysis which compared characteristics of language barrier nonrespondents to other sampled persons. The analysis was performed separately for language problems at each stage of data collection to take advantage of the additional data available. For screener-level nonresponse, basic Census block-level data, such as the percent of the population with less than a high school education, was available. At later stages, a wide variety of data was available, such as race/ethnicity or their self-assessed ability in English. Furthermore, literacy scores for cases such that interview disposition codes changed to complete during the field period could be used to estimate the bias attributable to outcome-related reasons.

Based on the information gathered on persons with language barriers, we are looking into ways to improve response rates and reduce bias, while weighing in the cost and actual benefits of such possible improvements. For example, it may seem that hiring an interviewer of a non-English language that is prevalent in a certain area would be beneficial. However, perhaps using the approach in section 3.4, the magnitude of the bias reduction due to such actions would also need to be considered.

5. Summary

A basic nonresponse bias analysis with demographic data is not sufficient to meet OMB guidelines. However, several approaches exist to incorporate key survey estimates in the analysis. The approaches include: a correlation analysis of demographic variables with key statistics, re-weighting, a comparison of late and early respondents, a calculation of the range of potential bias, and an evaluation of characteristics of outcome-related nonrespondents.

The results of the nonresponse bias analysis can be used to inform analysts of any limitations in the data because of nonresponse bias. It can also help improve data collection strategies and weighting methods for future rounds of the survey.

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