AN IDENTIFICATION STUDY OF NONRESPONDENTS TO THE 1993 SURVEY OF DOCTORATE RECIPIENTS

Ramal Moonesinghe, Susan Mitchell, and Daniel Pasquini

KEY WORDS: Nonresponse bias, pooled wave estimates

The purpose of this paper is to identify differences in response rates to the Survey of Doctorate Recipients (SDR) by subgroups, and to assess the effect of these differences on the quality of the survey estimates. This will be done by comparing the response rates of selected demographic subgroups, and then estimates produced by respondents to successive waves of data collection. In the 1993 SDR, there were 3 waves of data collection—2 questionnaire mailings followed by telephone interviewing. We will examine estimates using pooled data through each wave to see how estimates based on "early" respondents might differ from those based on "early" and "late" respondents combined. This analysis will point out which variables are more likely to be affected by nonresponse bias and if there is a reduction in nonresponse bias through successive waves.

1. Overview of the Survey

The Survey of Doctorate Recipients (SDR) is a longitudinal survey of science and engineering doctorates. The purpose of the survey is to collect information related to the U.S. supply and utilization of these doctorates, as well as demographic and employment information. Survey data are used to address education, human resource, and policy issues by a variety of users in government, academe, and industry. The National Research Council has conducted the survey biennially since 1973.[1]

The sampling frame for the survey is the Doctorate Records File (DRF), an on-going census of all research doctorates earned in the United States since 1920.[2] Information for the DRF is collected through the annual Survey of Earned Doctorates (SED), a questionnaire distributed to doctoral candidates in accredited U.S. colleges and universities at the time they complete their degree requirements.

The DRF is sampled at an overall rate of about 9 percent for the SDR sample. The resulting sample size is about 50,000. The basic sample design is a stratified random sample. In preparation for each survey, a sample of doctorates who graduated in the 2 years since the preceding survey is selected and added to the core sample that is conveyed from year to year. Those who have attained the age of 75 or died are deleted.

In 1993, the most recently completed survey, there were two phases of data collection: a mail survey and telephone follow-up interviewing. The mail survey consisted of an advance letter and two waves of a personalized questionnaire package, with a reminder postcard between waves 1 and 2. Computer-assisted telephone interviewing (CATI) was used to follow-up nonrespondents to the mail survey. Taken together, the two modes of data collection yielded a final response rate of about 86 percent.

2. Significance of Nonresponse

The greater the nonresponse, the more one has reason to worry about its harmful effects on the survey estimates. Although the rate of nonresponse to the SDR is not high, there is concern that nonrespondents may share common characteristics and that these may be underrepresented in the survey estimates. For example, if unemployed and retired individuals respond at low rates (and the SDR is geared toward employed individuals), then estimates of unemployment and retirement rates may be biased downward.

It is difficult to obtain an objective measure of bias, but it is relatively simple to quantify the extent of nonresponse. A simple measure of unit response is

[1] The SDR is sponsored by the National Science Foundation the National Institutes of Health, and the Department of Energy.

[2] The DRF is maintained by the NRC under separate contract with the National Science Foundation.

$$p_r = \frac{n_r}{n_s},$$

where n_r is the number of respondents and n_s is the sample size. Unit nonresponse is consequently measured by 1- p_r. Here p_r measures how well the survey has succeeded in obtaining at least partial response from the elements in the selected sample. Alternative measures are obtained by sample-weighted quantities. The sample-weighted measure of unit response is

$$pw_r = \frac{\sum_r (1/Q_k)}{\sum_s (1/Q_k)},$$

where r and s denote the set of respondents and the sample respectively and Q_k is the probability of selection of the kth unit. (The inverse of the probability of selection, $1/Q_k$, is the basic weight.) The quantity pw_r can be interpreted as an estimated average response probability in the population.

Unweighted and weighted measures may differ considerably. Weighted response rates are shown in this paper because they give a better indication of the potential for nonresponse bias by taking into account different probabilities of selection. Weighted response rates were derived by dividing the sum of the basic weights for in-scope respondents by the sum of the basic weights for in-scope sample cases.

3. Response Rates

Next, we will examine response rates by subgroups to identify which responded at lower or higher rates and which responded "early" versus "late." Table 1 shows 1993 weighted response rates by wave of data collection. Overall, the survey achieved an 86 percent response rate: 46 percentage points from wave 1, 21 percentage points from wave 2, and 19 percentage points from CATI. The residual, 14 percent, were nonrespondents.

By field, response rates ranged from a low of 84 percent for engineers to a high of 88 percent for life scientists. This range is not great, reflecting the fact that nonrespondents were intensively pursued at the CATI stage. Women were slightly more likely to respond to the SDR than men, with final response rates of 88 percent and 86 percent, respectively. Women were also slightly more likely to respond early: 48 percent of women returned the wave 1 questionnaire compared with 45 percent of men.

Response rates varied more widely by race. About 92 percent of Native Americans responded to the survey, followed by 90 percent of whites, 82 percent of Asians, and 79 percent of blacks. Whites were also more likely to respond early compared with other groups: 49 percent of whites completed the wave 1 questionnaire, compared with 43 percent of Native Americans, 36 percent of Asians, and 33 percent of blacks.

Response rates by citizenship status (at the time of degree award) also differed measurably. U.S. native-born citizens were much more likely to respond, 89 percent, and to respond early, 49 percent, than non-U.S. citizens. For example, non-U.S. temporary residents had a final response rate of only 76 percent and a wave 1 response rate of only 31 percent.

This analysis points out the potential for nonresponse bias in a number of demographic variables. Final response rates were lower for engineers, non-U.S. citizens, Asians, and blacks. These groups may be underestimated in the survey estimates. In the next section, we will see if this bears out in the analysis of pooled wave estimates.

4. Differences Among Pooled Wave Estimates

In this section, we will examine how estimates differ based on respondents to different waves. There are 3 sets of estimates: (1) early estimates are based on respondents to the first wave mailing, (2) interim estimates are based on respondents to the first and second mailing, and (3) final estimates are based on respondents to the first mailing, second mailing, and CATI follow-up interviews. At the conclusion of each wave, the response rates were 46 percent, 67 percent and 86 percent, respectively. The purpose of this analysis is to see how closely the early and interim estimates resemble the final (and presumably most reliable) estimates. Results are shown in Tables 2 and 3.

To construct the estimates for each wave. responding cases were weighted by their basic weight multiplied by a nonresponse adjustment factor. Differences in response distributions were not tested for statistical significance because the samples were not independent.

Population Totals

Most notably, a comparison of estimates based on pooled waves shows that early estimates were likely to overestimate the size of the in-scope population of doctoral scientists and engineers by as much as 7.6 percent (see Table 2). The early estimate of the population total was 552,440, compared with an interim estimate of 527,740, and a final estimate of 513,460. (The difference between the interim and final estimate was more modest, 2.8 percent.) The early overestimation occurred because sample members who were living outside the United States were more likely to respond later. (In fact, many were not identified until the CATI stage because they needed to be located.) Because these individuals are considered out of-scope for the survey population, and mail takes longer to reach them, they were underestimated in early estimates. This causes an overestimation of the in-scope population.

Demographic Characteristics

Next, we look at differences in proportions of demographic subgroups. As shown in Table 2, there is little difference between early, interim, and final estimates in terms of demographics—most differences in proportions do not exceed 1.5 percentage points. However, it is important to note that most of the demographic variables are known for the frame and function as "control totals" to which nonresponse adjustments are made. Although the correspondence between weighting classes and reporting domains is not perfect, it is close enough that differences between them would be minimized through weighting.

Employment Characteristics

A comparison of estimates of employment characteristics reveals more differences. Employment status, however, was comparatively stable. The proportion of the population who was full-time employed varied by only 0.1 percentage points between the early and final estimates (84.5 percent compared with 84.4 percent.) Similarly, the proportion who was unemployed changed only slightly—from an early estimate of 1.7 percent to a final estimate of 1.5 percent. This small change was unexpected considering that unemployed individuals might be less likely to respond (without prompting) to an "employment" survey and thus might be underestimated in early estimates.

By type of employer, the proportion of those academically employed increased between the early and interim estimate by about 3 percentage points, and between the early and final estimate by about 2 percentage points. Thus, it appears that early estimates underestimate the proportion of Ph.D.s employed in academe (and slightly overestimate those employed in the private-for-profit sector).

Primary work activity is closely correlated to sector of employment. As a result, the proportion who reported teaching increased between early and final estimates by 1.7 percentage points.

The distribution by academic rank showed considerable variation between the early estimate and final estimate. Full professors accounted for 32.4 percent of faculty in the early estimate, compared with an interim estimate of 36.9 percent and a final estimate of 36.2 percent. Conversely, those at the lower academic ranks, assistant professors, were better represented in the early estimate (21.0 percent) compared with the interim estimate (18.8 percent) and final estimate (19.1 percent).

Government support status indicates the proportion of the sample who received government funding in support of their work during the reference week. This response distribution showed little variation between the early and final estimate—26.6 percent received support in the early estimate compared with 26.1 percent in the final estimate.

Finally, the mean annual salaries for full-time employed doctoral scientists and engineers rose from $62,100 based on the early estimate to $64,100 based on the interim and final estimates. This may reflect the fact that more highly paid individuals have less discretionary time and require more prompting to respond.

In sum, this analysis shows that there is evidence of bias in the early estimates compared with the final estimates. The proportions who were academically employed, teaching, and full professors, may be underestimated in the early estimates. Most of these differences, however, disappear by the time of the interim estimates. The interim estimates—at least in terms of proportions—are strikingly similar to the final estimates. This suggests that interim estimates

may be useful as predictors of final estimates, although they will be less precise because they are based on fewer responses.

5. Conclusions

The analysis suggests the following three conclusions:

1. There are few, but important, variations in response rates to the SDR by subgroups. Certain groups—such as non-U.S. citizens, engineers, Asians, and blacks—have lower response rates. With the exception of engineers, these groups are also more reluctant participants, waiting until later waves to respond. Thus, although their totals may be controlled through weighting, estimates of subsets (such as the number of non-U.S. citizens employed in private-for-profit companies) may be biased, particularly in early estimates.

2. With the exception of population totals, the interim estimates closely resemble the final estimates. Consequently, the SDR should examine the feasibility of issuing interim estimates in advance of the final estimates in order to make data available sooner. However, before any action is taken, further analysis is needed to observe if this resemblance holds by field and not just for the population overall. Most analyses of SDR data are field-specific.

3. Estimates of population totals differ measurably across pooled wave estimates. This is because out-of-scope sample members are identified in greater numbers through successive waves. To improve the reliability of the interim estimates, the SDR should consider ways to classify some sample members as permanently out-of-scope. For example, if an individual is found to be living outside the United States for 3 successive survey cycles, and indicates no plans to return to the U.S., this individual should be classified as permanently out-of-scope. This will improve the correspondence between the interim and final estimate. Also, it will reduce costs by eliminating the need to locate and interview these individuals every 2 years.

Given these findings, further research is warranted to help inform the project staff and federal sponsors about ways to improve the adjustment for nonresponse and out-of-scope cases. Results of this research will be used to modify the data collection plan, and to consider alternative weighting procedures for future surveys.

Table 1 Weighted Response Rates for the 1993 Survey of Doctorate Recipients by Wave and Subgroup

Demographic Characteristics	Final Response Rate	Wave 1	Wave 2	CATI	Non-response
All	86.0	45.9	21.4	18.8	14.0
(Cumulative)		(45.9)	(67.3)	(86.1)	
Field of Doctorate					
Life sciences	88.1	46.3	23.6	18.1	11.9
Physical sciences	86.8	49.2	19.1	18.5	13.2
Math and computer sciences	85.6	42.7	22.2	20.8	14.4
Social sciences	85.0	44.0	21.7	19.3	15.0
Engineers	83.6	45.4	19.8	18.4	16.4
Sex					
Male	85.5	45.3	21.4	18.9	14.5
Female	88.1	48.4	21.4	18.2	11.9
Race					
White	89.7	49.2	22.2	18.3	10.3
Black	78.7	33.4	17.1	28.2	21.3
Asian	82.2	36.3	21.0	24.9	17.8
Native American	92.1	42.5	24.9	24.8	7.9
Age					
35 and under	84.2	43.8	19.2	21.2	15.8
36 to 45	88.5	48.0	20.3	20.2	11.5
46 to 55	85.2	44.2	22.8	18.2	14.8
56 and over	84.8	46.5	22.0	16.3	15.2
Citizenship Status (at Time of PhD)					
U.S. native	88.9	49.0	22.2	17.7	11.1
U.S. naturalized	85.6	41.9	23.5	20.2	14.5
Non-U.S. permanent resident	79.1	36.9	20.9	21.3	20.9
Non-U.S. temporary resident	75.4	30.8	18.6	26.0	24.6

SOURCE: 1993 Survey of Doctorate Recipients, National Research Council/National Science Foundation

Table 2 Demographic Characteristics of Doctoral Scientists and Engineers by Wave of Response, 1993

Demographic Characteristics	Early Estimates	Interim Estimates	Final Estimates
All	552,440	527,740	513,460
Field of Doctorate			
Life sciences	27.2	27.2	27.4
Engineering	16.2	16.1	15.9
Math and computer sciences	5.9	5.8	5.8
Physical sciences	22.0	22.0	22.0
Social sciences	28.8	28.9	28.9
Sex			
Male	80.4	80.2	79.9
Female	19.6	19.8	20.1
Race			
White	85.7	86.9	86.9
Black	1.9	1.8	2.0
Asian	12.0	10.9	10.7
Native American	0.3	0.4	0.4
Age			
35 and under	14.0	13.7	13.6
36 to 45	34.3	33.0	33.0
46 to 55	30.2	31.0	31.1
56 and over	21.5	22.4	22.3
Citizenship Status			
U.S. native	79.6	81.6	82.0
U.S. naturalized	10.8	11.0	10.2
Non-U.S. permanent resident	7.4	5.6	5.8
Non-U.S. temporary resident	2.1	1.8	1.8

SOURCE: 1993 Survey of Doctorate Recipients, National Research Council/National Science Foundation

Table 3 Employment Characteristics of Doctoral Scientists and Engineers by Wave of Response, 1993

Demographic Characteristics	Early Estimates	Interim Estimates	Final Estimates
Total Number	552,440	527,740	513,460
Employment Status			
Full-time employed	84.5	84.6	84.4
Part-time employed	5.7	5.6	5.8
Unemployed, seeking	1.7	1.5	1.5
Retired	6.7	6.9	6.8
Not employed, not seeking	1.5	1.4	1.6
Total Number Employed	498,220	476,020	462,870
Type of Employer			
Academe	44.5	47.3	46.8
Private for-profit	31.9	30.2	30.5
Self-employed	5.9	5.7	6.1
Private not-for-profit	5.5	5.2	5.1
Government	10.6	10.2	10.1
Other sector	1.6	1.4	1.4
Primary Work Activity			
Research and development	42.4	41.6	41.3
Teaching	20.2	22.0	21.9
Management and administration	18.2	17.9	17.6
Computer applications	4.3	3.9	4.0
Other work activities	14.9	14.6	15.2
Government Support			
Received federal support	26.6	26.8	26.1
No support	71.9	71.9	72.7
Do not know	1.5	1.4	1.3
Mean Salaries	$62,100	$64,100	$64,100
Number Academically Employed	221,870	225,120	216,780
Academic Rank			
Full professor	32.4	36.9	36.2
Associate professor	22.3	22.3	22.6
Assistant professor	21.0	18.8	19.1
Instructor/Lecturer	2.9	2.7	2.8
Other	3.0	2.8	3.1
Not applicable	18.4	16.5	16.4

SOURCE: 1993 Survey of Doctorate Recipients, Nation Research Council/National Science Foundation