

## A Cautionary Note on Adjusting Weights for Nonresponse

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### ABSTRACT

For surveys which involve more than one stage of data collection, one method recommended for adjusting weights for nonresponse (after the first stage of data collection) entails utilizing auxiliary variables (from previous stages of data collection) which are identified as predictors of nonresponse. In the final stage of data collection for the United States National Animal Health Monitoring System's Beef '97 Study, two variables were identified that clearly separated eligible producers by their propensity to respond. However, these variables were noticeably inferior to simple region by herd-size categories as predictors of responses that eligible producers gave for other questions in previous data-collection stages. Therefore, we decided to form weight-adjustment classes by region and herd size, even though other variables were greater predictors of response. When selecting auxiliary variables to adjust weights for nonresponse, we recommend that survey statisticians also evaluate the extent to which these auxiliary variables are related to data which nonrespondents would have provided. Using auxiliary variables which exhibit the greatest variation in response propensity may result in the greatest variation in weight-adjustment factors, but may bias population estimates for parameters unrelated to the chosen auxiliary variables.

KEY WORDS: Nonresponse bias; Response propensity; Logistic regression; National survey.

### 1. INTRODUCTION

In multistage surveys where some participants fail to respond during the final stage of data collection, one has considerable information about final-stage nonrespondents from previous stages of the survey. Rizzo, Kalton and Brick (1996) presented several methods for selecting auxiliary variables and adjusting weights for nonresponse when a large number of characteristics of the nonrespondents were known. These methods concentrated on identifying and using characteristics that discriminated between respondents and eligible nonrespondents. However, by adjusting weights based on specific variables which demonstrate the greatest difference in response rates, one may potentially introduce bias in the survey estimates if these variables are unrelated to responses that would have been given by nonrespondents during the final stage of data collection. Therefore, one should also utilize data from the previous stages of data collection to determine whether the chosen auxiliary variables are linked to other characteristics of those eligible to participate in the survey.

The Beef '97 Study (of the National Animal Health Monitoring System (NAHMS) of the United States Department of Agriculture (USDA)) took place in 23 states and involved three stages of data collection. In the first stage (December 30, 1996 through February 3, 1997), enumerators from the USDA: National Agricultural Statistics Service collected data on general management practices from 2,713 agricultural operations with one or more beef cows. First-stage respondents who had five or more beef cows on January 1, 1997 were eligible to continue in the

second stage of data collection (from March 3 through May 23, 1997), provided they had at least one beef cow and remained in business at the time of the second stage of data collection. A total of 1,190 producers participated in the second stage of data collection, which involved an on-farm visit by a veterinary medical officer or animal health technician and concentrated on the health management of the beef cattle.

All operations that participated in the second stage of data collection were eligible to participate in the third and final stage of data collection (August 1, 1997 through January 31, 1998). A total of 952 (80.0%) eligible operations responded in the final stage. From the first two stages of data collection, a considerable amount of information was available on the 238 nonrespondents for the final stage of data collection. The purpose of this note is to describe the methods that were evaluated for adjusting the sample weights for nonresponse in the final stage of data collection for the NAHMS Beef '97 Study.

In addition to region and herd-size (based on the number of beef cows) categories, 45 variables based on data collected during the first two stages of interviews were evaluated for their impact on final-stage response rates. A stepwise variable selection procedure, with region and herd size forced into a logistic regression model and a significance level of 0.05 for other variables to enter and remain in the model, was used (Table 1). The logistic regression analysis demonstrated that there were some differences in final-stage response by region, but that differences in response by herd size were not significant. Increased nonresponse was associated with having only one breeding

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season and not consulting a veterinarian to treat or diagnose disease during 1996. The potential use of the logistic-regression variables as auxiliary variables in creating cells to adjust weights for final-stage nonresponse was examined. Four categorization schemes for nonresponse weight adjustment were proposed:

1. The traditional region by herd size scheme with 15 cells.
2. Region by herd size except in the West, which was subdivided by the number of breeding seasons, for a grand total of 14 cells.
3. Subdividing the cells of option 2 (by either of the auxiliary variables) if the difference in response rate (between the two new subdivisions) was at least ten percent and at least 20 respondents remained in each cell. Two subdivisions occurred, which yielded a total of 16 cells.
4. Continuing the subdivision of categories, based on the greatest difference in response rate, until a minimum number of respondents (no fewer than 20) remained in each cell. This yielded a total of 24 cells.

**Table 1**

Results of Stepwise Logistic Regression to Identify Variables Associated With Nonresponse to the Final Stage of Data Collection for the National Animal Health Monitoring System's Beef '97 Study. Based on 1,190 Eligible Operations and 238 Nonrespondents

Variable/ Response	Parameter Estimate	P
Intercept	0.369	0.181
Region		
Northcentral	0.851	0.000
Southcentral	0.822	0.000
Central	2.062	0.000
Southeast	1.164	0.000
West	1.000	
Number of beef cows		
1 - 49	0.299	0.106
50 - 99	0.146	0.151
100 +	1.000	
Number of breeding Seasons		
1	-.370	0.039
>1 or no set season	1.000	
A veterinarian was consulted to treat or diagnose disease in 1996		
Yes	0.441	0.005
No	1.000	

Adjustment factors for weights of final-stage respondents were computed by dividing the sum of second-stage weights for eligible operations by the sum of second-stage weights for final-stage respondents within each cell.

Since the establishment of cells for schemes 2 through 4 was based on variables which demonstrated the greatest differences in response rates, differences in adjustment factors increased for particular subcategories from scheme 1 to scheme 4. For example, for the first scheme, adjustment factors for the Western region were 1.897, 1.504 and 1.579 for the small, medium and large herd size categories respectively. For the second scheme, adjustment factors in the Western region were 1.334 for operations that did not have one defined breeding season, and 1.875 for operations that did have one defined breeding season. For the third scheme, operations in the West that had one defined breeding season were split into two cells based on whether they had used a veterinarian to diagnose or treat disease during 1996: operations that had indicated "yes" received a weight adjustment of 1.548, while operations that had indicated "no" received a weight adjustment of 2.326.

To investigate how well the proposed auxiliary variables might have related to overall management strategies, we selected additional variables from the first two stages of data collection, and, within each region, examined differences in these variables by herd size category, number of breeding seasons, and whether a veterinarian had been consulted to diagnose or treat disease during 1996. Table 2 presents some representative results for the Western region. Some herd-size differences existed in the percent of operations that had one set breeding season and the percent of operations that had consulted a veterinarian during 1996. However, the percent of operations that had consulted a veterinarian was practically identical for operations that had one set breeding season versus operations that did not have one set breeding season, and vice versa. In addition, the percent of operations that vaccinated heifers for brucellosis and the percent of operations that implanted calves with a growth promotant exhibited a wider range by herd size category than by the other two proposed auxiliary variables. Moreover, mean weaning age and mean calf death loss varied more by herd size than by either number of breeding seasons or by whether a veterinarian was consulted. Similar patterns were noticed for other regions.

Although herd size was not a statistically significant predictor of participation in the final stage of data collection for the NAHMS Beef '97 Study (table 1), herd size was found to be more highly related to a number of questionnaire variables than either of the additional proposed auxiliary variables which derived from the logistic regression analysis. Therefore, we utilized the traditional region by herd size category scheme to perform the nonresponse weight adjustment for the final stage of data collection for the NAHMS Beef '97 Study.

**Table 2**

For 261 Western-Region Operations Eligible to Participate in the Third and Final Phase of Data Collection for the United States National Animal Monitoring System's 1997 Beef '97 Study (August 1 through January 31, 1998), Responses to Selected Variables From the First two Phases of Data Collection by Auxiliary Variables Examined for Weight Adjustment for the Final Stage of Data Collection

Auxiliary variables proposed for weight adjustment for third-stage nonresponse	Variables selected from the first two stages of data collection					
	1	2	3	4	5	6
	Percent			Mean		
Number of beef cows						
1 - 49	69.2	50.8	63.1	15.4	215	6.3
50 - 99	69.2	59.6	80.8	26.9	232	3.9
100+	88.2	70.1	85.4	52.8	223	4.1
Number of breeding seasons						
1	-	62.3	69.8	17.0	223	5.1
>1 or no set season	-	63.5	81.3	43.8	223	4.5
A veterinarian was consulted to treat or diagnose disease in 1996						
Yes	79.2	-	69.8	28.1	222	4.5
No	80.0	-	84.2	44.2	223	4.6

Variables selected from the first two phases of data collection:

- 1 = Operations with one set breeding season
- 2 = Operations that consulted a veterinarian to treat or diagnose disease in 1996
- 3 = Operations that vaccinate any heifers for brucellosis
- 4 = Operations that implanted any calves with a growth promotant prior to or at weaning during 1996
- 5 = Average age (in days) of calves at weaning
- 6 = Percent of calves that died in 1996

Researchers using survey data depend on sample weights to produce population parameter estimates that are approximately unbiased. In the final stage of data collection for the NAHMS Beef '97 Study, a logistic regression analysis identified two variables that were superior to herd size as

predictors of nonresponse in the final stage of data collection. However, these variables were generally inferior to herd size in differentiating how producers responded to a number of key questions related to operation management. Using these two variables to establish categories for weight adjustment for nonresponse could have reduced bias in estimates of parameters (from the third stage of data collection) with which they were correlated. However, estimates of parameters not correlated with these variables could have been distorted. Therefore, we chose the traditional approach of performing the nonresponse weight adjustment by region and herd size categories.

Identifying variables that are good predictors of panel nonresponse is a good practice in any multistage survey. Prior to using these variables to adjust weights for unit nonresponse, we recommend that survey statisticians first follow some procedures to determine the extent to which these variables are linked to other characteristics of those eligible to complete the survey. Adjusting the weights based solely on variables that prove to be good predictors of panel nonresponse could potentially result in warped population estimates if these variables are not also good predictors of data that nonrespondents would have provided on the survey instrument.

## ACKNOWLEDGEMENTS

The authors are grateful to the National Agricultural Statistics Service who initially selected the sample and the National Agricultural Statistics Service enumerators who made the first on-farm contact; the federal and state veterinarians and animal health technicians who made the subsequent on-farm visits; and all of the eligible beef producers, both respondents and nonrespondents.

## REFERENCE

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