Factors, Preventions and Correction Methods for Non-Response in Sample Surveys

GODWIN NWANZU, AMAHIA[1]

Missing survey data occur because of unit and item non-response. This is practically independent of the method of data collection. As a result of the bias that non-response sometimes introduces in survey estimates, identifying factors that promote it, and taking measures of prevention and correction methods are clearly necessary. The standard method to compensate for unit non-response is by weighting adjustment, while item non-responses are handled by some form of imputation. This paper reviews factors that give rise to non-response and the corresponding methods used for its prevention and control. It also discusses their properties.

Keyword: Non-response; Unit non-response; Weighting adjustment; Imputation

1.0 Introduction

Surveys usually collect responses to a large number of items for each sampled unit. One of the most obvious problems in surveys is the inability to collect responses on some or all of the items for a sampled unit or when some responses are deleted because they fail to satisfy edit constraints. This is called the problem of non-response. It indicates a clearly visible "flaw" in the survey operation and has important implications during design and analysis. This is because the sample respondents alone do not validly depict the population investigated and analysis based on respondents may result in misleading inference. It is common practice to distinguish between unit non-response when none of the survey responses are collected for a sampled unit, and item non-response when some but not all of the responses are available. Unit non-response arises because of refusals, inability to participate, not-at-homes, units closed, away on vacation, unit vacant or demolished, and untraced units. Item non-response arises because of item refusals, "don't knows", omissions and answers deleted in editing.

This paper identifies factors that promote survey non-response and reviews the methods available for handling it. The distinction between unit and item non-response is useful in this paper since different adjustment methods are used for these two cases. Generally, the only information available about unit non-respondents is that on the sampling frame from which the sample was drawn. For example, in a two-staged stratified sampling scheme, the primary sampling units, secondary sampling units and the strata in which the non-respondents are located are important. The importance of this information is usually incorporated into weighting adjustments that attempt to compensate for the missing data. As a rule, weighting adjustments are used for unit non-response. In the case of item non-response, a great deal of additional information is available for the element involved. Responses for other survey items are available, in addition to information from the sampling frame. In order to retain all survey responses for elements with some item non-responses, the usual adjustment procedure produces analysis records that incorporate the actual responses to items for which the answer were acceptable and inputed responses for other items.

1.2 Reasons for Non-Response

Reasons explaining why units fail to respond in a survey are often reported, although the words used to describe them may vary. Terminology here seems to depict the type of units being studied and the mode of data collection used in the survey. Durbin (1954) and Kish (1965) discuss some of the general reasons for non-response in household surveys. Research has found that three types of unit non-response have distinctive causes and, for many surveys, distinctive effects on the quality of survey statistics. These are failure to deliver the survey request, refusal to participate in the survey, and inability to participate in the survey.

1.3 Non-Response due to Failure to Deliver the Survey

Non-response due to non-contact or failure to deliver the survey request misses the sample persons whose activities make them unavailable in the specific mode of data collection. The key concept here is the "contactability" of sample units. That is, whether the sample unit is accessible to the survey researcher. In figure 1 below, we present a basic diagram of the influences acting on the contactability of sample units in a survey. In household surveys for

[1] Department of Statistics, University of Ibadan, Nigeria

example, if the researcher knows when people are at home and accessible, successful contact would be made in the first attempt. However, the accessible times of units are generally unknown; hence, interviewers are asked to make multiple calls (a maximum of five) on a sample unit. Some sampled units have "access impediments" that prevent interviewers from contacting them (e.g., locked apartment buildings). People who are rarely at home often remain uncontacted even after repeated call attempts by intervierwers. Similarly, people who have call blocking services on their telephone often are not aware of the attempts of telephone interviewers to reach them.

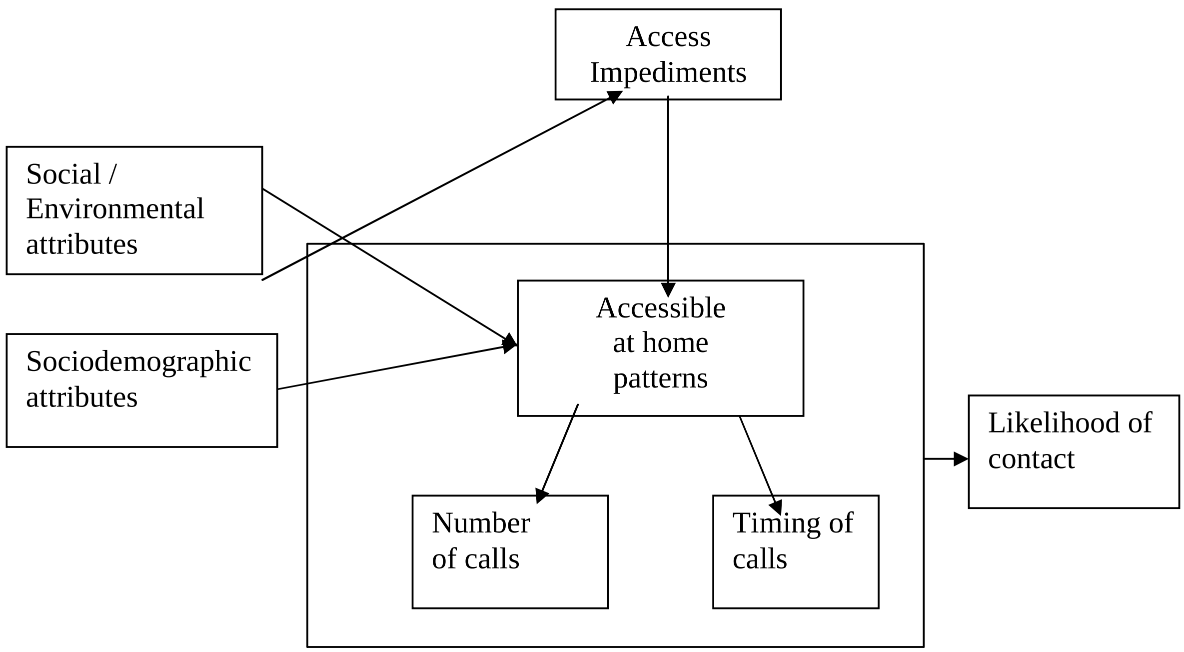

Figure 1: Causal influences on contact with sample household

In practice, the percentage of successful calls declines with each successful call. For example, figure 2 below presents the percentage of sample Agbowo community households contacted by call number among those yet never contacted in a demographic household survey conducted by the author in 2008. About 58% of the contacted households were reached in the first call. With each succeeding call, smaller and smaller percentages were reached.

It was observed that two principal factors predict the number of calls required to gain first contact in household surveys: calls in the evenings and on weekends were found to be more productive than calls at other times; different populations were found to have different accessibility likelihoods.

Generally, sample persons tend to be more accessible to interviewers when they are at home. The problem is to predict when sample persons would be at home. For those who are employed out of the home, most are away from home at set times, often the same periods each week. Most employed persons in Nigeria are away from home from 7.00 a. m. to 6.00 p.m, Mondays through Fridays. However, exceptions may be found in Lagos and Abuja as a result of poor traffic situations. If interviewers call at those times, proportionally fewer persons would be reached. The best times to meet people at home are Saturdays and Sundays and in the evenings from 6.00 p.m. to 9.00 p.m. local time. The easiest households to contact tend to be those in which someone is almost always at home. These include households with persons who are not employed outside the house, either because they care for young children not yet in school, or because they are too old to work. On the other hand, persons in households with access impediments are the most difficult to reach. These include persons in apartment buildings with locked central entrances (e.g. old and new Bodija in the city of Ibadan), and gated residences.

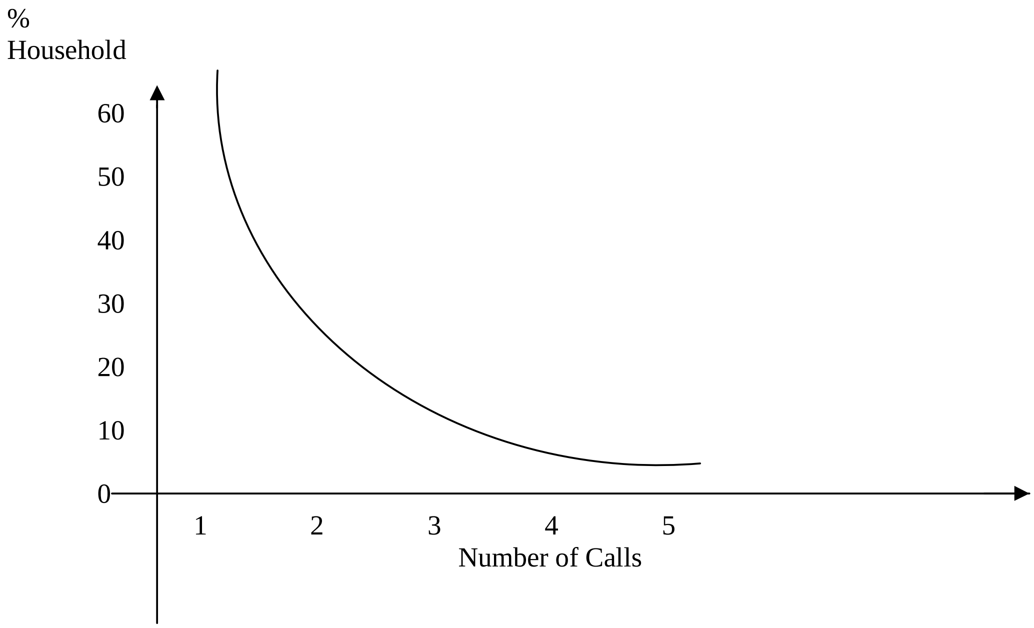

Figure 2: Percentage of eligible sample households by calls to first contact

It may be noted that non-contact non-response may be independent of the purpose of the survey. That is, the sample unit is not difficult to contact because of the topic of the survey but rather because of the set of influences that would be present for any survey request. Clearly, non-response error would arise only for statistics related to those influences.

1.4 Unit Non-Response due to Refusals.

Success in surveys requires the willingness of persons to respond to a complete stranger who calls them on the telephone, mails them a request, or visits their home. The sample persons must have little fear of financial harm from the interviewer, of reputational damage from the interaction or of psychological distress caused by the interviewer. The respondent must believe the pledge of confidentiality that the interviewer proffers; they must believe that they can speak their minds and report intimate details without recrimination or harm. Graves and Kahn (1979) argued that the essential societal ingredients for surveys to gain cooperation of sample persons are rare in human history. Research has shown that non-response involves influences that arise as a result of the following levels:

(a) The social environment [e.g., urban areas tend to generate more refusals in household surveys; households with more than one members generate fewer refusals than single person households (Groves and Couper, 1998].
(b) The person level [e.g., males tend to generate more refusals than females (Smith, 1983)].
(c) The interviewer level [e.g., more-experienced interviewers obtain higher cooperation rates than less-experienced interviewers (Groves and Couper, 1998)].
(d) The survey design level (e.g., incentives offered to sample persons tend to increase cooperation).

The first two influences are out of control of the researcher. For example, there are events that have nothing to do with a survey request that affect how people react to the request. The last two influences, the interviewer level and the survey design level are features that the researcher can manipulate to increase response rates.

The theoretical perspectives that have been applied to survey participation include:

(a) **Opportunity Cost** – this is based on the notion that busy persons disproportionately refuse to be interviewed because the cost of spending time away from other pursuits is more burdensome for them than for others.

(b) **Social Isolation** – this is based on the notion that persons at the high and low ends of the socioeconomic spectrum live isolated life, and consequently, have a tendency to refuse survey requests.
(c) **Topic Interest -** Those who are not interested in the topic of the survey have a tendency to refuse survey requests.
(d) **Over surveying –** This suggests fatigue from survey requests.

A theory known as Leverage – Salience (Groves, Singer, and Corning, 2000) attempts to describe the underpinnings of these behaviours. It claims that different individuals place different importance on features of the survey request (e.g., the sponsor of the survey, topic of the survey, how long the interview would take, what the data will be used for). While some individuals may positively value some attributes, others may negatively value them. As would be expected, these differences in individuals are generally unknown to the statistician. When the sample person is approached for survey requests, one or more of these attributes would be made salient in the interaction with the interviewer. Depending on what is made salient and how much the individual positively or negatively values the attributes would determine a response or refusal outcome. It follows that the value that a sample individual places on a specific attribute of the request, called the leverage of the request is very important in determining an outcome. Another determining factor is how important the specific attributes become in the description of the request, known as salient.

1.5 Unit Non-Response due to the Inability to Provide the Requested Data

Sometimes, sample persons are successfully contacted and would be willing to be respondents, but cannot. Their inability stems from several sources, including:
(a) They are mentally incapable of understanding the questions
(b) They are incapable of retrieving from memory the information requested
(c) Sometimes in business surveys, establishments do not have the necessary information available in the format, or time frame required by the survey

Since the reasons for their inability to comply with the survey request are diverse, statistics affected by non-response are diverse as well

2.0 Item Non-Response

Item non-response occurs when a response to a single question is missing. The impacts of item non-response on a statistic are exactly the same as that for unit non-response, but the damage is limited to statistics produced using data from the affected items.
The causes of item non-response are different from those of unit non-response. Whereas unit non-response arises from a decision based on a brief description of the survey, item non-response occurs after the measurement has been fully revealed. The causes of item non-response include:
(a) inadequate comprehension of the intent of the question, judged failure to retrieve adequate information, and
(b) lack of willingness or motivation to disclose the information, (Beatty and Herrmann, 2002; Krosnick, 2002).

Beatty and Herrmann (2002) posited a model of the response process which distinguishes four levels of cognitive states regarding the information sought by the survey question. These include:
(a) Available (information can be retrieved with minimal effort)
(b) Accessible (information can be retrieved with efforts or prompts)
(c) Generatable (information is not exactly known but can be estimated), and
(d) Inestimable (information is not known and no basis for estimating it)

The above four states are ordered by level of retrieved knowledge suitable for a question response. They posit both errors of commission (reporting an answer without sufficient knowledge) and errors of omission (failing to report an answer when the knowledge exists). Sometimes, social influence prompts sample persons to give an answer which may produce data with measurement errors. Item-missing data can arise legitimately (for those in an "inestimable" cognitive state) or as a response error (for those with the knowledge available). The latter

situation might arise when social desirability influences a respondent to refuse to answer a question (or answer, "do not know") instead of revealing a socially unacceptable attribute.
It follows that item non-response may be reduced by the reduction of the burden of any single question, the reduction of psychological threat or increase in privacy (e.g. , self-administration), and interviewer actions to clarify or probe responses.

The strategies used to compensate for item non-response are often quite different from those for unit non-response, as in the former case the analyst usually has sufficient vector of other responses with which to adjust. Hence, imputation is most often used for item-missing data, whereas weighting class adjustments are common for unit non-response.

3.0 Effect of Non-Response on the Quality of Survey Statistics.

Sometimes, non-response introduces systematic distortion in survey estimates; sometimes, it does not. The principles that determine when non-response distort survey estimates and when it does not are clear, but, in practice, researchers cannot know which situation they are facing.

Bias flows from non-response when the causes of the non-response are linked to the survey statistics measured. For example, if one mounts a survey whose key statistic is the average number of persons per household, $\hat{R}$, an item non-response like "household income" would not affect $\hat{R}$. However, empirical studies have shown that non-response may substantially distort estimates, that is, introduce bias. To give a numerical illustration of the possible effect of non-response on survey statistic, we consider a survey mounted to estimate the percentage P of deaf people in a city (Dalenius, 1985). A simple random sample of $n = 10{,}000$ people was selected and a questionnaire mailed to the 10,000 people, asking if they were deaf. Of these people, n_r returned the questionnaire with the answer (Yes or No) to the question. Among these n_r respondents, P_r^* percent responded that they were deaf. The question is: how close is P_r^* to the corresponding P^* for all 10,000? In order to answer the question, the following computations were considered.
Given the non-response, two quantities were computed, namely:

$Max\ P^*$, corresponding to the assumption that all non-respondents belong to the category of deaf people; and

$Min\ P^*$, corresponding to the assumption that none of the non-respondents belong to the deaf category

The table 1 below presents the two quantities for the case where 30% of the 10,000 were non-respondents.

P_r^*	$Max\ P^*$	$Min\ P^*$	$Max\ P^* - Min\ P^*$
0	30	0	30
10	37	7	30
50	65	35	30
90	93	63	30
100	100	70	30

It is no coincidence that $Max\ P^* - Min\ P^*$ is equal to 30, the percent non-response.

4.0 Design Features to Reduce Unit Non-Response

It is well known that the different modes of data collection tend to have different average response rates. The typical finding is that face-to-face surveys have higher response rates than telephone surveys. Telephone surveys have higher response than self-administered paper surveys, other things being equal. It is also a common finding that the use of interviewers in face-to-face surveys increases response rates, both because of higher success at delivering the survey request and because of their effectiveness in addressing any concerns about participation that sample persons may have.

Figure 3 presents several features that address interviewer actions. First, leverage-salience theory of survey participation offers several deductions about interviewer behaviour. It may be noted that different sample persons are likely to vary in how they evaluate the survey request (assigning different "leverages" to different attributes). Since these are unknown to the interviewer, the interviewer must discern them in order to gain their cooperation.

One further deduction from leverage-salience theory is that training interviewers to recite the same introductory description to each sample person will not be effective (see Morton – Williams, 1993). Groves and Coaper (1998) propose two principles of interviewer behaviour that may underlie the Morton-Williams experimental findings. The principles are maintaining interaction and tailoring. Expert interviewers appear to engage the sample persons in extended conversations (whether or not they are pertinent to the survey request). The interviewers "maintaining interaction" in such a way to attempt to gain information about the concerns of the survey person. Effective interviewers then "tailor" their remarks to the perceived concerns of the sample person. This tailoring appears to explain some of the tendency for experienced interviewers to achieve higher cooperation rates than novice interviewers. They carefully observe the verbal and non-verbal behaviour of the persons in order to discern their concerns. When they form hypotheses about those concerns, the interviewers "tailor" their behaviour to the concerns. They customize their description of the survey to those concerns.
Figure 3 also indicates that if the initial decision of the sample person does not yield an interview, further efforts to bring the person into the respondent pool involve switching interviewers, changing to a different mode or sending persuasion letters. Other methods to increase response rate include.

(a) Making the Public "Survey-Minded"

If the public has a positive appreciation of statistics, it will cooperate as respondents in surveys to a large extent than what else would be the case.

(b) Training the Statisticians

If the statisticians have a good understanding of the problem of non-response, they will address this problem, but without such an understanding, they may just disregard it.

(c) Call-Backs and Reminders

In an interview survey, a respondent may not be at home, at the time when the interviewer pays a visit to make the interview. This may happen, even if the time for that visit has been chosen so as to increase the likelihood that the respondent is at home. If contact is not established, it may be desirable and efficient to make call-backs. By the same token, in a mail survey, those who do not respond to the initial mailing may be sent a reminder (and a new copy of the questionnaire).

(d) Sub-sampling the Non-Respondents

This procedure was developed by Hansen and Hurwitz in 1946 and is widely used in surveys by mail or inter-net.

We will consider a specific case in order to estimate the percentage P of people who are deaf. A sample of $n = 10{,}000$ people is selected and a questionnaire is sent to them. 7,000 people fill in and return the questionnaire; thus the initial number of non-response is 3,000. A reminder is sent to the 3,000. Assume that 1,000 fill in and return the questionnaire; thus, there are 8,000 respondents (corresponding to a response rate of 0.80), and 2,000 non-response (corresponding to a non-response of 0.20). A second step calls for selecting simple random sample of say $n = 400$ of those non-respondents and having them interviewed. Assume all 400 cooperate.

In order to estimate , the following estimate is used;

$$\hat{P} = 0.8p_1 + 0.2p_2$$

where p_1 is the estimate applied to the data collected by mail, and p_2 is the estimate applied to the data collected by interview. The p_1 would have been the estimate if no interview were carried out.

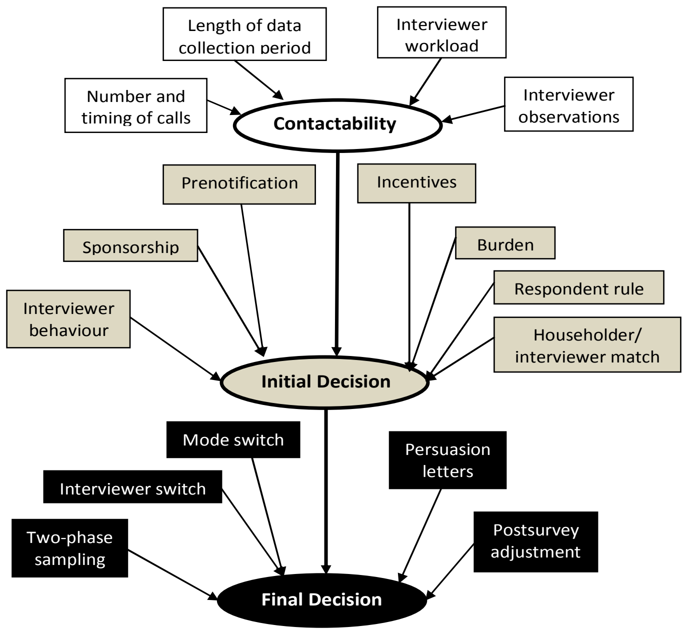

Figure 3: Tools for reducing unit non-response rates

5.0 Reducing the Effect of the Non-Response

The measures discussed in section 4 may greatly reduce the non-response, they may not eliminate it. To this end, measures to reduce the effect of non-response should be considered. These measures are in the nature of "adjustments" of the estimates based on the data available; the term "correction" is sometimes used but should be avoided, as it implies removal of the effects. We will consider two measures; weighting adjustments (used for unit non-responses) and imputations (used for item non-response).

The assumption underlying the weighting and imputation procedures is that once the auxiliary variables used have been taken into account, the missing values are missing at random. To this end, the non-respondents are assumed to be like the respondents within the weighting and imputation classes. Greenless et al (1982) has shown that this assumption can be avoided by using stochastic censoring models. However, as Little (1986) observes, the models are highly sensitive to the distributional assumptions made.

5.1 Weighting Adjustments

Surveys with complex sample designs, often also have unequal probabilities of selection, variation in response rates across important subgroups, and departures from distributions on key variables that are known from outside sources for the population. It is now common practice to generate adjustment weights to compensate for each of these features in analysis.
Weighting adjustments are primarily used to compensate for unit non-response. These procedures increase the weights of the specified respondents so that they represent the non-respondents. They require auxiliary information on either the non-respondents or the total population. There are five types of weighting adjustments; namely post stratification weighting adjustments, population weighting adjustments, sample weighting adjustments, ranking ratio adjustments, and weight based on response probabilities (details are provided by Kalton, 1983).

6.0 Post Stratification Adjustment

Post stratification uses the adjustment cells that are formed in the same way as strata sample selection. They are, however, defined by variables not available at the time the original data were selected. The cells are also mutually exclusive and exhaustive and it is expected that the values of the study variables, Y, in each cell be more similar than among all values in the sample. The best post stratification variables are those strongly correlated to the Y variable. To this end, they are often correlated with individual response probabilities.

Kovar and Poe (1985) used post stratification adjustment in the National Health Interview Survey (NHIS) conducted by the National Centre for Health Statistics. In this survey of the civilian, non-institutionalized population in the United States, each respondent was assigned to one of 60 age – race – sex cross-classification cells for which reliable current population figures $\Delta_h = N_1/N$ were available independent of the survey. A post stratification adjustment is computed for the $h(th)$ cell $(h = 1, 2, 3, \dots, 60)$ as

$$a_h^* = \Delta_h \sum_{h=1}^{H} \frac{\sum_{i=1}^{n_{1h}} W_{hi}^{(2)}}{\sum_{i=1}^{n_{1h}} W_{hi}^{(2)}} \tag{6.1}$$

where $W_{hi}^{(2)}$ is the raw sample weight $\left(W_{hi} = \pi_{hi}^{-1}\right)$ times a weighting class adjustment. The final adjustment sample weight is given by

$$W_{hi}^{(3)} = a_h^* W_{hi}^{(2)} \tag{6.2}$$

From (6.2), it follows that

$$\sum_{i=1}^{n_{1h}} W_{hi}^{(3)} / \sum_{h=1}^{H} \sum_{i=1}^{n_{1h}} W_{hi}^{(3)} = \Delta_h = N_h/N \tag{6.3}$$

This shows that post stratification attempts to make the weighted relative frequency distribution among cells to correspond to the relative distribution among those same cells in the population. By using this adjustment the NHIS sample weights were finally adjusted to bring the sample in line with the U.S. population, at least, with respect to the joint distribution by age, race, and sex as defined in the 60 cells. This means that a sample distorted by non-response, poor sample coverage, and sample variation now has weights allowing the weighted data more accurately to estimate parameters whose measurement of the response variable is correlated with the three post stratification variables.

For the special case where the initial sample is chose by simple random sampling, the same adjustment cells are used for the weighting class and stratification adjustments. Kalton (1983) presents statistical properties of the corresponding estimator of the population mean that uses the weighting class and post stratification adjustments, namely,

$$Est.\bar{Y}_{ps} = \sum_{h=1}^{H} \Delta_h \bar{y}_{1h} = \sum_{h=1}^{H} \frac{N_h}{N} \frac{y_{1h}}{n_{1h}} \tag{6.4}$$

where $\bar{y}_{ih} = \sum_{i=1}^{n_{ih}} Y_{hi}/n_{ih} = y_{ih}/n_{ih}$, and $W_{hi}^{(3)} = N_h/N$, with bias given by

$$Bias\left(Est.\bar{Y}_{ps}\right) = \sum_{h=1}^{H} \Delta_h \lambda_{0h} (\bar{Y}_{ih} - \bar{Y}_{oh}) \tag{6.5}$$

where $\lambda_1 = N_1/N$, expected response rate, and λ_{0h} = expected non-response in the hth cell. The result in (6.5) implies that the amount of non-response bias can be reduced to the extent that cells with equal respondent and non-respondent means are formed. The variance of $Est.\bar{Y}_{ps}$ is expressed as

$$Var\left(\bar{Y}_{ps}\right) \widehat{=} n \sum_{h=1}^{H} \frac{\Delta_h \lambda_{ih} S_{1h}^2 + n^2 \sum_{h=1}^{H} \lambda_{0h} S_{1h}^2 - \sum_{h=1}^{H} (1-\lambda_{1h}) S_{1h}^2}{n^2 \lambda_{1h}^2} \tag{6.6}$$

where S_{1h}^2 is the element variance among all respondents in the h^{th} cell.

7.0 Imputation Methods

Despite the researcher's best practices to minimize item non-response through preventive methods, some missing items almost always appear in survey data, thus requiring the researcher to find other ways to deal with the remaining non-response. A wide variety of imputation methods has been developed for assigning values for missing item responses. These methods range from simple ad hoc procedures used to ensure complete records in data entry to sophisticated hot-deck and regression techniques. The following are some common imputation procedures:

Mean-Value Imputation, Regression Methods, Deductive Imputation, Class Mean Imputation, Hot-Deck Methods, Distance Function Matching, Exact Match Imputation and Model-based Methods.

8.0 Choosing Among Methods

The methods for dealing with non-response are basically of two types, preventive and compensatory. Preventive methods are designed to reduce non-response rate, while compensatory methods serve to reduce the effect of remaining non-response, after suitable combination of preventive measures had been applied. In deciding on a suitable preventive strategy for survey non-response, one should take into consideration, the social – environmental attributes, socio-demographic attributes, and the culture of the target population. Based on our prior experience, a combination of incentives, multiple call-backs and endorsements will likely be most effective in many situations. The kind of incentive given would depend on whether the respondent is head of a household or an establishment. Advantages of incentive are more than the disadvantages: it enables timely response to questionnaire, motivates respondents to fill questionnaire or grant an interview, and breaks the resistance of respondents, and promotes propensity to fill questionnaire or grant an interview. For example, the distribution of CBN publications to respondents in establishment surveys will aid the respondent to understand the use of the data supplied, and would likely increase their willingness to co-operate in future surveys.

Assessing the utility of non-preventive methods in deciding on a strategy for dealing with non-response may involve:

(a) finding that method which allows the researcher make statistical inference he had intended while minimizing the effect of non-response on inference,

(b) identifying those methods with the smallest mean square error in evaluating non-preventive strategies,

(c) when investigating relationship (after cross-tabulation) one would like to pick the method that least alters the relationship being studied

(d) when using model-based approach, one may be concerned primarily about finding approaches that minimize the bias and variance arising from the assumed model and whose estimators are most robust to departures from the assumed model. Fast rates of convergence for iterative methods would also be desirable

(e) the cost effectiveness issue must be considered in choosing among approaches to dealing with non-response. Also, the complexity of implementing the methods must be considered. For example, sophisticated approaches such as multiple imputation applied to the hot-deck method may not be practical when staff are unavailable to apply the method and interpret its findings.

The challenge in making the final choice is to recognize the relative strengths and weaknesses of competing alternatives for the survey. The researcher should focus more intently on finding functional and rational basis for choosing among competing methods.

9.0 Conclusion Remarks

Surveys produce data that attempt to describe large populations by measuring and estimating only a sample of those populations. When the designated sample cannot be completely measured and estimates are based only on responding cases, the quality of survey statistics can be threatened. Prevention methods are mandatory for the planning stage of every survey, because no researcher or beneficiary can afford to lose the significance of the collected data. Any survey design should have at the planning stage, the action to be taken when non-response occurs, and appropriate tool for data-collection developed so as to make it possible to obtain maximum information from the sampled units. It seems that the quality of the questionnaire, the training, and experience of the interviewer are the most important aspects that insure the success of a survey.

Not all non-response distort the quality of survey estimates. Non-response produced by causes that are related to key survey statistics is the most harmful kind. Such non-response is termed "non-ignorable non-response. Non-response can harm the quality of both the descriptive and analytic statistics.

There are many tools that survey researchers have to increase the response rates in surveys. These include repeated call backs, small interviewer workloads, advance letters, short-questionnaires, tailoring of interviewer behaviour to the concerns of the sample person, mode and interviewer switches for reluctant respondents. Almost all of these methods require spending more time or effort contacting or interacting with the sample units. This generally increases the costs of surveys.

An important remaining challenge to survey research, regarding non-response is determining when it decreases the quality of survey statistics and when it does not.

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